

Introduction to clinical chemistry

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- **Clinical Chemistry** (also known as **chemical pathology**) is the area of pathology that involves the **analysis of bodily fluids** (e.g., blood, urine, cerebrospinal fluid) to diagnose and monitor diseases.

Main Goals:

- Diagnose diseases
- Monitor progression
- Evaluate treatment response
- Assess organ function

Key Areas of Clinical Chemistry:

- Metabolic disorders (e.g., diabetes)
- Electrolyte and fluid balance
- Enzymes and liver function
- Hormones and endocrinology
- Toxicology and drug testing
- Protein, lipid, and carbohydrate analysis

The Cell in Clinical Chemistry

Definition

- The **cell** is the **basic structural and functional unit of life**.
- All living organisms, from single-celled bacteria to complex multicellular organisms like humans, are composed of cells.
- In the context of human biology and clinical chemistry, cells are the foundation of all tissues, organs, and systems.

Types of Human Cells

- Human beings are made up of **trillions of cells** that differ in function and structure.
- Broadly, human cells can be classified into:
 - **Epithelial cells** – line body surfaces and cavities (e.g., skin, gastrointestinal lining)
 - **Muscle cells** – specialized for contraction (e.g., skeletal, cardiac, smooth)
 - **Nerve cells (neurons)** – transmit electrical signals
 - **Connective tissue cells** – provide structural support (e.g., fibroblasts, blood cells)

- **Stem cells** – undifferentiated cells that can differentiate into other cell types

Cellular Functions

- Cells perform several essential functions, including:
 - **Metabolism:** biochemical reactions for energy production
 - **Growth and division:** proliferation for tissue growth and repair
 - **Protein synthesis:** production of enzymes, hormones, and structural proteins
 - **Transport:** movement of substances across membranes
 - **Communication:** via receptors and signal transduction pathways
 - **Apoptosis:** programmed cell death for normal tissue homeostasis

Major Organelles and Their Roles

Organelle	Function
Nucleus	Contains DNA; regulates gene expression
Mitochondria	Produces ATP through cellular respiration
Endoplasmic Reticulum (ER)	Synthesizes proteins (RER) and lipids (SER)
Golgi Apparatus	Processes and packages proteins
Lysosomes	Breaks down waste and cellular debris
Cell Membrane	Regulates substance entry/exit

Cell Membrane Composition

- Phospholipid bilayer
- Proteins (receptors, transporters)
- Cholesterol (maintains fluidity)
- Carbohydrates (glycoproteins/glycolipids – cell signaling)

Composition of the Cell

Cells consist of **multiple components**, each with specific roles. The main components include:

Cell Membrane (Plasma Membrane)

- **Structure:** A lipid bilayer with embedded proteins.
- **Function:** Regulates the entry and exit of substances, communicates with other cells, maintains cellular integrity.

Cytoplasm

- The fluid portion inside the cell membrane that contains:
 - **Cytosol:** the liquid matrix
 - **Organelles:** specialized structures that perform specific cellular functions

Organelles and Their Functions

1. Nucleus

- Contains DNA (genetic material)
- Controls gene expression and cell replication
- Surrounded by a nuclear envelope

2. Mitochondria

- Powerhouse of the cell
- Site of ATP (energy) production via cellular respiration

3. Endoplasmic Reticulum (ER)

- **Rough ER:** Has ribosomes; involved in protein synthesis
- **Smooth ER:** Involved in lipid synthesis and detoxification

4. Golgi Apparatus

- Modifies, sorts, and packages proteins and lipids for secretion or use in the cell

5. Lysosomes

- Contain digestive enzymes to break down waste materials and cellular debris

6. Peroxisomes

- Involved in lipid metabolism and detoxification of harmful substances

7. Ribosomes

- Sites of protein synthesis
- Found free in cytoplasm or attached to the rough ER

8. Cytoskeleton

- A network of protein filaments (microtubules, actin filaments)
- Maintains cell shape, provides mechanical support, and assists in cell movement

9. Centrioles

- Important in cell division and formation of the spindle apparatus

Macromolecular Composition of Cells

1. **Water:** ~70% of cell content; medium for biochemical reactions
2. **Proteins:** Enzymes, structural components, signaling molecules

3. **Lipids:** Membrane structure, energy storage
4. **Carbohydrates:** Energy source and cell signaling (e.g., glycoproteins)
5. **Nucleic acids:** DNA and RNA; genetic material and protein synthesis templates
6. **Ions:** Na^+ , K^+ , Ca^{2+} , Cl^- ; involved in osmoregulation, signaling, and enzyme function

Malfunction of the Cell

- Cell malfunction is a **disruption in normal cell structure or function**, leading to **disease**.
- This can occur due to **genetic, environmental, infectious, or immune-related causes**.

Below are key types of cellular malfunction:

1. Genetic Mutations

- Changes in DNA sequence leading to production of abnormal proteins.
- Examples:
 - **Sickle cell anemia:** mutation in hemoglobin gene
 - **Cystic fibrosis:** mutation in CFTR gene

2. Mitochondrial Dysfunction

- Reduced ATP production affects energy-demanding tissues.
- Seen in metabolic disorders and neurodegenerative diseases.

3. Oxidative Stress

- Excess production of **reactive oxygen species (ROS)** damages DNA, proteins, and lipids.
- Linked to cancer, aging, cardiovascular diseases.

4. Cell Membrane Dysfunction

- Altered permeability or receptor function
- Example: **Insulin resistance** in type 2 diabetes, where insulin receptors are less responsive.

5. Abnormal Cell Division

- **Uncontrolled proliferation** of cells leads to cancer
- Caused by mutation in **oncogenes** or **tumor suppressor genes**

6. Defective Protein Folding

- Misfolded proteins can aggregate and cause cellular toxicity.
- Example: **Alzheimer's disease** (accumulation of beta-amyloid)



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