# NAVOI STATE UNIVERSITY

## GGA13410 FUNDAMENTALS OF GENETICS AND GENOMICS — COURSE SYLLABUS

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

**COURSE PASSPORT & ACADEMIC METADATA**

**Course Title**: Fundamentals of Genetics and Genomics

**Course Code:** GGA13410

**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

**Total Workload Allocation:** 300 Hours Total (150 Contact Hours: 60 Lectures, 30 Practical, 60 Lab + 150 Independent Study)

**Credits:** 10 ECTS

**Aligned UN SDGs:** SDG 3 (Good Health & Well-being), SDG 9 (Industry, Innovation & Infrastructure), SDG 15 (Life on Land)




### 1. Course Description & Molecular Framework

This comprehensive 2-semester course covers classical transmission genetics, chromosome theory, population genetics, and modern molecular genomics. Students examine DNA replication,

transcription, translation, epigenetics, NGS sequencing, CRISPR/Cas9 gene editing, bioinformatics, and pharmacogenomics.

Aligned with SDG 3, 9, and 15, the curriculum equips biology students with hands-on skills in DNA isolation, PCR amplification, gel electrophoresis, gene mapping, and phylogenetic data analysis.

## 2. Course Aims & Scientific Competencies

Course Aim: To provide advanced theoretical knowledge and laboratory expertise in genetic inheritance, genomic architecture, molecular markers, bioinformatics, and gene therapy technologies.

- Transmission & Cytogenetics: Master Mendelian laws, non-allelic gene interactions, Morgan's chromosome theory, crossing over, and karyotype analysis.
- Genomic Architecture & Sequencing: Understand pro/eukaryotic gene organization, Sanger sequencing, NGS, cDNA/EST libraries, and genome annotation.
- Epigenetics & Gene Editing: Master histone modifications, DNA methylation (MSP), CRISPR/Cas9, TALEN, and zinc finger nucleases.
- Bioinformatics & Medical Genomics: Apply NCBI databases, BLAST alignment, phylogenetic trees, pharmacogenomics, and genetic risk assessment.

## 3. Prerequisites

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

## 4. Course Structure & Workload Allocation

| Semester / Activity | Curriculum & Technical Focus | Workload Allocation |
|---|---|---|
| **Semester III: Transmission & Classical Genetics** | 30 Lectures, 10 Practical, 20 Lab + 60 Independent | 120 Hours Total |
| **Semester IV: Genomics, Sequencing & Gene Editing** | 30 Lectures, 20 Practical, 40 Lab + 90 Independent | 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: Introduction & Development of Genetics and Genomics:** Scope, historical milestones, research methods, and theoretical/practical significance.

• **L2: Concept of Gene, Genome, and Genetic Analysis:** Transmission genetics, structural gene organization across prokaryotes and eukaryotes.

• **L3: Genetic Diversity, DNA Replication & Recombination:** Molecular mechanisms of replication, recombination, transduction, and transposition.

• **L4: Inheritance via Allelic Gene Interactions:** Complete dominance, incomplete dominance, codominance, and multiple allelism.

• **L5: Non-Allelic Gene Interactions:** Complementary action, dominant/recessive epistasis, and modifying genes.

• **L6: Polygenic Inheritance & Quantitative Genetics:** Cumulative and non-cumulative polymeric effects, transgression, and quantitative trait genetics.

• **L7: Inheritance of Quantitative Traits in Cotton:** Crossing schemes for cotton fiber yield and seed fuzziness inheritance.

• **L8: Molecular Structure of Chromosomes:** Karyotype morphology, chromosome size, and structural organization.

• **L9: Chromosome Theory of Heredity:** Cytological bases of asexual/sexual reproduction, gene linkage, and crossing over.

• **L10: Genetic and Cytogenetic Maps:** Human karyotype, autosomal/sex chromosome grouping, and mapping principles.

• **L11: Genetic Material Variability & Mutation Theory:** Types of variation, mutational mechanisms, and mutagenic agents.

• **L12: Gene (Point) Mutations & Chromosomal Aberrations:** Molecular mechanisms of point mutations, deletions, inversions, and polyploidy.

• **L13: Population Genetics & Hardy-Weinberg Equilibrium:** Genetic structure of self-pollinating and cross-pollinating populations.

• **L14: Human Genetics & Medical Cytogenetics:** Material basis of human heredity, pedigree analysis, and anthropogenetic methods.

• **L15: Classification of Genetic Diseases & Immunogenetics:** Inborn errors of metabolism, immunogenetics, and genetic counseling.

• **L16: Introduction to Genomics & Genome Projects:** Recombinant DNA, genomic revolution, genome mapping, and gene ontology.

• **L17: Concept of Gene Structure: Exons, Introns & Promoters:** Exon-intron boundaries, TATA box, SAT box, and regulatory elements.

• **L18: Diversity of Genome Architectures:** Prokaryotic vs. eukaryotic genome organization, viral/organellar genomes.

• **L19: Transcription, Translation & Protein Synthesis:** RNA polymerases, genetic code properties, tRNA charging, and ribosomal translation.

• **L20: Structural Genomics & Real-Time PCR Data Analysis:** Gene identification techniques, expression profiling, and RT-qPCR data processing.

• **L21: Functional Genomics, Transcriptomics & Proteomics:** Small RNAs, cDNA libraries, EST markers, and proteomic profiling.

• **L22: Comparative Genomics & Phylogenetics:** Orthologs, paralogs, STR markers, sequence alignment, and phylogenetic trees.

• **L23: Population Genomics & Evolutionary Genomics:** Population genomics applications, evolutionary drivers, and medical insights.

• **L24: Epigenetics & Epigenomics:** Human Epigenome Project, DNA methylation (MSP), and histone modifications.

• **L25: Medical Genomics & Gene Therapy:** Pre-symptomatic diagnostics, gene therapy vectors, cell therapy, and genetic passports.

• **L26: Pharmacogenomics & Personalized Medicine:** Single nucleotide polymorphisms (SNPs), drug response variation, and precision medicine.

• **L27: Bioinformatics in Genomic Research:** Algorithmic tools, human genome decoding, and genomic databases.

• **L28: Gene Mapping Techniques:** Cytogenetic, molecular, radiation hybrid (RH) mapping, Shotgun, and STS markers.

• **L29: DNA & Genome Sequencing Methodologies:** Sanger chain termination, Next-Generation Sequencing (NGS), and third-gen technologies.

• **L30: Genome Editing Technologies:** Zinc finger nucleases, TALENs, and CRISPR/Cas9 systems.

### 5.2 Practical & Seminar Discussion Outline

- Solving genetic problems on mono-, di-, and polyhybrid crosses.
- Chi-square (X2) goodness-of-fit test for phenotypic ratios.
- Solving genetic problems on complementary, epistatic, and polymeric gene interactions.
- Analyzing autosomal and sex-linked inheritance patterns.
- Population genetics calculations: Determining gene/genotype frequencies via Hardy-Weinberg law.
- Analysis of fundamental genomic projects and practical applications.
- 3D modeling of DNA, chromosome, and genome structural organization.
- Solving mathematical problems on gene, genome, and DNA sequence parameters.
- Video-assisted analysis of molecular mechanisms of DNA replication and recombination.
- Genotyping and sequencing protocols analysis.
- Satellite DNA analysis: Micro- and minisatellite profiling.
- Molecular marker applications in plant and animal breeding.
- Hands-on exercise: Introduction to gene mapping software.
- Hands-on exercise: Gene annotation tools and genome browsing.
- Constructing and interpreting gene phylogenetic trees using bioinformatic software.

### 5.3 Laboratory & Field Diagnostics Outline

- Safety regulations for handling chemical reagents and equipment in genetics lab.
- Molecular structure of chromosomes and differential staining of autosomes vs. sex chromosomes.

- Methods for constructing genetic and cytogenetic maps.
- Determining gene and genotype frequencies in isolated plant and animal populations.
- Constructing linkage maps based on recombination frequencies.
- Population genetics laboratory assays.
- Genetic analysis of quantitative trait inheritance.
- Statistical processing of morpho-economic traits in genetic collection lines.
- Measuring cotton fiber turnout and fuzziness index in hybrid populations.
- Evaluating 1000-seed weight and plant yield parameters in cotton breeding lines.
- Operation of analytical balances, autoclaves, centrifuges, electrophoresis, spectrophotometer, and thermal cyclers.
- Sterilization protocols, pH meter operation, and buffer calibration.
- Reagent preparation for genomic DNA extraction.
- Preparing buffer solutions and agarose gels for DNA electrophoresis.
- Genomic DNA extraction from biological tissues.
- Assessing DNA concentration and purity using UV spectrophotometry.
- Preparing PCR master mix and thermal cycling profile set-up.
- Primer design for polymerase chain reaction (PCR).
- Preparing polyacrylamide and agarose gels.
- Visualization of PCR and restriction fragments via agarose gel electrophoresis.
- Restriction Fragment Length Polymorphism (RFLP) analysis of DNA molecules.
- NCBI database navigation, literature retrieval, and sequence fetching.
- Eukaryotic gene structure and function analysis using genomic databases.
- Eukaryotic protein domain structure and function analysis via UniProt/PDB.
- Quantitative gene expression measurement using transcriptomic data.
- Molecular marker detection via PCR amplification.
- Electrophoretic separation and scoring of molecular markers.
- Gel documentation system operation and band pattern analysis.
- Introduction to genome editing design tools (CRISPR guide RNA design).
- Bioinformatic reconstruction of phylogenetic trees from DNA sequence alignment.

### 5.4 Independent Study & Analytical Projects

- Development of genetic research infrastructure in Uzbekistan and modern trends.
- Biological significance and molecular mechanisms of meiosis.
- Molecular mechanisms of gene mutations and DNA repair pathways.
- Cytoplasmic (maternal) inheritance and organellar genomes.
- Genetic heterogeneity and structure of natural populations.
- Pharmacogenomics and personalized drug therapy design.
- Sanger chain-termination method for DNA sequencing.
- Polymerase Chain Reaction (PCR) principles and modern modifications.
- Genome editing using ZFN and TALEN technologies.

- Genetically Modified Organisms (GMOs): Biosafety, regulation, and applications.
- Biomarkers in medical diagnostics and environmental monitoring.
- Comparative and evolutionary genomics: Synteny and genome evolution.

## 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 (Textbook). Samarkand: SamSU Press, 2021.
- Bryukhin V.B., Andrusenko E.V. Functional Genetics and Genomics. St. Petersburg: ITMO University, 2021.
- Sobirov R.S. et al. Genetics (Textbook). Tashkent: Yoshlar Publishing, 2020.
- Baxramov I.Z., Yusupov D.F. Solving Problems and Exercises in Biology. Tashkent: Bookmany Print, 2024.