Curriculum and Credit Framework for Postgraduate Programme (CCFPP),

as per N.E.P. 2020, w.e.f. 2026 – 2027

TWO YEAR POSTGRADUATE PROGRAMME

In

Molecular Biology and Human Genetics

Department of Molecular Biology and Human Genetics
THE UNIVERSITY OF BURDWAN

Course Eligibility and Admission

As per PGBS meeting held on 21/07/2026

Entry to the First Year of the Two-Year Postgraduate Programme (As per NEP 2020)

1. The draft Curriculum and Credit Framework for the Postgraduate Programme (CCFPP) under NEP 2020, effective from the 2026–2027 academic session, was placed before the Committee. After discussion and modification, the first-year curriculum have been finalized for further necessary step.
2. As the University does not offer an undergraduate programme in Molecular Biology and Human Genetics, it was resolved to offer only the two-year postgraduate programme.
3. Graduates with a three-year B.Sc. degree in Science or a four-year professional degree (e.g., B.Tech., B.V.Sc., B.Sc. (Ag.)) are eligible for admission to the first year of the two-year postgraduate programme, subject to the University's admission regulations.
4. Students completing a four-year undergraduate programme under NEP 2020 in relevant disciplines shall also be eligible for admission to the first year of the two-year postgraduate programme, not second year, in accordance with the University's admission policy.

Entry to the Second Year of the Two-Year Postgraduate Programme (As per NEP 2020)

5. Students exiting after the first year with a Postgraduate Diploma (from the 2026–2027 syllabus onwards) may re-enter the second year of the postgraduate programme, subject to University regulations and NEP 2020 provisions.

Course Level with Degree and Diploma and Exit option

1. In accordance with NEP 2020, the programme shall have the following exit and award structure:
    - **After 1 year:** Postgraduate Diploma in Molecular Diagnostics and Applied Genomics.
    - **After 2 years:** Master's Degree in Molecular Biology and Human Genetics.

Program Specific Outcomes (PSOs)

Upon successful completion of Two Year PG Program

Students will be able to:

PSO 1: Computational Genomics and Systems Biology

Apply knowledge of genomics, bioinformatics, computational biology, systems biology, artificial intelligence, and multi-omics data analysis for research in genomic, biotechnology, pharmaceutical, and healthcare, and employment opportunities genomic industries.

PSO 2: Synthetic Biology Applications

Demonstrate theoretical and practical expertise in recombinant DNA technology, vaccine development, recombinant protein production, genome engineering, and translational biotechnology for industrial and biomedical applications.

PSO 3: Research and Innovation Capability

Develop independent research capability in the areas of genomics, transcriptomics, proteomics, metabolomics, genome engineering, molecular therapeutics, vaccine development, precision medicine, and computational drug discovery and design.

PSO4: Genetic Counsellor

Suitable for carrier as genetic counsellor in different Multi-specialty Hospitals

Upon Successful Completion of the One-Year PG Diploma
(PG Diploma in Molecular diagnostics and Applied Genomics)

Students will be able to:

PSO 1: Molecular Diagnostics

Develop technical competency in molecular biology techniques, genome analysis, PCR-based diagnostics, sequencing technologies, and molecular diagnostic workflows suitable for molecular diagnostic in clinical sectors.

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PSO 2: **Applied Genomics**

Acquire foundational skills in genomics, bioinformatics, computational genomics, systems biology, next-generation sequencing (NGS) data analysis, and genome informatics suitable for employment in genomic industries.

PSO3: Genetic Counsellor

Suitable for carrier as genetic counsellor in different Multi specialty Hospitals

Semester wise Course and Credit Distribution

1st Semester & 2nd. Semester *

SEMESTER	Course Type	Code & Level (as per CCFPP)	Name of the Course	Credit	L – T - P	Marks	Marks Dist. End Sem - IA
I	Major/Core Course	**PG2MBHG1011 (400-499)**	Human Genetics and Human Evolution	6	L	75	60 - 15
	Major/Core Course	**PG2 MBHG 1012 (400-499)**	Molecular Biology and Immune biology (Including Bioinformatics)	6	L	75	60 - 15
	Major/Core Course	**PG2 MBHG 1013 (400-499)**	IKS : Human Health and Ayurgenomics (Including Yoga and naturopathy)	6	L	75	60 - 15
	Minor Course	**PG2 MBHG 1021 (300-399)**	Basic Biology OR Equivalent Course from SWAYAM	4	L	50	40 - 10
	Major/Core Course	**PG2 MBHG 1014 (400-499)**	**Laboratory - I**	6	P	75	60 - 15
	TOTAL			28		350	
	Major/Core Course	**PG2 MBHG 2011 (400-499)**	Computational Genomics and Machine Learning	6	L	75	60 - 15
II	Major/Core Course	**PG2 MBHG 2012 (400-499)**	Molecular Diagnostics and Sequencing Technologies	6	L	75	60 - 15
	Major/Core Course	**PG2 MBHG 2013 (400-499)**	Recombinant DNA and gene therapy (Th)	6	L	75	60 - 15
	Minor Course	**PG2 MBHG.2021 (300-399)**	Basic Computer and data science (Th) OR Equivalent Course from SWAYAM	4	L	50	40 - 10
	Major/Core Course	**PG2 MBHG 2014 (400-499)**	Laboratory II (Pr) and Industry Visit (IA)	6	**P**	75	60 - 15
	Total			**28**		**350**	

***Option to Exit from Post graduate Program with PG Diploma in Molecular diagnostics and Applied Genomics**

3rd Semester & 4th Semester

SEMESTER	Course Type	Code & Level	Name of the Course	Credit	L – T - P	Marks	Marks Dist. Th. – Pr. – IA*
III	Major/Core Course	**PG2 MBHG.3011 (500-599)**	Stem cell and regenerative medicine (Th) and Presentation (IA)	4	L	50	40 - 10
	Major/Core Course	**PG2 MBHG 3012 (500-599)**	Protein engineering and drug development (Th) And Presentation (IA)	4	L	50	40 - 10
	Major/Core Course	**PG2 MBHG3013 (500-599)**	Vaccine development (Th) And Presentation (IA)	4	L	50	40 - 10
	Major/Core Course	**PG2 MBHG 3014 (500-599)**	Good Laboratory and Manufacturing Practice, Entrepreneurship, IPR (Th) and Colloquium Talk (IA)	4	L	50	40 - 10
	Major/Core Course	**PG2 MBHG 3015 (500-599)**	laboratory III (Pr) and Journal Club (IA)	4	P	50	40 - 10
	Total			**20**		**250**	
IV	Research Thesis/ Project / Patent	**PG2 MBHG4031 (500-599)**	Industrial Internship, and Project work and Grand Viva	20	0- 0- 20	250	0-250-0 Seminar Presentation, Preparation & Submission of Research Thesis/ Project / Patent Document-150 + Viva-100
	Total			**20**		**250**	

Th: Theoretical , Pr: Practical , IA: Internal Assessment

PG2MBHG1011 (400-499)	Human Genetics and Human Evolution	Credit 6
Evaluation: Internal: 15 marks : End semester :60 Marks		Total : 75
End semester: Question Framework	From each unit one question of 5 marks and one question of 10 marks need to be answered out of two questions of 5 marks and two question of 10 marks from each unit	Unit I: 5+10 Unit II: 5+10 Unit III: 5+10 Unit IV: 5+10

Unit I: Human Genetics and Genome Variation

- Human genome organization and chromosome structure, karyotype, banding techniques
- Chromosomal abnormalities: : Numerical (aneuploidy) and structural (translocations, deletions, duplications, inversions)
- Human genetic variation: SNPs, Indels, CNVs, STRs, VNTRs structural variants, repeat polymorphisms
- Human Genome Project, Shotgun sequencing , Genome Asia and Genome India Project, T2T Genome Sequence
- Patterns of Mendelian and non-Mendelian inheritance, genomic imprinting, mosaicism,
- Genetic linkage, recombination and haplotype analysis, LOD score analysis,
- Heritability estimation, Multifactorial and polygenic traits

Unit II: Medical Genetics

- Single-gene (Mendelian) disorders: autosomal dominant, autosomal recessive, X-linked conditions
- Mitochondrial inheritance and Mitochondrial genetic disorders
- Poly genic Disorders: Phenotype – Genotype correlation, Genetic architecture of complex diseases (diabetes, cardiovascular disease, neuropsychiatric and neuro muscular disorders)
- Genetic background of Rare Genetic Disorders: Neuromuscular Disorders and Lysosomal Storage Disorders
- Introduction to pharmacogenomics and personalized medicine
- Nutrigenomics
- Marfan syndrome, hematopoietic system: sickle cell disease, thalassemias and hemophilia
- Genetic disorders of muscle: Duchenne muscular dystrophy, Becker muscular dystrophy, myotonias and myopathies
- Genetic disorders of the eye: retinitis pigmentosa, congenital cataract, glaucoma and colour blindness
- Genomic imprinting disorders: Prader-Willi syndrome, Angelman syndrome and Beckwith-Wiedemann syndrome
- Inborn errors of metabolism: phenylketonuria, maple syrup urine disease, galactosemia and mucopolysaccharidoses
- Human genetic databases (OMIM, ClinVar, dbSNP, HGMD, Ensembl)

Unit III: Cancer Genomics

- Molecular basis of cancer: oncogenes, tumor suppressor genes, DNA repair genes
- Hallmarks of cancer; multistep carcinogenesis
- Cancer genome landscape: driver and passenger mutations
- Tumor microenvironment
- Tumor heterogeneity, clonal evolution, and cancer stem cells
- Hereditary cancer syndromes: BRCA1/BRCA2, Lynch syndrome,
- Chromosomal aberration and Genomic instability - blood cancer : CML, AML, Lymhoma
- Microsatellite instability (MSI) : colorectal, endometrial, and gastric cancers,
- Chemotherapy
- Precision oncology and targeted therapy: Genomic mutations , EGFR, KRAS, BRAF, Cancer markers: ER, PR, HER2, CEA, CYFRA21-1, PSA
- Immunotherapy
- Liquid biopsy concepts,:
- Large-scale cancer genomics initiatives (TCGA, ICGC) and their data resources

Unit IV: Human Evolution and Population Genetics

- Human migration and demographic history from genomic data: Mitochondrial DNA and Y-chromosome
- Comparative genomics: human genome vs primate genomes; conserved and human-specific elements
- Ancient DNA analysis: Neanderthal and Denisovan genomes; archaic admixture in modern humans

- Molecular evidence for human origins; Out-of-Africa vs multiregional hypotheses
- Principles of population genetics: Hardy–Weinberg equilibrium, genetic drift, gene flow, mutation, natural selection
- Molecular phylogenetics and molecular clock hypothesis
- Human microbiome and co-evolution

Internal Assessment

A. Class Attendance and Participation

B. Continuous Assessment *(Based on one or more of the following):*

- Assignment submission
- Group discussion
- Seminar presentation
- Popular science lecture/presentation
- Mock teaching

Suggested Books and Monographs:

Books:

- Nussbaum RL, McInnes RR, Willard HF. Thompson & Thompson Genetics in Medicine. 8th ed. Elsevier; 2016.
- Turnpenny PD, Ellard S. Emery's Elements of Medical Genetics and Genomics. 16th ed. Elsevier; 2022.
- Jobling MA, Hollox E, Hurles M, Kivisild T, Tyler-Smith C. Human Evolutionary Genetics: Origins, Peoples & Disease. 2nd ed. Garland Science (Taylor & Francis); 2014.
- Cavalli-Sforza LL. Genes, Peoples, and Languages. University of California Press; 2000.
- Weinberg RA. The Biology of Cancer. 3rd ed. W. W. Norton & Company; 2023.
- Pelengaris S, Khan M. The Molecular Biology of Cancer: A Bridge from Bench to Bedside. 2nd ed. Wiley-Blackwell; 2013.

Monographs / Journal Article

- Chakravarty D., Solit D.B. **Clinical Cancer Genomic Profiling.** *Nature Reviews Genetics* (2021). (Nature)
- Wong A.K. et al. **Decoding disease: from genomes to networks to phenotypes.** *Nature Reviews Genetics* (2021). (Nature)
- Dukda S. et al. **Increasing pathogenic germline variant diagnosis rates in precision medicine.** *Human Genomics* (2025). (Springer)

PG2 MBHG 1012 (400-499)	Molecular Biology and Immunobiology	Credit 6
Evaluation: Internal: 15 marks : End semester :60 Marks		Total : 75
End semester: Question Framework	From each unit one question of 5 marks and one question of 10 marks need to be answered out of two questions of 5 marks and two question of 10 marks from each unit	Unit I: 5+10 Unit II: 5+10 Unit III: 5+10 Unit IV: 5+10

Unit I. DNA/RNA Biology and Gene Regulation

- DNA replication in prokaryotes and eukaryotes: replisome architecture, origin licensing, replication timing and checkpoint regulation
- DNA replication fidelity, proofreading, replication stress and genome stability
- DNA damage response (DDR) and repair pathways: MMR, BER, NER, homologous recombination, non-homologous end joining and translesion synthesis
- Transcriptional regulation in prokaryotes and eukaryotes: RNA polymerases, promoter architecture, enhancers, silencers, transcription factors and mediator complex
- RNA processing and post-transcriptional regulation: alternative splicing, RNA editing, alternative polyadenylation and RNA surveillance
- Translational regulation, ribosome dynamics, protein quality control and major post-translational modifications
- Epigenetic regulation of gene expression: chromatin remodeling, histone modifications, DNA methylation, chromatin looping and higher-order genome organization
- Functional roles of regulatory non-coding RNAs (miRNA, siRNA, lncRNA, circRNA) in development and disease

Unit II. Molecular Biology Techniques and Functional Genomics

- Recombinant DNA technology and advanced cloning strategies (Gateway, Gibson Assembly and seamless cloning)
- Quantitative nucleic acid technologies: PCR, qPCR, digital PCR
- High-throughput gene expression analysis: RNA-Seq, single-cell transcriptomics and spatial transcriptomics
- CRISPR screening method
- Protein–protein and protein–DNA interaction studies: Co-IP, ChIP, EMSA, Yeast Two-Hybrid and mass spectrometry-based interactomics
- Functional genomics approaches using RNA interference, and reporter assays

Unit III. Immunobiology

- Molecular basis of innate and adaptive immunity; pattern recognition receptors and innate immune signalling
- Antigen processing and presentation: MHC pathways, cross-presentation and immunoproteasome
- Molecular mechanisms underlying B-cell development, antibody diversification, affinity maturation and class switching
- T-cell biology: TCR signalling, T-cell differentiation, immune tolerance and regulatory T cells
- Cytokine signalling, chemokine networks
- Immune regulation by checkpoint molecules (CTLA-4, PD-1, TIM-3, LAG-3) and immune tolerance
- Molecular basis of autoimmunity, hypersensitivity, transplantation immunology and primary immunodeficiencies

- Vaccines, monoclonal antibodies, cell-based immunotherapy (CAR-T), immune checkpoint inhibitors and emerging immunotherapeutics

Unit IV. Bioinformatics and Computational Biology

- Biological databases and data resources: NCBI, Ensembl, UniProt, PDB, GEO, SRA
- Sequence analysis and comparative genomics: BLAST, multiple sequence alignment, orthologue identification and genome annotation
- Structural bioinformatics: protein structure prediction, AlphaFold, molecular visualization and structure-function relationships
- Immunoinformatics: epitope prediction, HLA binding analysis, antigenicity and vaccine design

Internal Assessment

A. Class Attendance and Participation

B. Continuous Assessment *(Based on one or more of the following):*

- Assignment submission
- Group discussion
- Seminar presentation
- Popular science lecture/presentation
- Mock teaching

Suggested Books and Monographs:

Books:

- Alberts B., Johnson A., Lewis J., et al. (2022). *Molecular Biology of the Cell.* 7th Edition. Garland Science.
- Watson J.D., Baker T.A., Bell S.P., Gann A., Levine M. & Losick R. (2023). *Molecular Biology of the Gene.* 8th Edition. Pearson.
- Lodish H., Berk A., Kaiser C.A., et al. (2021). *Molecular Cell Biology.* 9th Edition. W.H. Freeman.
- Murphy K. & Weaver C. (2022). *Janeway's Immunobiology.* 10th Edition. Garland Science.
- Abbas A.K., Lichtman A.H. & Pillai S. (2024). *Cellular and Molecular Immunology.* 11th Edition. Elsevier.
- Brown T.A. (2023). *Gene Cloning and DNA Analysis: An Introduction.* 9th Edition. Wiley.
- Primrose S.B. & Twyman R.M. (2023). *Principles of Gene Manipulation and Genomics.* 9th Edition. Wiley.
- Glick B.R., Pasternak J.J. & Patten C. (2021). *Molecular Biotechnology: Principles and Applications of Recombinant DNA.* ASM Press.
- Pevsner J. (2024). *Bioinformatics and Functional Genomics.* 4th Edition. Wiley.
- Mount D.W. (2024). *Bioinformatics: Sequence and Genome Analysis.* Cold Spring Harbor Laboratory Press.
- Lesk A.M. (2023). *Introduction to Bioinformatics.* Oxford University Press.

PG2MBHG1013 (400-499)	IKS : Human Health and Ayurgenomics (Including Yoga and naturopathy)	Credit 6
Evaluation: Internal: 15 marks: End semester :60 Marks		Total : 75
End semester: Question Framework	From each unit one question of 5 marks and one question of 10 marks need to be answered out of two questions of 5 marks and two question of 10 marks from each unit	Unit I: 5+10 Unit II: 5+10 Unit III: 5+10 Unit IV: 5+10

Unit I. History and Foundations of Indian Knowledge System in Human Health

- Indian Knowledge System (IKS): historical evolution, philosophy, and scientific relevance in modern healthcare
- Fundamental principles of Ayurveda: Panchamahabhuta, Tridosha (Vata, Pitta, Kapha), Dhatu, Mala, Agni, Ojas and Prakriti
- Concepts of health (Swasthya) and disease (Vyadhi) in Ayurveda
- Preventive and promotive healthcare: Dinacharya, Ritucharya, Sadvritta and Ahara-Vihara
- Principles and scientific basis of Yoga and Naturopathy in health promotion
- Integrative medicine: convergence of Ayurveda, Yoga, Naturopathy and modern biomedical sciences

Unit II. Ayurgenomics and Personalized Medicine

- Concept and scope of Ayurgenomics
- Correlation of Prakriti with genomic, epigenomic, transcriptomic and metabolomic profiles
- Molecular basis of constitutional types (Vata, Pitta and Kapha)
- Precision medicine and personalized healthcare: integration of Ayurveda with genomics
- Gene–environment–lifestyle interactions in health and disease
- Epigenetics, nutrigenomics and microbiome in Ayurvedic concepts of health
- Biomarkers and systems biology approaches in Ayurgenomics
- Applications of Ayurgenomics in chronic diseases, cancer, metabolic disorders and healthy ageing

Unit III. Yoga, Naturopathy and Lifestyle Medicine

- Scientific principles of Yoga: Ashtanga Yoga, Yoga physiology and mind–body interactions
- Molecular and physiological effects of Yoga on stress, immunity, inflammation and metabolic health
- Yoga-based interventions in non-communicable diseases, mental health and rehabilitation
- Principles of Naturopathy: hydrotherapy, mud therapy, fasting therapy, diet therapy and lifestyle modification
- Role of Yoga, meditation and pranayama in neuroendocrine and immune regulation
- Evidence-based integrative approaches for cardiovascular diseases, diabetes, obesity, cancer and healthy ageing
- Clinical research and outcome assessment in Yoga and Naturopathy

Unit IV. Translational Research and Emerging Trends in Ayurgenomics

- Omics technologies in Ayurgenomics: genomics, transcriptomics, proteomics, metabolomics and microbiomics
- Bioinformatics and artificial intelligence applications in Ayurvedic research and personalized healthcare
- Clinical trial design, biostatistics and evidence generation for Ayurveda and Yoga research
- Standardization, quality control and safety evaluation of Ayurvedic formulations
- National initiatives: Ministry of AYUSH, CCRAS, National AYUSH Mission and WHO Global Centre for Traditional Medicine
- Ethical, regulatory and intellectual property issues in traditional knowledge and integrative medicine
- Future perspectives of Ayurgenomics in precision medicine, preventive healthcare and public health

Internal Assessment

A. Class Attendance and Participation

B. Continuous Assessment *(Based on one or more of the following):*

- Assignment submission
- Group discussion
- Seminar presentation
- Popular science lecture/presentation
- Mock teaching

Suggested Books and Monographs:

Books

- Nagarathna, R. & Nagendra, H.R. *Integrated Approach of Yoga Therapy for Positive Health.* Swami Vivekananda Yoga Anusandhana Samsthana (S-VYASA).
- Nagarathna, R. & Nagendra, H.R. *Integrated Approach of Yoga Therapy for Positive Health.*

PG2 MBHG 1021 (300-399)	Basic Biology	Credit 4
Evaluation: Internal: 10 marks : End semester :40 Marks		Total : 50
End semester: Question Framework	One compulsory sort answer type question of 1 marks out of 10 questions. Four questions of 8 marks from each unit out of two questions . .	8x1 =8 Unit I: 1x 8 =8 Unit II: 1x 8 =8 Unit III: 1x 8 =8 Unit IV: 1x 8 =8 Total: 40

Unit I. Cell Biology

- Introduction to Cell Biology and Cell Theory
- Prokaryotic and Eukaryotic Cell Organization
- Cell Membrane: Structure and Fluid Mosaic Model
- Membrane Transport: Diffusion, Osmosis, Active and Passive Transport
- Cell Organelles: Nucleus, Endoplasmic Reticulum, Golgi Apparatus, Lysosomes, Peroxisomes, Ribosomes, Mitochondria and Chloroplast
- Cytoskeleton and Cell Junctions
- Cell Cycle and Cell Cycle Regulation
- Mitosis and Meiosis
- Cell Signalling and Signal Transduction
- Cell Death: Apoptosis and Necrosis (Introduction)

Unit II. Microbiology

- History and Scope of Microbiology
- Classification and Diversity of Microorganisms
- Structure and Ultrastructure of Bacterial Cells
- Structure and Classification of Viruses
- Introduction to Fungi, Protozoa and Algae
- Microbial Nutrition and Growth
- Bacterial Growth Curve and Culture Techniques
- Sterilization, Disinfection and Aseptic Techniques
- Microbial Metabolism: Aerobic Respiration, Anaerobic Respiration and Fermentation
- Antibiotics and Antimicrobial Resistance
- Beneficial Microorganisms and Applications in Agriculture, Food and Biotechnology

Unit III. Biochemistry

- Water, pH and Biological Buffers
- Carbohydrates: Structure and Biological Functions
- Lipids: Classification, Structure and Biological Functions
- Amino Acids, Peptides and Protein Structure
- Nucleic Acids: DNA, RNA and Nucleotides
- Enzymes: Classification, Mechanism of Action and Enzyme Kinetics
- Factors Affecting Enzyme Activity and Enzyme Inhibition
- Bioenergetics and ATP
- Glycolysis and Gluconeogenesis
- Citric Acid Cycle (TCA Cycle)
- Electron Transport Chain and Oxidative Phosphorylation
- Glycogen Metabolism
- Lipid Metabolism and β-Oxidation
- Nitrogen Metabolism and Urea Cycle (Overview)

Unit IV. Human Physiology

- Homeostasis and Feedback Regulation

- Blood: Composition, Functions, Blood Groups and Hemostasis
- Cardiovascular System and Cardiac Cycle
- Blood Pressure and Electrocardiogram (ECG)
- Respiratory System and Gas Exchange
- Digestive System and Digestion of Nutrients
- Excretory System and Renal Physiology
- Fluid, Electrolyte and Acid–Base Balance
- Endocrine System and Hormonal Regulation
- Nervous System: Neuron, Synapse and Reflex Action
- Skeletal Muscle Structure and Muscle Contraction

Suggested Books

Books

- Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell* (7th Edition). W.W. Norton & Company.
- Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Orr, R. B. (2023). *Campbell Biology* (13th Edition). Pearson Education.
- Nelson, D. L., & Cox, M. M. (2021). *Lehninger Principles of Biochemistry* (8th Edition). W.H. Freeman.
- Tortora, G. J., Funke, B. R., & Case, C. L. (2023). *Microbiology: An Introduction* (14th Edition). Pearson Education.
- Hall, J. E. (2021). *Guyton and Hall Textbook of Medical Physiology* (14th Edition). Elsevier.
- Lodish, H., Berk, A., Kaiser, C. A., et al. (2021). *Molecular Cell Biology* (9th Edition). W.H. Freeman.

PRACTICAL PAPER	**PG2 MBHG 1014 (400-499)**	**Laboratory I**	Credit : 6	Total marks 75	End semester : 60 Internal : 15

Module I. Human Genetics

1. Human pedigree analysis and interpretation
2. Karyotype analysis, manual and software based
3. Variant interpretation using ClinVar and OMIM
4. Population genetics using PLINK and Haploview
5. Genome browser (UCSC, Ensembl)
6. GWAS data interpretation
7. Cancer mutation databases (COSMIC, TCGA, cBioPortal)
8. RNA-seq and cancer genomics analysis
9. Variant annotation using ANNOVAR and VEP

Module II. Molecular Biology and Immunobiology

10. Isolation, quantification, and quality assessment of genomic DNA and total RNA by spectrophotometry and agarose gel electrophoresis.
11. PCR amplification of a target gene, primer design, and quantitative gene expression analysis using Real-Time PCR (qPCR).
12. Quantitative detection of antigen or antibody by Enzyme-Linked Immunosorbent Assay (ELISA).
13. Retrieval and analysis of nucleotide and protein sequences using NCBI/UniProt, sequence alignment (BLAST/Clustal Omega), and phylogenetic tree construction.
14. Protein structure visualization and functional annotation using PyMOL/ChimeraX, UniProt, KEGG/Reactome, and basic immunoinformatics (epitope prediction).
15. Identification of lymphoid organs
16. Isolation of peripheral blood mononuclear cells (PBMCs) by density-gradient centrifugation
17. Isolation of T cell from Mouse spleen
18. Flow cytometry-based analysis of PBMC

Module III. Practical from Basic Biology

19. Observation of mitosis in onion root tip.
20. Gram staining of bacteria.

21. Preparation of bacterial growth curve.
22. Sterilization techniques and microbial culture methods.
23. Qualitative tests for carbohydrates, proteins and lipids.
24. Estimation of reducing sugars and proteins.
25. Enzyme assay (amylase/catalase) and effect of pH and temperature.
26. Determination of ABO and Rh blood groups.
27. Estimation of hemoglobin and measurement of blood pressure.

Module IV: Assessment of Integrated Prakriti with Ayurgenomics (Internal Assessment based on submission on the report)

Evaluation of Physiological Parameters Before and After Yoga Practice

- Measurement of pulse rate, blood pressure, respiratory rate and oxygen saturation before and after selected yoga practices (e.g., Surya Namaskar, Pranayama or meditation) and interpretation of physiological responses.

Assessment of Prakriti

- Determination of individual **Vata, Pitta and Kapha Prakriti** using a standardized Ayurvedic questionnaire, followed by interpretation of health predisposition and personalized lifestyle recommendations

Module V: Laboratory Diary (Internal Assessment)

Option to Exit from Post graduate Program with PG Diploma in Molecular diagnostics and Applied Genomics

SEMESTER -II

PG2 MBHG 2011 (400-499)	Computational Genomics and Machine Learning	Credit 6
Evaluation: Internal: 15 marks : End semester :60 Marks		Total : 75
End semester: Question Framework	From each unit one question of 5 marks and one question of 10 marks need to be answered out of two questions of 5 marks and two question of 10 marks from each unit	Unit I: 5+10 Unit II: 5+10 Unit III: 5+10 Unit IV: 5+10

Unit I: Statistical Principles for Genomics

- Basic probability theory and common distributions (binomial, Poisson, normal) in biological data
- Hypothesis testing, p-values, confidence intervals
- Multiple testing correction (Bonferroni, FDR/Benjamini-Hochberg)
- Correlation and regression models; linear and logistic regression in biology
- Statistical genetics: linkage analysis, association testing, and Genome-Wide Association Studies (GWAS)
- computational tools/languages (R/
- Polygenic risk scores

Unit II: Machine Learning Fundamentals and application

- TensorFlow
- Overview of supervised vs. unsupervised learning paradigms
- Data preprocessing, feature selection, and normalization for biological datasets
- Supervised classification methods: logistic regression, decision trees, random forests, support vector machines
- Basics of neural networks and deep learning (feedforward networks, CNNs) for biological data
- Unsupervised methods: k-means and hierarchical clustering
- Dimensionality reduction: Principal Component Analysis (PCA), t-SNE, UMAP
- Model evaluation: cross-validation, accuracy, sensitivity/specificity, ROC-AUC
- Digital pathology
- AI-assisted diagnosis
- Ethical AI

Unit III: Foundations of Computational Genomics

- Linux and Python ecosystems for genomics
- for genomics
- Variant calling pipelines and workflow concepts- GATK HaplotypeCaller
- **DeepVariant**
- CNV caller, CNVkit, CNVCaller
- Overview of genomic data types and file formats (FASTA, FASTQ, SAM/BAM, VCF, GFF)
- Genome assembly: reference-based and de novo assembly algorithms
- Sequence alignment algorithms: dynamic programming, hashing/indexing methods (BWA, Bowtie concepts)

Unit IV: Applications in Genomics and integrated omics

- Applications in variant classification and pathogenicity prediction
- Machine learning in disease risk prediction and biomarker discovery
- Functional genomics and transcriptomics data analysis: RNA-Seq workflow, differential gene expression and pathway enrichment analysis
- Single-cell genomics data analysis approaches (clustering, cell-type annotation)
- Special transcriptomics
- Methylomics and epigenomics
- Multi-omics data integration strategies
- ChIP-Seq, ATAC-Seq,

Internal Assessment

A. Class Attendance and Participation

B. Continuous Assessment *(Based on one or more of the following):*

- Assignment submission
- Group discussion
- Seminar presentation
- Popular science lecture/presentation
- Mock teaching

Suggested Books and Monographs:

Books

- Compeau, P. E. C., & Pevzner, P. A. (2020). *Bioinformatics Algorithms: An Active Learning Approach* (2nd Edition). Active Learning Publishers.
- Pevsner, J. (2024). *Bioinformatics and Functional Genomics* (4th Edition). Wiley-Blackwell.
- Lesk, A. M. (2023). *Introduction to Bioinformatics* (6th Edition). Oxford University Press.
- Brown, T. A. (2023). *Genomes 5*. Garland Science (Taylor & Francis).
- James, G., Witten, D., Hastie, T., & Tibshirani, R. (2023). *An Introduction to Statistical Learning with Applications in Python*. Springer.
- Hastie, T., Tibshirani, R., & Friedman, J. H. (2021). *The Elements of Statistical Learning* (2nd corrected printing). Springer.
- Bishop, C. M., & Bishop, H. (2024). *Deep Learning: Foundations and Concepts*. Springer.
- Aggarwal, C. C. (2023). *Neural Networks and Deep Learning* (2nd Edition). Springer.

Suggested Monographs

- Baldi, P., & Brunak, S. (2022). *Bioinformatics: The Machine Learning Approach*. MIT Press.
- Jones, N. C., & Pevzner, P. A. (2022 Reprint). *An Introduction to Bioinformatics Algorithms*. MIT Press.
- Zvelebil, M., & Baum, J. O. (2021). *Understanding Bioinformatics*. Garland Science.
- Durbin, R., Eddy, S. R., Krogh, A., & Mitchison, G. (2022 Reprint). *Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids*. Cambridge University Press.
- Shalev-Shwartz, S., & Ben-David, S. (2022). *Understanding Machine Learning: From Theory to Algorithms*. Cambridge University Press.
- Raschka, S., Liu, Y., & Mirjalili, V. (2022). *Machine Learning with PyTorch and Scikit-Learn*. Packt Publishing

Suggested Recent Review Articles

- Eraslan, G., Avsec, Ž., Gagneur, J., & Theis, F. J. (2022). *Deep learning: New computational modelling techniques for genomics*. **Nature Reviews Genetics**.
- Greener, J. G., Kandathil, S. M., Moffat, L., & Jones, D. T. (2022). *A guide to machine learning for biologists*. **Nature Reviews Molecular Cell Biology**.
- Reel, P. S., Reel, S., Pearson, E., Trucco, E., & Jefferson, E. (2021). *Using machine learning approaches for multi-omics data analysis*. **Nature Reviews Genetics**.
- Argelaguet, R., et al. (2023). *Computational principles and challenges in multi-omics data integration*. **Nature Reviews Genetics**.
- Huang, S., Chaudhary, K., & Garmire, L. X. (2022). *More is better: Recent progress in multi-omics data integration methods*. **Frontiers in Genetics**.
- Avsec, Ž., et al. (2021). *Effective gene expression prediction from sequence by integrating long-range interactions*. **Nature Methods**.
- Kuenzi, B. M., et al. (2023). *Artificial intelligence and machine learning in precision oncology*. **Nature Reviews Clinical Oncology**.
- Marx, V. (2023). *Method of the Year: Spatially resolved transcriptomics*. **Nature Methods**.
- Min, S., Lee, B., & Yoon, S. (2023). *Deep learning in bioinformatics*. **Briefings in Bioinformatics**.
- Angermueller, C., et al. (2024). *Foundation models for genomics*. **Nature Reviews Genetics**.

PG2 MBHG 2012 (400-499)	**Molecular Diagnostics and Sequencing Technologies**	Credit 6
Evaluation: Internal: 15 marks : End semester :60 Marks		Total : 75
End semester: Question Framework	From each unit one question of 5 marks and one question of 10 marks need to be answered out of two questions of 5 marks and two question of 10 marks from each unit	Unit I: 5+10 Unit II: 5+10 Unit III: 5+10 Unit IV: 5+10

Unit I. Principles of Molecular Diagnostic methods Introduction and history of molecular diagnostics

- Principles of molecular diagnosis: sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV)
- Diagnostic approaches: antigen tests, antibody tests, nucleic acid tests, rapid tests and point-of-care molecular diagnostics
- Conventional PCR, multiplex PCR, nested PCR and real-time quantitative PCR (qPCR)
- Hybridization-based diagnostics: fluorescence in situ hybridization (FISH) and DNA microarrays
- Mutation detection methods: RFLP, ARMS-PCR, GAP-PCR, MLPA, high-resolution melting (HRM) analysis and Sanger sequencing
- Serological diagnosis: ELISA for IgG, IgM and allergy testing
- Triple marker screening and prenatal risk assessment

Unit II. Molecular Diagnostic Technologies and Clinical Applications

- Molecular diagnosis of cancer: breast cancer subtyping (IHC), EGFR mutation testing, cervical cancer, leukemia immunophenotyping
- Precision oncology assays: Oncomine, Oncotype DX, liquid biopsy and circulating tumor DNA (ctDNA)
- Molecular diagnostic biomarkers: cardiac troponin testing and molecular testing for gout
- Molecular diagnosis of infectious diseases: HIV, HCV, tuberculosis (TrueNat and CBNAAT), COVID-19, malaria and dengue
- Variant interpretation and classification using ACMG/AMP guidelines

Unit III. Genetic counselling and Quality assurance

- Genetic counselling: principles, risk assessment, ethical considerations
- Prenatal and preimplantation, genetic diagnosis,
- carrier screening,
- Newborn screening programmes
- Clinical genetic reporting and integration with genetic counselling
- Quality assurance, assay validation and accreditation (NABL, CLIA and ISO 15189, CAP)

Unit IV Sequencing Technologies and Genomic Data Analysis

- Principles of Sanger (first-generation) DNA sequencing
- Next-generation sequencing (NGS): Illumina, Ion Torrent, Roche 454 and SOLiD platforms
- Third-generation sequencing: Pacific Biosciences (PacBio SMRT) and Oxford Nanopore technologies
- Comparison of sequencing platforms and their clinical applications
- Library preparation strategies and target enrichment methods for different NGS platform
- Whole-genome sequencing (WGS), whole-exome sequencing (WES) and targeted sequencing
- Deep sequencing, amplicon sequencing and ChIP sequencing
- RNA sequencing: whole transcriptome, small RNA and non-coding RNA sequencing
- Sequencing workflow: quality control, filtering, genome assembly and reference genome mapping
- Sequence alignment formats (SAM/BAM) and mapping software (Bowtie, BWA, MAQ)
- Variant detection, annotation and overview of clinical bioinformatics pipelines
- Clinical applications of low pass whole-genome for ASD
- Different Genomic Panel testing for Cardiac disorders, and others
- Clinical genomics for diagnosis of rare genetic disorders
- NGS based Clinical case studies in genomic medicine

Internal Assessment

A. Class Attendance and Participation

B. Continuous Assessment *(Based on one or more of the following):*

- Assignment submission
- Group discussion
- Seminar presentation
- Popular science lecture/presentation
- Mock teaching

Suggested Books and Monographs:

Books

- Brown, T. A. (2023). *Genomes 5*. Garland Science (Taylor & Francis).
- Nussbaum, R. L., McInnes, R. R., & Willard, H. F. (2024). *Thompson & Thompson Genetics in Medicine* (10th Edition). Elsevier.
- Strachan, T., & Read, A. P. (2025). *Human Molecular Genetics* (6th Edition). Garland Science (Taylor & Francis).
- Jorde, L. B., Carey, J. C., Bamshad, M. J., & White, R. L. (2020). *Medical Genetics* (6th Edition). Elsevier.
- Buckingham, L. (2021). *Molecular Diagnostics: Fundamentals, Methods and Clinical Applications* (4th Edition). F.A. Davis Company.
- Kulkarni, S. (2023). *Genomic Medicine: Principles and Practice* (2nd Edition). Oxford University Press.
- Voet, D., Voet, J. G., & Pratt, C. W. (2023). *Fundamentals of Biochemistry: Life at the Molecular Level* (6th Edition). Wiley.
- Pevsner, J. (2024). *Bioinformatics and Functional Genomics* (4th Edition). Wiley-Blackwell.
- Lesk, A. M. (2023). *Introduction to Bioinformatics* (6th Edition). Oxford University Press.
- Xiong, J. (2022). *Essential Bioinformatics* (2nd Edition). Cambridge University Press.

Suggested Monographs / Advanced References

- Rehm, H. L., et al. (2023). *Molecular Genetic Pathology*. Elsevier.
- Korf, B. R., & Rehm, H. L. (2021). *Human Genetics and Genomics*. Wiley-Blackwell.
- Van Ness, B., & Baughn, L. (2022). *Next Generation Sequencing in Clinical Oncology*. Springer.
- Kulkarni, S., Pfeifer, J., & Vnencak-Jones, C. (2022). *Clinical Genomics: Practical Applications in Diagnostic Medicine*. Springer.
- Goodwin, S., McPherson, J. D., & McCombie, W. R. (2022 Reprint). *Next-Generation Sequencing Technologies and Their Applications*. Cold Spring Harbor Laboratory Press.
- Metzker, M. L. (2021). *Sequencing Technologies: Principles and Clinical Applications*. Springer.
- Schrijver, I. (2022). *Diagnostic Molecular Pathology in Practice*. Springer.
- National Academies of Sciences, Engineering, and Medicine. (2022). *An Evidence Framework for Genetic Testing*. National Academies Press.
- DePristo, M. A., & Shendure, J. (2023). *Clinical Genome Sequencing and Precision Medicine*. Cold Spring Harbor Laboratory Press.
- International Agency for Research on Cancer (IARC). (2022). *WHO Classification of Tumours: Molecular Pathology and Precision Oncology*. IARC Press.

PG2 MBHG 2013 (400-499)	Recombinant DNA and gene therapy	Credit 6
Evaluation: Internal: 15 marks : End semester :60 Marks		Total : 75
End semester: Question Framework	From each unit one question of 5 marks and one question of 10 marks need to be answered out of two questions of 5 marks and two question of 10 marks from each unit	Unit I: 5+10 Unit II: 5+10 Unit III: 5+10 Unit IV: 5+10

Unit I: Recombinant DNA Technology

- Restriction enzymes, DNA ligases, and other enzymes used in genetic engineering
- Coning vectors: plasmids, bacteriophage, cosmids, BAC/YAC vectors
- Expression vector systems
- Methods of transformation and transfection

Unit II: Advanced Genetic Engineering

- Construction of genomic and cDNA libraries
- Cloning: PCR-based cloning strategies, Gibson assembly,
- Site-directed mutagenesis techniques

Unit III: Recombinant Protein Production

- Outline procedure for Recombinant protein production for biopharma
- Prokaryotic expression systems,
- Yeast expression system,
- Insect cell expression systems,
- Mammalian cell expression systems (CHO, HEK293)
- Different Therapeutic Proteins and their salient production procedure: Human insulin, Erythropoietin, Interferon-α

Unit IV: Advanced Gene Therapy and Applications

- Concepts and classification of gene therapy: ex vivo vs. in vivo approaches
- Viral vector systems: retroviral, adenoviral, adeno-associated virus (AAV), lentiviral vectors
- Non-viral gene delivery systems: liposomes, nanoparticles, electroporation
- CRISPR-based therapeutics and genome, cas9. Cas Nikase, FnCase, Prime editing, clinical application of gene editing based therapy in Sickle cell anemia, Thalassemia and others
- RNA-based therapeutics: siRNA, antisense oligonucleotides, mRNA therapeutics
- Gene therapy strategies for monogenic disorders (e.g., SCID, hemophilia, muscular dystrophy)
- Ethical, biosafety, and regulatory considerations in gene therapy development

Internal Assessment

A. Class Attendance and Participation

B. Continuous Assessment *(Based on one or more of the following):*

- Assignment submission
- Group discussion
- Seminar presentation
- Popular science lecture/presentation
- Mock teaching

Suggested Books and Monographs:

Books

- Primrose, S. B., & Twyman, R. M. (2023). *Principles of Gene Manipulation and Genomics* (9th Edition). Wiley-Blackwell.
- Glick, B. R., Pasternak, J. J., & Patten, C. L. (2022). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (6th Edition). ASM Press.
- Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2024). *Lewin's GENES XIII*. Jones & Bartlett Learning.
- Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2022). *Molecular Biology of the Gene* (8th Edition). Pearson.
- Lodish, H., Berk, A., Kaiser, C. A., et al. (2021). *Molecular Cell Biology* (9th Edition). W.H. Freeman.

- Clark, D. P., & Pazdernik, N. J. (2023). *Molecular Biology* (4th Edition). Academic Cell.
- Green, M. R., & Sambrook, J. (2021). *Molecular Cloning: A Laboratory Manual* (4th Edition). Cold Spring Harbor Laboratory Press.
- Nussbaum, R. L., McInnes, R. R., & Willard, H. F. (2024). *Thompson & Thompson Genetics in Medicine* (10th Edition). Elsevier

Suggested Monographs / Advanced References

- Friedmann, T., Dunbar, C. E., & High, K. A. (2024). *Gene Therapy: A Primer for Physicians* (2nd Edition). Academic Press.
- Templeton, N. S. (2023). *Gene and Cell Therapy: Therapeutic Mechanisms and Strategies* (5th Edition). CRC Press.
- Kay, M. A., Glorioso, J. C., & Naldini, L. (Eds.). (2022). *Gene Therapy for Genetic and Acquired Diseases*. Cold Spring Harbor Laboratory Press.
- Carroll, D. (2021). *Genome Engineering with CRISPR-Cas9*. Cold Spring Harbor Laboratory Press.
- Qi, L. S. (Ed.). (2022). *CRISPR: Methods and Protocols* (Methods in Molecular Biology Series). Humana Press (Springer Nature).
- Porteus, M. H. (2022). *Genome Editing: The Next Step in Gene Therapy*. Springer Nature.
- Verma, I. M., & Weitzman, M. D. (Eds.). (2023). *Gene Therapy: Vectors, Genome Editing and Clinical Applications*. Elsevier.
- Current Protocols Editorial Board. (2023). *Current Protocols in Molecular Biology*. Wiley.
- Methods in Molecular Biology Series. (2022). *Recombinant DNA Technologies: Methods and Protocols*. Humana Press (Springer Nature).
- National Academies of Sciences, Engineering, and Medicine. (2020). *Heritable Human Genome Editing*. National Academies Pres

PG2 MBHG.2021 (300-399)	Basic Computer and data science	Credit 4
Evaluation: Internal: 10 marks : End semester :40 Marks		Total : 50
End semester: Question Framework	One compulsory sort answer type question of 1 marks out of 10 questions. Four questions of 8 marks from each unit out of two questions . .	8x1 =8 Unit 1: 1x 8 =8 Unit 2: 1x 8 =8 Unit 3: 1x 8 =8 Unit 4: 1x 8 =8 Total: 40

Unit I. Computing Fundamentals

- Computer architecture and organization
- Operating systems (Windows and Linux) and file management
- Linux shell environment and basic command-line operations
- Programming language , C++ , Visual basic
- Computer networks, internet and cloud computing, remote computing and file transfer protocol
- High-performance computing (HPC): concepts and applications
- Data storage, backup and cloud repositories
- Internet and Cybersecurity, data privacy and digital ethics

Unit II. Statistical Foundations for Data Science

- Types of biological and scientific data
- Data collection, sampling methods and experimental design
- Data organization and data preprocessing
- Descriptive statistics: measures of central tendency and dispersion
- Probability concepts and probability distributions
- Normal distribution and data transformation
- Correlation and simple linear regression
- Hypothesis testing: *t*-test, Chi-square test and ANOVA (concepts and applications)
- Introduction to statistical software (R/RStudio or PSPP/JASP)
- Statistical reporting and interpretation of scientific results

Unit III. Scientific Data Management and Visualization (10 Hours)

- Scientific data formats (CSV, Excel, TXT, JSON)
- Database concepts and relational databases
- SQL fundamentals for scientific data retrieval
- Data cleaning and quality assessment and normalization
- Exploratory data analysis (EDA)
- Data visualization principles
- Scientific graph preparation using R, Excel or Python
- Heat maps, scatter plots, box plots, bar charts and histograms
- Dashboard concepts and scientific reporting
- Reproducible research and data documentation

Unit IV. Introduction to Data Science and AI

- Data science workflow for scientific research
- Automation of routine computational tasks
- Introduction to scripting for data handling
- Introduction to artificial intelligence and data-driven application
- Big data concepts in biology and healthcare
- Scientific databases and public repositories
- Case studies in biomedical and life science data analysis

Internal Assessment

A. Class Attendance and Participation

B. Continuous Assessment *(Based on one or more of the following):*

- Assignment submission
- Group discussion

- Seminar presentation
- Popular science lecture/presentation
- Mock teaching

Suggested Books and Monographs:
Books

- Sokal, R. R., & Rohlf, F. J. (2012). *Biometry: The Principles and Practice of Statistics in Biological Research* (4th Edition). W.H. Freeman.
- Zar, J. H. (2019). *Biostatistical Analysis* (5th Edition). Pearson Education.
- Motulsky, H. (2022). *Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking* (5th Edition). Oxford University Press.
- Pagano, M., & Gauvreau, K. (2018). *Principles of Biostatistics* (2nd Edition). CRC Press.
- James, G., Witten, D., Hastie, T., & Tibshirani, R. (2023). *An Introduction to Statistical Learning with Applications in Python*. Springer.
- Xiong, J. (2022). *Essential Bioinformatics* (2nd Edition). Cambridge University Press.
- Lesk, A. M. (2023). *Introduction to Bioinformatics* (6th Edition). Oxford University Press.
- Pevsner, J. (2024). *Bioinformatics and Functional Genomics* (4th Edition). Wiley-Blackwell.
- Wickham, H., & Grolemund, G. (2017). *R for Data Science*. O'Reilly Media.

Suggested Monographs / Advanced References

- Cox, N. J. (2020). *Speaking Stata: Visualizing Data*. Stata Press.
- Kabacoff, R. I. (2021). *R in Action: Data Analysis and Graphics with R* (3rd Edition). Manning Publications.
- Peng, R. D. (2020). *R Programming for Data Science*. Leanpub.
- Irizarry, R. A. (2020). *Introduction to Data Science: Data Analysis and Prediction Algorithms with R*. CRC Press.
- Gentleman, R., Carey, V. J., Huber, W., & Hahne, F. (2021). *Bioconductor Case Studies*. Springer.
- Dalgaard, P. (2020). *Introductory Statistics with R* (2nd Edition). Springer.
- Chang, W. (2023). *R Graphics Cookbook* (2nd Edition). O'Reilly Media.
- Wilke, C. O. (2019). *Fundamentals of Data Visualization*. O'Reilly Media.
- National Academies of Sciences, Engineering, and Medicine. (2021). *Reproducibility and Replicability in Science*. National Academies Press.
- Peng, R. D., & Matsui, E. (2021). *The Art of Data Science: A Guide for Anyone Who Works with Data*. Leanpub.

Major/Core Course	**PG2 MBHG 2014 (400-499)**	**Laboratory II and Industry Visit**	4	**P**	75	End semester : 60 Internal : 15

Module I. Computational Genomics and Machine Learning

1. Linux and Python based sceptring for genomic data
2. Retrieval and preprocessing of publicly available genomic and transcriptomic datasets from NCBI, GEO, TCGA and Ensembl.
3. Quality assessment and visualization of NGS datasets using FastQC and MultiQC.
4. Sequence alignment and genome visualization using BWA/Bowtie2 and Integrative Genomics Viewer (IGV).
5. Variant annotation and interpretation using ANNOVAR, Ensembl Variant Effect Predictor (VEP), ClinVar and gnomAD.
6. Differential gene expression analysis and functional enrichment using GEO2R, DAVID, Enrichr and Gene Ontology tools.
7. Construction and evaluation of simple machine learning models for biological datasets (classification, clustering and model performance assessment).

Module II. Molecular Diagnostics, Clinical Genomics and Sequencing Technologies

7. Interpretation of Sanger sequencing chromatograms for mutation detection and confirmation.
8. Analysis of quantitative PCR (qPCR) amplification plots, Ct values and melting curve data.
9. Clinical interpretation of genomic variants following ACMG/AMP guidelines.
10. Analysis of targeted sequencing, whole-exome and whole-genome sequencing datasets using online pipelines
11. Interpretation of molecular diagnostic reports for inherited disorders, infectious diseases and cancer genomics.
12. Clinical case studies involving prenatal diagnosis, carrier screening and precision oncology.

Module III. Recombinant DNA Technology and Gene Therapy

13. In silico restriction mapping and recombinant plasmid construction using online tools
14. Design of cloning strategies for expression vectors and recombinant protein production.
15. Blue white screening
16. Design and evaluation of CRISPR-Cas guide RNAs using online tool
17. In silico analysis of homologous recombination and CRISPR-mediated gene correction strategies.
18. Bioinformatic analysis of viral and non-viral gene delivery systems for gene therapy.

Module IV. Basic Computing, Statistics and Scientific Data Analysis

19. Statistical analysis of biological datasets using R/RStudio (descriptive statistics, hypothesis testing, ANOVA and correlation analysis).
20. Data visualization using R (box plots, scatter plots, volcano plots, heat maps and principal component analysis).
21. Scientific data management using relational databases and SQL for biological datasets.
22. Reproducible computational workflows using R Markdown or Jupyter Notebook.
23. Integrated analysis of multi-omics datasets using publicly available resources.
24. Linux operation and scripting and shell programming

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Module V: Diagnostic Laboratory Exposure and Industry Visit (For Internal Assessment)
Module VI: Laboratory Diary (For Internal Assessment)