NAVOI STATE UNIVERSITY

BFB15608 BIOPHYSICS AND BIOINFORMATICS — COURSE SYLLABUS

Faculty of Natural Sciences & Medicine | Department of Biology | Field of Study: 60510100 Biology

COURSE PASSPORT & ACADEMIC METADATA

Course Code: BFB15608

Course Title: Biophysics and Bioinformatics

Course Type: Elective Course (60510100-1.04)

Field of Knowledge: 500000 Natural Sciences, Mathematics & Statistics

Field of Education: 510000 Biological Sciences

Academic Year: 2026–2027

Semesters: V & VI

Form of Education: Full-time

Language of Instruction: Uzbek

Total Workload Allocation: 240 Hours Total (90 Classroom Contact Hours: 40 Lectures, 40 Laboratory/Practical + 120 Independent Study)

Credits: 8 ECTS (4+4)

Aligned UN SDGs: SDG 3 (Good Health & Well-Being), SDG 4 (Quality Education), SDG 9 (Industry, Innovation & Infrastructure), SDG 15 (Life on Land)



1. Course Aims & Interdisciplinary Objectives

The aim of the course is to equip students with a comprehensive understanding of the living cell at the molecular and biophysical level, fostering critical and logical reasoning for solving complex biological and bioinformatic problems using macromolecular and genomic data.

The course integrates classical thermodynamics, enzymatic reaction kinetics, membrane biophysics, and modern bioinformatic algorithms (BLAST, phylogenetics, molecular docking).

2. Intended Learning Outcomes (LO)

Upon successful completion of the course, students will attain the following competencies:

- LO1–LO8 (Professional Knowledge): Understanding nonlinear thermodynamics, Prigogine's theorem, Michaelis-Menten enzyme kinetics, biological membrane architecture, action potentials, as well as sequence alignment algorithms and database architectures.
- LO9–LO14 (Practical Skills): Proficiency in applying thermodynamic laws to bio-systems, utilizing NCBI, UniProt, and PDB databases, performing multiple sequence alignments (ClustalW, T-Coffee), predicting 3D protein structures (Modeller, UCSF Chimera), and conducting molecular docking (AutoDock).

3. Course Prerequisites

Prerequisites: Physics (UKF11210), Biochemistry and Molecular Biology (BVM13408), Fundamentals of Genetics and Genomics (GGA13410).

4. Course Structure & Workload Allocation

Semester / Academic Activity	Curriculum Modules & Analytical Focus	Workload Allocation
Semester V: Biophysics Module	20 Lectures, 20 Laboratory + 60 Independent Study Hours	100 Hours (4 ECTS)
Semester VI: Bioinformatics Module	20 Lectures, 20 Laboratory + 60 Independent Study Hours	100 Hours (4 ECTS)
Total Workload (BFB15608 Module)	Full 2-Semester Comprehensive Academic Course	240 Hours Total (8 ECTS)

5. Detailed Course Curriculum Outline

5.1 Lecture Syllabus Outline

• L1: Introduction to Biophysics: Scope, historical milestones, research methods, and biophysical research in Uzbekistan.

• L2: Thermodynamics of Biological Processes: Nonlinear thermodynamics, thermodynamic laws, Onsager reciprocal relations, Prigogine theorem, synergetics.

• L3: Kinetics of Biological Processes & Mathematical Modeling: Differential equations, phase space, Verhulst and Volterra models, self-oscillatory biological processes.

• **L4: Fundamentals of Molecular Biophysics:** Intermolecular forces (Van der Waals, electrostatic, hydrogen bonds, hydrophobic interactions), cooperativity, Hill plot.

• **L5: Quantum Biophysics Elements:** Singlet and triplet excited states, absorption spectra, inductive-resonance energy transfer, free radicals.

• **L6: Structure and Functions of Biological Membranes:** Membrane fluidity, phase transitions, passive/active transport, ionophores, facilitated diffusion.

• **L7: Action Potential and Synaptic Transmission:** Ion channels, cable properties of nerve fibers, membrane impedance, electrostatic surface potential.

• **L8: Biophysics of Muscle and Non-Muscle Contraction:** Role of Ca2+ ions, Ca-ATPase structure, sliding filament model, non-muscle cellular movement.

• **L9: Photobiology & Photophysical Processes:** Primary photophysical and photochemical reactions, photodynamic damage mechanisms.

• **L10: Intracellular Signaling Cascades:** Primary/secondary messengers, G-proteins, protein kinases, adenylate cyclase and phosphatidylinositol systems.

• **L11: Introduction to Bioinformatics:** History, scope, future perspectives, and fundamental concepts of bioinformatics.

• **L12: Genomics, Proteomics, and Biological Databases:** GenBank, EMBL, DDBJ, UniProt, PDB, and metabolic pathway databases (MetaCyc, HSLS).

• **L13: Biological Sequence Alignment & Searching:** Pairwise and multiple alignments, BLAST search suite at NCBI, Hidden Markov Models (HMMs).

• **L14: Advanced Protein Structure & Pathway Databases:** PIR, PDB, KEGG, MetaCyc, and molecular pathway analytical tools.

• **L15: Transcriptomics & TALEN Nucleases:** Bioinformatic analysis of transcription dynamics and site-specific TALEN nucleases.

• **L16: Genome Editing & CRISPR Technologies:** Open reading frame identification (ORF Finder), exon-intron boundaries, CRISPR-Cas9 technology.

• **L17: Molecular Phylogenetics:** Phylogenetic tree reconstruction, ClustalW2, T-Coffee, RFLP, SSR, and AFLP molecular markers.

• **L18: Gene Ontology & Epigenomics:** DNA methylation profiling, histone modifications, functional gene ontology annotation.

• **L19: Macromolecular Visualization & Homology Modeling:** Global vs. local alignment, 3D macromolecular structure prediction using Modeller.

• **L20: Computer-Aided Protein Structure & Docking:** Ramachandran plots, protein folding stability, hydrophobicity profiles, molecular docking algorithms.

5.2 Laboratory & Practical Sessions Outline

- Instrumentation and safety protocols in a biophysics laboratory; working with membrane preparations.
- Determining steady-state entropy in open biological systems using the Teorell model.

- Measuring surface tension of biological fluids using the Rebinder method.
- Conductometric determination of critical micelle concentration (CMC) in surfactant solutions.
- Measuring osmotic pressure of tissue fluids using the Barger-Rast method.
- Biological kinetics: Calculating activation energy of frog cardiac tissue using the Straub method.
- Measuring diffusion and membrane potential differences in electrolyte solutions.
- Assessing tissue injury potential in natural plant tissues (apple skin, aloe vera leaf).
- Measuring resting potential and electrophoretic (zeta) potential in yeast cells.
- UV-Visible spectrophotometric characterization of biological macromolecules.
- Navigating bibliographic and genomic databases at NCBI; text search tools.
- Nucleotide and amino acid sequence alignment using NCBI BLAST tools.
- Identification and analysis of Open Reading Frames using ORF Finder.
- Multiple sequence alignment and phylogenetic tree construction using ClustalW, T-Coffee, and MEGA X.
- Analyzing 3D protein structures using PDB and UniProt databases.
- Homology modeling of 3D protein structures using Modeller software.
- Visualization and rendering of protein structures in RasMol and UCSF Chimera.
- Ligand-receptor interaction prediction and molecular docking using AutoDock software.

5.3 Independent Study Assignments

- Enzyme kinetics of simple reactions, Michaelis-Menten equation and linearized forms.
- Biophysics of muscular contraction: Sliding filament mechanism and Ca2+ regulation.
- Bilayer lipid membranes, mobile ion carriers, and channel-forming ionophores.
- Molecular architecture of photoreceptor membranes and visual signal transduction.
- Algorithms and mathematical models for phylogenetic tree reconstruction.
- Bioinformatics applications in genomics, proteomics, and structure-based drug design.

6. Recommended Literature & Information Sources

- Gulamov M.I. Biophysics (Textbook). Bukhara, 2020.
- Khurramov P.E. et al. Biophysics Laboratory Manual. Termez, 2023.
- Roziboyev Kh., Komilova N., Radjabova G. Bioinformatics (Study Guide). Tashkent, 2023.
- Young L., Zhang H., Zhang M.K. Fundamentals of Bioinformatics. Samarkand: Springer, 2023.
- Albert I. Biostar Handbook: A Practical Guide to Bioinformatics Data Analysis, 2021.
- Bazarbayev M.I., Mullajonov I. Biophysics. Tashkent, 2018.