Syllabus

M.Sc. in Genome Science

Choice Based Credit System
(CBCS)

School of Interdisciplinary Studies
University of Kalyani
(2019 onwards)

Course Name

M.Sc. in Genome Science

About the course

Genome Science is an Interdisciplinary field of Biology focusing on the structure, function, evolution, mapping and editing of Genome. It involves the collective characterization and quantification of the organism's genes, their interrelation and influence on the organism. This course is aimed to assess the relationships among sequence structure and function in complex biological Networks.

Globally acclaimed Universities and Institutions have already started post graduate program in Genome Science for better understanding the roles of genes in human health, animals and plants by fostering collaboration and serving as resource investigators engaged in Genetics and Genomics Research and Education. However, in India, only a few educational institutions/ Universities offer this kind of advanced course. Introducing the M.Sc. program in Genome Sciences is a first-of-its-kind initiative in Eastern and North-Eastern India.

The program on **Genome Science** will enhance the knowledge and skill of the students from a wide range of backgrounds (e.g. Botany, Zoology, Biochemistry, Microbiology, Medical Science, Biotechnology etc.). The program consists of flexible and modular course structure and includes full-time M.Sc. course, delivered over two years, covering four semesters. The course module will broadly include **Animal, Plant and Microbial Genomics, Human Genetics, Population Genetics, Pharmacogenomics, Epigenetics, Proteomics, Computational Biology and Bioinformatics**. The Department will function in association with State-of-the-art Instrumentation facility in Kalyani University. This facility includes ***Automated DNA Sequencer, Next Generation Sequencer, PCR, Gel documentation system, Confocal and Electron Microscopy and High performance computation facility for Big-data Analysis***.

This program aims to enhance knowledge and skill development in this fast evolving discipline by providing a flexible, interdisciplinary course in Genomics at both basic and applied levels to different stakeholders (basic Biologist to Clinicians).

Objective

Human Resource Development with wide, cutting-edge and in-depth knowledge in Genome Science with the ability to translate in the benefit of the society.

Evaluation

Continuous evaluation based on specific components such as Class Tests, Seminars, Assignments/quiz carries 20% weightage and end semester examination carries 80% weightage. For laboratory courses, end semester examination carries 70% weightage and continuous assessment carries 30% weightage. Overall performance of the student will be indicated in Grades.

Course Credits

Minimum credit required for successful completion of the program is **80 credits** including that of core courses, Elective Courses and Dissertation

Duration

Two years covering four semesters self-financed CBCS curriculum-based M.Sc. Program

Outline of the Choice Based Course & Credit Semester System

1st Semester

A		Theory			
Sl. No.	**Course Code**	**Course Title**	**Hrs/Wk [L-T-P]**	**Credit**	**Points**
1	GST101	Biomolecules	3-1-0	4	100
2	GST102	Cell biology and Immunology	3-1-0	4	100
3	GST103	Genetics & Molecular Biology	3-1-0	4	100
4	GST104	Biostatistics & Bioinformatics	3-1-0	4	100
		Total Theory	**12-4-0**	**16**	**400**
B		**Practical**			
5	GSP111	Biochemistry Lab	0-0-6	2	50
6	GSP112	Molecular Biology Lab	0-0-9	3	75
7	GSP113	Biostatistics & Bioinformatics Lab	0-0-6	2	50
		Total Practical	**0-0-21**	**7**	**175**
C		**Sessional**			
8	LSS121	Communicative English & HR management - I	0-0-3	1	25
		Total Sessional	**0-0-3**	**1**	**25**
		Semester Total	**12-4-24**	**24**	**600**

2nd Semester

A		Theory			
Sl. No.	**Course Code**	**Course Title**	**Hrs/Wk [L-T-P]**	**Credit**	**Points**
1	GSTO201	Fundamentals of Genome Science (Open Choice - CBCS Course)	3-1-0	4	100
2	GST202	Genetic Engineering	3-1-0	4	100
3	GST203	Omics	3-1-0	4	100
4	GST204	Computational Biology	3-1-0	4	100
		Total Theory	**12-4-0**	**16**	**400**
B		**Practical**			
5	GSP211	Advanced Molecular Biology Lab	0-0-9	3	75
6	GSP212	Instrumentation Lab	0-0-6	2	50
7	GSP213	Computational Biology Lab	0-0-6	2	50
		Total Practical	**0-0-21**	**7**	**175**
C		**Sessional**			
8	LSS221	Communicative English & HR management - II	0-0-3	1	25
		Total Sessional	**0-0-3**	**1**	**25**
		Semester Total	**12-4-24**	**24**	**600**

3rd Semester

A		Theory			
Sl. No.	**Course Code**	**Course Title**	**Hrs/Wk [L-T-P]**	**Credit**	**Points**
1	GST301	Bioentrepreneurship, IPR & Bioethics	2-1-0	3	75
2	GST302	Research Methodology	2-1-0	3	75
3	GSE303	Elective – I	0-2-0	2	50
4	GSE304	Elective – II	0-2-0	2	50
5	GSE305	Elective – III (Student's Choice)	0-2-0	2	50
		Total Theory	**4-8-0**	**12**	**300**
C		**Sessional**			
9	GSS321	Review on frontiers in Genome Science	0-0-6	2	50
10	GSS322	Project/Training Seminar		2	50
		Total Sessional	**0-0-6**	**4**	**100**
		Semester Total	**4-8-6**	**16**	**400**

List of Electives (For GSE303 & GSE304)

1) Molecular Phylogeny
2) Animal Genomics
3) Plant Genomics
4) Microbial Genomics
5) Biomedical Genomics
6) Comparative Genomics
7) Pharmacogenomics

4th Semester

C		Sessional			
Sl. No.	**Course Code**	**Course Title**	**Hrs/Wk [L-T-P]**	**Credit**	**Points**
1	GSS421	Dissertation (Final)	0-0-40	10	250
2	GSS422	Seminar	0-0-6	2	50
3	GSS423	Grand Viva		4	100
		Total Sessional	**0-0-46**	**16**	**400**
		Semester Total	**0-0-46**	**16**	**400**

Details of abbreviated paper codes

GST Genome Science Theory
GSP Genome Science Practical
LSS Life Skill course Sessional
GSTO Genome Science Theory (Open Choice)
GSE Genome Science Elective
GSS Genome Science Sessional

1st Digit in the Suffix No. of Semester [1= Semester I, 2= Semester II, 3= Semester III, 4= Semester IV]
2nd Digit in the Suffix Type of paper [0 = Theory paper; 1 = Practical paper; 2 = Sessional Paper]
3rd Digit in the Suffix No. of paper [1 = 1st paper; 2 = 2nd paper; 3 = 3rd paper; 4 = 4th paper]

Detailed Syllabus: 1st Semester

GST101 - Biomolecules

[L-T-P = 3-1-0] **Credit: 4**

Module - I [10L]

Chemistry of nucleic acid (DNA, RNA), proteins, carbohydrates, lipids; Chemistry of nucleosides and nucleotides; nucleic acid structures and composition: A, B, and Z forms of DNA, super coiling of DNA, denaturation and renaturation kinetics, nucleotide sequence composition: unique, middle and highly repetitive DNA; primary, secondary & tertiary structure of protein, protein folding.

Module - II [10L]

Isolation, detection and characterization of nucleic acids and proteins by various spectroscopic and biophysical (centrifugation) methods; Electrophoresis (Agarose gel electrophoresis, PFGE, PAGE), Southern, Northern and Western blotting/hybridization; Chromatographic methods for protein characterization (brief principles for all the methods may be provided).

Module - III [10L]

Macromolecular structure determination: Basic concepts and principles of X-ray diffraction, crystallography; *Spectroscopy*: UV-Visible, fluorescence; Nuclear Magnetic Resonance (NMR), AAS, Circular Dichroism, *Electron Microscopy*: TEM, SEM, STM; cryo-EM, Atomic Force, Phase contrast, Fluorescence and Confocal microscopy; Automated DNA Sequencer.

Module - IV [10L]

Structure-Prediction of Biomolecules with applications in Bioinformatics

Structure classification of proteins (SCOP, CATH), Secondary structure prediction of various protein categories (e.g. transmembrane and helical proteins), RNA secondary structure prediction methods; ***Patterns, motifs and Profiles in sequences***: Derivation and search methods; Derived Databases of patterns, motifs and profiles e.g. Prosite, Blocks, Prints-S, Pfam; ***Overview of tertiary structure prediction methods***: algorithms for modeling protein folding; algorithms for 3D structure prediction with representative examples; Protein structure prediction by comparative modeling approaches (homology modeling and fold recognition); *ab initio* structure prediction methods.

Reference books:

1. Lehninger Principles of Biochemistry- David L. Nelson and Michael M. Cox (W. H. Freeman & Co Ltd)
2. Biochemistry- Donald Voet and Judith G. Voet (John Wiley & Sons, Inc)
3. Biochemistry- Jeremy M. Berg, Lubert Stryer, John Tymoczko and Gregory Gatto (W.H. Freeman)
4. Principles of Physical Biochemistry-Kensal E van Holde, Curtis Johnson and Pui Shing Ho (Pearson)
5. Physical Biochemistry: Applications to Biochemistry and Molecular Biology-David M Freifelder (W. H. Freeman)
6. Practical Biochemistry Principles and techniques-Ed Wilson and Walker (Cambridge University Press)

GST102 - Cell Biology and Immunology

[L-T-P = 3-1-0] Credit: 4

Module – I [10L]

Cell Communication: Cellular structures and functions, General principles of cell-cell communication in prokaryotes and eukaryotes (multi-cellular organization), Paracrine, Autocrine and Endocrine signaling; Exosomes as mediators of cell-to-cell Communication, signaling through G-protein linked cell surface receptors, MAP kinase pathway; ***The Cell Cycle and programmed cell death***: An overview of the cell cycle, components of the cell cycle control system, apoptosis, Necroptosis, Ferroptosis.

Module – II [10L]

Germ cells and early development; Stem cell concepts & Technologies; ***Developmental genetics***: pattern formation genes, Homeotic Genes and evolution, Stages of Development, Germ layers and fate map, Cell fate and commitment, Mechanisms of Differentiation, Pattern formation, Organogenesis, ***Model organisms***: Drosophila, *C. elegans*.

Module – III [10L]

Fundamental concepts of the Immune system: components of innate and acquired immunity; Antigens – immunogens, hapten, adjuvant, carrier. MHC – structure, HLA typing; ***Molecular basis of immune responses***: Primary and secondary immune response; Immunoglobulins – class and structure, affinity, avidity, allotype, isotype, idiotype; Antibody genes and antibody diversity; VDJ recombination. Immunoassays, ELISA, ***Vaccine technology*:** Active and Passive immunization, recombinant DNA and protein-based vaccines, peptide vaccines, conjugate vaccines, cell-based vaccines.

Module – IV [10L]

Immune disorders: Graves' disease; Autoimmune diseases like Rheumatoid arthritis, Systemic Lupus Erythematosus, Type 1 diabetes, psoriasis, Myasthenia Gravis, Multiple sclerosis

Cancer and immune system: Development of tumor, accumulation of somatic mutations, Types of tumor; special properties of cancer cells; oncogenes; tumor suppressor genes; tumor antigens; tumor evasion of the immune system; immunotherapy of cancer, liquid biopsy. ***Imaging techniques:*** Antibodies as *in vivo* and *in vitro* probes; Immunofluorescence microscopy; Techniques for live cell imaging and fixed cells.

Reference Books:

1. Kuby Immunology-J. Punt, S. Stranford, P. Jones, and J. A. Owen (W H Freeman)
2. Cellular and Molecular Immunology-A. K. Abbas, A. H. Lichtman and S Pillai (Elsevier)
3. Immunology and Immunotechnology-A.K. Chakrabarty (Oxford University Press.)
4. Molecular Biology of the Cell-Bruce Alberts (Garland Science)
5. The Problems Book – for Molecular Biology of the Cell - Tim Hunt, John Wilson (W. W. Norton & Company)
6. Molecular Cell Biology- H. Lodish, A. Berk, C. A. Kaiser, M. Krieger, A. Bretscher, H. Ploegh, A. Amon, K. C. Martin (WH Freeman) 2016.
7. Cell Biology-T.D. Pollard & William C. Earnshaw (Saunders Elsevier)
8. Cell and Molecular Biology: Concepts and Experiments-Gerald Karp (John Wiley & Sons)
9. Cells-Benjamin Lewin, Lynne Cassimeris, V.R. Lingappa, George Plopper (Jones and Bartlett Publishers)
10. The Cell: A Molecular Approach-Geoffrey M. Cooper & Robert E. Hausman (Sinauer Associates)
11. Developmental Biology-Scott F Gilbert (Sinauer Associates Inc.)

GST103 - Genetics & Molecular Biology

[L-T-P = 3-1-0] **Credit: 4**

Module – I [10L]

Classical genetics

Mendel's Laws, concept of dominance, segregation, independent assortment, physical basis of inheritance; concept of gene, gene-gene interactions; multiple alleles; complementation; linkage, recombination and chromosome mapping (genetic) with examples for linkage/genetic mapping extra-chromosomal inheritance; transposable elements (Ac-Ds, IS, P-elements). ***Chromosomal aberrations*****:** ***Numerical variations*****:** euploidy and aneuploidy; ***Structural variations*****:** deletion, duplication, inversion and translocation, Chromatin structure, DNA damage and repair; Epigenetic modifications.

Module - II [10L]

Basics of Human genetic diseases and population genetics

Mendelian genetic disease, and Non-Mendelian/common/complex genetic diseases; Construction and interpretation of pedigree, identification of genes causing Mendelian genetic disease and complex genetic disease; Genetic Diversity: concepts of allele, gene frequency; Hardy Weinberg Law and its application, Concepts of Evolution, mutational processes, evolution of mutation rates; evolution of DNA sequences; Natural selection and Genetic Drift: population bottleneck and founder effect; migration: demographic expansion, spatial expansion.

Module - III [10L]

Replication, transcription, translation and regulation of gene expression

Central Dogma in molecular Biology, DNA Replication; Transcription; Translation in prokaryotes and eukaryotes, Concept of genetic code (degeneracy of codons, codon bias), Regulation of gene expression in prokaryotes– concept of operon (lac and trp), transcriptional and post transcriptional processing of mRNA in eukaryotes; Translation machinery and its regulation in eukaryotic system, post translational modifications.

Module - IV [10L]

Tools and techniques of Molecular Biology

Gene Cloning: Restriction endonuclease, DNA modifying enzymes, Different types of vectors for Cloning (plasmid, phasmid, cosmid, bacterial artificial chromosome, yeast artificial chromosome, mammalian artificial chromosome); PCR; Different modified PCR; quantitative PCR; ddPCR; DNA, RNA and protein probes (production, labeling by radioactive and non-radioactive method); Fluorescence in situ Hybridization (FISH); ***Basics of Array, Sequencing techniques and applications:*** Microarray (Basic principles and technology of cDNA microarrays and their applications, case studies); DNA, RNA and protein sequencing methods; DNA fingerprinting for parenting and forensics sciences.

Reference books:

1. *i*Genetics- A Molecular Approach- Peter J. Russell (Pearson Int. Edition)
2. Concepts of Genetics- Klug W.S., Cummings M.R., Spencer C.A. and Palladino M.A. (Pearson Int. Edition).
3. Genes XII- Lewin Benjamin (Jones & Bartlett publishers)
4. Molecular Cell Biology- Lodish H, Berk A, Kaiser C.A., Krieger M., Scott M.P., Bretscher A., Ploegh H. &Matsudaira P. (W.H. Freeman & Co.)
5. Principles of Genetics- Snustad D.P. and Simmons M.J. (John Wiley & sons Inc.)
6. Principles of Genetics- Robert H. Tamarin (Tata McGraw-Hill)
7. An Introduction to Genetic Analysis- Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll, John Doebley (WH Freeman)
8. Gene Cloning and DNA analysis- T.A. Brown (Wiley-Blackwell)
9. Principles of Gene Manipulation- S.B. Primrose, R.M. Twyman and R.W. Old. (Blackwell Scientific Publishers)
10. Molecular Biology of the Gene- James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick (Pearson)
11. Solving Problems in Genetics- Richard Kowles (Springer)
12. Molecular Population Genetics-Matthew W. Hahn (OUP USA)
13. Population Genetics-Matthew B. Hamilton (Wiley-Blackwell)

GST104 - Biostatistics & Bioinformatics

[L-T-P = 3-1-0] **Credit: 4**

Module-I [12L]

Statistics of dispersion: Variability, Range, Mean, mode, Mean deviation, Standard Deviation, Variance, central moments, Coefficient of Quartile deviation, Coefficient of variation, Coefficient of dispersion; ***Probability Distribution***: Probability mass function for discrete random variables and probability density function for continuous random variables; Skewness, Kurtosis; ***Testing of Hypothesis:*** Concepts and importance in experimental research, type of errors; testing means, Significance of difference between means using Z-score; Large sample tests based on normal distribution – Test based on t and F distributions, Chi square test for goodness of fit, Correlation and Regression: Multiple correlation, Linear, logistic, and multiple regression; ***Multivariate Methods***: PCA, MDS; Cluster analysis (Hierarchial, k-means, SOM); factor analysis; Modeling using Boolean Networks; ***Non-parametric and distribution-free statistics***: Sign test, Wilcoxon's rank test and Spearman's rank correlation; MDR analysis, ***Analysis of Variance***: One way and two way classifications of Anova, Post-hoc analysis, ROC curve analysis – applications in Biological Sciences.

Module-II [8L]

Biological databases: NCBI-GenBank, UniProt, DDBJ, EMBL, PDB, KEGG; Biological data handling and sequence manipulations by *in silico* techniques; ***NCBI different modules***: ORF-finder, Taxonomy browser, BOLD, PubMed. ***Sequence analysis:*** Introduction to sequence analysis, local and global alignment, pairwise and multiple alignment, Substitution Matrix (introduction: PAM, BLOSUM), BLAST, FASTA algorithms. ***Sequence alignment algorithm***: Dot matrix, Needleman-Wunsch algorithm, Smith-Waterman algorithm; Introduction to EMBOSS.

Module – III [10L]

Basics of molecular phylogenetics

Distance Based methods: clustering based methods, optimality based methods: Fitch-Margoliash and Minimum evolution methods, Neighbor joining and related neighbor methods; ***Character Based methods***: Maximum parsimony methods, Maximum likelihood method; Phylogenetic trees and other models; optimality criteria for selecting phylogenetic hypothesis; ***Phylogenetic tree evaluation***: Bootstrap analysis, Interior branch testing.

Module – IV [10L]

Advanced molecular phylogenetics

Fossils, Molecular clock; Haplotype analysis; estimation of population structure, molecular diversity indices, mismatch distribution, analyses of molecular variance (AMOVA); Migration analysis; ***Phylogenetic dating***: ρ-statistic; Bayesian analysis: Markov Chain Monte Carlo; ***Comparative Genomics***: Gene duplication and phylogeny, Gene order, Lateral and Horizontal gene transfer, Transposable elements, Metagenomics; ***Application of molecular phylogenetics***: Examples of some entrepreneurships [e.g. 23 and me].

Reference books:

1. Introduction to Biostatistics-Pranab K Banerjee. (S. Chand & Co.)
2. Biostatistics-P.N. Arora, P.K. Malhan (Himalaya Publishing House)
3. Essential Bioinformatics- JinXiong, (Oxford University Press)
4. Statistics in Biology and Psychology-Debajyoti Das and Arati Das (Academic Publishers)
5. Bioinformatics: Sequence and Genome Analysis-David W. Mount. (CSHL Press).
6. Bioinformatics and Functional Genomics-Jonathan Pevsner, (Wiley-Liss)
7. Structural Bioinformatics-P. E. Bourne and H. Weissig. (Wiley)
8. Introduction to Bioinformatics-Arthur W. Lesk (Oxford University Press.)
9. Bioinformatics-Principles and Applications-Z.Ghosh and B. Mallick (Oxford University Press.)

GSP111 - Biochemistry Lab

[L-T-P = 0-0-6] **Credit: 2**

List of Experiments:

1. Quantitative analysis of amino acids
2. Protein estimation by Lowry/Bradford method
3. Total sugar estimation by phenol-sulphuric acid reagent method
4. Estimation of reducing sugar from biological sample
5. pH metric titration of glycine for determination of pI
6. Ascorbic acid estimation from lemon juice
7. Chromatography techniques.
8. Chromosome preparation for Karyotyping and Banding

GSP112 - Molecular Biology Lab

[L-T-P = 0-0-9] **Credit: 3**

Core Experiments:

1. Isolation of DNA from different sources (Buccal swab, blood, animal & plant tissue)
2. Agarose gel electrophoresis
3. Quantitative & qualitative analysis of nucleic acid (NanoDrop, Qubit)
4. Polymerase chain reaction: general

Advanced Experiments:

1. PCR - multiplex & nested PCR
2. PCR-RFLP
3. Elution of PCR product
4. Sanger sequencing
5. Fragment analysis (e.g. SNaPshot multiplex genotyping assay)

GSP113 - Biostatistics & Bioinformatics Lab

[L-T-P = 0-0-6] **Credit: 2**

1. Introduction to C, R, SPSS, MS Excel for statistical analysis
2. Primer designing: Primer3, Oligocalc, SMS2, BLAST
3. Handling of Databases: NCBI, BOLD etc.
4. Raw Sequence: Reading & Editing; Pre-submission sequence analysis and annotation
5. Sequence submission in NCBI-GenBank/BOLD
6. Basic phylogenetic analysis: Distance Based methods and Character Based methods
7. Advanced phylogenetic analysis, Molecular Clock
8. Structure-Prediction of Biomolecules with applications in Bioinformatics

Detailed Syllabus: 2nd Semester

GSTO201 - Fundamentals of Genome Science (CBCS Course)

[L-T-P = 3-1-0] **Credit: 4**

Module - I [10L]

Basic structural chemistry of biomolecules

Chemistry of carbohydrates, Lipids, Amino Acids and Nucleic acids; Isolation and detection of Nucleic acids and protein; Electrophoresis; Basic concepts and principles of the tools for macromolecular structure determination: X-ray diffraction, crystallography, *Spectroscopy*: UV-Visible, fluorescence, Concept of microscopy - SEM, fluorescence, Confocal

Module - II [10L]

Basic concept of genetics & biostatistics

Genetics: Mendelian and Non-Mendelian inheritance; Construction and interpretation of pedigree; Chromosomal aberrations; Chromatin structure, Basics of Epigenetic modifications; ***Biostatistics***: Statistics of dispersion; Testing of Hypothesis; Non-parametric and distribution-free statistics; Analysis of Variance

Module - III [10L]

Tools and techniques of Molecular Biology

Gene Cloning: Restriction endonuclease, DNA modifying enzymes, Different types of vectors for Cloning; PCR; Different modified PCR; quantitative PCR; ***Basics of Array and Sequencing techniques:*** Microarray (Basic principles and technology of cDNA microarrays); Evolution of DNA sequencing methods - from Sanger to NGS; Basic overview of NGS data handling; Introduction to Genome editing

Module - IV [10L]

Application of Genome science

Types of genetic variations; Identification of human biomarkers using genomics; Principles of inheritance and working with family-based genetic disorders; Genomics in child development and population-based carrier screening for genomic disorders; Genomics of cardiovascular disease and cancer; Concept of pharmacogenomics; Concept of genetic counseling; Predicting disease in healthy (pre-symptomatic) people and its ethical concern.

GST202 - Genetic Engineering

[L-T-P = 3-1-0] Credit: 4

Module - I [10L]

Cloning, Selection and expression of engineered DNA

Different types of cloning and expression techniques in prokaryotic and Eukaryotic model cell system (restriction cloning, TOPO TA cloning, PCR product cloning, and GATEWAY cloning technology); Construction and screening of genomic and cDNA library

Module - II [10L]

Manipulation of animals and plants

Transfer of genes in animal oocyte; cloning of animals, Gene targeting; techniques of creating transgenic mice, homologous recombination and knockout mice; Direct and Indirect methods of Gene transfer and techniques of creating transgenic plants; Application, Biosafety measures and regulation.

Module - III [10L]

Application of Genetic Engineering

Genetically engineered vaccine, Recombinant Enzyme in industry, production of biopharmaceuticals (insulin, interferon, tPA and growth hormones)

Module - IV [10L]

Gene therapy: DNA based diagnosis of genetic diseases and pathogen detection (HIV etc.); Genome editing (CRISPR-Cas9, CRISPR-Cas13, TALEN, LEAPER, Meganuclease, ZFN; Base editor; gene drive)

Reference books:

1. Introduction to Genetic Engineering-Rastogi and Pathak (Oxford University Press.)
2. Molecular Biotechnology: Principles and Applications of Recombinant DNA - B. R. Glick and J.J. Pasternak (ASM press)
3. Principle of Gene Manipulation & Genomics - S.M. Primrose, Twyman, and R.W. Old, (2006) (Blackwell Science Inc.)
4. Recombinant DNA -Genes and Genomes- A Short Course J. D. Watson, Richard M Myers, Amy A. Caudy and Jan A. Witkowski (W.H. Freeman and Company)
5. DNA cloning: A Practical Approach- D. M. Glover and B.D. Hames, (IRL Press.)
6. Molecular cloning: A Laboratory A manual-J. Sambrook and D. Russell (CHL Press.)
7. Gene Cloning and DNA Analysis - An Introduction- T. A. Brown (Blackwell)
8. A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution-Jennifer A. Doudna and Samuel H. Sternberg (Houghton Mifflin Harcourt)
9. Plant Genome Editing with CRISPR Systems Methods and Protocols- Yiping Qi (Humana Press)
10. Genome Editing- Kursad Turksen (Ed.) (Springer)
11. Genome Editing and Engineering: From TALENs, ZFNs and CRISPRs to Molecular Surgery- Krishnarao Appasani (Ed.) (Cambridge University Press)

GST203 - Omics

[L-T-P = 3-1-0] Credit: 4

Module - I [10L]

Concept of genome, genomics and epigenomics

Structural genomics**:** Eukaryotic organelle genomes (human and other organisms); Assigning loci to specific chromosome; high resolution chromosome mapping; markers for mapping (RFLP, single nucleotide polymorphism, microsatellite markers, copy number variation, methods for detection of markers), Physical mapping of genome; Linkage mapping; Using genome maps for genetic analysis - organizational principles of human genes: application of comparative genomics to understand the molecular mechanism; ***Genome sequencing***: Whole genome shotgun sequencing; Introduction to various databases, genome browsers & associated tools: ENSEMBL, GeneCards, UCSC Genome Browser, Galaxy and their application; Overview of various genome scale projects: Human genome project, HapMap project, 1000 genome projects, Expressed sequence Tag (EST) project; ethical, legal, and social implications addressed by the Human Genome Project; Concept of Epigenomics, microRNA, long non-coding RNA; Concept of three dimensional genome

Module – II [10L]

Functional Genomics**:** SAGE, characterize the proteome by ORF analysis, study of gene interactions by yeast two-hybrid system, study of developmental regulation by using DNA chips, ***Biomedical Genomics*****:** Introduction to NGS-based targeted re-sequencing; Single cell sequencing; *Experimental design*: WES, Transcriptome, WGBS, ChIP-Seq; Concept of metabolomics; ***Molecular basis of genetic variations leading to medical disorders*****:** Types of genetic variations; Identification of human biomarkers using genomics; Concept of Genome-wide association studies (GWAS), related databases and its limitations

Module – III [10L]

Impacts of genomics in human development & healthcare

Principles of inheritance and working with family-based genetic disorders: autosomal dominant, autosomal recessive, X-linked, Y-linked, Mitochondrial; Genomics in child development and population-based carrier screening for genomic disorders: newborn screening, preconception carrier screening; Genomics of cardiovascular disease and cancer; Concept of pharmacogenomics; Concept of genetic counseling; Predicting disease in healthy (pre-symptomatic) people and its ethical concern

Module-IV [10L]

Tools and Techniques for Proteomics

From Genomics to Proteomics, Strategies of Protein Separation and quantification: 2D gel electrophoresis, Liquid chromatography in Proteomics. Strategies of identification: MALDI-TOF mass spectrometry, ESI-TOF MS and MS-MS methods; Protein chips in functional proteomics, Medical proteomics in disease diagnosis; Pharmaceutical proteomics in drug discovery

Reference books:

1. Principles of Proteomics- Richard Twyman (Garland Science)
2. Principles of Gene Manipulation and Genomics- Primrose S & Twyman R, and Old (Blackwell Pub)
3. Genomes III - T. A. Brown. (Garland Science)
4. Human Molecular Genetics- T. Strachan and A. P. Read, (Garland Science.)
5. Principles of Genome analysis- S.B. Primrose and R. M. Twyman (Blackwell Pub)
6. Genomics: Application in Human Biology -S.B. Primrose and R. M. Twyman. (Blackwell Pub.)
7. Functional Genomics: A practical Approach- S. P. Hunt and R. Livesey (Oxford University Press.)
8. DNA Microarray: A practical approach - M. Schlena (Oxford University Press.)
9. Discovering Genomics, proteomics and Bioinformatics - A. M. Campbell and L. J. Heyer.(Pearson)
10. Essentials of Genomics and Bioinformatics by C. W. Sensen (John Wiley & Sons Inc.)
11. Proteomics- T. Palzkil (Kluwer Academic pub.)
12. Protein and Proteomics by Richard J Simson (I K Publishers.)
13. Introduction to Proteomics: by D. C. Liebler, Tools for the New Biology (Humana Press.)
14. Molecular Biology of the Cell - B. Alberts, D. Bray, J. Lewis et al, (Garland Pub. N.Y)

15. Genomics- Cantor & Smith (John Wiley & Sons)
16. Introduction to Proteomics- Nawin C. Mishra (John Wiley Sons. Inc.)
17. A Primer of Genome Science - G. Gibson and S.V. Muse. (Sinauer Associates. Inc. Pub)
18. Genetic Counseling- Arthur L Caplan (Taylor & Francis Ltd)
19. A Guide to Genetic Counseling-Wendy R. Uhlmann, Jane L. Schuette, Beverly Yashar (Wiley-Blackwell)

GST204 - Computational Biology

[L-T-P = 3-1-0] Credit: 4

Module - I [10L]

Introduction to big data analysis

Introduction, distributed file system, Big Data and its importance, Drivers, Big data analytics, Big data applications. Algorithms, Matrix-Vector, Multiplication by Map Reduce; Data visualization.

Module - II [10L]

Handling of NGS data

Overview of different NGS data formats, Sequencing machine to raw sequence, Initial QC (e.g. Phred Score), Alignment, Post alignment processing, Depth and Coverage, Variant Calling, Annotation, data visualization (in IGV), Downstream analysis (PLINK, Haploview); handling of microarray data: data normalization, detection of over expression and under expression; handling of RNA sequencing data.

Module – III [10L]

Principles of sequence annotation, resources for annotation, Coding sequence, intron-exon, promoter prediction: *in silico* structural and functional annotation of non-synonymous variants using various amino acid substitutions (AAS) tools; Access and uses of PANTHER database; use of PROMO-ALGGEN; *in silico* biophysical validation of variants using HOPE and NetSurfP; annotation of synonymous and intronic variants using different in silico tools - HSF, RegulomeDB, PredictSNP; visualization of the gene-gene interactions using GeneMANIA, protein-protein interactions using STRING, Pathway analysis.

Module - IV [10L]

Molecular Modeling and Simulation*:** Force fields and their evaluation (e.g. AMBER); Monte Carlo and molecular dynamics simulations (e.g. GROMACS); Energy minimization techniques; Structure comparison using database formalisms (DALI, VAST); ***Drug designing: Classification of drug targets, characterization of drugs, Target discovery and validation methodologies, Structure based drug design methods including computer-aided drug design (pharmacophore development) and recent technology developments; Target selection, Ligand (lead compound) design,optimization and analysis; Protein-ligand docking; QSAR; molecular descriptors; ADME parameters and their optimization; molecular diversity and Combichem; case studies.

Reference books:

1. Guidebook on Molecular Modeling in Drug Design-N. R. Cohen, Editor. (Academic Press.)
2. Introduction to Protein Structure-C. Branden and J. Tooze (Garland Publishing)
3. Molecular Modelling: Principles and Applications-Andrew Leach (Pearson Education)
4. Drug Discovery and Design-Scolnick. J., (Academic Press, London)
5. Bioinformatics-Principles and Applications-Z.Ghosh and B. Mallick (Oxford University Press)
6. Introduction to Computational Biology Maps, Sequences and Genomes- Michael S. Waterman (Chapman and Hall/CRC)

GSP211 - Advanced Molecular Biology Lab

[L-T-P = 0-0-9] Credit: 3

Core Experiments:

1. Introduction to Microbial culture/animal cell culture/plant tissue culture
2. Analysis of protein by SDS-PAGE
3. Western blotting and ELISA

Advanced Experiments:

1. Isolation of genomic DNA from bacteria
2. Isolation of plasmid DNA & restriction enzyme analysis
3. Isolation of total RNA /poly-A mRNA and cDNA amplification by RT-PCR
4. Bacterial transformation & cloning, Selection of recombinant colonies
5. Real-time / quantitative PCR (q-PCR)
6. NGS library preparation
7. Targeted re-sequencing

GSP212 - Instrumentation Lab

[L-T-P = 0-0-4] Credit: 2

Experiments:

1. Spectroscopy: UV-Visible, fluorescence
2. NMR
3. AAS
4. Powder XRD
5. SEM
6. AFM
7. Phase contrast microscopy
8. Fluorescence microscopy
9. Confocal microscopy
10. Techniques for live cell imaging and fixed cells

GSP213 - Computational Biology Lab

[L-T-P = 0-0-6] Credit: 2

1. Introduction to Linux and common terminal commands
2. Python programming and packages
3. Information visualization using R, Python, Tableau/Power BI
4. Acquisition and analysis of NGS data
5. Structural and functional annotation of variants
6. Pathway analysis
7. Molecular Modeling and Simulation
8. Drug designing

Detailed Syllabus: 3rd Semester

GST301 – Bioentrepreneurship, IPR & Bioethics

[L-T-P = 2-1-0] Credit: 3

Module - I [10L]

Bioethics

Introduction to ethics and bioethics, the responsible conduct of biotechnological research; research with human subjects; social commitment of a biotechnologist; **Ethical legal and social issues (ELSI) in biotechnology:** Biotechnology/ biomedicine application **-** ethical consideration; ethics and the natural world: environmental ethics (protecting public health and environment; genetically modified foods – the ethical and social issues. ELSI in genetic engineering/biomedical science, Eugenics, Use and Misuse of genetic information, Human gene patenting – ethics and policy issues, genetic testing and screening, human gene therapy and genetic modification – ethical and public consideration, legal implication of somatic cell, gene therapy- germ line gene therapy.

Module - II [10L]

Intellectual Property Rights (IPR), Patents and protection

IPR: Jurisprudential definition and concept of property rights, duties and their correlations, history and evaluation of IPR – like patent design and copyright. Distinction among the various forms of IPR, requirements of a patentable invention like novelty, inventive step and prior art and state of the art procedure; Rights/ protection, infringement or violation, remedies against infringement, civil and criminal, Indian patent act 1970 (2000) international convention in IPR, major changes in Indian patent system as post TRIPS-GATT-International conventions effects. Contents of patent specification and procedure for patents: a) obtaining patents, b) geographical indication c) WTO. Detailed information on patenting biological products, Biodiversity and farmer rights, Budapest treaty, Case studies on - Patents (basmati rice, turmeric, neem, etc.)

Module- III [10L]

Biosafety-Regulatory Framework in India & International Level

Biosafety**:** The legal and socioeconomic impact of biotechnology, public education of the process of biotechnology involved in generating new forms of life for informed decision making, biosafety regulation and national & international guidelines, r-DNA guidelines, experimental protocol approvals, levels of containment, levels of safety. ***Regulations on ethical principles in biomedical/ biotechnological practice***: The Nuremberg code, declaration of Helsinki; the Belmont report, cooperational guidelines – WHO, guidelines of DBT (India), ICMR guidelines, Guidelines for an informed consent.

Module- IV [10L]

Entrepreneurship – Objectives and Fundamentals

Entrepreneur & Entrepreneurship concept: role of entrepreneurship in economic development; factors affecting entrepreneurial growth; developing and evaluating opportunities; ***Growing & sustaining enterprise*****:** Developing start-up strategies, measuring market opportunities. ***Role of knowledge centres***: Knowledge centres like Universities & research Institution, Role of technology & up-gradation, managing technology transfer, regulations for transfer of foreign technologies, support mechanism for entrepreneurship in India.

Reference Books:

1. IPR, Biosafety and Bioethics. DeepaGoel. (Pearson Education)
2. Intellectual Property Law. P. Narayanan. (Eastern Law House)
3. Biotechnology and Patent protection-Beier, F.K., Crespi, R.S. and Straus, T. (Oxford and IBH Publishing Co. New Delhi.)
4. Biotechnologies and Development-Sasson A, (UNESCO Publications)
5. Intellectual Property rights on Biotechnology-Singh K, (BCIL, New Delhi)
6. Regulatory Framework for GMOs in India (2006) Ministry of Environment and Forest, Government of India, New Delhi.
7. Cartagena Protocol on Biosafety (2006) Ministry of Environment and Forest, Government of India, New Delhi.
8. Biotechnology and Genomics-P.K. Gupta (Rastogi Publications)
9. Patent Strategy For Researchers & Research Managers- Knight (Wiley Publications)
10. Agriculture & Intellectual & Property Rights - V. Santaniello & R E Evenson (University Press)
11. Intellectual Property Protection & Sustainable Development, Philippe C. (LexisNexis India)

GST302 - Research Methodology

[L-T-P = 2-1-0] **Credit: 3**

Module - I [10L]

Research objective and statement of problem, types of research; Research proposal designing and formulation; Research Methodology; Review of literature, meaning of concept, construct, laws, theory and hypothesis

Module - II [10L]

Application of MS-office in research; Introduction to databases (Pubmed, Google Scholar etc.) required for literature review; Data analysis using MS-Excel; PowerPoint presentations and Software for Graphics

Module - III [10L]

Writing of Research Proposal, Report and Research Paper: Meaning and types -Stages in preparation - Characteristics - Structure - Footnotes and Bibliography- use of Endnote. Checklist for a good proposal/ report/ research paper

Module - IV [10L]

Concept of impact factor, i-10 index, H-index; Methods of the best journal selection; checklist for avoiding predatory/fake journals; steps for publishing an article in a peer-reviewed journal

Reference Books

1. Kothari, Chakravanti Rajagopalachari. *Research methodology: Methods and techniques*. New Age International, 2004.
2. Kumar, Ranjit. *Research methodology: A step-by-step guide for beginners*. Sage Publications Limited, 2019.

GSE303 - Elective – I

One paper is to be chosen from list of electives to be offered.

GSE304 - Elective – II

One paper is to be chosen from list of electives to be offered.

GSE305 - Elective – III

One paper is to be chosen by the students themselves and to be learned in self-learning mode.

GSS321 - Review on frontiers in Genome Science

A review is to be prepared on frontiers in Genome Science and the students need to give a presentation.

GSS322 - Project/Training Seminar

Each student will undertake a minor research project in Industry/Research Institute visits/Internship, and they will be asked to deliver a seminar on the project topic and submit a report/write-up on that.

Detailed Syllabus: 4th Semester

GSS421 - Dissertation (Final)

Each student will undertake a major research project.

GSS422 - Seminar

Each student will be asked to deliver a seminar on the major research project undertaken.

GSS423 - Grand Viva

Each student will face a grand viva.