NAVOI STATE UNIVERSITY

BVM13408 BIOCHEMISTRY AND MOLECULAR BIOLOGY — COURSE SYLLABUS

Faculty of Natural Sciences & Medicine | Department of Biology | Program: 60510100 Biology

COURSE PASSPORT & ACADEMIC METADATA

Course Title: Biochemistry and Molecular Biology

Course Code: BVM13408

Course Type: Mandatory

Field of Study: 500000 Natural Sciences, Math & Statistics

Field: 510000 Biological & Related Sciences

Program: 60510100 Biology

Academic Year: 2026–2027

Semesters: III & IV

Form of Education: Full-time

Language: Uzbek / English / Russian

Total Workload Allocation: 300 Hours Total (150 Contact Hours: 70 Lectures, 80 Lab + 150 Independent Study)

Credits: 10 ECTS

TOP-300 Benchmarked (* Alberts et al. 2022, Lodish, Lehninger)

Aligned UN SDGs: SDG 3, SDG 9 & SDG 12







1. Course Description & TOP-300 Benchmarking Framework

This course provides a detailed exploration of biological chemistry and molecular biology, benchmarked against leading TOP-300 global university curricula (Alberts et al. Molecular Biology of the Cell 7th Ed., Lehninger Principles of Biochemistry).

Students analyze biomolecule structures (proteins, nucleic acids, lipids, carbohydrates), enzymatic kinetics, metabolic pathways (glycolysis, Krebs cycle, oxidative phosphorylation), DNA replication, transcription, translation, epigenetics, recombinant DNA, and apoptosis.

2. Course Aims & Laboratory Competencies

Course Aim: To cultivate theoretical mastery and experimental proficiency in biomolecular characterization, enzymatic assays, DNA/RNA isolation, PCR amplification, gel electrophoresis, spectrophotometry, and bioinformatic analysis.

- Biochemical Characterization: Master qualitative and quantitative assays for proteins, carbohydrates, lipids, enzymes, vitamins, and hormones.
- Metabolic Pathway Analysis: Analyze bioenergetics, carbohydrate glycolysis/TCA cycle, lipid beta-oxidation, and amino acid metabolism.
- Molecular Biology Mechanics: Understand semi-conservative DNA replication, prokaryotic/eukaryotic transcription, mRNA processing, and translation regulation.
- Advanced Experimental Skills: Perform differential ultracentrifugation, plasmid/genomic DNA isolation, agarose gel electrophoresis, PCR, and BLAST analysis (* TOP-300).

3. Prerequisites

Prerequisites: Cytology, Histology & Embryology (SGE11208), Botany (BOT11210), Human Anatomy (OAN1206).

4. Course Structure & Workload Allocation

Semester / Activity	Curriculum & Laboratory Focus	Workload Allocation
Semester III: General & Metabolic Biochemistry	30 Lectures, 30 Lab + 60 Independent Study	120 Hours Total
Semester IV: Molecular Biology & Gene Expression	40 Lectures, 50 Lab + 90 Independent Study	180 Hours Total
Total Workload (Full Academic Module)	2-Semester Comprehensive 10 ECTS Module	300 Hours Total

5. Detailed Course Curriculum Outline

5.1 Lecture Syllabus Outline

• **L1: Scope, History & Methods of Biochemistry:** Aims, historical landmarks, interdisciplinary links, and core biochemical methodologies.

• **L2: Chemical Composition & Functions of Proteins:** Amino acids, peptide bonds, denaturation/renaturation, globular vs. fibrillar proteins.

• **L3: Structural Organization of Proteins:** Primary, secondary (alpha-helix, beta-sheet), tertiary, and quaternary protein structures.

• **L4: Nucleic Acids: Chemical & Molecular Architecture:** Purine/pyrimidine bases, ribose/deoxyribose, phosphodiester bonds, and double helix.

• **L5: DNA and RNA Structures & Biological Roles:** DNA cellular localization, mRNA, tRNA, rRNA structural traits, and nucleotide chemistry.

• **L6: Carbohydrates: Classification & Biological Significance:** Monosaccharides, disaccharides, polysaccharides (starch, glycogen, cellulose) and functions.

• **L7: Lipids: Structure, Classification & Membrane Roles:** Simple and complex lipids, fatty acids, phospholipids, and biological membrane organization.

• **L8: Enzyme Structure & Catalytic Mechanisms:** Active site, enzyme-substrate complexes, activation energy lowering, and catalytic strategies.

• **L9: Enzyme Kinetics & Regulation Mechanisms:** Cofactors, coenzymes, Michaelis-Menten kinetics, pH/temperature effects, and inhibition.

• **L10: Vitamology: Classification, Structure & Functions:** Water-soluble and fat-soluble vitamins, coenzyme derivatives, and deficiency states.

• **L11: Hormones: Endocrine Regulation & Signaling:** Steroid, peptide, and amino acid-derived hormones, second messengers, and metabolic control.

• **L12: Bioenergetics & Lipid Metabolism:** Catabolism/anabolism, fatty acid beta-oxidation, triglyceride synthesis, and ketone bodies.

• **L13: Carbohydrate Metabolism: Digestion & Storage:** Intestinal absorption, glycogenogenesis, glycogenolysis, and blood glucose regulation.

• **L14: Glycolysis & The Tricarboxylic Acid (Krebs) Cycle:** Aerobic/anaerobic glycolysis, ATP yield, pyruvate dehydrogenase complex, and TCA cycle reactions.

• **L15: Protein & Amino Acid Catabolism:** Transamination, deamination, urea cycle, and fate of carbon skeletons.

• **L16: Scope & Objectives of Molecular Biology (*):** Central Dogma of molecular biology, information flow, and cellular mechanisms.

• **L17: Research Methodologies in Molecular Biology (*):** DNA/RNA extraction, PCR, restriction digestion, gel electrophoresis, and blot assays.

• **L18: Structural Levels of Proteins & Folding Mechanics (*):** Chaperones, protein folding dynamics, and structural domain organization.

• **L19: Chemistry & Molecular Topology of Nucleic Acids:** Nucleosides, nucleotides, polynucleotide chains, and supercoiling.

• **L20: DNA Double Helix Structural Variations:** B-DNA, A-DNA, Z-DNA conformations, and biochemical stability.

• **L21: RNA Structural Diversity & Ribozymes:** Secondary/tertiary RNA folding, tRNA cloverleaf, and catalytic RNA.

• **L22: Molecular Mechanisms of DNA Replication (*):** Semiconservative replication, replication fork, helicase, primase, and DNA polymerases.

• **L23: Prokaryotic DNA Replication Mechanisms (*):** OriC initiation, DNA pol I/III, Okazaki fragment processing, and Ter-Tus termination.

• **L24: Eukaryotic DNA Replication & Cell Cycle Control (*):** Replicons, telomeres, telomerase, and cell cycle checkpoint coordination.

• **L25: DNA Repair Systems & Genome Stability (*):** Direct repair, BER, NER, mismatch repair, homologous recombination, and NHEJ.

• **L26: Transcription Process & RNA Polymerases (*):** Promoter recognition, initiation, elongation, and termination in pro/eukaryotes.

• **L27: Post-Transcriptional RNA Processing (*):** 5' capping, 3' polyadenylation, pre-mRNA splicing, and alternative splicing.

• **L28: Gene Organization: Prokaryotes vs. Eukaryotes (*):** Operon model (lac/trp), polycistronic vs. monocistronic mRNA, enhancers, and silencers.

• **L29: Organellar Genomes: Mitochondria & Chloroplasts (*):** Mitochondrial/chloroplast DNA, maternal inheritance, and heteroplasmy.

• **L30: Genetic Code & Amino Acid Activation (*):** Codon triplets, degeneracy, wobble hypothesis, and aminoacyl-tRNA synthetases.

• **L31: Translation Initiation & Elongation Mechanics (*):** Ribosomal sub-units (A, P, E sites), initiation factors, and peptide bond formation.

• **L32: Translation Termination & Gene Regulation (*):** Release factors, polyribosomes, lac operon repression, and attenuation control.

• **L33: Nuclear Architecture & Chromatin Organization (*):** Nucleosomes, histones (H1, H2A, H2B, H3, H4), euchromatin, and heterochromatin.

• **L34: Recombinant DNA & Genetic Engineering (*):** Restriction enzymes, plasmids, recombinant expression, CRISPR-Cas9, and transgenic models.

• **L35: Programmed Cell Death (Apoptosis) (*):** Caspase cascades, intrinsic/extrinsic apoptotic pathways, Bcl-2 family, and cell homeostasis.

5.3 Laboratory & Field Diagnostics Outline

- Safety rules in biochemistry laboratory, reagent preparation, and equipment orientation.
- Color reactions specific for proteins and amino acids (Biuret, Ninhydrin, Xanthoproteic).
- Physico-chemical properties of proteins and quantitative Biuret assay.
- Protein precipitation reactions: Heat coagulation and heavy metal salt precipitation.
- Chromatographic separation of amino acids using paper chromatography.
- Reducing properties of monosaccharides and disaccharides (Fehling/Trommer tests).
- Polysaccharide identification: Starch-iodine complex reaction.
- Determining acid value of fats and oils.
- Determining iodine value of fatty acids.
- Enzymatic activity: Salivary amylase action on starch.
- Enzyme specificity and thermal lability assays.
- Effect of pH on enzymatic reaction rates.
- Effect of activators and inhibitors on enzyme kinetics.

- Quantification of Vitamin C (Ascorbic acid) by iodometric titration.
- Qualitative identification test for pancreatic hormone insulin.
- Safety protocols for molecular biology lab and contamination prevention.
- Operating molecular biology equipment: Thermal cyclers, centrifuges, UV transilluminators.
- Preparing buffer solutions (Molar, Normal, Percent, TAE/TBE) for molecular assays.
- Preparing cell homogonates from plant and animal tissues.
- Subcellular fractionation of cell organelles by differential ultracentrifugation.
- Chlorophyll fluorescence examination using fluorescence microscopy.
- Infrared (IR) spectroscopy for amino acid characterization.
- Plasmid DNA isolation from Escherichia coli bacterial cultures.
- Genomic DNA extraction from plant leaf tissue.
- Genomic DNA extraction from human buccal mucosal epithelial cells.
- Isolation of deoxyribonucleoproteins (DNP) from mammalian liver/spleen.
- Isolation of yeast nucleoproteins.
- Total RNA extraction from Phaseolus vulgaris seeds.
- Genomic DNA extraction from mammalian whole blood.
- Quantifying DNA/RNA concentration and purity (A260/A280 ratio) via spectrophotometry.
- Colorimetric quantification of nucleic acids.
- Nucleoprotein acid hydrolysis and identification of breakdown products.
- Preparing agarose gel matrix for nucleic acid electrophoresis.
- Horizontal agarose gel electrophoresis of DNA/RNA samples.
- Electrophoretic gel band visualization and digital image analysis.
- Preparing PCR amplification reaction mix and master mix formulation.
- Introduction to Thermal Cycler programming and PCR reaction dynamics.
- Targeted PCR amplification of purified genomic DNA.
- Bioinformatics: BLAST sequence alignment and restriction mapping.
- Single Nucleotide Polymorphism (SNP) genotyping analysis.

5.4 Independent Study & Analytical Projects

- Chemical structure of proteins, amino acids, and peptide bond geometries.
- Non-covalent interactions maintaining tertiary and quaternary protein structures.
- Higher-order structures of nucleic acids and RNA secondary folding.
- B-DNA double helix model, phosphodiester linkages, and base stacking energy.
- Complete enzymatic reactions and energy yield of the Tricarboxylic Acid (Krebs) Cycle.
- Compiling a comprehensive glossary of molecular biology terms.
- Determining 3D spatial alignment of amino acid residues and nucleotide motifs.
- Designing a conceptual research project based on advanced molecular biotechnology.
- Solving mathematical problems and exercises on DNA/RNA base composition and translation.

6. Recommended Literature & Information Sources

- Alberts B. et al. Molecular Biology of the Cell (7th Ed.). W.W. Norton & Company, 2022. (* TOP-300)
- Clark D., Pazdernik N., McGehee M. Molecular Biology (3rd Ed.). Academic Cell, 2018. (* TOP-300)
- Mirkhamidova P. et al. Biochemistry (Textbook). Tashkent, 2020.
- Hodjiyev S.O., Gaybullayeva O.O., Baratov U.D. et al. Biochemistry (Textbook). Navoi: Techno Print, 2025.
- Dalimova S.N. et al. Biochemistry and Molecular Biology: Laboratory Manual. Tashkent: NUUz Press, 2023.
- NCBI Database: www.ncbi.nlm.nih.gov
- Protein Data Bank: www.rcsb.org