DEPARTMENT
of
MOLECULAR BIOLOGY & BIOTECHNOLOGY
COTTON UNIVERSITY
Panbazar, Guwahati-78001, Assam

Postgraduate Syllabus:
M.Sc. in Molecular Biology and Biotechnology

2022

PART-I

Introduction:

MSc in Molecular Biology and Biotechnology is a four semesters programme which encompasses theory and practical in different areas of Molecular Biology and Biotechnology. It also contains a research component through one semester project work to enhance the depth of knowledge and to develop research skills. The programme consists of 84 credits in total, of which theory component bears 64 credits and practical component is of 20 credits.

Aims of Master's degree programme in Biotechnology

MSc in Molecular Biology and Biotechnology (MBBT) is a postgraduate programme where students are admitted through the Cotton University entrance examination. The syllabus is inspired by the DBT approved syllabus as well as the content of the CSIR NET syllabus. The course is an interdisciplinary programme aimed at developing skills to understand the complex biological phenomena at the molecular level. The course is designed to enable the students to apply the acquired knowledge and skills to develop sustainable technologies for better future. On completion of the course graduates will be competent to take up research in future or any other jobs in academia or biotech industries.

Graduate Attributes

The disciplinary expertise or technical knowledge that has formed the core of the university courses. They are qualities that also prepare graduates as agents for social good in future. Some of the characteristic attributes that a graduate should demonstrate are as follows:

1. **Disciplinary knowledge**: Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines
2. **Research-related skills**: A sense of inquiry and capability for asking relevant/appropriate questions, problematizing, synthesizing and articulating
3. **Analytical reasoning**: Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others
4. **Critical thinking**: Capability to apply analytic thought to a body of knowledge
5. **Problem solving**: Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems
6. **Communication Skills**: Ability to express thoughts and ideas effectively in writing and orally
7. **Information/digital literacy**: Capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources; and use appropriate software for analysis of data.

8. **Self-directed learning**: Ability to work independently, identify appropriate resources required for a project, and manage a project through to completion.
9. **Cooperation/Team work**: Ability to work effectively and respectfully with diverse teams
10. **Scientific reasoning**: Ability to analyze, interpret and draw conclusions from quantitative/qualitative data; and critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective
11. **Reflective thinking**: Critical sensibility to lived experiences, with self-awareness and reflexivity of both self and society.
12. **Multicultural competence**: Possess knowledge of the values and beliefs of multiple cultures and a global perspective
13. **Moral and ethical awareness/reasoning**: Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work
14. **Leadership readiness/qualities**: Capability for mapping out the tasks of a team or an organization, and setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision, and using management skills to guide people to the right destination, in a smooth and efficient way.
15. **Lifelong learning**: Ability to acquire knowledge and skills, including 'learning how to learn', that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of work place through knowledge/skill development/reskilling.

Programme Outcomes (POs)

1. **In depth knowledge**: Acquire a systematic, extensive and coherent knowledge and understanding to their academic discipline as a whole and its applications, and links to related disciplinary areas/subjects of study; demonstrate critical understanding of the latest developments in the subject, and an ability to use established techniques of analysis and enquiry within the subject domain.
2. **Understanding Theories**: Apply, assess and debate the major schools of thought and theories, principles and concepts, and of a number of advanced and emerging issues in the academic discipline.
3. **Analytical and critical thinking**: Demonstrate independent learning, analytical and critical thinking of a wide range of ideas and complex problems and issues.
4. **Critical assessment**: Use knowledge, understanding and skills for critical assessment of a wide range of ideas and complex problems and issues relating to the chosen field of study.

5. **Research and Innovation**: Demonstrate comprehensive knowledge about current research and innovation; and to acquire techniques and skills required for identifying problems and issues to produce a well-researched written work that engages with various sources employing a range of disciplinary techniques and scientific methods applicable.
6. **Interdisciplinary Perspective:** Commitment to intellectual openness and developing understanding beyond subject domains; answering questions, solving problems and addressing contemporary social issues by synthesizing knowledge from multiple disciplines.
7. **Communication Competence:** Demonstrate effective oral and written communicative skills to covey disciplinary knowledge and to communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s) of study
8. **Career development**: Demonstrate subject-related knowledge and skills that are relevant to academic, professional, soft skills and employability required for higher education and placements.
9. **Team work**: Work in teams with enhanced inter-personal skills and leadership qualities.
10. **Commitment to the society and to the Nation:** Recognize the importance of social, environmental, human and other critical issues faced by humanity at the local, national and international level; appreciate the pluralistic national culture and the importance of national integration.

Qualification descriptors for the graduates

QD1-Knowledge and Understanding

- In-depth knowledge and understanding in Molecular Biology and Biotechnology
- In-depth knowledge and understanding Biochemistry and Immunology
- In-depth knowledge and understanding Cell biology and Microbiology

QD-2 Skill and Technique

- Graduates will be skilled in Molecular biology
- Graduates will be skilled in Recombinant DNA technology
- Graduates will be skilled in Industrial Biotechnology and Microbial Technology

QD-3 Competence

- Graduates will be competent to critically analyze biological problem
- Graduates will be able to carry out research in diverse areas of Molecular Biology and Biotechnology.
- Graduates will be empowered to take up bio-entrepreneurship initiatives
- Graduates will develop competence for employment in academia and/or in biotech industries.

Program Specific Learning Outcomes (PSOs) for MSc Molecular Biology and Biotechnology

Program Specific Learning Outcomes	**Description of the Program Learning Outcomes of Graduates**
PSO1	**Demonstrate** a fundamental and holistic understanding of the core, interdisciplinary and allied fields of molecular biology and biotechnology
PSO2	**Demonstrate** aptitude for critical thinking and analytical reasoning to address real-time research problems. Acquaint with the contemporary research in the field of molecular biology and biotechnology as well as other related subjects
PSO3	**Understand** the need and impact of biotechnological solutions for addressing endemic societal and environment problems and attempt solutions for sustainable glocal development. Acquire hands on training on entrepreneurial ventures for sustainable livelihood.
PSO4	**Develop** competencies for effective communication (oral/written/ICT) at various levels, capacities and situations.
PSO5	**Demonstrate** the ability to comprehend/ identify moral, ethical and professional values and be responsible for the same
PSO6	**Acquire** practical skills and the ability to apply theoretical concepts for designing, conducting, analysing and interpreting experimental data. Develop an inclination for future research based on the aforementioned skills
PSO7	**Graduates** will gain basic and applied knowledge to enable them for start-ups/bioentrepreneurship.

Teaching-learning process:

The department of MBBT, Cotton University has student-centric teaching-learning pedagogies to enhance the learning experiences of the students. All classroom lectures are interactive in nature, allowing the students to have meaningful discussions and question and answer sessions. Apart from the physical classes, lectures are also held in online mode where students can have doubt clearing and discussions with the teachers. Most of the teachers use ICT facilities with power-point presentations, e-learning platforms and other innovative e- content platforms for student-centric learning methods.

The Department has adopted participative teaching-learning practices, which includes seminars, presentations and group discussions. These participative teaching-learning practices are included in the curricula of almost all the courses. Apart from these, exposure visits, special lectures by invited experts, workshops, and National/International seminars are held to augment knowledge, encourage innovative ideas and expose the students to global academic and research advancement.

The short-term projects, research projects, assignments and field work, which are the integral components of all the courses, enable the students to solve practical problems. Students are also being engaged in sample surveys, data collection and analysis works of the in-house and external research projects for acquiring experiential learning. The laboratories of the department offer hands-on learning experiences to the students.

Assessment methods:

A variety of assessment methods that are appropriate to the discipline are used to assess progress towards the course/programme learning outcomes. Priority is accorded to formative assessment. Progress towards achievement of learning outcomes is assessed using the following: closed-book examinations; problem-based assignments; practical assignment; laboratory reports; individual project reports (case-study reports); team project reports; oral presentations, including seminar presentation; viva-vice interviews; computerised testing and any other pedagogic approaches as per the context.

PART-II

Outline of the courses under Choice Based Credit System:

The Postgraduate programmes consist of four semesters with minimum credits required for the complete programme being 84.

Each course in a programme will be from one of the following categories:

1.Core Course (Core): A course that should compulsorily be studied by a candidate as a core requirement is termed a Core Course. Each core course is of 4 credits.

2.Lab Course (LAB): A Lab (Laboratory) course is a compulsory course in the first two semesters of the M.Sc. programme where the major part of the study involves laboratory work. Each Lab course is of 4 credits.

3. Elective Course: A course that can be chosen from a pool of courses and which may extend the discipline/subject of study or provides exposure to some other discipline/subject or which enhances the student's proficiency or skill is termed an Elective course.

(i) Special Paper (SPL): A course within the parent department that will lead to specialized knowledge and expertise. Each SPL course is of 5 credits.

(ii) Open Elective (OPE): An elective course offered under the main discipline/subject of study is an Open Elective and may be offered to students of other disciplines. A student from a given discipline will be eligible to take one open elective in the third semester and one in the fourth semester. Each OPE course is of 4 credits.

(iii) Skill Enhancement Course (SEC): These courses may be chosen from a pool of courses designed to provide skill-based knowledge and should ideally contain both theory and lab/hands-on/training/fieldwork. The primary purpose is to provide students with life skills in hands-on mode to increase their employability. Each SEC course is of 2 credits.

4. Practical/Tutorials: A practical or tutorial component (or both) is to be provided with every core and special paper/open elective paper.

5. Dissertation/Project Work (DPW): A course designed for students to acquire special/advanced knowledge that they study on their own with advisory support by a teacher/faculty member is a dissertation/project work. A DPW course is of 6 credits.

COURSE STRUCTURE: M.Sc. in Molecular Biology & Biotechnology Programme

Semesters	Code	Courses	Course Names	Credits (L+T+P)
I	MBB701C	Core 1	Cell and Molecular Biology	3 + 1 + 0
	MBB702C	Core 2	Biochemistry	3 + 1 + 0
	MBB703C	Core 3	Microbiology	3 + 1 + 0
	MBB704C	Core 4	Genetics	3 + 1 + 0
	MBB705L	LAB1	Lab course	0 + 0+ 4
		SEC1	Will be offered by the University	2
II	MBB801C	Core 5	Immunology	3 + 1 + 0
	MBB802C	Core 6	Bioinformatics and Biostatistics	3 + 1 + 0
	MBB803C	Core 7	Genetic Engineering	3 + 1 + 0
	MBB804C	Core 8	Genomics and Proteomics	3 + 1 + 0
	MBB805L	LAB2	Lab course	0 + 0 + 4
	MBB004S	SEC2	Molecular Techniques	1+0+1
III	MBB901C	Core 9	Plant and Animal Biotechnology	3 + 0 + 1
	MBB902C	Core 10	Biophysics and Instrumentation	3 + 0 + 1
	MBB903C	Core 11	Industrial Biotechnology	3 + 0 + 1
	MBB904SP1	SPL 1	Biomedical Genetics and Personalized Medicine	3 + 1 + 1
	MBB905OE1	OPE1	Environmental Biotechnology	3 + 1 + 0
IV	MBB1001C	Core 12	Bioethics, Biosafety and IPR	3 + 1 + 0
	MBB1002SP1	SPL 2	Plant Functional Genomics	3 + 1 + 1
	MBB1003OE1	OPE2	Biodiversity and Conservation Genetics	3 + 1 + 0
	MBB1004DPW	DPW	Dissertation	0+0+6

Course Detail	Number	Total Credit
Core	12	**48**
LAB	2	**8**
SEC	2	**4**
SPL	2	**10**
OPE	2	**8**
DPW	1	**6**
Total		**84**

Core: Core Course, **SEC:** Skill Enhancement Course, **OPE:** Open Elective **SPL:** Special Paper, **DPW**: Dissertation

N.B.

- **DPW**: The student will have to carry out a Dissertation/Project work of six months duration at the parent institute or any other institute at the vicinity.
- SEC 1 and SEC 2 are choice based courses offered by the University.

Mapping of POs and Course Learning Outcomes of the M.Sc. in Molecular Biology & Biotechnology Programme

Table 1: M.Sc. in MBBT COURSES													
Programme Outcomes		**Cell and Molecular Biology (MBB701C)**	**Biochemistry (MBB702C)**	**Microbiology (MBB703C)**	**Genetics (MBB704C)**	**Lab course 1 (MBB705L)**	**Skill Enhancement Course (Choice based)**	**Immunology (MBB801C)**	**Bioinformatics and Biostatistics (MBB802C)**	**Genetic Engineering (MBB803C)**	**Genomics and Proteomics (MBB804C)**	**Lab course 2 (MBB805L)**	**Molecular Techniques Skill Enhancement Course (MBB004S)**
		Core-1	**Core-2**	**Core-3**	**Core-4**	**LAB-1**	**SEC-1**	**Core-5**	**Core-6**	**Core-7**	**Core-8**	**LAB-2**	**SEC-2**
PO1	**In depth knowledge**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO2	**Understanding Theories**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO3	**Analytical and critical thinking**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO4	**Critical assessment**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

PO5	**Research and Innovation**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO6	**Interdisciplinary Perspective**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO7	**Communication Competence**												
PO8	**Career development**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO9	**Team work**					✓	✓					✓	✓
PO10	**Commitment to the society and to the Nation**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓	Compliant
	Non-compliant

Mapping of POs and Course Learning Outcomes of the M.Sc. in Molecular Biology & Biotechnology Programme

Table 2: M.Sc. in MBBT COURSES										
Programme Outcomes		**Plant and Animal Biotechnology (MBB901C)**	**Biophysics and Instrumentation (MBB902C)**	**Industrial Biotechnology (MBB903C)**	**Biomedical Genetics and Personalized Medicine (MBB904SP1)**	**Environmental Biotechnology (MBB905OE1)**	**Bioethics, Biosafety and IPR (MBB1001C)**	**Plant Functional Genomics (MBB1002SP1)**	**Biodiversity and Conservation Genetics (MBB1003OE1)**	**Dissertation (MBB1004DPW)**
		Core-9	**Core-10**	**Core-11**	**SPL-1**	**OPE-1**	**Core-12**	**SPL-2**	**OPE-2**	**DPW**
PO1	**In depth knowledge**	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO2	**Understanding Theories**	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO3	**Analytical and critical thinking**	✓	✓	✓	✓	✓		✓	✓	✓
PO4	**Critical assessment**	✓	✓				✓	✓	✓	✓

PO5	**Research and Innovation**	✓	✓	✓	✓	✓		✓	✓	✓
PO6	**Interdisciplinary Perspective**	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO7	**Communication Competence**									✓
PO8	**Career development**	✓	✓	✓	✓	✓	✓	✓	✓	✓
PO9	**Team work**		✓					✓		✓
PO10	**Commitment to the society and to the Nation**	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓	Compliant
	Non-compliant

SEMESTER I
PAPER CODE: MBB701C
CELL AND MOLECULAR BIOLOGY
CREDITS: 3+1+0

Course Outcome:
CO1: Ability to understand three fundamental aspects in biological phenomenon: a) what to seek; b) how to seek; c) why to seek?
CO2: Understand about cells, organelles and biomolecules.
CO3: Comprehend and relate to the molecular basis of replication, transcription and translation

THEORY:

Unit	**Internal organization of the cell**	**No. of Lectures**
I	The chemical components of a cell, intracellular compartments and protein sorting, mitochondria and chloroplasts, cytoskeleton and cell motility; major functions of cytoskeleton	9
Unit	**Nucleic acid metabolism**	**No. of Lectures**
II	Structure of DNA and its physico-chemical properties; DNA replication in prokaryote and eukaryote; structure and properties of RNA polymerases in prokaryote and eukaryote; mechanism of transcription; eukaryotic promoters and enhancers; general transcription factors, TATA binding proteins, activators and repressors; Post transcriptional modifications of RNA.	10
Unit	**Regulation of gene expression**	**No. of Lectures**
III	Prokaryotic gene expression with reference to inducible and repressible operons, concept of lac, trp operon, concept of eukaryotic gene regulation, antisense RNA and RNA interference, post transcriptional controls	10
Unit	**Translation and transport**	**No. of Lectures**
IV	Translation machinery, ribosomes, composition and assembly, universal genetic code, degeneracy of codons, termination codons, iso accepting tRNA, wobble hypothesis, mechanism of initiation, elongation and termination, co- and post-translational modifications.	10
Unit	**Cell cycle & Cell signaling**	**No. of Lectures**
V	General principle of cell signalling: signalling molecules and their receptors, G-protein coupled receptors, second messengers, intracellular messengers, signal transduction: protein tyrosine phosphorylation. Receptor mediated signalling related to EGFR, WNT, SMAD. An overview of gene control, checkpoint pathways induced in response to DNA damage, signal transduction pathways of apoptosis, defective apoptotic/cell proliferation pathways leading to cancer	15
Unit	**Basic concepts of development**	**No. of Lectures**
VI	Stages of development, cell fate and commitment – potency- concept of embryonic stem cells, differential gene expression, terminal differentiation, lineages of three germ layers, fate map, mechanisms of differentiation, pattern formation- axis specification, positional identification (regional specification), morphogenetic movements. Development in invertebrate/vertebrate models - *Drosophila, C. elegans*& Mouse	10

Suggested Readings

1. Lewin. B. Gene IX. 9th Ed, Jones and Barlett Publishers, 2007.
2. Lehninger. A. L., Nelson. D. L., Cox. M. M., Principles of Biochemistry. CBS Publications, 2001.
3. Karp. G. Cell and Molecular Biology. 6th Ed, John Wiley and Sons, Inc, 2010.
4. Gilbert S.F. Developmental Biology. 6th Ed, Sinauer Associates, 2000.

SEMESTER I
PAPER CODE: MBB702C
BIOCHEMISTRY
CREDITS: 3+1+0

Learning Outcome:

CO1: Learn in detail the structures, functions and classification of biological molecules (protein, carbohydrate, lipid, nucleic acids).
CO2: Learn the basic concept of enzyme function and action, Inhibition of enzyme activity.
CO3: Comprehend the vital metabolic pathways of living organisms and the interconversion of metabolic fuels.

THEORY:

Unit	**Chemical Foundation of Biology and Bioenergetics**	**No. of Lectures**
I	Acids, Bases and buffers, Henderson- Hasselbach equation, biological buffer solution, pH, pK. Concept of free energy: Principles of thermodynamics, kinetics, dissociation and association constant, energy rich bonds, weak interactions, coupled reactions and oxidative phosphorylation, group transfer	10
Unit	**Biochemistry of Macromolecules**	**No. of Lectures**
II	**Sugars:** Classification, occurrence, isolation, purification, properties and biological reaction, Glycoproteins and Proteoglycans **Proteins:** Amino acids and Peptides – classification, Physio- chemical properties, peptide bond, Primary, Secondary and tertiary structure of protein, Conformation of protein and polypeptide **Lipids:** Structure and function, Triglycerides, Phospholipids, steroids and terpenes, Role of lipids in biomembranes	15
Unit	**Enzymology**	**No. of Lectures**
III	Nomenclature, Enzyme kinetics, Regulation of enzymatic activity, Enzyme catalysis. Active sites: Enzymes and coenzymes: coenzymes interactions: activators and inhibitors, kinetics of enzyme inhibitors, isoenzymes, allosteric enzymes, ribozymes. Abzyme.	10
Unit	**Metabolism I**	**No. of Lectures**
IV	Glycolytic pathway; Gluconeogenesis; Pentose Phosphate pathway; Kreb's cycle; Fatty acid catabolism; Amino acid oxidation; Biosynthesis of carbohydrates, lipids; amino acid biosynthesis and oxidation . Biosynthesis and degradation of nucleotides.	9
Unit	**Vitamins, Minerals and Hormones:**	**No. of Lectures**
V	Sources, biological and biochemical functions, Steroids and isoprenoid derivations from vitamins. Minerals: requirements, macro and minor minerals-source and function. Hormones: Classification of hormones, function of hormones and their regulation, mechanism of hormone action, site of biosynthesis and physiological function.	10
Unit	**Metabolism II**	**No. of Lectures**
VI	Oxidative phosphorylation; Photosynthesis; Elucidation of metabolic pathways; Logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; Principles of metabolic regulation; Regulatory steps; Signals and second messengers	10

Suggested Readings

1. Berg. J. M, Tymoczko. JL and Stryer. L. Biochemistry. 5th Ed, WH Freeman, New York, 2002.
2. Voet. D and.Voet. JG, Biochemistry. 3rd Ed, John Wiley, New York, 2004.
3. Nelson. D. L and Cox. MM, Lehninger Principles of Biochemistry. 5th Ed, W.H Freeman and Company, 2008.
4. Sadasivam. SK and Manikam. A, Biochemical methods. 2nd Revised Ed, New Age International, 2005.

SEMESTER I
PAPER CODE: MBB703C
MICROBIOLOGY
CREDITS: 3+1+0

Course Outcome:

CO1: Ability to identify the major categories of microorganisms and analyze their classification, diversity, and ubiquity.
CO2: Ability to identify and demonstrate the structural, physiological, and genetic similarities and differences of the major categories of microorganisms.
CO3: Ability to control microbial growth, evaluate the interactions between microbes, hosts and environment

THEORY:

Unit	**Microbial characteristics**	**No. of Lectures**
I	Cell division and growth curve, Bacterial culture methods, Bacterial metabolism, bacterial genetics.	9
Unit	**Microbial diversity**	**No. of Lectures**
II	Classical and modern methods and concepts, domain and kingdom concepts in classification of microorganisms, Criteria for classification; Classification of Bacteria according to Bergey's manual; Bacteria: Purple and Photosynthetic, green bacteria, cyanobacteria, Archaea, Eukarya: Algae, Fungi.	15
Unit	C**ontrol of microorganisms**	**No. of Lectures**
III	Microbial diseases, detection and Control of microorganisms: Physical and chemical control of microorganisms, antibiotics, antifungal drugs, mode of action, antimicrobial drug resistant	10
Unit	**Virology**	**No. of Lectures**
IV	Virus and bacteriophages, General properties of Viruses, Viral structure, Taxonomy of virus, Purification and Isolation, cultivation and identification of viruses, viral replication. Control of virus, Subviral particles – viroids and prions.	10
Unit	**Host-microbe interaction**	**No. of Lectures**
V	Host-pathogen interaction, Symbiosis, Microbes infecting humans, veterinary animals and plants	10
Unit	**Applied Microbiology**	**No. of Lectures**
VI	Microbial communication system; Microbial fuel cells; Prebiotics and Probiotics	10

Suggested Readings

1. Pelczar. M. J Jr, Chan. E.C.S. and Kreig. NR., Microbiology. 5thEd, Tata McGraw Hill New Delhi, 2004.
2. Madigan. M.T., Martinko. J. M., Stahl. D.A., and Clark. D. P. Brock's Biology of Microorganisms. 13th Ed. Benjamin Cummings, San Francisco, CA, 2012.
3. Maloy. S. R., Cronan, J. E. Jr. and Freifelder, D.J. Microbial Genetics, 2nd Ed, Bartlett Publishers.1994.
4. Willey. JM, Sherwood. LM, and Woolverton. CJ. Prescott, Harley and Klein's Microbiology. 7th Ed, McGraw Hill Higher Education, 2008.

SEMESTER I
PAPER CODE: MBB704C
GENETICS
CREDITS: 3+1+0

Course Outcome:
CO 1: Ability to understand the fundamental molecular principles of genetics.
CO 2: Ability to establish the relationship between phenotype and genotype
CO 3: Ability to do mapping and understand how gene expression is regulated.
THEORY:

Unit	**Patterns of inheritance**	**No. of Lectures**
I	Mendel's law of inheritance, multiple allelic systems, Co-dominance, sex determining mechanisms, sex-linked, sex-influenced and sex-limited inheritance, Epistasis, Pleiotropy. Cytoplasmic inheritance. Linkage and chromosome mapping: linkage, crossing over, genetic recombination, genetic mapping.	15
Unit	**Mutagenesis**	**No. of Lectures**
II	Mutagenic agents, mechanisms of mutagenesis-chemical and radiation; Expression of mutations – gene mutation; point mutations and frameshift mutations, isolation of auxotroph, conditional, lethal Assay of mutagenic agents (Ames test).	10
Unit	**Cytogenetics**	**No. of Lectures**
III	Cell division and errors in cell division; non disjunction; structural and numerical chromosomal abnormalities – deletion, duplication, translocation; Disorders of sex chromosomes and autosomes. Molecular cytogenetics – Fluorescence *In Situ* Hybridization (FISH), Comparative Genomic Hybridization (CGH).	10
Unit	**Microbial genetics**	**No. of Lectures**
IV	Conjugation, transduction and transformation in bacteria, lambda phage – genetic map, lysogenic and lytic cycles; Transposable genetic elements.	10
Unit	**Human genetics**	**No. of Lectures**
V	The human chromosome, types of genetic diseases, genetic screening; biochemical markers, pre-natal diagnosis, ethical issues, concept of epigenetics.	9
Unit	**Population genetics and evolution**	**No. of Lectures**
VI	Phenotype, Genotype, Gene frequency; Hardy-Weinberg law; Factors distinguishing Hardy-Weinberg equilibrium; Mutation selection; Migration; Gene flow; Genetic drift	10

Suggested Readings
1. Gardner EJ and Sunstad DP, Principles of Genetics, John Wiley and Sons, 2000.
2. Strickburger MW, Genetics, Macmillan Pub. Co.,1994.

3. Strachan T and Read AP, Human Molecular Genetics, Garland Science, 2004.
4. Peter J. Russell, Genetics, Benjamin-Cummings Publishing Company, 1998.

SEMESTER I
PAPER CODE: MBB705L
LAB COURSE-1
CREDITS: 0+0+4

Course Outcome:

CO 1: ***Ability*** *to understand the fundamentals of biosafety, experimental design and practices*
CO 2: ***Ability*** *to design and execute basic biochemical and microbiological experiments*
C*O 3:** ***Ability *to design and execute basic molecular biology and genetic engineering experiments*

List of practical

1. Washing, sterilization techniques, basic safety measures and laboratory record keeping.
2. Handling and safe operation of instruments, housekeeping for sophisticated instrumentation and personal protective equipment.
3. Preparation of blood smear, staining and observation under microscope.
4. Antibiotic sensitivity assay.
5. Study of bacterial growth kinetics.
6. Protein estimation by Bradford method.
7. DNA extraction from bacteria or plant /animal tissues.
8. Amplification of DNA using Polymerase Chain Reaction.

SEMESTER II
PAPER CODE: MBB801C
IMMUNOLOGY
CREDITS: 3+1+0

Course Outcome:
CO1: Ability to comprehend and design immunological experiments
CO2: Ability to determine the varied immune responses during infection.
CO3: Ability to apply the knowledge of vaccinology and clinical immunology in translational research

THEORY:

Unit	**Basic concepts and anatomy of the immune system**	**No. of Lectures**
I	Components of innate and acquired immunity; Phagocytosis, inflammation, Molecules, cells and organs of the immune system: Lymphoid cells, Mononuclear phagocytes, Granulocytic cells; Primary Lymphoid Organ, Secondary Lymphoid Organ, Mucosa-associated lymphoid tissues	10
Unit	**Antigens and antigen recognition**	**No. of Lectures**
II	Antigens, immunogen, hapten, adjuvants, epitopes, major histocompatibility complex antigens-MHC genes, HLA typing. Non self-recognition by the innate system; pattern recognition receptors, toll like receptors, B cell recognition of antigen, T cell recognition of antigen.	10
Unit	**Immune response mechanism**	**No. of Lectures**
III	B-cell generation, activation and differentiation; T-cell maturation; activation and differentiation; antigen processing and presentation- antigen presentation; antigen processing pathways-cytosolic and endocytic pathway. Acute inflammatory response, cytokines families and functions, therapeutic use; cell mediated immune response-subsets of CD4+ effector T cells and their functions; antibody dependent cellular cytotoxicity (ADCC); opsonization.	10
Unit	**Immunoglobulin and antigen antibody interaction**	**No. of Lectures**
IV	Basic structure of immunoglobulins; classes and subclasses; generation of antibody diversity, antigen-antibody reactions-precipitation, agglutination, complement fixation. Activation of complement system; alternative and classical pathway, functions, regulation of complement system	9
Unit	**Immunotechnology and Immunization**	**No. of Lectures**
V	Immunoassay using labelled reagents (RIA, solid phase radio immunoassay, ELISA), western blotting; Immunohistochemistry; cytokine immunoassays; monoclonal antibodies-production and applications. Active and passive immunization; vaccines; whole organism, live attenuated, subunit, purified macromolecules, inactivated exotoxins, recombinant-vector vaccines; DNA vaccines	15
Unit	**Clinical immunology**	**No. of Lectures**
VI	Hypersensitivity- type I, type II, type III and type IV; autoimmunity-types of auto immune diseases, mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; immunological basis of graft rejection, clinical transplantation and immunosuppressive therapy, cancer immunotherapy, reproductive immunology-Th1, Th2 shift. tumour antigens, immune responses to tumours, tumour vaccines	10

Suggested Readings

1. Kindt. T. J., Goldsby, R. A., Osborne, B. A. and Kuby, J. Immunology. W. H. Freeman, 2007.
2. Roitt. I. V. and Delves, P. J. Essential Immunology. 10th Ed, Blackwell Publishing Company, 2004.
3. Abbas. A. K., Lichtman. A. H. and Pillai, S. Cellular and Molecular Immunology. Elsevier. 8th Ed, 2015.
4. Owen. J., Punt J. and Stranford. S. Kuby Immunology. 7th Ed, W. H. Freeman, 2013.

SEMESTER II
PAPER CODE: MBB802C
BIOINFORMATICS AND BIOSTATISTICS
CREDITS: 3+1+0

Course Outcome:

CO1: Ability to use computational tools for bioinformatics
CO2: Ability to investigate specific contemporary biological questions using bioinformatics
CO3: Ability to critically analyze and interpret biological results using biostatistics tools

THEORY:

Unit	**Introduction to computer, hardware and software**	**No. of Lectures**
I	Introduction to computer, hardware and software; Basics of operating system and their use in Bioinformatics; Computational infrastructure for bioinformatics; Types of operating systems-Introduction to Windows operating system, LINUX and; PERL.	5
Unit	**Basics of Bioinformatics**	**No. of Lectures**
II	Introduction to Bioinformatics; Biological databases (protein and nucleic acid); Sequence data formats; Conversion of sequence formats; Sequence submission to databases; Sequence flatfile format.	10
Unit	**Sequence alignment and similarity search**	**No. of Lectures**
III	Sequence alignment and similarity search- sequence identity, sequence similarity and sequence homology, global alignment, local alignment, pairwise alignment, multiple alignment, Basics of alignment algorithm, introduction of scoring matrices, alignment score, Exploring resources at NCBI; Basic local alignment search tool (BLAST); sequence assembly	15
Unit	**Molecular phylogeny**	**No. of Lectures**
IV	Molecular phylogeny-Molecular evolution, phylogenetic tress, types of trees, phylogenetic analysis, tree building methods, software for phylogenetic analysis.	9
Unit	**Protein modeling and Drug design**	**No. of Lectures**
V	Protein modeling and Drug design-protein Secondary structure prediction, visualisation of molecular structures- RasMol and Pymol; Fold Recognition; Protein modelling methods-Homology modelling, *Ab initio/ de novo* methods; Drug discovery process; Techniques in drug design; Molecular docking.	10
Unit	**Basics of Biostatistics**	**No. of Lectures**
VI	Terms and symbols used in Biostatistics; Sample and sampling methods; Data collection and representation-collection, classification and tabulation of data, graphic and diagrammatic representation of data. Measure of central tendency and dispersion-Types of measure of central tendency-mean, mode, median; Measure of dispersion- range, mean deviation, standard deviation, variance; Test of significance-Null hypothesis, Alternative hypothesis, Hypothesis testing, z-test, t-test, ANOVA; Chi-Square test; Probability distribution-Binomial, Poisson and Normal; Introduction to correlation and regression.	15

Suggested Readings

1. Campbell and Heyer, Discovering Genomics, Proteomics, and Bioinformatics. 2nd Ed, Benjamin Cummings, 2002.
2. Baxevanis. A.D. and Ovellette B. F. F. Bioinformatics: A practical guide to the analysis of genes and proteins. Wiley-Interscience, 2002.
3. Prem S. M., Introductory Statistics. Latest Ed, Wiley..
4. John. A. R., Mathematical Statistics and Data Analysis. 3rd Ed, Duxbury Press, 2007.

SEMESTER II
PAPER CODE: MBB803C
GENETIC ENGINEERING
CREDITS: 3+1+0

Course Outcome:

CO1: Ability to isolate nucleic acids from any organism and amplify using PCR
CO2: Ability to clone gene in cloning and expression vectors and transform them in a suitable host.
CO3: Ability to express the recombinant protein in different host

THEORY:

Unit	Tools and techniques in Genetic Engineering	No. of Lectures
I	Restriction Endonuclease-Nomenclature, restriction mapping, type I to IV; Isoschizomers and Neoschizomers; Start Activity; DNA ligase; DNA modifying enzymes-Nucleases, DNA Polymerases, alkaline phosphatase, polynucleotide kinase, and terminal transferase; Labeling of DNA-End labelling, Nick translation, Random priming, Northern, Southern and Colony hybridization	15
Unit	**Polymerase chain reaction and application**	**No. of Lectures**
II	Polymerase Chain reaction (PCR); Primer design; PCR types-multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, PCR based methods for site-directed mutagenesis; Mutation detection methods-Single Strand Conformation Polymorphism (SSCP), Denaturing Gradient Gel Electrophoresis (DGGE).	10
Unit	**Vectors**	**No. of Lectures**
III	Cloning vectors-plasmid vectors, phage vectors, cosmids, YACs, BACs, PACs, BIBACs, Protein expression vectors; Protein expression and purification; Animal Virus derived vectors-SV-40, vaccinia/ baculoviruses and retroviral vectors; Host cells for cloning.	15
Unit	**Cloning strategies I**	**No. of Lectures**
IV	Transformation and Transfection; Construction of genomic and cDNA libraries; Jumping and hopping libraries; Phage display; cDNA and genomic cloning.	7
Unit	**Cloning strategies II**	**No. of Lectures**
V	Expression cloning; Yeast two hybrid system; Selection and screening of transformants- marker and reporter genes, positive and negative selection, insertion inactivation, alpha complementation; Cloning strategies for PCR product cloning.	7
Unit	**Nucleic acid sequencing methodologies**	**No. of Lectures**
VI	Sanger's method of DNA sequencing; Automated DNA sequencing by capillary electrophoresis; Dye chemistries and sequencing platforms; Interpretation of Electropherogram; Next Generation sequencing technologies (1^{st} , 2^{nd} and 3rd generation) sequencing	10

Suggested Readings

1. Brown. T. A, Genomes 3. 3rd ed. Garland Science, 2007.
2. Brown. T. A, Gene Cloning and DNA Analysis: An Introduction, 7th Ed, 2016
3. Primrose. S. B. and Twyman. R.M, Principles of Gene Manipulation and Genomics. Wiley Blackwell, 7th Ed., 2007.
4. Watson. J. D., Gilman M., Witkowski, J and Zoller. M. Recombinant DNA Technology. 2nd Ed, Scientific American Books, 1992.

SEMESTER II
PAPER CODE: MBB804C
GENOMICS AND PROTEOMICS
CREDITS: 3+1+0

Course Outcome:

CO1: Ability to understand the fundamentals of genomics and proteomics
CO2: Ability to comprehend genome sequencing and mapping for understanding the evolutionary relationships
CO3: Comprehend and relate to the use of genomics, transcriptomics and proteomics in applied research

THEORY:

Unit	Basics of genomics and proteomics	No. of Lectures
I	Prokaryotic and Eukaryotic genome organization, Extra-chromosomal DNA: mitochondria, Chloroplast, bacterial plasmids. Genome sequencing projects: Microbes, plants and animals, Accessing and retrieving genome project information from web, Human Genome Project.	9
Unit	**Genome mapping and sequencing**	**No. of Lectures**
II	Genetic and physical maps; markers for genetic mapping- AFLP, SSLP, SSR, SNPs; Linkage and Pedigree analysis in genome mapping; Techniques for physical mapping-restriction mapping, Fluorescence *in situ* Hybridization (FISH), sequence tagged sites (STS).Sequencing and analyzing genome – Sequencing strategies for the systematic sequencing of complex genomes, sequence assembly and analysis, gene location in genome sequence and gene function prediction.	10
Unit	**Comparative genomics**	**No. of Lectures**
III	Identification and classification of organisms using molecular markers-16S rRNA typing/sequencing, SNPs. Use of genomes to understand the evolution of eukaryotes, to track emerging diseases, to design new types of antibiotics and new class of medication, gene location in genome sequence.	10
Unit	**Proteomics**	**No. of Lectures**
IV	Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing), 2-D electrophoresis of proteins, isoelectric focusing, Peptide fingerprinting, LC/MS-MS for identification of proteins and modified proteins, MALDI-TOF, PAGE and Differential display proteomics, Protein-protein interactions such as Yeast two hybrid system, Analytical ultracentrifuge and SPR methodologies	10
Unit	**Functional genomics and proteomics**	**No. of Lectures**
V	Cloning systems used in genomics-cosmids, P1 bacteriophage, BAC and YAC cloning vectors, Isolation of High molecular weight DNA and separation of chromosomes by PFGE, Transcriptome analysis for identification and functional annotation of gene, Contig assembly, Chromosome walking and map-based cloning, Mining functional genes in the genome, Gene function-forward and revere genetics, Gene tagging strategies and application. ESTs and its utility in genomics, Differential gene profiling methods, reverse transcription PCR, Real time PCR, Protein and peptide microarray-based technology.	15

Unit	Application of genomics and proteomics	No. of Lectures
VI	Genomics application: Genomics in Biopharmaceutical Industry, pharmacokinetics, Chemoinformatics, New Pathogen Discovery and Microbial Typing, Gene Therapy, drug discovery and development, toxicology . Proteomics applications: Understanding the mechanism of pathogenesis, Drug discovery, Disease diagnosis, identification and characterization of novel proteins, Proteomics in plant genetics and breeding.	10

Recommended Textbooks and References:

1. Genes IX- Benjamin, L. Johns and Bartlett Publisher; 2006.
2. Modern Biotechnology (2nd edition)-Primrose, S.B. Blackwell Publishing; 1987.
3. Molecular Cloning: A Laboratory Manual (Vol. I to III)- Sambrook, J. and Russell, D. Cold Spring Harbor Laboratory Press, US; 2000.
4. Principles of Gene Manipulation (6th Ed)- Primrose, S.B.,Twyman, R.M and Old, R.W. Wiley-Blackwell; 2001.

SEMESTER II
PAPER CODE: MBB805L
LAB COURSE-2
CREDITS: 0+0+4

Course Outcome:

CO1: Ability to use computational tools for bioinformatics
CO2: Ability to use genetic engineering tools in research and design experiments
CO3: Comprehend and use immunotechniques in applied research

List of practical

1. Procedure for submission of DNA sequences to public database.
2. Phylogenetic tree construction using MEGA.
3. Homology searching using BLAST.
4. Competent cell preparation and cloning in E coli.
5. Calculation of mean, mode, and median, standard deviation and standard error.
6. Experiment on agglutination and radial immunodiffusion for testing the antigen antibody reaction.
7. Demonstration of Enzyme Linked Immunosorbent Assay (ELISA) technique.
8. SDS-PAGE for protein analysis.

SEMESTER-II
PAPER: SEC-4
PAPER CODE: MBB004S
MOLECULAR TECHNIQUES
CREDITS: 1+0+1

Course Outcome:
CO1: Learn the skills and techniques associated with engineering of biochemical and clinical aspects of clinical biotechnology
CO2: Learn the skills and techniques associated with disease diagnostics and therapeutics relevant to placement in the biotechnology/biomedical industry

THEORY:

Unit	**Immunoassays**	**No. of Lectures**
I	Use of polyclonal or monoclonal antibodies in enzymes immunoassays. Enzyme-linked immunoassay. Immunohistochemical techniques.	4
Unit	**Microbial Diagnostics**	**No. of Lectures**
II	Polymerase Chain reaction, Quantitative polymerase chain reaction. Antibiotic Susceptibility Testing	4
Unit	**Molecular Diagnostics**	**No. of Lectures**
III	Detection of genetic polymorphism, SNP. Application of PCR-RFLP	4
Unit	**Flow Cytometry**	**No. of Lectures**
IV	Basics of Flow Cytometry and cell sorting	4

PRACTICAL:
1. Perform/demonstrate RFLP and its analysis.
2. Demonstration of immunohistochemical techniques.
(N.B.:- Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

Recommended Textbooks and References:
1. Practical Biochemistry, Principles and Techniques- Wilson, K. and Walker, J. Cambridge University Press; 2000.
2. Bioinstrumentation- Webster, J.G. John Wiley & Sons; 2008.
3. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes- Van Impe, J.F., Vanrolleghem, P.A. and Iserentant, D.M. Springer; 1998.
4. Jawetz, Melnick and Adelberg's Medical Microbiology (24th edition)- Brooks, G.F., Carroll, K.C., Butel, J.S. and Morse, S.A. McGraw- Hill Publication; 2007.

SEMESTER III
PAPER CODE: MBB901C
PLANT AND ANIMAL BIOTECHNOLOGY
CREDITS: 3+0+1

Course Outcome:

CO1: Ability to manipulate plants systems using biotechnological tools.
CO2: Ability to manipulate animal systems using biotechnological tools
CO3: Ability to design experiments related to genetic transformation of plants and animals.

THEORY:

Unit	**Plant Cell and Tissue Culture**	**No. of Lectures**
I	Tissue culture media; Callus and suspension culture; Somaclonal variation; Micropropagation; Organogenesis; Somatic embryogenesis; transfer and establishment of whole plants in soil; Embryo culture and embryo rescue; Protoplast fusion and somatic hybridization.	6
Unit	**Vectors and Markers for Plant Transformation**	**No. of Lectures**
II	Agrobacterium mediated gene transfer-Agrobacterium and crawn gall disease, Ti plasmids, Basic features of a plant transformation vector- promoters and terminators, selectable markers, reporter genes, Binary vectors and co-integrative vectors. Role of markers with special emphasis on RFLPs, RAPD markers, STS, EST, microsatellites	10
Unit	**Plant Genetic manipulation**	**No. of Lectures**
III	Genetic manipulation of herbicide resistance; pest resistance; Plant disease resistance- natural disease resistance; Viral resistance; Antisense RNA approaches; strategies for engineering stress tolerance, Phenylalanine and Shikimate pathway, molecular pharming.	8
Unit	**Animal cell and Tissue Culture**	**No. of Lectures**
IV	Laboratory facilities for Animal cell and tissue culture; Substrate for cell culture; Culture Media; 3D culture; Organ culture: Embryo culture and tissue engineering. Primary culture-Isolation of tissue, Tissue disaggregation methods and selection of viable cells, Establishment of cell lines, Immortalization of cell lines and maintenance, Characterization of cell lines; Application of animal cell culture-vaccine production, interferons, recombinant proteins.	8
Unit	***In vitro* fertilization and embryo transfer**:	**No. of Lectures**
V	Media for IVF; Steps in IVF; Different techniques of micromanipulation to assist fertilization; Stem cells; embryonic stem cell and their applications; Ethical issues in animal biotechnology.	6
Unit	**Expression of Recombinant DNA in Animal Cells**	**No. of Lectures**
VI	Cell lines; Gene transfer techniques; Gene construct, selectable markers; transient expression of cloned genes; Virus based vector for gene cloning-Adenovirus, adeno-associated virus, retrovirus, Herpes virus, Vaccinia virus, and Baculovirus; Expression of therapeutic proteins in yeast, Transgenic animals, knockout mice; Gene therapy-Somatic and germline, gene replacement, in vivo and ex vivo gene delivery, gene replacement/augmentation, editing, regulation and silencing	10

Practical

1. Basic plant tissue culture techniques (Demonstration).
2. Basic animal cell culture techniques (Demonstration).

Suggested Readings

1. Slater, A. N. S. and Fowler M. Plant Biotechnology: The genetic manipulation of plants, oxford University Press, Oxford, 2008.
2. Razdan, M.K. Plant Tissue Culture, Oxford and IBH Pub. Co. Pvt. Ltd.
3. Freshney R. Ian, Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6th Ed, Wiley-Blackwell, 2010.
4. Puhler. A, Genetic Engineering of Animals, Vch Publisher, 1993.

SEMESTER III
PAPER CODE: MBB902C
BIOPHYSICS AND INSTRUMENTATION
CREDITS: 3+0+1

Course Outcome:

CO1: Ability to recognize and demonstrate the principles of laboratory instruments
CO2: Understand the working principles of chromatography, Microscopy and spectroscopy-based instruments
CO3: Comprehend and relate to the use and applications of radioactivity

THEORY:

Unit	**Introduction to Biophysics**	**No. of Lectures**
I	Level of molecular organization, Structure of proteins, nucleic acid, protein-protein and protein-nucleic acid interaction; Role of protein and Lipids in biological membrane.	6
Unit	**Chromatography and electrophoretic techniques**	**No. of Lectures**
II	Chromatography Techniques: TLC, Gel Filtration Chromatography, Ion exchange chromatography, Affinity Chromatography, GLC, HPLC, ion exchange chromatography, molecular exclusion chromatography. Electrophoretic techniques: Capillary electrophoresis, Isoelectric Focusing, Pulse field gel electrophoresis.	8
Unit	**Centrifugation**	**No. of Lectures**
III	Basic principles and theory, types of centrifuge: Preparative and Analytical Centrifuges, Density gradient centrifugation and Ultracentrifugation	6
Unit	**Microscopy**	**No. of Lectures**
IV	Introduction to microscopy-light and Dark Interference microscopy-differential and fluorescence interference contrast microscopy, Principle, instrumentation and application of Fluorescence microscopy, Scanning and Transmission Electron microscopy, Atomic force Microscopy, Confocal Microscopy	10
Unit	**Spectroscopy Techniques**	**No. of Lectures**
V	UV, LASER Raman Spectroscopy, MALDI-TOF Mass Spectrometry, Fluorescence Spectroscopy, X Ray spectroscopy, Circular dichroism spectroscopy.	10
Unit	**Radioactivity**	**No. of Lectures**
VI	Radioactive decay, units of radioactivity, Geiger Muller counter, Scintillation counter, Autoradiography, Application of radio isotopes, X-ray crystallography.	8

Practical

1. GC-MS for compound identification.
2. Spectrophotometric analysis of biomolecules.

Suggested Readings

1. Upadhyay. A, Upadhyay. K and Nath. N, Biophysical chemistry. Himalayan Publishing House, Bombay, 1993.
2. Palanivelu. P. Analytical Biochemistry and Separation Techniques. 3rd Ed, 21st Century Publication, Palkalai Nagar, Madurai, 2004.
3. Wilson. K and Walker. J, Principles and techniques of Biochemistry and Molecular Biology. 7th Ed, Cambridge University Press, 2010.

SEMESTER III

PAPER CODE: MBB903C

INDUSTRIAL BIOTECHNOLOGY

CREDITS: 3+0+1

Course Outcome:

CO1: Ability to isolate and grow microorganism which have industrial relevance
CO2: Ability to understand the operation of fermenters for bio-based products
CO3: Comprehend and **design** experiments for bioremediation and waste water treatment

THEORY:

Unit	**Introduction to Industrial Microbiology**	**No. of Lectures**
I	Isolation, screening and preservation of industrially important microorganisms; Development of inoculum for industrial fermentations; aseptic inoculation of the fermenter; Strain improvement and selection	8
Unit	**Media formulation and Bioreactors**	**No. of Lectures**
II	Microbial substrates and Media formulation; Types of Bioreactor: continuous stirred tank flow reactors, loop reactors, air lift reactors, fed batch reactors, fluidized bed reactors, Rotatory Disc reactor.	8
Unit	**Bioprocess technology**	**No. of Lectures**
III	Types of fermentation process: Batch process, continuous process, recycled and non-recycled processes, liquid and solid state fermentations. Bioreactor operation; Sterilization; Aeration and agitation; Sensors; Instrumentation; Concept of control, basic control theory, turbidostatic and chemostatic control.	8
Unit	**Downstream processing**	**No. of Lectures**
IV	Bioseparation - filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultrafiltration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal.	8
Unit	**Industrial Biotechnology I**	**No. of Lectures**
V	Primary metabolites - amino acid; secondary metabolite- antibiotics production, Microbes as source of industrially important enzymes, immobilized enzymes and their applications. Microbial polysaccharides and polyester, microbial insecticides.	8
Unit	**Industrial Biotechnology II**	**No. of Lectures**
VI	Bioremediation , waste water treatment. Single cell protein, Fermented foods and beverages, fermentation as a method of preparing and preserving foods	8

Practical

1. Isolation and screening of industrially important microorganisms from natural environments.
2. Microbial production and downstream processing of an enzyme: *Amylase*.

Suggested Readings

1. Glazer. A.N and Nikaido B. H, Microbial Biotechnology, Fundamentals of Applied Microbiology. 2nd Ed, Cambridge University Press, 2007.
2. Rittmann. B and Perry McCarty, Environmental Biotechnology: Principles and Applications. McGraw Hill, 2000.
3. Casida. L.E, Industrial Microbiology, 1st Edition, Wiley Eastern Limited, 1991.
4. Stanbury. P.F, Whittaker. A and Hall SJ, Principles of Fermentation Technology. 2nd Ed, Pergamon Press, Oxford, 1995.

SEMESTER III
PAPER CODE: MBB904SP1
SPL 1: BIOMEDICAL GENETICS AND PERSONALIZED MEDICINE
CREDITS: 3+1+1

Course Outcome:

CO1: Ability to the basics of Human cytogenetics and Organization of the Human Genome
CO2: Understand the basic concepts of biochemical genetics, Genetic inheritance and Screening
CO3: Comprehend the concepts of personalized medicine/biological therapies and their ethical /economic aspects

THEORY:

Unit	**Human cytogenetics andOrganization of the Human Genome**	**No. of Lectures**
I	Chromosome number and morphology, banding techniques, karyotype, idiogram, sex chromatin, normal variable chromosome features, numerical chromosome abnormalities, structural chromosome rearrangements, Turner females, Klinefelter syndrome, Down's syndrome and Philadelphia chromosome. General features: Gene density, CpG islands, RNA-encoding genes. Gene clusters, Pseudogenes. Types of repetitive DNA: LINES, SINES. Genetic markers and their applications.	15
Unit	**Biochemical genetic**s	**No. of Lectures**
II	Inborn errors in metabolism; galactosemia, glycogen storage disease, peroxisomal disorders, phenylketonuria. Molecular basis of genetic diseases: single gene disorders-cystic fibrosis, Huntington's disease, Duchenne muscular dystrophy & hemophilia. Cancer genetics: oncogenes, viral oncogenes, activation of proto-oncogenes by mutation, activation of proto-oncogenes by insertions, tumor suppressor genes, regulation of gene expression by oncoproteins, signal transduction by oncoproteins, gene-environment interaction, hereditary cancers.	15
Unit	**Genetic inheritance and Screening**	**No. of Lectures**
III	Single gene inheritance**,** multifactorial inheritance, chromosome abnormalities**,** mitochondrial inheritance. Identification of genetic disorders, biochemical markers associated with cystic fibrosis and beta thalassemia, prenatal diagnosis, and preimplantation genetic diagnosis.	10
Unit	**Gene therapy & Molecular epidemiology**	**No. of Lectures**
IV	Concept, Somatic and germline gene therapy, gene therapy in adenine deaminase deficiency, cystic fibrosis and cancer. Concept of genetic	10

	epidemiology, genetic association study, disease susceptibility genes, gene – environment interactions.	
Unit	**Basic aspects of personalized medicine**	**No. of Lectures**
V	Molecular diagnostics in personalized medicine, role of biomarkers in personalized medicine, basic concept of pharmacogenetics, pharmacogenomics, pharmacoproteomics, development of personalized medicine.	7
Unit	**Personalized biological therapies & Ethical /economic aspects**	**No. of Lectures**
VI	Personalized therapy of cancer; personalized management of infectious disease, cardiovascular disorders, pulmonary disorders, genetic disorders, immune disorders. Ethical aspects of personalized medicine; regulatory aspects, economics and future of personalized medicine	7

Practical

1. Collection and processing of biomedical samples with ethical clearance; buccal swab and blood.
2. DNA extraction from human blood and quantification of DNA.
3. Assessment of biochemical parameter using biomarker.

Suggested Readings

1. Jorde. L. B., Carey, J. C., White R. L., Medical Genetics, Mosby Press, 2002.
2. Scriver*et al.*, The metabolic and molecular basis of inherited disease. 8th Ed, McGraw-Hill, 2002
3. Strachan. T and Andrew, P, Human Molecular Genetics. John Wiley-New York, 2001.

SEMESTER III
PAPER: OPE 1
PAPER CODE: MBBB905OE1
ENVIRONMENTAL BIOTECHNOLOGY
CREDITS: 3+1+0

Course Outcome:

CO1: Ability to understand the basic microbiological, molecular and analytical methods used in environmental biotechnology.
CO2: Ability to use the tools of biotechnology in environmental applications
CO3: Understand the use of Biotechnology in management of resources and economic importance of Environmental Biotechnology

Unit	**Introduction to Environmental Biotechnology**	**No. of Lectures**
I	Definition, scope and importance of environmental studies; Concept of ecosystem, structure and function; Ecosystem management; Renewable and non-renewable resources; Conservation of renewable resources.	10
Unit	**Environmental monitoring and sample analysis**	**No. of Lectures**
II	Sampling of air and water pollutants; Monitoring techniques and methodology, pH, Dissolved Oxygen (DO); Chemical oxygen demand (COD); Biological Oxygen Demand (BOD); Speculation of metals, Pesticide residue.	10
Unit	**Bioremediation and environmental management**	**No. of Lectures**
III	Types of bioremediations; Biodegradation of hydrocarbons; green technology; Bio-plastic; Bio-composting; Bio-fertilizers; Phytoremediation; genetically modified organisms in bioremediation; Bioremediation of soil and ground water; Industrial waste water treatment.	15

Unit	Biotechnology, health and society	No. of Lectures
IV	Recombinant therapeutic products in human healthcare; Genetically modified organisms; Gene and Environment; Metagenomics; Remote sensing and GIS in ecological mapping and environmental hazard prediction; Bioindicators and biosensors for food, environmental monitoring and healthcare; Environmental impact assessment (EIA).	15
Unit	**Biotechnology in management of resources**	**No. of Lectures**
V	Need for management of resources; Role of environmental biotechnology in management of resources; Reclamation of wasteland.	7
Unit	**Economic importance of Environmental Biotechnology**	**No. of Lectures**
VI	Biogas and biofuel production; Development of environmentally friendly processes such as integrated waste management. Microorganism in mineral recovery, Microbes and Nutrient cycles.	7

Suggested Readings:

1. Bhattacharyya. B. C and Banerjee. R, Environmental Biotechnology. Oxford University Press., 2007.
2. Abbasi.S. A andRamaswami. E, Biotechnological Methods of Pollution Control,1st Ed. Universities Press,1999.
3. Allsopp. D, Seal. K. J. and Gaylard.CC, Introduction to Biodeterioration .1st Ed, Cambridge Univ.Press, U. K, 2004.
4. Wainwright. M, An Introduction to Environmental Biotechnology. 1st Ed. Kluwer Academic Publishers, Springer, 1999.

SEMESTER IV
PAPER CODE: MBB1001C
PAPER: CORE 12
BIOETHICS, BIOSAFETY AND IPR
CREDITS: 3+1+0

Course Outcome:

CO1: **Ability** to establish the intellectual property rights of any material.
CO2: Ability to assess the risk of products derived from recombinant DNA research.
CO3: **Ability** to compile as per the national and international regulations related to biological, biomedical, health care and biotechnology research

Unit	Bioethics, general concept	No. of Lectures
I	Fundamentals of bioethics; Animal rights, environmental protection, the complex nature of human society, social experimentation and role of ethics, ethical committee's role, biopiracy. Biotechnology in agriculture and environment: ethical aspects of genetic testing, ethical aspects relating to use of genetic information – genetic engineering and biowarfare.	10
Unit	**Bioethics, plants and environment**	**No. of Lectures**
II	GM crops: consumer wellbeing-food safety, allergenicity, antibiotic resistance genes, invasiveness, toxicity to wildlife, development of resistance; modern food system-functional foods-genetic modifications, GM foods- golden rice; Gaia hypothesis, sustainability and ethics.	10
Unit	**Ethical implications of cloning**	**No. of Lectures**

III	Reproductive cloning, therapeutic cloning; ethical, legal and socio-economic aspects of gene therapy, germ line, somatic, embryonic and adult stem cell research-genetically modified crops and genetically modified organisms, transgenic animals.	7
Unit	**Case studies and issues in Bioethics**	**No. of Lectures**
IV	Silicon womb, IVF, cloning humans, designer babies, allotransplantation, stem cell research, sexing the unborn, sex discrimination, monopolizing economy and starvation, biodiversity, clinical trials.	7
Unit	**Biosafety**	**No. of Lectures**
V	Biosafety- definition, requirement, biosafety issues- biosafety for human health and environment, biosafety in relation to transgenic research. Biosafety levels and containment facilities: introduction to biological safety cabinets, primary containment for biohazards, biosafety levels for microorganisms, plants and animals. Biosafety guidelines: Institutional Biosafety committee (IBSC), RCGM, GEAC for GMO applications in food and agriculture; environmental release of GMOs, risk analysis, risk management and communication; overview of national regulations and relevant international agreements including Cartagena protocol.	15
Unit	**Intellectual property rights**	**No. of Lectures**
VI	Introduction to Intellectual Property: types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, international framework for the protection of IP, IP as a factor in R & D; IPs of relevance to biotechnology; introduction to history of GATT, WTO, WIPO and TRIP. Core areas of biotechnology involving IPR: pharmaceuticals, technology in genetic manipulations of cells and organisms, development of crop varieties, transgenic plants and animals, bioremediation, enzymes, vaccines, diagnostic tests.	15

Suggested Readings

1. BT guidelines, Biotech Consortium India Limited, New Delhi.
2. Galston. A. W. and Peppard. C. Z. Expanding horizons in bioethics. Springer, 2005.
3. Casey Chosewood, L and Deborah E. Wilson, Biosaftey in Microibiological and Biomedical Laboratories. 5th edition. U.S. Government Printing Office, 2007.
4. Krishna. V. S. Bioethics and Biosafety in Biotechnology. New Age International Publisher, 2007.

SEMESTER IV
PAPER: SPL 2
PAPER CODE: MBB1002SP1
PLANT FUNCTIONAL GENOMICS
CREDITS: 3+1+1

Course Outcome:

CO1: Ability to understand the fundamentals of functional genomics

CO2: Ability to understand the applications of biological databases, genome mapping and next generation sequencing

CO3: Ability to design experiments based on the applications of RNAi & Genome editing tools

Unit	Structure of plant gene and genome	No. of Lectures
I	Variation of DNA-quantity; chromosome variation; origin of DNA variation-low copy, moderately repetitive, or highly repetitive sequences; polyploidy and its consequences; Methods for determination of genome size; typical organization of a plant gene and its regulatory sequences.	10

Unit	Introduction to functional genomics	No. of Lectures
II	Pre- and post-genomic era; major advancements in genomic approaches; epigenetics and metagenomics; forward versus reverse genetics.	10
Unit	**The basic tool box—Acquiring functional genomic data**	**No. of Lectures**
III	Cloning systems-Plasmid based vectors-ideal characteristics of a plasmid cloning vector, selectable markers; Large-insert vectors-Yeast artificial chromosome (YAC), Bacterial artificial chromosome (BAC), Generation and utilization of BAC libraries; cDNA and genomic DNA libraries, Substractive libraries; different sequencing strategies	10
Unit	**Biological databases**	**No. of Lectures**
IV	Introduction to biological databases; DNA, RNA and Protein databases; gene prediction methods, ORF finding, functional annotation of genome and transcriptome.	10
Unit	**Genome mapping**	**No. of Lectures**
V	Various sequencing approaches for genome, physical and genetic maps; Transcriptome library construction, sequencing and analysis for gene prediction and functional annotation.	14
Unit	**RNAi & Genome editing tools**	**No. of Lectures**
VI	Introduction to RNAi; Mechanism of RNAi; RNA silencing pathways in plants; types of small RNA; RNAi as a tool for gene silencing. Introduction to genome editing; Genome editing tools; Genome editing for crop improvement; The CRISPR/Cas9 System and its Applications in plant breeding.	10

Practical

1. Isolation of high quality gDNA from plant tissue
2. Construction of cDNA library (Demonstration).

Suggested Reading

1. Plant Functional Genomics- Methods and protocol; Edited by J M walker, Humana Press.
2. Bioinformatics and Functional Genomics- Jonathan Pevsner; Wiley Blackwell publisher.
3. Plant Functional Genomics- Methods and Protocols, Edited by J M walker, Humana Press.
4. Plant Genomics and Proteomics- Christopher A. Cullis, A John Wiley & Sons, Inc., Publication

SEMESTER IV
PAPER CODE: MBB1003OE1
PAPER: OPE 2
BIODIVERSITY AND CONSERVATION GENETICS
CREDITS: 3+1+0

Course Outcome:

CO1: Ability to understand the fundamentals of Biodiversity Documentation and Assessment
CO2: Ability to understand the applications population genetics
CO3: Ability to design experiments for genetic management and biodiversity conservation

Unit	Introduction to Biodiversity	No. of Lectures
I	Biodiversity concept; Levels of biological diversity; genetic diversity and need of biodiversity conservation; Ex-situ and In-situ conservation; Biodiversity hot-spots. Genetics in conservation; recognition of genetic factors in conservation biology, Genetic versus demographic and environmental factors in conservation biology.	10

Unit	Biodiversity Documentation and Assessment	No. of Lectures
II	Morphological and molecular characterization of biodiversity; introduction to biodiversity databases; endemism; Red data book; germplasm conservation and biological repository. Data submission and data retrieval; phylogenetic tree.	7
Unit	**Genetics and Extinction**	**No. of Lectures**
III	Genetic and evolutionary consequences of small population size in plants, ecological implications of genetic variation; Genetics and the fate of endangered animal species, relationship between inbreeding and extinction, Relationship between loss of genetic diversity and extinction.	7
Unit	**Population Genetics**	**No. of Lectures**
IV	Hardy-Weinberg equilibrium, Low genetic diversity and threatened species, Genetic drift, Mutation, Natural selection, Migration and gene flow, Bottleneck and Founder effect. Evolution in large populations; Importance of mutation, migration and their interactions with selection in conservation, Selective value of mutations, Migration–selection equilibria and clines. Loss of genetic diversity in small populations; Changes in genetic diversity over time.	15
Unit	**Genetic management for reintroduction**	**No. of Lectures**
V	Conservation strategies for genetic diversity; hybridization in rare plants, off-Site breeding of animals and implications for plant conservation strategies, conservation of rare trees in tropical rain forests, correlations between species traits and allozyme diversity, sampling strategies for genetic variation in *Ex Situ* collections of endangered plant species. Reintroduction, supportive breeding in animals, genetic changes in captivity that affect reintroduction success, genetic adaptation to captivity, reintroduction success; case studies.	10
Unit	**Molecular Genetics tools in Biodiversity conservation**	**No. of Lectures**
VI	Use of molecular genetics to understand species biology; Forensics: detecting illegal hunting and collecting, Gene trees and coalescence, population size and demographic history. Allozymes; Microsatellites; RFLP; RAPD; AFLP; ISSR; SSR; VNTRs; SNPs; Chloroplast DNA; Mt DNA; DNA barcoding; DNA sequencing.	15

Suggested Readings

1. Wilson. E. O, Biodiversity. National Academy Press, Washington, D.C, 1988.
2. Frankham. R, Ballou.J.D and Briscoe.D.A, A primer of Conservation Genetics. Cambridge University Press, 2004.
3. Hamilton. M. B, Population Genetics. 1st Ed, Wiley - Blackwell, 2009.
4. Nei. M and Kumar. S, Molecular Evolution and Phylogenetics. 1st Ed, Oxford University Press, 2000.

SEMESTER-IV
PAPER: DSE-4
PAPER CODE: MBB1004DPW
DISSERTATION
CREDITS: 0+0+6

[Dissertation to be assigned to the students by respective supervisor(s) or teacher(s) in charge]

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