# **B. Pharmacy** 1st semester - **Human Anatomy** and **Physiology 1** Notes

## **UNIT - 1**



## **Definition and Scope of Anatomy and Physiology**

**Anatomy** is the scientific study of the structure of living organisms and their parts. It involves the examination of organs, tissues, cells, and their spatial relationships within the body.

**Physiology** is the scientific study of the functions and mechanisms of living systems. It focuses on how organs and organ systems work together to maintain life.

## Scope of Human Anatomy and Physiology:

- Understanding structural organization from molecular to organism level
- Studying functional relationships between different body systems
- Investigating normal and abnormal body functions
- Providing foundation for medical and pharmaceutical sciences
- Contributing to disease diagnosis and treatment approaches

## Levels of Structural Organization 🔀

The human body exhibits hierarchical organization from simple to complex:

#### 1. Chemical Level

- Atoms combine to form molecules
- Basic building blocks of all matter
- Include elements like carbon, hydrogen, oxygen, nitrogen

#### 2 Cellular Level

- Molecules combine to form organelles
- Organelles work together to form cells
- Cells are the basic structural and functional units of life

#### 3 Tissue Level

- Groups of similar cells performing specific functions
- Four primary tissue types: epithelial, connective, muscle, nervous

## 4. Organ Level

- Two or more tissue types working together
- Perform specific complex functions
- Examples: heart, liver, kidney, brain

## 5. Organ System Level

- Groups of organs working together
- Carry out major body functions
- Examples: cardiovascular, respiratory, digestive systems

## 6. Organism Level

- All organ systems functioning together
- Represents the complete living individual
- Maintains homeostasis and reproduction

## **Body Systems**

System	Primary Functions	Major Organs	
Integumentary	Protection, temperature regulation	Skin, hair, nails	
Skeletal	Support, protection, movement Bones, cartilage, ligament		
Muscular	Movement, posture, heat production	Skeletal, cardiac, smooth muscles	
Nervous	Control, coordination, communication	Brain, spinal cord, nerves	
Endocrine	Hormone production, regulation	Glands, hormones	
Cardiovascular	Transport, circulation	Heart, blood vessels, blood	
Lymphatic	Immunity, fluid balance  Lymph nodes, spleer thymus		
Respiratory	Gas exchange, pH regulation	Lungs, airways	
Digestive	Nutrient breakdown, absorption	Stomach, intestines, liver	
Urinary	Waste elimination, fluid balance	Kidneys, bladder, ureters	
Reproductive	Reproduction, hormone production	Gonads, reproductive organs	

#### **Basic Life Processes** •

## 1. Metabolism

- Sum of all chemical reactions in the body
- Includes catabolism (breakdown) and anabolism (synthesis)
- Provides energy for cellular activities

### 2. Responsiveness (Irritability)

- Ability to detect and respond to environmental changes
- Involves sensory reception and motor response
- Essential for survival and adaptation

#### 3. Movement

- Motion of whole body or body parts
- Includes locomotion and internal movements
- Facilitated by muscular and skeletal systems

#### 4. Growth

- Increase in body size and complexity
- Results from cell division and enlargement
- Continues throughout life in some tissues

## 5. Differentiation

- Process of unspecialized cells becoming specialized
- Occurs during development and tissue repair
- Enables diverse cellular functions

### 6. Reproduction

- Formation of new cells or new individuals
- Ensures species survival
- Involves cellular and organismal reproduction

#### Homeostasis 4

**Definition:** The maintenance of relatively stable internal conditions despite continuous external changes.

## **Components of Homeostatic Control Systems:**

### 1. Receptor (Sensor)

- Detects changes in controlled variable
- Monitors internal and external environment
- Sends information to control center

## 2. Control Center (Integrator)

- Processes information from receptors
- Determines appropriate response
- Sends commands to effectors

#### 3. Effector

- Receives commands from control center
- Produces responses to counteract changes
- Muscles, glands, or organs

## **Types of Feedback Mechanisms:**

#### **Negative Feedback:**

- Most common homeostatic mechanism
- Response opposes or reverses the initial stimulus
- Maintains stability and prevents extreme changes

Example: Body temperature regulation

#### **Positive Feedback:**

- Response enhances or amplifies the initial stimulus
- Less common but important in specific processes
- Often leads to rapid changes or completion of processes
- Example: Blood clotting, childbirth

## **Basic Anatomical Terminology**



#### **Anatomical Position:**

- Standard reference position for anatomical descriptions
- Body erect, feet parallel, arms at sides
- Palms facing forward, thumbs pointing away from body

#### **Directional Terms:**

Term	Definition	Example		
Superior	Toward the head/upper	Heart is superior to stomach		
(Cranial)	part			
Inferior (Caudal)	Away from head/lower part	Stomach is inferior to heart		
Anterior	Toward the front	Sternum is anterior to		
(Ventral)	Toward the nont	vertebrae		
Posterior	Toward the back	Vertebrae are posterior to		
(Dorsal)	Toward the back	sternum		
Medial	Toward the midline			
Lateral	Away from the midline Ears are lateral to the nose			
Proximal	Closer to attachment point	Shoulder is proximal to elbow		
Distal	Farther from attachment point Fingers are distal to shoulde			
Superficial	Toward the surface	Skin is superficial to muscles		
Deep	Away from the surface	Bones are deep to skin		
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## **Body Planes:**

- Sagittal Plane: Divides body into left and right parts
- Frontal (Coronal) Plane: Divides body into anterior and posterior parts
- Transverse (Horizontal) Plane: Divides body into superior and inferior parts



## Cellular Level of Organization

Structure and Functions of Cell 🥕



**Cell Definition:** The basic structural and functional unit of all living organisms.

## **Major Cellular Components:**

#### 1. Plasma Membrane

- Selective barrier surrounding the cell
- · Composed of phospholipid bilayer with embedded proteins
- Controls entry and exit of substances
- Maintains cell shape and integrity

#### **Functions:**

- Transport regulation
- Cell recognition and communication
- Enzymatic activity
- Signal transduction

## 2. Cytoplasm

- Gel-like substance between nucleus and plasma membrane
- Contains water, salts, organic molecules, and organelles
- Site of many metabolic reactions
- Provides medium for organelle movement

#### 3. Nucleus

Control center of the cell

- Contains DNA organized in chromosomes
- Surrounded by nuclear envelope with pores
- Contains nucleolus for ribosome synthesis

#### **Functions:**

- Gene expression regulation
- DNA replication
- RNA synthesis
- Cell division control

## 4. Major Organelles:

## Mitochondria:

- Powerhouses of the cell
- Double membrane structure with cristae
- Site of cellular respiration and ATP production
- Contains own DNA and ribosomes

## **Endoplasmic Reticulum (ER):**

- Network of interconnected membranes
- Rough ER: Studded with ribosomes, protein synthesis
- Smooth ER: Lacks ribosomes, lipid synthesis and detoxification

## **Golgi Apparatus:**

Series of flattened membranous sacs

- Processes, modifies, and packages proteins
- Forms secretory vesicles and lysosomes

#### **Ribosomes:**

- Protein synthesis machinery
- Free ribosomes: proteins for cytoplasm
- Bound ribosomes: proteins for secretion

## **Lysosomes:**

- Digestive organelles containing enzymes
- Break down worn-out organelles and materials
- Autophagy and cellular cleanup

## **Cytoskeleton:**

- Network of protein filaments
- Maintains cell shape and organization
- Facilitates organelle movement
- Composed of microfilaments, microtubules, intermediate filaments

## Transport Across Cell Membrane 🚚

## **Passive Transport Processes:**

## 1. Simple Diffusion

- Movement along concentration gradient
- No energy required

- Small, nonpolar molecules
- Rate depends on concentration gradient, temperature, molecular size

#### 2. Facilitated Diffusion

- Uses transport proteins (channels or carriers)
- No energy required
- Specific for particular substances
- Follows concentration gradient

#### 3. Osmosis

- Diffusion of water across selectively permeable membrane
- Movement from low to high solute concentration
- Determines cell volume and shape
- Affected by tonicity of solutions

## **Active Transport Processes:**

## 1. Primary Active Transport

- Requires direct energy (ATP)
- Moves substances against concentration gradient
- Uses pump proteins
- Example: Sodium-potassium pump

## 2. Secondary Active Transport

Uses energy from concentration gradients

- Coupled transport systems
- Symport: Same direction movement
- Antiport: Opposite direction movement

## 3. Vesicular Transport

## **Endocytosis:**

- **Phagocytosis:** Cell eating (large particles)
- **Pinocytosis:** Cell drinking (fluids)
- Receptor-mediated: Specific substance uptake

## **Exocytosis:**

- Secretion of materials from cell
- Fusion of vesicles with plasma membrane
- Release of proteins, hormones, waste products

#### Cell Division

### **Cell Cycle Phases:**

## 1. Interphase (90% of cell cycle)

#### G1 Phase (Gap 1):

- Cell growth and normal metabolic activities
- Organelle production
- Accumulation of materials for DNA synthesis
- G1/S checkpoint controls progression

## S Phase (Synthesis):

- DNA replication occurs
- Histone protein synthesis
- Chromosome duplication
- Cell continues to grow slowly

## G2 Phase (Gap 2):

- · Continued cell growth
- Protein synthesis for chromosome condensation
- Organelle duplication
- G2/M checkpoint ensures DNA integrity

## 2. M Phase (Mitosis)

## **Mitotic Stages:**

## **Prophase:**

- Chromatin condenses into visible chromosomes
- Nuclear envelope begins to fragment
- Centrioles move to opposite poles
- Spindle apparatus formation begins

#### **Metaphase:**

- Chromosomes align at cell equator
- Spindle checkpoint ensures proper attachment

- Maximum chromosome condensation
- Cell arrests until all chromosomes attach

#### **Anaphase:**

- Sister chromatids separate and move to poles
- Cell elongation begins
- Irreversible commitment to division
- Two identical sets of chromosomes formed

### **Telophase:**

- Nuclear envelopes reform around chromosome sets
- Chromosomes begin to decondense
- Spindle apparatus disassembles
- Organelles redistribute

## **Cytokinesis:**

- Division of cytoplasm
- Contractile ring formation (actin and myosin)
- Formation of two daughter cells
- Occurs simultaneously with telophase

#### **Cell Junctions** 🔗



### **Types of Cell Junctions:**

## 1. Tight Junctions

- Seal adjacent cells together
- Prevent passage of materials between cells
- Form permeability barriers
- Common in epithelial tissues
- Maintain tissue integrity

#### 2. Adherens Junctions

- Provide mechanical strength
- · Connect actin filaments of adjacent cells
- Allow some flexibility
- Important in tissue development
- Maintain tissue architecture

#### 3. Desmosomes

- Strong adhesive junctions
- Connect intermediate filaments
- · Resist mechanical stress
- Common in tissues under tension
- Provide structural stability

### 4. Gap Junctions

- Allow direct communication between cells
- Permit passage of small molecules and ions
- Enable electrical coupling

- Coordinate cellular activities
- Important in cardiac and smooth muscle

## General Principles of Cell Communication

## Intracellular Signaling Pathway Activation 🗟

## **Signal Transduction Components:**

## 1. Signal Molecule (Ligand)

- · Chemical messenger carrying information
- Can be hormones, neurotransmitters, growth factors
- Determines specificity of response
- Concentration affects response magnitude

## 2. Receptor Protein

- Specific binding site for signal molecule
- Can be cell surface or intracellular
- Undergoes conformational change upon binding
- Initiates downstream signaling events

### 3. Intracellular Signaling Proteins

- Relay, amplify, and integrate signals
- Include enzymes, adaptor proteins, transcription factors
- Form signaling cascades
- Allow signal modification and control

## 4. Target Proteins

- Final effectors in signaling pathway
- Undergo functional changes
- Produce cellular response
- Can be enzymes, channels, transcription factors

## **Signal Transduction Steps:**

## **Step 1: Signal Recognition**

- Ligand binds to specific receptor
- Receptor-ligand complex formation
- Specificity determined by molecular shape
- Binding affinity affects sensitivity

## **Step 2: Signal Transduction**

- Receptor conformational change
- Activation of intracellular signaling cascade
- Signal amplification occurs
- Multiple pathways may be activated

#### **Step 3: Cellular Response**

- Target protein modification
- Changes in enzyme activity, gene expression, or cell behavior

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- Response magnitude depends on signal strength
- Response duration varies with signal persistence

## **Step 4: Signal Termination**

- Ligand degradation or removal
- Receptor desensitization
- Negative feedback mechanisms
- Return to baseline state

## Forms of Intracellular Signaling 📶

Signaling Type	Distance	Speed	Duration	Examples
Contact- dependent	Direct contact	Very fast	Brief	Cell adhesion molecules
Paracrine	Local (nearby cells)	Fast	Short to medium	Growth factors
Synaptic	Specific target	Very fast	Very brief	Neurotransmitters
Endocrine	Long distance	Slow	Long lasting	Hormones

## a) Contact-Dependent Signaling 🤛

#### **Characteristics:**

- Direct physical contact between cells required
- Signal molecule remains attached to signaling cell surface
- Highly localized and specific communication
- Important during development and immune responses

#### **Mechanisms:**

- Membrane-bound signal molecules
- Cell adhesion molecules serve dual role
- Receptor activation upon cell-cell contact
- No diffusion of signal required

#### **Functions:**

- Cell recognition and adhesion
- Developmental pattern formation
- Immune cell activation
- Tissue organization and maintenance

## b) Paracrine Signaling

#### **Characteristics:**

- Signaling molecules released into extracellular space
- · Affects nearby cells within local tissue environment
- Signal concentration decreases with distance
- Rapid response but limited range

#### **Mechanisms:**

- Local hormone or growth factor release
- Diffusion through extracellular matrix
- Binding to receptors on neighboring cells

• Quick degradation limits signaling range

#### **Functions:**

- Tissue homeostasis and repair
- Local inflammatory responses
- Growth and differentiation control
- Coordinated cellular activities

## c) Synaptic Signaling 🔸

#### **Characteristics:**

- Highly specialized form of paracrine signaling
- Occurs at synapses between neurons
- Extremely rapid and precise communication
- Signal transmitted across synaptic cleft

#### Mechanisms:

- Neurotransmitter release from presynaptic terminal
- Rapid diffusion across narrow synaptic cleft
- Binding to postsynaptic receptors
- Quick removal or degradation of neurotransmitter

## **Functions:**

- Nervous system communication
- Muscle contraction initiation

- Sensory information processing
- Cognitive functions and memory

## d) Endocrine Signaling



#### Characteristics:

- Hormones travel through bloodstream
- Can affect cells throughout entire body
- Slower onset but longer-lasting effects
- Requires specific hormone receptors

#### Mechanisms:

- Hormone synthesis in endocrine glands
- Release into circulation
- Transport via bloodstream
- Binding to target cell receptors

#### **Functions:**

- Body-wide physiological regulation
- Metabolism control
- Growth and development
- Reproduction and stress responses

## 拳 Tissue Level of Organization

Classification of Tissues 📊



## **Four Primary Tissue Types:**

- 1. **Epithelial Tissue** Covers and lines body surfaces
- 2. **Connective Tissue** Supports and connects other tissues
- 3 Muscle Tissue Produces movement
- 4. **Nervous Tissue** Controls and coordinates body functions

## **Epithelial Tissue •**



## General Characteristics:

- Cells closely packed with minimal extracellular matrix
- Forms continuous sheets with distinct surfaces
- Avascular (no blood vessels) but innervated
- High regeneration capacity
- Basement membrane attachment

## **Classification by Shape:**

## Squamous Epithelium:

- Flat, scale-like cells
- Nucleus appears flattened
- Facilitates diffusion and filtration
- Found in alveoli, blood vessels

### **Cuboidal Epithelium:**

Cube-shaped cells

- Round, centrally located nucleus
- Specialized for secretion and absorption
- Found in kidney tubules, glands

## **Columnar Epithelium:**

- Tall, column-like cells
- Oval nucleus near base
- Often have microvilli or cilia
- Found in digestive tract, respiratory tract

## **Classification by Layers:**

## **Simple Epithelium:**

- Single layer of cells
- All cells contact basement membrane
- Functions: diffusion, osmosis, filtration, secretion, absorption
- Found where protection is not primary concern

## **Stratified Epithelium:**

- Multiple layers of cells
- Only basal layer contacts basement membrane
- Primary function: protection
- Found in areas subject to wear and tear

## **Pseudostratified Epithelium:**

- · Appears multilayered but is single layer
- All cells contact basement membrane
- Nuclei at different levels create layered appearance
- Often ciliated for movement of materials

### **Functions of Epithelial Tissue:**

- **Protection:** Physical barrier against damage and pathogens
- **Absorption:** Nutrient and material uptake
- Secretion: Hormone, enzyme, and product release
- Excretion: Waste product elimination
- **Filtration:** Selective passage of materials
- Sensation: Contains sensory nerve endings

## **Connective Tissue**

#### **General Characteristics:**

- Most abundant and widely distributed tissue
- Cells separated by abundant extracellular matrix
- Matrix composed of protein fibers and ground substance
- Usually well vascularized (except cartilage)
- Derived from mesenchymal cells

## **Components:**

#### Cells:

• Fibroblasts: Produce matrix components

- Macrophages: Phagocytic immune cells
- Mast cells: Release histamine and heparin
- Plasma cells: Produce antibodies
- Adipocytes: Store fat

#### **Protein Fibers:**

- Collagen fibers: Strength and flexibility
- Elastic fibers: Stretch and recoil
- Reticular fibers: Support and filtration

#### **Ground Substance:**

- · Gel-like material between cells and fibers
- Composed of glycoproteins and proteoglycans
- Facilitates diffusion and cell migration
- Varies in consistency among tissue types

#### Classification:

#### **Loose Connective Tissue:**

#### **Areolar Connective Tissue:**

- Most widely distributed connective tissue
- Loose arrangement of fibers and cells
- Fills spaces between organs
- Functions: support, cushioning, immune defense

## **Adipose Tissue:**

- Specialized for fat storage
- Adipocytes filled with lipid droplets
- Functions: energy storage, insulation, protection
- Two types: white and brown adipose tissue

#### **Reticular Connective Tissue:**

- Network of reticular fibers
- Forms framework of lymphoid organs
- Supports blood cells in bone marrow
- Functions: support, filtration

## **Dense Connective Tissue:**

## **Dense Regular:**

- Parallel arrangement of collagen fibers
- Provides strength in one direction
- Found in tendons and ligaments
- Withstands tension along fiber direction

### **Dense Irregular:**

- Random arrangement of collagen fibers
- Provides strength in multiple directions
- Found in dermis, organ capsules
- Resists tension from various directions

## **Specialized Connective Tissues:**

## Cartilage:

- **Hyaline:** Smooth surfaces, flexible support
- **Elastic:** Maintains shape while allowing flexibility
- **Fibrocartilage:** Absorbs compression, prevents bone-to-bone contact

#### Bone:

- Hardest connective tissue
- Mineralized matrix provides strength
- Functions: support, protection, mineral storage, blood cell production

#### Blood:

- Liquid connective tissue
- Plasma matrix with formed elements
- Functions: transport, immune defense, homeostasis

## Muscle Tissue 🦾



#### **General Characteristics:**

- Specialized for contraction and force generation
- Contains actin and myosin protein filaments
- Excitable tissue responding to stimuli
- Three distinct types with different functions

### **Types of Muscle Tissue:**

#### **Skeletal Muscle:**

#### Structure:

- Long, cylindrical, multinucleated cells (muscle fibers)
- Striations due to organized contractile proteins
- Nuclei located peripherally
- Attached to bones via tendons

#### **Functions:**

- Voluntary body movements
- Posture maintenance
- Heat generation
- Facial expressions

## **Properties:**

- Under conscious control
- Contracts rapidly and forcefully
- Fatigues relatively quickly
- · Can regenerate to limited extent

#### **Cardiac Muscle:**

#### Structure:

- Branched, shorter cells with single nucleus
- Striations similar to skeletal muscle

- Connected by intercalated discs
- Gap junctions allow electrical coupling

#### **Functions:**

- Pumps blood throughout body
- Maintains circulation
- Adjusts heart rate based on demand

## **Properties:**

- Involuntary control
- Rhythmic, continuous contractions
- Highly fatigue resistant
- Limited regeneration capacity

#### **Smooth Muscle:**

#### **Structure:**

- Spindle-shaped cells with single nucleus
- No striations (smooth appearance)
- Dense bodies anchor contractile proteins
- Gap junctions coordinate contractions

#### **Functions:**

- Controls diameter of blood vessels
- Moves materials through hollow organs

- Regulates airway diameter
- Controls pupil size

## **Properties:**

- Involuntary control
- Slow, sustained contractions
- Very fatigue resistant
- Good regeneration capacity

#### Nervous Tissue

## **General Characteristics:**

- Specialized for electrical and chemical communication
- Excitable tissue capable of generating electrical signals
- Controls and coordinates body activities
- Two main cell types: neurons and neuroglia

## **Neurons (Nerve Cells):**

#### Structure:

- Cell Body (Soma): Contains nucleus and most organelles
- Dendrites: Branched processes receiving signals
- Axon: Long process transmitting signals away from cell body
- Synaptic Terminals: Release neurotransmitters

## **Classification by Function:**

- Sensory (Afferent): Carry information to CNS
- Motor (Efferent): Carry commands from CNS
- Interneurons: Process information within CNS

## **Classification by Structure:**

- Multipolar: Multiple dendrites, one axon
- **Bipolar:** One dendrite, one axon
- **Unipolar:** Single process that splits

#### **Functions:**

- Generate and conduct electrical signals
- Process and integrate information
- Control muscle contractions
- Regulate glandular secretions

## **Properties:**

- High metabolic activity
- Limited regeneration in CNS
- Long-lived cells
- Extreme longevity (lifetime of organism)

### Neuroglia (Glial Cells):

## **Types and Functions:**

## **Central Nervous System:**

- Astrocytes: Support neurons, maintain blood-brain barrier
- Oligodendrocytes: Form myelin sheaths in CNS
- Microglia: Immune defense in brain
- Ependymal cells: Line ventricles, produce cerebrospinal fluid

## **Peripheral Nervous System:**

- Schwann cells: Form myelin sheaths in PNS
- Satellite cells: Support neuron cell bodies in ganglia

#### **General Functions:**

- Physical and metabolic support for neurons
- Insulation and protection
- Immune defense
- Maintenance of extracellular environment

This comprehensive organization covers all the essential topics for UNIT-1 of B. Pharmacy 1st semester Human Anatomy and Physiology, presented in the detailed style requested with proper formatting, tables, and emoji headers