

Overview of Biomedical Science

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An interdisciplinary field that applies biological and physiological principles to understand health, disease, and medical interventions.

1. What Is Biomedical Science?

Aspect	Description
Definition	The study of the molecular, cellular, and systemic mechanisms that underlie normal physiology and pathological conditions.
Goal	Translate basic scientific discoveries into clinical applications (diagnostics, therapeutics, preventive strategies).
Core Disciplines	• Molecular Biology • Cell Biology • Genetics • Immunology • Microbiology • Physiology • Pathology • Pharmacology
Work Settings	Universities, research institutes, hospitals, biotech/pharma companies, regulatory agencies, public health labs.

2. Major Subfields & Their Focus

Subfield	Key Topics	Typical Techniques
Molecular & Cellular Biology	Gene expression, signal transduction, protein interactions	PCR, Western blot, flow cytometry, CRISPR, confocal microscopy
Genomics & Genetics	DNA sequencing, genome-wide association studies, epigenetics	Next-generation sequencing (NGS), SNP arrays, qPCR
Immunology	Innate & adaptive immunity, vaccine development, autoimmunity	ELISA, flow cytometry, cytokine profiling, animal models
Microbiology & Infectious Disease	Pathogen biology, antimicrobial resistance, host-pathogen interactions	Culture methods, MALDI-TOF, metagenomics, biosafety labs
Physiology & Pathophysiology	Organ system function, disease mechanisms (e.g., cardiovascular, neurodegenerative)	In-vivo imaging, electrophysiology, organ-on-chip

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Subfield	Key Topics	Typical Techniques
Pharmacology & Toxicology	Drug action, metabolism, safety assessment	High-throughput screening, LC-MS/MS, ADME studies
Clinical Laboratory Science	Diagnostic testing, biomarker validation	Hematology analyzers, clinical chemistry platforms, molecular diagnostics
Bioinformatics & Systems Biology	Data integration, network modeling, machine learning	R/Python programming, pathway analysis, AI-driven diagnostics

3. Research Workflow in Biomedical Science

1. Identify a Biological Question

- Clinical observation ? hypothesis generation.

2. Literature Review & Feasibility Assessment

- Systematic search, gap analysis, ethical considerations.

3. Experimental Design

- Choose model system (cell line, animal, organoid).
- Define controls, sample size, statistical power.

4. Method Development & Validation

- Optimize assays, confirm specificity/sensitivity.

5. Data Acquisition

- Generate raw data (e.g., sequencing reads, imaging files).

6. Data Processing & Analysis

- Quality control ? normalization ? statistical testing ? bioinformatic pipelines.

7. Interpretation & Biological Insight

- Relate findings to hypothesis, consider alternative explanations.

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8. Communication

- Write manuscript, present at conferences, deposit data in public repositories.

9. Translation

- Patent filing, clinical trial design, regulatory submission (FDA/EMA).

4. Key Technologies Shaping the Field

Technology	Impact on Biomedical Science
Next-Generation Sequencing (NGS)	Enables whole-genome, transcriptome, and epigenome profiling at scale.
CRISPR-Cas Gene Editing	Precise manipulation of DNA for functional studies and therapeutic development.

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