MULTIDISCIPLINARY CENTRE FOR ADVANCED RESEARCH & STUDIES (MCARS)

Syllabus Outline for PG Diploma in Molecular Diagnostics

(48 credits=1200 marks)

S. No.	Course	Course title	Credit	Period per week			Distribution of marks			
				L	T	P	Mid Sem Evaluation		End Sem exam	Total
							CWS	MST		
	FIRST SEMESTER									
01	**GTM-114**	**Biochemical & Immuno-diagnostics**	**4**	**3**	**1**	**0**	**20**	**20**	**60**	**100**
02	GTM-124	Molecular Genetics and Recombinant DNA Technology	4	3	1	0	20	20	60	100
03	GTM-134	Data management, Analysis and Statistics	4	3	1	0	20	20	60	100
04	GTM-144	OMICs & Bioinformatics	4	3	1	0	20	20	60	100
05	**GTM-154**	**Microbial pathology and diagnostics**	**4**	**3**	**1**	**0**	**20**	**20**	**60**	**100**
06	**GPM-112**	**Lab-I**	**4**	**3**	**1**	**0**	**20**	**20**	**60**	**100**
		TOTAL CREDITS	24			TOTAL MARKS				600
	SECOND SEMESTER									
01	GTM-214	Project Dissertation and Viva	16	-	-	-	0	0	400	400
02	GTM-224	Seminar Presentation and Review article	4	4	0	0	0	0	0	100
03	GTM-234	**Swayam course-II***	**1or 2 or 3**	**-**	**-**	**-**	**0**	**0**	**25/50 /75**	**25/50 /75**
04	GPM-244	**Swayam course-III***	**1 or 2 or 3**	**-**	**-**	**-**	**0**	**0**	**25/50 /75**	**25/50 /75**
			or							
05	**GTM-254**	**Swayam course-IV***	**4**	**-**	**-**	**-**	**0**	**0**	**100**	**100**
		TOTAL CREDITS	**24**				**TOTAL MARKS**			**600**

Note: The marks distribution for the final examination and internal assessment will be as per the JMI rules.

*** Students must choose either GTM234 and GTM244 together, or GTM254 alone. If choosing GTM234 and GTM244, the combined credit of both courses must be at least 4. GTM254 is a standalone 4-credit course.**

GTM-114- Biochemical Techniques in Immunodiagnostics: (4 Credits, 100 Marks)

Unit I: Introduction and History of Diagnostics: Historical perspective and evolution of biochemical diagnostics., Biochemical tests for detection and quantification of sugars, albumin, urea, proteins, globulins, and vitamins., Importance of molecular biology in diagnostics., Collection, storage, shipping, and transport procedures for clinical samples.

Unit II: Isolation and Purification of Nucleic Acids: Principles and methods of nucleic acid isolation., Role of different reagents in DNA and RNA isolation., Isolation of bacterial DNA., Isolation of DNA and RNA from eukaryotic (human) cells., Complementary DNA (cDNA) synthesis from RNA., Analysis of genomic and plasmid DNA migration patterns using agarose gel electrophoresis.

Unit III: Molecular Cloning: Gene cloning: principles and applications., Restriction enzymes: introduction, palindromic sequences, isoschizomers., Cloning strategies: TA cloning, blunt-end cloning, staggered-end cloning., Labelling of nucleic acids: radioactive and fluorescent probes., End-labelling and body-labelling of nucleic acid probes., Nucleic acid hybridization techniques., Northern blotting: experimental set-up, reagents, and applications., Southern blotting: experimental set-up, reagents, and applications., Western blotting: primary and secondary antibodies, detection methods, and applications.

Unit IV: Molecular Techniques for Nucleic Acid and Protein Detection: PCR and advanced PCR techniques: principle, components, procedure., Primer designing and concept of melting temperature (Tm)., PCR variants: qPCR, multiplex-PCR., Concepts of hybridization, annealing, extension, and proofreading activity of DNA polymerases., qPCR chemistries: SYBR Green and TaqMan probes (principles and applications)., DNA fingerprinting and RFLP., DNA sequencing: Sanger sequencing and introduction to next-generation methods., Electrophoresis: agarose and SDS-PAGE., Chromatography for biomolecule separation and detection: HPLC., Mass spectrometry (MALDI-TOF): introduction, diagnostic applications, and interpretation of spectra.

Textbook

1. **Genomes 4**, 4th Edition, T. A. Brown (2017). CRC Press. ISBN: 9780815345084.

Reference Books

1. Chatterjee K.D. (1997). **Parasitology**. Chatterjee Medical Publishers. ISBN: 108123918100.
2. Greenwood D., Slack R., Peutherer J. (1997). **Medical Microbiology**. ELST Publishers. ISBN: 9780702040894.
3. Forbes B.A., Sahm D.F., Weissfeld A.S., Trevino E.A. (2002). **Bailey & Scott's Diagnostic Microbiology**. C.V. Mosby. ISBN: 9780323075022.
4. Bruns D.E., Ashwood E.R., Burtis C.A. (2007). **Fundamentals of Molecular Diagnostics**. Saunders. ISBN: 9781416037378.

GTM-124- Molecular Genetics and Recombinant DNA Technology: (4 Credits, 100 Marks)

Unit I: Introduction to Human Genetics: Chromosome and DNA structure and function., Cell cycle and

cell division: G1, S, G2, M phases, and checkpoints., Mitosis: stages, mitotic apparatus, cytokinesis, mitogens, inhibitors, and significance., Meiosis: stages, synaptonemal complex, crossing over, chiasma formation, and significance., Laws of inheritance: Mendel's laws, dominance, segregation, independent assortment., Concept of alleles, types of dominance, lethal alleles, multiple alleles., Linkage, recombination, gene mapping, sex-linked inheritance, quantitative inheritance, and cytoplasmic inheritance., Mutations, genetic diseases and disorders., Changes in chromosome number and structure: polyploidy, aneuploidy, chromosomal rearrangements (deletion, duplication, inversion, translocation).

Unit II: Cell Culture and Chromosome Study: Principles of cell culture., Induction of metaphase and cell cycle arrest., Chromosome staining and visualization., Chromosome karyotyping., Chromosome banding techniques (G-banding, C-banding, R-banding, etc.)., Chromosome labeling., In situ hybridization (FISH)., Chromosome painting., Comparative genome hybridization (CGH).

Unit V: Principles of Recombinant DNA Technology: Historical background and milestones in recombinant DNA technology., Restriction enzymes: classification, recognition sequences, and applications., DNA ligases, linkers, adaptors, and homopolymer tailing., Cloning vectors: plasmids, bacteriophages, cosmids, BACs, YACs., Expression vectors and shuttle vectors., Polymerase Chain Reaction (PCR): principle, variations, and applications in recombinant DNA research., Selection and screening of recombinants: blue-white screening, antibiotic resistance markers, reporter genes.

Unit VI: Applications of Recombinant DNA Technology: Recombinant protein production: insulin, growth hormone, vaccines., Transgenic plants and animals: methods and applications., Gene therapy: strategies, viral and non-viral vectors., RNA interference (RNAi) and CRISPR-Cas9-based genome editing., Molecular diagnostics using recombinant DNA techniques., Ethical, biosafety, and regulatory issues in recombinant DNA research., Future prospects of recombinant DNA technology in medicine and biotechnology.

Textbook

1. Cagle, Philip T., Allen, Timothy C. (Eds.) (2009). **Basic Concepts of Molecular Pathology**. Molecular Pathology Library, Springer. ISBN: 9780387896250.

Reference Books

1. Coleman, W.B., Tsongalis, G.J. (Eds.) (2009). **Molecular Pathology: The Molecular Basis of Human Disease**. Academic Press. ISBN: 9780123744197.
2. Jorde, L.B., Carey, J.C., Bamshad, M.J. (2009). **Medical Genetics**. 4th Edition, Mosby. ISBN: 9780323053730.
3. Persing, D.H., Tenover, F.C., Versalovic, J., Tang, Y.-W., Unger, E.R., Relman, D.A., White, T.J. (Eds.) (2003). **Molecular Microbiology: Diagnostic Principles and Practice**. ASM Press. ISBN: 155581221X.
4. Walsh, G. (2014). **Proteins: Biochemistry and Biotechnology**. 2nd Edition, Wiley-Blackwell. ISBN: 9780470669853.
5. Kurien, B.T., Scofield, R.H. (Eds.) (2012). **Protein Electrophoresis: Methods and Protocols**. Springer Protocols. ISBN: 9781617798214.
6. Aloisi, R.M. (1988). **Principles of Immunology and Immunodiagnostics**. Lippincott Williams & Wilkins. ISBN: 9780812111330.
7. Brown, T.A. (2016). **Gene Cloning and DNA Analysis**. 7th Edition, Wiley-Blackwell. ISBN: 9781119072560.

GTM-134- Data management, Analysis and Statistics: (4 Credits, 100 Marks)

Unit-I: Introduction to Bio-statistics: Descriptive Statistics., Measures of central tendency: Mean (Sample mean, Population mean, and Weighted mean), Median, Mode., Measures of dispersion: Range, Variance (Sample and Population), Standard Deviation, Standard Errors, Coefficient of Variation, and Covariance., Displaying Descriptive Statistics: Histogram, Frequency distributions, Box plots, and Scatter plots., Probability distributions: Normal distribution (properties, dispersion percentages, Z-score), Binomial distribution, and Poisson distribution with biological applications., Inferential Statistics: Concept of population and sample, Hypothesis testing (Null and Alternative hypothesis), Levels of significance, Type I and Type II errors, p-value and confidence intervals., Statistical tests: χ^2 test (goodness of fit and independence), t-tests (one sample t-test, independent two-sample t-test, and paired sample t-test), ANOVA (one-way analysis of variance) and post-hoc analysis., Introduction to Multivariate Statistics: Principal Component Analysis (PCA) and its applications in biological data.

Unit-II: Data Analysis: Curve fitting: Straight line, Exponential and Logarithmic fitting and their biological applications., Polynomial fitting and goodness-of-fit (R^2 value)., Linear regression: assumptions, slope, intercept, and applications in prediction models., Correlation analysis: Pearson correlation coefficient, Spearman's rank correlation, and interpretation of correlation in biological data., Residual analysis and error estimation., Introduction to non-linear regression models and their use in biological systems.

Unit-III: Programming for Data Analysis: Introduction to Linux environment., File handling (creation, sorting, filtering), Logical and mathematical operators, Control structures (if, loops, case)., Automating basic statistical calculations through shell scripts., Python programming – Introduction to Python for scientific computing., Data structures in Python (lists, dictionaries, arrays). Introduction to R programming: data import, manipulation, and simple statistical analysis (optional extension).

Unit-IV: Application of Statistics in Biological Data: Hands-on sessions for handling and analyzing experimental data sets., Protein quantification assays through Western blotting: densitometry and normalization of band intensities., Quantitative Real-Time PCR (qRT-PCR): data preprocessing, Ct values, fold change calculation (ΔΔCt method), and statistical comparison., Cytopathic assays: paired t-test analysis and interpretation., Enzyme kinetics data: curve fitting (Michaelis–Menten model) and parameter estimation., High-throughput biological data: microarray and next-generation sequencing datasets – introduction to normalization, variance analysis, and visualization., Case studies highlighting real-world applications of statistical tools in biomedical research.

Text Book:

1. Donnelly Jr., R.A. (2007). **The Complete Idiot's Guide to Statistics**. 2nd Edition, Alpha Publishing. ISBN: 1592576346.

Reference Books:

1. Indrayan, A., Malhotra, R.K. (2017). **Medical Biostatistics**. 4th Edition, Chapman and Hall/CRC. ISBN: 9781498799539.
2. Motulsky, H. (2015). **Essential Biostatistics: A Nonmathematical Approach**. 4th Edition, Oxford University Press. ISBN: 0199365067.
3. Lutz, M. (2010). **Programming Python**. 4th Edition, O'Reilly Media. ISBN: 9780596158101.
4. Robbins, A., Beebe, N.H.F. (2005). **Classic Shell Scripting: Hidden Commands that Unlock the Power of Unix**. 1st Edition, O'Reilly Media. ISBN: 0596005954.
5. Field, A. (2013). **Discovering Statistics Using IBM SPSS Statistics**. 4th Edition, Sage Publications.

ISBN: 9781446249185.

GTM-144- OMICs & Bioinformatics: (4 Credits, 100 Marks)

Unit-I: Introduction to Genomics: Genomes of Prokaryotes and Eukaryotes; Prokaryotic and Eukaryotic genes; Open Reading Frame (ORF) prediction; Genetic Code and codon usage bias; Genome organization and packaging; Human Genome Project – history, goals, and outcomes; Structural, Common, and Rare variants in the genome (SNPs, CNVs, Indels, Structural rearrangements); Comparative Genomics and evolutionary insights; Genome-wide association studies (GWAS); Sequence alignment and homology search methods (PUBMED, BLAST, CLUSTALW, FASTA); Multiple sequence alignment; Applications of genomics in health, agriculture, and biotechnology.

Unit-II: Introduction to Next-Generation Sequencing (NGS): Overview of Sanger vs. Next-Generation Sequencing platforms (Illumina, Ion Torrent, PacBio, Nanopore); Library preparation and sequencing chemistry; NGS-based approaches: ChIP-seq (protein-DNA interactions), Metagenomics (microbial community analysis), Epigenomics (DNA methylation and histone modifications), Exome sequencing (targeted sequencing); Sequencing depth, coverage, and quality assessment; Genome assembly (de novo and reference-based) and annotation; Genome databases and browsers (UCSC, ENCODE, Ensembl, NCBI); Introduction to NGS data analysis pipelines (Galaxy, Bioconductor); Applications of NGS in diagnostics, personalized medicine, and evolutionary studies.

Unit-III: Introduction to Transcriptomics: Transcription in Prokaryotes and Eukaryotes; Promoters, enhancers, and regulatory elements; mRNA splicing, splicing variations, and alternative splicing; Non-coding RNAs (miRNA, lncRNA, siRNA); Transcriptome profiling techniques (Microarrays, RNA-seq); RNA-seq workflow – sample preparation, sequencing, mapping, quantification, and differential expression analysis; Comparative Genomic Hybridization (CGH); Applications of transcriptomics in disease biomarker discovery, drug development, and functional genomics.

Unit-IV: Introduction to Proteomics: Translation in Prokaryotes and Eukaryotes; Post-translational modifications (PTMs); High-throughput protein profiling; Mass spectrometry-based proteomics (MALDI-TOF, LC-MS/MS); 2D gel electrophoresis and protein separation methods; Protein-protein interaction networks; Databases for proteomics (UniProt, PRIDE, PeptideAtlas); Biological pathway databases (KEGG, Reactome, STRING); Gene Ontology (GO) terms and annotations; GO enrichment analysis and functional clustering; Network analysis using PANTHER and Cytoscape; Applications of proteomics in biomarker discovery, systems biology, and therapeutic targeting.

Text Books:

1. *Introduction to Genomics* (2017). Arthur Lesk. Oxford University Press, 3rd Edition. ISBN: 9780198754831.
2. *Genomes 4* (2017). T. A. Brown. CRC Press, 4th Edition. ISBN: 9780815345084.

Reference Books:

1. *Bioinformatics for Omics Data: Methods and Protocols* (2011). Mayer Bernd (Ed). Springer. ISBN: 978-1-61779-027-0.
2. *Next Generation Sequencing: Methods and Protocols* (2018). Steven R. Ordoukhanian, Phillip, Salomon, Daniel R. (Eds.). Springer, 4th Edition. ISBN: 978-1-4939-7514-3.
3. *Metagenomics: Theory, Methods and Applications* (2010). Diana Marco. Caister Academic Press. ISBN: 978-1904455547.
4. *Integration of Omics Approaches and Systems Biology for Clinical Applications* (2018). Antonia Vlahou, Harald Mischak, Jerome Zoidakis, Fulvio Magni (Eds). Wiley Online Library. ISBN: 9781119181149.

5. *Principles of Proteomics* (2013). Richard Twyman. Garland Science. ISBN: 9781859962732.

GTM-154- Microbial pathology and diagnostics: (4 Credits, 100 Marks)

Unit I: Fundamentals of Microbiology: History and scope of microbiology. Classification of microorganisms: Bacteria, Viruses, Fungi, and Parasites. Structure and function of microbial cell (Prokaryotic vs. Eukaryotic). Growth curve of bacteria; Nutritional requirements and culture techniques. Sterilization and disinfection: Principles and methods (Physical, Chemical, Radiation). Biosafety levels and good laboratory practices.

Unit II: Diagnostic Microbiology – Bacteriology: Collection, transport, and processing of clinical specimens. Staining techniques: Gram staining, Acid-fast staining, and special stains. Culture methods: Solid, Liquid, Selective, and Differential media. Identification of bacteria: Morphological, Biochemical, and Serological methods. Antibiotic sensitivity testing (Kirby-Bauer, MIC). Common pathogenic bacteria and their laboratory diagnosis such as *E. coli, Staphylococcus, Salmonella, and Mycobacterium tuberculosis.*

Unit III: Diagnostic Microbiology – Virology, Mycology, and Parasitology: Viruses: General properties, cultivation, and detection methods including hemagglutination, ELISA, and PCR-based techniques. Common viral infections such as Hepatitis viruses, Influenza, HIV, and Dengue with their diagnostic approaches. Fungi: Morphology, culture methods, and identification, with laboratory diagnosis of common fungal infections such as *Candida, Aspergillus,* and Dermatophytes. Parasites: Classification, life cycles, and diagnostic methods including microscopy, concentration techniques, and antigen/antibody detection, with examples such as *Plasmodium, Entamoeba histolytica,* and *Giardia.*

Unit IV: Advanced Diagnostic Techniques: Microscopy: principles and applications of light, phase-contrast, fluorescence, and electron microscopy in microbiology. Immunological techniques for microbial detection: ELISA, Western blotting, immunofluorescence assays. Molecular diagnostics in microbiology: PCR, real-time PCR, RT-PCR, LAMP, and DNA hybridization. Automation in microbiology: automated culture and identification methods including MALDI-TOF MS. Point-of-care testing and rapid diagnostic tests for infectious diseases.

Text Books

- Prescott's Microbiology (2019). Joanne Willey, Linda Sherwood, Christopher Woolverton. McGraw Hill, 11th Edition. ISBN: 9781260211887.
- Medical Microbiology (2020). Murray, Rosenthal, Pfaller. Elsevier, 9th Edition. ISBN: 9780323674508.

Reference Books

- Practical Medical Microbiology (2012). Collee, Marmion, Fraser, Simmons. Churchill Livingstone, 14th Edition. ISBN: 9780443046880.
- Diagnostic Microbiology (2015). Connie R. Mahon, Donald C. Lehman, George Manuselis. Elsevier, 5th Edition. ISBN: 9780323292627.
- Molecular Diagnostics: Fundamentals, Methods, and Clinical Applications (2019). Lela Buckingham, Maribeth L. Flaws. F.A. Davis, 3rd Edition. ISBN: 9780803668294.

GPM-112- LAB-I: (4 Credits, 100 Marks)

1. Demonstration of good laboratory practices (GLP), biosafety levels, and handling of clinical samples.
2. Qualitative and quantitative estimation of proteins (Biuret test, Lowry's method, Bradford assay).
3. Isolation of genomic DNA from bacterial culture.
4. Agarose gel electrophoresis for DNA visualization and molecular weight estimation.
5. Preparation of restriction digestion of plasmid DNA and visualization by agarose gel electrophoresis.
6. Transformation of *E. coli* with plasmid DNA.
7. Polymerase Chain Reaction (PCR) amplification of target gene.
8. qRT-PCR based amplication and Ct value determination
9. Calculation of measures of central tendency (mean, median, mode) using given biological data.
10. Calculation of measures of dispersion (variance, standard deviation, coefficient of variation).
11. Preparation of frequency distributions, histograms, box plots, and scatter plots from given data sets.
12. Probability distribution experiments: normal and binomial distribution using sample data.
13. Application of Student's t-test (paired/unpaired) for biochemical data.
14. Application of one-way ANOVA for comparison of biological groups.
15. Handling and analysis of qRT-PCR dataset (ΔΔCt method).
16. Introduction to NCBI databases: sequence retrieval from GenBank and PubMed search.
17. Sequence alignment using BLAST (nucleotide/protein).
18. Multiple sequence alignment using CLUSTALW.
19. ORF prediction and gene annotation using online tools.
20. Preparation of culture media (nutrient agar, selective, and differential media).
21. Isolation and pure culture of bacteria by streak plate method.
22. Growth curve analysis and CFU calculation

Semester-II

GTM-214-Project Dissertation and Viva (16 Credits, 400 Marks): Students will undertake project-based or hands-on training in R&D laboratories, research institutes, hospitals, or diagnostic centers to gain practical exposure in microbiology and diagnostics. The training will emphasize the application of microbiological, biochemical, and molecular diagnostic techniques in real-world settings. Upon completion, students are required to submit a comprehensive project dissertation based on their work and defend it through a viva voce examination, which will assess their technical knowledge, analytical ability, and presentation skills.

GTM-224 – Seminar Presentation and Review Article (4 Credits, 100 Marks): Students will select a contemporary topic in the field of diagnostics, prepare a detailed review article based on recent literature, and deliver a seminar presentation. The course will assess their ability to critically analyze scientific data, synthesize information into a structured review, and effectively communicate their findings through oral presentation and discussion.

GTM-234 & GPM-244 – SWAYAM Courses (1, 2 or 3 credits, 25, 50 or 75 Marks each): Students may opt for two SWAYAM courses, cumulatively amounting to 4 credits (100 marks). The combination can be either two 2-credit courses or one 1-credit plus one 3-credit course. Final approval of the selected courses shall rest with the Director and CoS members.

Or

GTM-254 – SWAYAM Courses (4 credit, 100 Marks each): Student may opt for only one SWAYAM course of 4 credits (100 marks). Final approval of the selected courses shall rest with the Director and CoS members.

As these are online and self-paced, students can complete them alongside their project dissertation.