NAVOI STATE UNIVERSITY

GNA404 FUNDAMENTALS OF GENOMICS — COURSE SYLLABUS

Faculty of Natural Sciences & Medicine | Department of Biology | Program: 60110900 Biology

COURSE PASSPORT & ACADEMIC METADATA

Course Code: GNA404

Course Title: Fundamentals of Genomics

Course Type: Elective Course (60110900-2.19)

Field of Knowledge: 100000 Education

Field of Education: 110000 Education

Field of Study: 60110900 Biology

Academic Year: 2026–2027

Semester: VIII

Form of Education: Full-time

Language of Instruction: Uzbek

Total Workload Allocation: 120 Hours Total (60 Classroom Contact Hours: 30 Lectures, 30 Practical/Lab + 60 Independent Study)

Credits: 4 ECTS

Aligned UN SDGs: SDG 3 (Good Health & Well-Being - Medical Genomics & Pharmacogenomics), SDG 9 (Industry, Innovation & Infrastructure - Genome Editing & CRISPR-Cas9), SDG 15 (Life on Land - Crop Genomics & Conservation Genetics)



1. Course Purpose & Alignment with UN Sustainable Development Goals (SDGs)

The primary goal of the course is to provide students with advanced theoretical and practical knowledge regarding genome architecture, sequencing technologies, functional and comparative genomics, bioinformatic gene mapping, and genome editing systems.

The course directly maps to key UN SDGs for THE Impact Rankings:

• SDG 3 (Good Health & Well-Being): Medical genomics, pre-symptomatic gene diagnostics, gene therapy, personalized medicine, and pharmacogenomics.

• SDG 9 (Industry, Innovation & Infrastructure): Next-generation sequencing (NGS), CRISPR-Cas9, TALEN genome editing tools, and bioinformatic pipelines.

• SDG 15 (Life on Land): Agricultural crop genomics (e.g., cotton genome analysis), molecular markers (SSR, SNP), and evolutionary population genomics.

2. Intended Learning Outcomes (LO)

Upon completing the course, students will master the following competencies:

- LO1–LO5 (Professional Knowledge): Understanding gene concept, operons, transcription, translation, structural/functional/comparative genomics, epigenomics, and pharmacogenomics.
- LO6–LO9 (Practical Skills): Genomic DNA extraction, agarose gel electrophoresis, PCR amplification, NCBI database navigation, phylogenetic tree construction, and RNA-seq data interpretation.

3. Prerequisites

Prerequisites: Biochemistry and Molecular Biology (BVM13408), Microbiology and Virology (MKV13410).

4. Course Structure & Workload Allocation

Semester / Academic Activity	Curriculum Focus & SDG Analytical Focus	Workload Allocation
Semester VIII: Interactive Lectures (M)	30 Hours of Advanced Theoretical Genomics	30 Contact Hours
Semester VIII: Practical / Lab Work (A)	30 Hours of Hands-on Molecular & Bioinformatic Training	30 Contact Hours
Semester VIII: Independent Study	60 Hours of Computational Projects & Literature Review	60 Hours
Total Workload (GNA404 Module)	Full Academic Module	120 Hours Total (4 ECTS)

5. Detailed Course Curriculum Outline

5.1 Lecture Syllabus Outline

• **M1: Genomics Concept and Historical Evolution:** Recombinant DNA revolution, genome mapping, Sanger sequencing, gene ontology, and genome annotation.

• **M2: Structure and Concept of the Gene:** Alleles, exons, introns, promoters, TATA-box, prokaryotic vs. eukaryotic gene organization.

• **M3: Genome Diversity and Structural Organization:** Prokaryotic, eukaryotic, organellar, and viral genome architectural variations.

• **M4: Transcription, Translation, and Protein Synthesis:** RNA polymerases, genetic code properties, ribosomal machinery, and polypeptide synthesis.

• **M5: Structural Genomics & Expression Profiling:** Gene discovery, expression pathways, Real-time PCR data processing, and expression quantification.

• **M6: Functional Genomics, Transcriptomics & Proteomics:** Small RNAs, cDNA libraries, EST markers, transcriptomic profiling, and proteomic analytics.

• **M7: Comparative Genomics & Molecular Evolution:** Homologs, orthologs, paralogs, STR markers, haplotype concepts, and comparative algorithms.

• **M8: Population & Evolutionary Genomics (SDG 15):** Population genomic diversity, evolutionary dynamics, and medical applications of evolutionary genomics.

• **M9: Epigenetics and Epigenomics:** Human Epigenome Project, DNA methylation, histone modifications (acetylation, methylation), and MSP-PCR.

• **M10: Medical Genomics & Gene Diagnostics (SDG 3):** Preventive medicine, single-nucleotide polymorphisms (SNPs), gene therapy, and genetic passports.

• **M11: Pharmacogenomics & Personalized Medicine (SDG 3):** Genetic variations in drug response, drug metabolism genes, and personalized therapeutic regimens.

• **M12: Role of Bioinformatics in Genomics:** Algorithms for Human Genome Project, sequence repositories (GenBank, UniProt), and bioinformatic pipelines.

• **M13: Gene Mapping Strategies:** Genetic, cytogenetic, molecular, and radiation hybrid (RH) mapping; Shotgun sequencing and STS markers.

• **M14: DNA Sequencing Technologies:** Sanger sequencing vs. Next-Generation Sequencing (NGS) platforms and high-throughput chemistry.

• **M15: Genome Editing Technologies (SDG 9):** Zinc-Finger Nucleases (ZFNs), TALENs, and CRISPR-Cas9 endonuclease systems.

5.2 Laboratory & Practical / Seminar Sessions Outline

- Comparative structural organization of prokaryotic and eukaryotic genomes.
- Genomic DNA extraction and isolation from plant tissues.
- Genomic DNA extraction and isolation from animal tissues.
- Spectrophotometric quantification and purity analysis of isolated DNA.
- Agarose gel electrophoresis of genomic DNA.
- Polymerase Chain Reaction (PCR) amplification setup and optimization.
- Electrophoretic visualization and analysis of PCR amplicons.
- Navigating the NCBI database portal for genomic data retrieval.
- Nucleotide sequence retrieval and analysis in GenBank.
- Exon-intron boundary analysis and gene structure visualization.
- Simple Sequence Repeat (SSR) marker data analysis.

- Single Nucleotide Polymorphism (SNP) marker genotyping.
- Phylogenetic tree reconstruction using molecular sequences.
- Cotton (Gossypium) genome sequence data mining and analysis (SDG 15).
- RNA-seq gene expression differential analysis.

5.3 Independent Study Assignments

- Sanger chain-termination DNA sequencing chemistry.
- Optimization parameters for Polymerase Chain Reaction (PCR).
- ZFN and TALEN precision genome editing mechanisms.
- Genetically Modified Organisms (GMOs): Biosafety, regulation, and ethical considerations.
- Biomarkers and their applications in clinical diagnostics.
- Comparative-evolutionary genomics across plant and animal model organisms.

6. Recommended Literature & Information Sources

- Musayev J.A. et al. Fundamentals of Genetics and Genomics (Textbook). Tashkent: Ma’rifat, 2024.
- Yakubov I.T. Fundamentals of Genomics (Study Guide). Tashkent: UZ Print, 2023.
- Dushanova G.A., Ruziyev F.A. Fundamentals of Genomics. Samarkand: SamDU Press, 2021.
- Bryukhin V.B., Andrusenko E.V. Functional Genetics and Genomics. Saint Petersburg: ITMO Univ., 2021.