Master of Science (M.Sc. Microbiology)
Course Structure

INVERTIS UNIVERSITY
Invertis Village, Delhi Lucknow Highway
NH-24, Bareilly, Uttar Pradesh Pin - 243
123, India |

M.Sc. Microbiology

Programme outcome of M.Sc Microbiology is to produce competent microbiologist's who can employ and implement their knowledge base in premium processes and applications which will profoundly influence or utilized for existing paradigm of agriculture, industry, healthcare and restoration of degraded environment to provide sustainable competitive edge to present society. Students will exhibit contemporary knowledge in Biotechnology and students will be eligible for doing jobs in various sectors of pharmaceutical and biotechnological industry.

PROGRAMME OUTCOMES:

1. Students will be able design, conduct experiments, analyze and interpret data for investigating problems in Microbiology and allied fields.
2. Students will think creatively about the use of Microbiology to address local and global problems.
3. Higher studies (M.Phil, Ph.D) can be pursued in order to attain research positions. Various examinations such as CSIR-NET, ARS-NET GATE, ICMR, DBT and many other opens channels for promising career in research.
4. Students can become Junior Production Officer and Technical Assistant in Microbiology, pharmaceutical Companies, bio fertilizer industry, aquaculture industries, environmental units, crop production units & food processing industries.
5. Entrepreneurship ventures such as consultancy and training centres can be opened.
6. Some of the major pharmaceutical and drug companies' highering Microbiologists include Dabur, Ranbaxy, Hindustan Lever and Dr Reddy's Labs, food processing industries, chemical industry and textile industry as well. Beside this industries also employ microbiological professionals in their marketing divisions to boostup business in sectors where their products would be required.
7. Beside industrial sector there are ample opportunities in academics as well. Students will be able to understand the potentials, and impact of biotechnological innovations on environment and their implementation for finding sustainable solution to issues pertaining to environment, health sector, agriculture, etc.
8. Several career opportunities are available for students with microbiology background abroad especially in countries like Germany, Australia, Canada, USA and many more where biotechnology is a rapidly developing field.

STUDY AND EVALUATION SCHEME
Master of Science [M.Sc. Microbiology]
(Effective from Session 2021-2022)

YEAR I, SEMESTER I

S.No.	COURSE CODE	COURSE TITLE	COURSE CATEGORY	HOURS			EVALUATION SCHEME		SUBJECT TOTAL	CREDIT
				L	T	P	CA	EE		
1.	MMB 101	Diversity Of Prokaryotic & Eukaryotic Microbes	CC	3	1	0	30	70	100	4
2.	MMB 102	Microbial Physiology & Metabolism	CC	3	1	0	30	70	100	4
3.	MMB 103	Molecular Biology	CC	3	1	0	30	70	100	4
4.	MMB 104	Immunology	CC	3	1	0	30	70	100	4
5.	MMB 105	Computer Applications & Biostatistics	DSE*	3	1	0	30	70	100	4
	MMB 106	Food Biotechnology	DSE*							
6.	MMB 151	Microbial Diversity & Physiology Lab'	AEC	0	0	4	15	35	50	2
7.	MMB 152	Molecular Biology Lab	AEC	0	0	4	15	35	50	2
8.	MMB 153	Immunology Lab	AEC	0	0	4	15	35	50	2
9.	MMB 155	Seminar I	SE	0	0	4	50	0	50	2
TOTAL				**15**	**5**	**16**	**245**	**455**	**700**	**28**

CC-Core Course; **DSE**-Discipline Specific Elective; **AEC**-Ability Enhancement Course; **SE**-Skill Enhancement
L – Lecture; **T –** Tutorial; **P –** Practical; **C –** Credit; **CA**-Continuous Assessment; **EE –** End Semester Exam
DSE*= Elect any one of the prescribed

YEAR I, SEMESTER II

S.No.	COURSE CODE	COURSE TITLE	COURSE CATEGORY	HOURS			EVALUATION SCHEME		SUBJECT TOTAL	CREDIT
				L	T	P	CA	EE		
1.	MMB 201	Enzyme And Techniques In Biochemistry	CC	3	1	0	30	70	100	4
2.	MMB 202	Industrial Microbiology	CC	3	1	0	30	70	100	4
3.	MMB 203	Genetic Engineering	CC	3	1	0	30	70	100	4
4.	MMB 204	IPR & Biosafety	CC	3	1	0	30	70	100	4
5.	MMB 205	Environmental Microbiology	DSE*	3	1	0	30	70	100	4
	MMB 206	Advancements In Applied Microbiology	DSE*							
6.	MMB 251	Enzyme And Techniques & Biochemistry Lab	AEC	0	0	4	15	35	50	2
7.	MMB 252	Industrial & Environmental Microbiology Lab	AEC	0	0	4	15	35	50	2
8.	MMB 253	Genetic Engineering Lab	AEC	0	0	4	15	35	50	2
9.	MMB 255	Seminar II	SE	0	0	4	50	0	50	2
TOTAL				**15**	**5**	**16**	**245**	**455**	**700**	**28**

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L – Lecture; **T –** Tutorial; **P –** Practical; **C –** Credit; **CA**-Continuous Assessment; **EE –** End Semester Exam

DSE*= Elect any one of the prescribed

YEAR II, SEMESTER III

S.No.	COURSE CODE	COURSE TITLE	COURSE CATEGORY	HOURS			EVALUATION SCHEME		SUBJECT TOTAL	CREDIT
				L	T	P	CA	EE		
1.	MMB 301	Fermentation Technology	CC	3	1	0	30	70	100	4
2.	MMB 302	Medical Microbiology	CC	3	1	0	30	70	100	4
3.	MMB 303	Microbial Genetics	CC	3	1	0	30	70	100	4
4.	MMB 304	Bioinformatics	CC	3	1	0	30	70	100	4
5.	MMB 305	Plant Pathogen Interaction	DSE*	3	1	0	30	70	100	4
	MMB 306	Molecular dynamics and bioenergetics	DSE*							
6.	MMB 351	Fermentation Technology Lab	AEC	0	0	4	15	35	50	2
7.	MMB 352	Medical Microbiology Lab	AEC	0	0	4	15	35	50	2
8.	MMB 353	Bioinformatics Lab	AEC	0	0	4	15	35	50	2
9.	MMB 355	Seminar III	SE	0	0	4	50	0	50	2
TOTAL				**15**	**5**	**16**	**245**	**455**	**700**	**28**

CC-Core Course; **DSE**-Discipline Specific Elective; **AEC**-Ability Enhancement Course; **SE**-Skill Enhancement

L – Lecture; **T –** Tutorial; **P –** Practical; **C –** Credit; **CA**-Continuous Assessment; **EE –** End Semester Exam

DSE*= Elect any one of the prescribed

YEAR II, SEMESTER IV

S.No.	COURSE CODE	COURSE TITLE	COURSE CATEGORY	HOURS			EVALUATION SCHEME		SUBJECT TOTAL	CREDIT
				L	T	P	CA	EE		
1.	MMB 451	Project Work	AEC	0	0	28	0	350	350	14

CC-Core Course; **DSE**-Discipline Specific Elective; **AEC**-Ability Enhancement Course; **SE**-Skill Enhancement

L – Lecture; **T –** Tutorial; **P –** Practical; **C –** Credit; **CA**-Continuous Assessment; **EE –** End Semester Exam

DSE*= Elect any one of the prescribed

M.Sc. Microbiology: Semester-I MMB 101: DIVERSITY OF PROKARYOTIC AND EUKARYOTIC MICROBES	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: - Student should have basic knowledge of cell biology, Biochemistry & Molecular Biology.

Course Objective

1. The course aims to demonstrate an understanding of current and relevant knowledge acquired about prokaryotic and eukaryotic cellular processes, interaction of microorganisms in environment.
2. To give an overview of Microbiological systematic.
3. To give basic knowledge of Structure, biosynthesis and function of PHA& PHB.
4. To have an overview of Microorganism: Origin of microbiology, Types of microbes, Classification of microbes.

Course Learning Outcomes

After completing the course, the student shall be able to:

CO1: Understand various applications of Microbial diversity

CO2: Learn Conventional and molecular systematic

CO3: Identify different types of microbes and their overview, classification and importance

CO4: Understand the concept of microbial diversity using different methods and systematics of bacteria and archaea using polyphasic approach.

CO5: To understand cellular organization and significance of prokaryotic (Eubacteria, Archaea, Cyanobacteria) and Eukaryotic (Algae, Fungi and protozoans).

CO6: To understand the biodiversity analysis tools and its biotechnological applications.

Detailed Syllabus

UNIT I : Archaea
Archaea: Systematics, and occurrence, diversity, characteristic features, significance and potential applications (eg. biochips, methane generation, ultrafiltration membranes, production of PHB and PHA, desulphurization of coal and crude oil, bioleaching of metals, enzymes, compatible solutes and others) of different groups of archaebacteria (Crenarchaeota, Euarchaeota, Korarchaeota, Nanoarchaeota).

UNIT II: Bacteria
Bacteria: Conventional and molecular systematics, and general discussion on the occurrence, diversity,characteristic features, significance and potential applications of various groups of bacteria according to Bergey's Manual of Systematic Bacteriology.
UNIT III: Fungal Systematics and diversity:
Fungal Systematics and diversity: Implications of molecular and biochemical methods including rDNA analysis, RFLP, RAPD and other fingerprinting techniques. Fatty acids, polysaccharides and lipids and role of secondary metabolites. **Mycorrhizal fungi:** Diversity of endo and ectomycorrhizal fungi. **Fungal endophytes of tropical plants and their applications:**Endophytes as latent pathogens and biocontrol agents, colonization and adaptation.**Agriculturally important toxigenic fungi:** Biodiversity, Chemical and biological characterization of toxic metabolites, toxigenic fungi in sustainable agriculture, Biopesticides.
UNIT IV: Biodiversity and Biotechnological applications of yeast
Biodiversity of yeast: Gene duplication leading to adaptation and biodiversity, functional evolution, diversity in central metabolism. **Biotechnological applications of yeasts:** Yeasts as producers of bioactive molecules such as pigments, lipids, organic acids and EPS, yeasts as probiotics, yeasts in bioremediation and in alcoholic fermentations.
UNIT V: Algal diversity from morphology to molecules
Algal diversity from morphology to molecules: Importance of algae in production of algal pigments, biofuels, hydrogen production, important bioactive molecules, role of algae in sustainable environment.

Suggested Readings:

1. The Prokaryotes. A handbook on the biology of bacteria: ecophysiology, isolation, identification, applications. Volumes I-IV by Balows, A., Trüper, H. G., Dworkin, M., Harder, W., Schleifer, K. H. Springer-Verlag, New York;1992
2. Microbiology : An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case Benjamin-Cummings Publishing Company ; 2008.
3. Principles of Microbiology by R.M. Atlas , Mosby publishers, St. Louis; 1995
4. The Yeast Handbook: Biodiversity and Ecophysiology of yeasts by Carlos A. Rosa and Gabor Peter. Springer- Verlag Berlin Heidelberg; 2006
5. Algae: Anatomy, Biochemistry and Biotechnology by Laura Barsanti and Paolo Gualtieri. Taylor and Francis Group, LLC; 2006.
6. Fundamentals of the fungi by Elizabeth Moore, Fourth edition, Benjamin Cummings; Landecker; 1996.
7. Algae: Anatomy, Biochemistry and Biotechnology by Laura Barsanti and Paolo Gualtieri. Taylor and Francis Group, LLC; 2006.

M.Sc. Microbiology: Semester-I MMB102: MICROBIAL PHYSIOLOGY AND METABOLISM	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: - Knowledge of basic Biochemistry.

Course Objectives:

1. To give an overview of biomolecules and their significance.
2. To give basic knowledge of properties of water, weak interaction in aqueous systems, ionization of water.
3. To have an overview of Protein: Amino acids, peptieds and polypeptiedes.
4. To explain about the different biosynthetic pathways.
5. To explain the translation and post translational modification of proteins.
6. To explain about the different types of lipids.

Course Learning Outcomes

After completing the course, the student shall be able to:

CO1 : Understand various applications of Biomolecules,their structure and function.
CO2 : Analyze the Gibbs frees energy and enthalpy.
CO3 : Identify different types of biosynthetic pathways of different biomolecules.
CO4 : Understand the concept of lipids and their significance.
CO5 : Knowledge of Electron-Transfer Reactions in Mitochondria. ATP Synthesis, Regulation of Oxidative Phosphorylation.
CO6: Understand various aspects of metabolism of biomolecules.

Detailed Syllabus

UNIT I: Growth and cell division
Growth and cell division: Measurement of growth, growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth.
UNIT II: Solute Transport
Solute Transport: Primary and Secondary transport: Introduction, Kinetics, ABC transporters, Phosphotransferase system, Drug export systems, amino acid transport.
UNIT III: Central Metabolic Pathways and Regulation
Central Metabolic Pathways and Regulation: Glycolysis, PPP, ED pathway, Citric acid cycle: Branched TCA and Reverse TCA, glyoxylate cycle. Utilization of sugars other than glucose and complex polysaccharides
UNIT IV: Nitrogen, Lipid and nucleotides metabolism
Nitrogen metabolism: Metabolism of amino acids: Amino acid biosynthesis and utilisation, lysine and glutamine overproduction, stringent response, polyamine biosynthesis and regulation. **Metabolism of lipids and hydrocarbons:** Lipid composition of microorganisms, biosynthesis and degradation of lipids, lipid accumulation in yeasts, hydrocarbon utilization, PHA synthesis and degradation.**Metabolism of nucleotides:** Purine and pyrimidine biosynthesis, regulation of purine and pyrimidine biosynthesis, inhibitors of nucleotide synthesis.
UNIT V: Physiological Adaptations and Intercellular signaling
Physiological Adaptations and Intercellular signaling: Introduction to two component system, regulatory systems during aerobic- anaerobic shifts: Arc, Fnr, Nar, FhlAregulon, response to phosphate supply: The Pho regulon Quorum sensing: A and C signaling system, sporulation in Bacillus subtilis, control of competence in Bacillus subtilis.Heat-Shock responsespH homeostasis, osmotic homeostasis.

Suggested Readings:

1. Biochemistry by Geoffrey L. Zubay. Fourth Edition, Addison-Wesley educational publishers Inc., 2008
2. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox.Fifth Edition, W.H. Freeman and Company; 2008.
3. Microbial lipids edited by C. Ratledge and SG Wilkinson, second edition, Academic Press; 1988.
4. Microbial Physiology by Albert G. Moat and John W. Foster. Third edition, John Wiley and Sons; 2002
5. The Physiology and Biochemistry of Prokaryotes by David White. Second Edition, Oxford UniversityPress; 2000.

M.Sc. Microbiology: Semester-I MMB 103: MOLECULAR BIOLOGY	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: - Knowledge of basic Biochemistry, Molecular Biology& Cell biology.

Course Objectives:

The objectives of this course are to sensitize the students about the recent advances in molecular biology and various facets of molecular medicine which has the potential to profoundly alter many aspects of modern medicine including the pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

Course Learning Outcomes

After completing the course, students will be able to:

CO1: Students will learn DNA replication, recombination and repair, transcription and translation.

CO2: Students will be aware of the modern tools and techniques of genomics and isolation and identification of genes.

CO3: Understand Genomic organization

CO4: Learn Transposable genetic elements in prokaryotes and eukaryotes

CO5: Learn Transport of proteins and molecular chaperones

CO6: Students will understand the biology and application of antisense technologies and biology of cancer.

Detailed Syllabus:

Unit I *:* Genome organization
Genome organization : Organization of bacterial genome; Structure of eukaryotic chromosomes; Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitiveregions; DNA methylation & Imprinting.

Unit II: DNA Structure; Replication; Repair & Recombination
DNA Structure; Replication; Repair & Recombination Structure of DNA - A-,B-, Z- and triplex DNA; Measurement of properties-Spectrophotometric, CD, AFM and Electron microscope analysis of DNA structure; Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA; Gene stability and DNA repair-enzymes; Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous; Site specific recombination; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination.
Unit III: Prokaryotic & Eukaryotic Transcription
Prokaryotic & Eukaryotic Transcription : Prokaryotic Transcription; Transcription unit; Promoters-Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Anti-termination; Transcriptional regulation-Positive and negative; Operon concept-lac, trp, ara, his, and gal operons; Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional and post-transcriptional gene silencing.
Unit IV: Post Transcriptional Modifications
Post Transcriptional Modifications : Processing of mRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA. **Translation & Transport** Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co- and post-translational modifications; Genetic code in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation .
Unit V: Mutations; Oncogenes and Tumor suppressor genes
Mutations; Oncogenes and Tumor suppressor genes: Nonsense, missense and point mutations; Intragenic and Intergenic suppression; Frame shift mutations; Physical, chemical and biological mutagens; Transposition - Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation; Viral and cellular oncogenes; Tumor suppressor genes from humans; Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins; Activation of oncogenes and dominant negative effect; Suppression of tumor suppressor genes; Oncogenes as transcriptional activators.

Suggested Readings:

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
2.J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th Edition, Benjamin Cummings Publishing Company Inc, 2007.
3. Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002.

M.Sc. Microbiology: Semester-I MMB 104: IMMUNOLOGY	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: - Biochemistry, Molecular Biology.

Course Objectives:

The objectives of this course are to make students learn about the structural features of the components of the immune system as well as their function. The major emphasis of this course will be on the development of the immune system and mechanisms by which our body elicit the immune response. This will be imperative for the students as it will help them to think like an immunologist and predict about the nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Evaluate the usefulness of immunology in different pharmaceutical companies.

CO2: Students will understand the basic concept of innate and acquired immunity.

CO3: Understand Hypersensitivity reactions.

CO4: Students will gain knowledge about immunoglobulin structures and diversity of antibodies, morphology and functions of various immune cells such as dendritic cells, macrophages, neutrophils and their association with MHC molecules will be studied.

CO5: This study will make the students to understand the basic mechanisms of hypersensitivity responses and their associations with different diseases.

CO6: The main goal of the course is to provide basic understanding of immunology and immune responses in response to various infectious and non infectious diseases.

Detailed Syllabus:

UNIT I: Immune Response
Immune response: Innate and adaptive immune system: Inflammation and that Stimulates Immune Responses, Toll-like receptor-component of innate immune system; Antigen presenting cells, Artigens, Heptanes: factor effecting immunogenicity. Adaptive Immunity: Antigenic specificity, Diversity, Immunologic memory, Self / nonself recognition. B lymphocytes and T lymphocytes; Antigenicity and immunogenicity. Immune dysfunction and Its Consequences.
UNIT II: Cells and organs of the immune system
Cells and organs of the immune system: Hematopoiesis and its control, Clonal selection theory. Programmed Cell Death; Lymphoid Cells: lymphocytes and their subsets, natural killer cell, Mononuclear Phagocytes. Antimicrobial and cytotoxic activities. Lymphoid Organs: Primary (thymus, bone marrow) and secondary lymphoid organs (Lymph nodes, spleen).
UNIT III: Antigens and Epitopes
Antigens and epitopes: immunogenicity, antigenicity and haptens; factors affecting immunogenicity. Lipids as antigens. Adjuvants, epitopes, or antigenic determinants, ag recognition by t cells and b cells, properties of b-cell epitopes and t-cell epitopes, blood group antigens. Structure, functions and characteristics of different classes of antibodies, Antigenic Determinants on Immunoglobulins.
UNIT IV: Antigen-Antibody Interactions
Antigen-Antibody Interactions: Strength of Antigen-Antibody Interactions, Cross-Reactivity, Precipitation Reactions, Agglutination Reactions, Radioimmunoassay, Enzyme-Linked Immunosorbent Assay, Western, Blotting, Immunoprecipitation. Production and application of monoclonal antibody: hybridoma technology. Major histocompatibility systems: Structure of MHC I and II molecule, Association of MHC with disease. Recognition of antigens by T and B Cells: Antigen processing, role of MHC molecules in antigen presentation. T-cell receptor complex, B-cell receptor complex.
UNIT V
Compliment system, components, Activation pathway and regulation of activation pathway, complement deficiency, role of complement system in immune responses opsonization (opsonin). Hypersensitivity: Definition, lgE mediated Hypersensitivity, mechanism of mart cell degranulation, mediators of type I reactions and consequences type II reaction, immune complex mediated Hypersensitivity and delayed type Hypersensitivity. Autoimmunity and Cancer.

Suggested Readings:

1. Immunology by Kuby J et al. W. H. Freeman & Company.
2. Immunology, L.M. Roitt, J. Brestoff and D.K. Male, 1996.
3. Immuno-biology, Janeway CA and Paul Travers 1994.
4. Immunological techniques, D.M. Weir, 1992.
5. Current Protocols in Immunology 3 Volumes, Wiley Publications 1994.

M.Sc. Microbiology: Semester-I MMB 105: COMPUTER APPLICATION AND BIOSTATISTICS	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: MMB 101, MMB 151 Biochemistry, MMB 103, MMB 153 Molecular Biology.

Course Objectives:

The objective of this course is to give conceptual exposure of essential contents of mathematics, statistics and basic concepts of computer hardware to students.

Course Learning Outcomes:
After completing the course, students will be able to:

CO1: Gain broad understanding in mathematics and statistics.

CO2: Recognize the importance and value of mathematical and statistical thinking, training and approach to problem solving, on a diverse variety of disciplines.

CO3: Have thorough knowledge of statistical techniques and application of computer in microbiology.

CO4: Understand the practice of statistical methods with specific reference to problems in microbiology.

Detailed syllabus:

Unit-I: Definition of selected terms Scale of measurements Related to statistic
Definition of selected terms Scale of measurements Related to statistic, Methods of collecting data, Presentation of data, statistical Tables, Calculation of basic statistical parameters (mean, median, mode, standard deviation, standard error etc.). Correlation concept and applications; Regression concept and application; Concepts of statistical population and sample need for sampling studies; Simple procedures of random sampling; Methods of sampling, Estimation of sample size for clinical experiments Basic concepts of Probability , Basic theorems of probability addition and multiplication theorems; Conditional probability of Bayes Theorems; Probability distribution definition & applications;

Unit –II: Critical region and level of significance
Critical region and level of significance, Test of a simple hypothesis against simple alternative, composite hypothesis, Neymen Pearson test of hypothesis, UMP test, UMP unbiased test, Likelihood ratio test, Test on the mean of normal population, Difference between the mean of two normal populations, Test on the variance of normal populations, $\chi 2$ test, $\chi 2$ goodness of fit test and test of independence of contingency tables. Test of proportion, Test of correlation and regression coefficient, , Test based on t and f, Multiple comparisons.
Unit-III: Non-parametric tests-Wilcoxon Mann Whitney
Non-parametric tests-Wilcoxon Mann Whitney, Kolmogorov Smirnov tests (two sample tests)Planning of experiments, Basic principles of experimental design, uniformity trails, analysis of variance, one-way, two-way and three-way classification models, completely randomized design (CRD), randomized block design (RBD) latin square design (LSD) and Graeco-latin square designs, Analysis of covariance (ANCOVA), ANCOVA with one concomitant variable in CRD and RBD.
Unit-IV: Introduction to MS Excel
Introduction to MS Excel, creating a data file, data manipulations, simple statistical analysis using Excel, making graphs and charts.MS PowerPoint, different types of statistical software for analysis (introduction) MINITAB, MATLAB, R, SAS.
Unit-V: Introduction of Statistical package (SPSS)
Introduction of Statistical package (SPSS), Data view and variable view, importing a file, Data transformations (compute, recode, count, If,). Sort cases, merging and appending data, Frequencies, descriptive statistics, cross tabulations. Statistical analysis: independent samples‘t’ test, paired ‘t’ test, ANOVA, chi square, Fisher’s exact test, McNemar chi-square test, correlation and regression, Multiple Linear Regression, Principal Component Analysis (PCA). Non-parametric methods: Mann Whitney U test, Wilcoxon Signed rank test, Spearman’s correlation.

Suggested Readings:

1. Principles of Biostatistics- M. Pagano, Cengage Learning Publishers, 2ndEdition, 2008.
2. Kempthorne, O(1966): The Design and Analysis of Experiments, John Wileyand Sons.
3. Introduction to Biostatistics. Glover T. and Mitchell K. (2002). McGraw Hill, New York.
4. Fundamentals of Biostatistics. Rosner Bernard (1999), Duxbury Press.
5. R Cookbook. Paul Teetor (2011), United States of America.

M.Sc. Microbiology: Semester-I MMB 106: Food Biotechnology	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: Basic Knowledge of genetic engineering in food.

Course Objectives: The objective of this course is to give conceptual exposure of fermentation, probiotic and single cell proteins.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Students can understand: Applications of biotechnology in food production.. CO2: Enhancing the quality and quantity of food materials through genetic engineering.

CO3: Understand the rules and regulations in genetic modification in food and plants.

CO4: Students will gain knowledge about safety assessment of food.

CO5: The main goal of the course is to provide basic understanding the student can be able to setup the industry of food materials.

Detailed Syllabus:

Unit-I: Introduction of Food Production
Food production through fermentation-Bread making, cheese production-process, starter culture, types of cheese. Other fermented dairy products-buttermilk, acidophilus milk, yogurt, butter, paneer, kefir, marine fermented foods, koji, tempeh. Fermented bevarages-beer and wine. Enzymes in food processing: amylase, protease,chymosin, lipase, cellulase, hemicellulase, pectinase, pectin lyase, catalase, glycosidase, invertase, glucose oxidase, glucose isomerase.
Unit-II: Single cell protein-from bacteria and algae-spirulina and probiotics
Single cell protein-from bacteria and algae-spirulina, probiotics-significance, role in health, prebiotics, Edible mushrooms, Steps of mushroom production, microbial production of vitamins-riboflavin, vitamin C, lite beer, HFCS(High Fructose corn syrup).Buffalo cloning in India
Unit-III: Transgenic plants
Transgenic plants-Flavr savr tomato; Methionine-enriched oil; Frost-resistant food; -Starlink corn, Btmaize; Fungal Resistant potatoes; Transgenic Fish -Atlantic salmon.Plant Pharmaceuticals, Biopharming -beta -carotene in rice; Edible vaccines -Hepatitis B vaccine in maize-Cholera vaccine in potatoes; Bovine Somatotropin in Milk; Chymosineand mycoproteins. Growth hormone gene in pigs -alpha-lactalbumin and lactoferrin in milk;

Unit-IV: Food preservation
Food preservation:, contamination of milk, Preservation of milk, microbial contamination and spoilage of food, foodborne illness-salmonellosis, listeriosis, botulism, staphylococcal infection, preservation methods: Effect of low temperature, freezing, effect of heat, drying, concentration, fermentation, canning, radiation, chemical preservatives..
Unit-V: Significance of food safety assessments & surveillance.GM food
Significance of food safety assessments & surveillance.GM food: Regulations, Risks, possible danger to individuals, society or nature-Terminator genes and loss of biodiversity.HACCPconcepts and risk assessment. Government regulatory agencies and food policies -Food and Drug Administration, The Centers for Disease Control and Prevention, The Environmental Protection Agency.

Suggested Readings:

1. Biotechnological innovations in foodprocessing: Editor : Dr. J Green, Butterworth-Heinman Pub.
2. Food-Facts and PrinciplesII Ed: N Shakuntala Manay, M. Shadakshara Swamy. New Age International Pub:
3.Bioprocess Technology: P T Kalaichelvan, I Arul Pandy : MJP Publishers.
4. George J.B., "Basic Food Microbiology", CBS Publishers & Distributors, 1987
5.Roger A., Gorden B., and John T., " Food Biotechnology", 1989

M.Sc. Microbiology: Semester-I MMB151: MICROBIAL DIVERSITY AND PHYSIOLOGY LAB	
Teaching Scheme	**Examination Scheme**
Practicals: 4 hr/Week	Internal Assessment -15Marks
Credits: 2	External Assessment - 35Marks

Prerequisite: - MMB 101, MMB151 Biochemistry, MMB103, MMB 153 Molecular Biology.

Course Objectives:

The objectives of this course are to teach students with various approaches to analyze microbial diversity that they can apply to their future career in biological research as well as in biotechnology industries.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Students will become familiar with the tools and techniques of genetic diversity analysis

CO2: This course exposes students to the applications of genetic diversity in biological research.

CO3: Students will be able to perform diversity analysis experiments at the end of course.

CO4: Students will acquire knowledge of advances in biotechnology- healthcare, agriculture and environment cleanup.

Detailed Syllabus:

1. Preparation of media for growth of various microorganisms.
2. Staining and enumeration of microorganisms
3. Determination of thermal death point and thermal death time of microorganisms.
4. Evaluation of bacterial growth in liquid media.
5. Isolation of bacteria from various samples by enrichment techniques and their identification
6. Endospore formation in Bacillus subtilis: Requirements for germination and outgrowth of spores, correlation between sporulation and protease activity.
7. To evaluate antimicrobial chemical agents.
8. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen.
9. Study of physiological parameters of poly hydroxyl alkanoates accumulation in bacteria
10. Assay of antibiotics production and demonstration of antibiotic resistance.
11. Isolation and screening of industrially important microorganisms.

M.Sc. Microbiology: Semester-I MMB152: MOLECULAR BIOLOGY LAB	
Teaching Scheme	**Examination Scheme**
Practicals: 4 hr/Week	Internal Assessment -15Marks
Credits: 2	External Assessment - 35Marks

Prerequisite: MMB101, MMB151 Biochemistry, MMB103, MMB153 Molecular Biology.

Course Objectives:

1. To understand the basic of fermentation, different bioreactor design, different media used for the fermentation of product, overview of product produced by biotechnological industries.
2. To learn the different instrumentation used for the downstream processing of different products.
3. To learn and have complete knowledge of type of enzymes and different fermented food products of different industries.
4. To understand how downstream processing instrumentation works or they can use like crystallization,
5. during, liquid-liquid extraction, centrifugation, chromatography etc.
6. To learn the enzyme kinetics, microbial kinetics, thermal kinetics and the application of these in fermentation.
7. To expertise in the process involved in the effluents or waste of fermentation industries by latest technologies involved in treatment of waste like, Activated sludge process, Rotating Disk Biological Contractor (RBC) etc.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Gain hands-on experience on gene cloning, protein expression and purification.

CO2: This experience would enable them to begin a career in industry that engages in genetic engineering as well as in research laboratories conducting fundamental research.

Detailed Syllabus:

1. Plasmid DNA isolation and DNA quantitation: Plasmid minipreps
2. Restriction digestion
3. Preparation of competent cells.
4. Agarose gel electrophoresis
3. Restriction Enzyme digestion of DNA
4. Purification of DNA from an agarose gel
5. DNA Ligation
6. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency
7. Cloning of genomic DNA in standard plasmid vectors
8. Confirmation of the insert, Miniprep of recombinant plasmid DNA, Restriction mapping
9. Polymerase Chain reaction, using standard 16srRNA eubacterial primers
10. RFLP analysis of the PCR product
11. Transformation of yeast *Saccharomyces cerevisiae.*

M.Sc. Microbiology: Semester-I MMB 153: IMMUNOLOGY LAB	
Teaching Scheme	**Examination Scheme**
Practicals: 4 hr/Week	Internal Assessment -15 Marks
Credits: 2	External Assessment - 35 Marks

Prerequisite: - MMB 101, MMB151 Biochemistry, MMB 103, MMB 153 Molecular Biology.

Course Objectives:

The objectives of this laboratory course are to make students develop an understanding about practical aspects of the components of the immune system as well as their function. Basic as well as advanced methods will be taught to detect different antigen and antibody interactions, isolation of different lymphocyte cells etc. and how they can be used in respective research work.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Evaluate the usefulness of immunology in different pharmaceuticalcompanies.

CO2: Identify proper research lab working in the area of their own interests.

CO3: Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out the kind of immune responses in the setting of infection (viral or bacterial) by looking at cytokine profile.

Detailed Syllabus:

1. Selection of animals, Preparation of antigens, Immunization and methods of bleeding, Serum separation.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum.
6. SDS-PAGE, Immunoblotting, Dot blot assays
7. Blood smear identification of leucocytes by Giemsa stain
8. Separation of leucocytes by dextran method
9. Demonstration of Phagocytosis of latex beads
10. Separation of mononuclear cells by Ficoll-Hypaque
11. Flowcytometry, identification of T cells and their subsets
12. Lymphoproliferation by mitogen / antigen induced
13. Lymphnode Immunohistochemistry (direct and indirect peroxidase assay)
14. Hybridoma technology and monoclonal antibody production.
15. Immunodiagnostics using commercial kits

M.Sc. Microbiology: Semester-I MMB 155: SEMINAR I	
Teaching Scheme	**Examination Scheme**
Lectures: 4 hrs/Week	Internal Assessment -15 Marks
Credits: 2	External Assessment - 35 Marks

Prerequisite: - MMB101, MMB151 Biochemistry, MMB103, MMB153 Molecular Biology.

Course Objectives: The objectives of this course are to train the students to evaluate research papers, to assess quality of the papers and how the papers are refereed and published as well as learn how to get the papers published.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Critically analyse the research papers from different upcoming topics.

CO2: Understand the weaknesses and strengths of the paper and what additional experiments could have been done to strengthen the research study.

CO3: Understand the context of the paper and identify important questions. - Acquire the skills in paper writing and getting it published.

Detailed syllabus:

It's compulsory for all the students to give a seminar on the topic assigned by the Department of Microbiology in the staring of the semester, in the supervision of the assigned supervisor. If the discussion session of seminar / presentation is not found satisfactory then the next date for the said presentation will be given immediately.		
Presentation Time duration	:	30 - 45 minutes
Discussion duration	:	15 - 20 minutes

M.Sc. Microbiology: Semester-II MMB201: ENZYME AND TECHNIQUES IN BIOCHEMISTRY	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: - Biochemistry, Molecular Biology, Microbiology & Industrial Applications.

Course Objectives:

The objective of this course is to make the students familiar with concepts of enzyme, Enzyme kinetics, Inhibition, regulation and specificity.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Basic Enzymology.

CO2: Enzyme kinetics and inhibitions.

CO3: Catalytic mechanisms and regulation.

CO4: Industrial applications of enzymes and extremozymes.

Detailed syllabus:

UNIT I: Enzymology
Enzymology: Introduction, General characteristics of enzymes, Activation energy, Coupled reactions, active site and its importance, Factors influencing catalytic efficiency.**Enzyme kinetics:** Rapid Equilibrium, Henry-Nucgaekkus-Menten's equations,Steady State approach, significance of Km, Haldane equation, Velocity vital Substrate concentration curves.**Methods of plotting enzyme kinetics data:** Lineweaver-Burk, Hanes-Woolf, Woolf-Augustinsson-Hofstee, Eadsie-Scatchard; Advantages and disadvantages of the methods, Comparisons and applications; Integrated form of the Henry-Michaelis-Menten equation.
UNIT II: Equilibrium dialysis & General mechanistic principles
Equilibrium dialysis, Scatchard plot for equilibrium binding, Effect of pH on enzyme stability and activity, Effect of temperature on enzyme stability, Arrhenius equation. Formation of E.S covalent intermediates, transient kinetics, flow techniques (continuous, stopped, quenched), Temp-Jump.**General mechanistic principles:** Role of proximity effect, bound distortion, multistep catalysis, bi-functional catalysis and solvent effects.

UNIT III: Enzyme Inhibition & Regulation of enzyme activity
Enzyme Inhibition: Models and types of inhibition. **Regulation of enzyme activity:** Feedback inhibition, reversible covalent modification, irreversible covalent modification, allosteric concept, Aspartate transcarbamylalse, ligand-protein interaction, scatchard plot, Hill plot, cooperativity index, Models for allostery (MWC, KNF), Half site reactivity.
UNIT IV: Applied enzymology
Applied enzymology: Application of enzymes in analytical labs. (clinical and industrial), enzymes as industrial catalysts, Immobilized enzymes, enzyme electrodes, assay of enzyme activities for diagnostic purposes, abzymes, recent developments.
UNIT V: Biochemical Techniques
Techniques: Protein purification & Chromatography: Gel filtration, ion-exchange, hydrophobic interaction chromatography, hydroxyapatite and affinity chromatography, FPLC HPLC. Molecular spectroscopy, IR, ESR, FRET.

Suggested Readings:

1. Enzyme Kinetics and Mechanism by P. F. Cook, W.W. Cleland. Garland Science Publishing, London, England and New York, USA, 2007.
2. Biocatalysts and Enzyme Technology by K. Buchholz, V. Kasche, U.T. Bornscheuer., Wiley-VCH, Weinheim, Germany, 2005.
3. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer Horwood Publishing House, Chichester, England, 2001.
4. Biochemical Calculations by Irwin Segel., John Wiley and Sons, California, USA, 2004.
5. Biocatalysis – Fundamentals and Applications by A.S. Bommarius, B.R. Riebel, Wiley-VCH, Weinheim, Germany, 2004.

M.Sc. Microbiology: Semester-II MMB202: INDUSTRIAL MICROBIOLOGY	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: - Biochemistry, Molecular Biology, Genetic Engineering.

Course Objectives:

The objectives of this course are to introduce the students to the field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes and host-microbe interactions.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1:Identify the major categories of microorganisms and analyze their classification, diversity, and ubiquity.

CO2:Identify and demonstrate the structural, physiological, and genetic similarities and differences of the major categories of microorganisms.

CO3: Identify and demonstrate how to control microbial growth. - Demonstrate and evaluate the interactions between microbes, hosts and environment.

Detailed syllabus:

Unit I: Microbial Diversity & Systematics
Microbial Diversity & Systematics 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; Molecular methods such as Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE), Amplified rDNA Restriction Analysis and Terminal Restriction Fragment Length Polymorphism (T-RFLP) in assessing microbial diversity; 16S rDNA sequencing and Ribosomal Database Project.
Unit II: Microbial Growth & Physiology
Microbial Growth & Physiology Ultrastructure of Archaea (Methanococcus); Eubacteria (*E.coli*); Unicellular Eukaryotes (Yeast) and viruses (Bacterial, Plant, Animal and Tumor viruses); Microbial growth: Batch, fed-batch, continuous kinetics, synchronous growth, yield constants, methods of growth estimation, stringent response, death of a bacterial cell. Microbial physiology: Physiological adoption and life style of Prokaryotes; Unicellular Eukaryotes and the Extremophiles (with example from each group)

Unit III: Microbial Interactions and Infection
Microbial Interactions and Infection Host–Pathogen interactions; Microbes infecting humans, veterinary animals and plants; Pathogenicity islands and their role in bacterial virulence
Unit IV: Microbes and Environment **Microbes and Environment *:*** Role of microorganisms in natural system and artificial system; Influence of
Microbes on the Earth's Environment and Inhabitants; Ecological impacts of microbes; Symbiosis (Nitrogen fixation and ruminant symbiosis); Microbes and Nutrient cycles; Microbial communication system; Quorum sensing; Microbial fuel cells; Prebiotics and Probiotics; Vaccines.
Unit V: Industrial Applications
Industrial Applications Basic principles in bioprocess technology; Media Formulation; Sterilization; Thermal death kinetics; Batch and continuous sterilization systems; Primary and secondary metabolites; Extracellular enzymes; Biotechnologically important intracellular products; exopolymers; Bioprocess control and monitoring variables such as temperature, agitation, pressure, pH Microbial processes-production, optimization, screening, strain improvement, factors affecting downstream processing and recovery; Representative examples of ethanol, organic acids, antibiotics etc. Enzyme Technology-production, recovery, stability and formulation of bacterial and fungal enzymes-amylase, protease, penicillin acylase, glucose isomerase; Immobilised Enzyme and Cell based biotransformationssteroids, antibiotics, alkaloids, enzyme/cell electrodes.

Suggested Readings:

1. Pelczar MJ Jr., Chan ECS and Kreig NR., Microbiology, 5th Edition, Tata McGraw Hill, 1993.
2. Maloy SR, Cronan JE Jr., and Freifelder D, Microbial Genetics, Jones Bartlett Publishers, Sudbury, Massachusetts, 2006.
3. Crueger and A Crueger, (English Ed., TDW Brock); Biotechnology: A textbook of Industrial Microbiology, Sinaeur Associates, 1990.
4. G Reed, Prescott and Dunn's, Industrial Microbiology, 4th Edition, CBS Publishers, 1987.
5. M.T. Madigan and J.M. Martinko, Biology of Microorganisms, 11th Edition, Pearson Prentice Hall, USA, 2006.

M.Sc. Microbiology: Semester-II MMB203: GENETIC ENGINEERING	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: - Biochemistry, Molecular Biology.

Course Objectives:

The objectives of this course are to teach students with various approaches to conducting genetic engineering that they can apply to their future career in biological research as well as in biotechnology industries. Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course. This technology has revolutionized the way modern biological research is done and has impacted mankind with a number of biological products and processes.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Students will become familiar with the tools and techniques of genetic engineering- DNA manipulation enzymes, genome and transcriptome analysis and manipulation tools, gene expression regulation, production and characterization of recombinant proteins.

CO2: This course exposes students to the applications of genetic engineering in biologicalresearch.

CO3: Students will be able to perform basic genetic engineering experiments at the end of course.

CO4: Students will acquire knowledge of advances in biotechnology- healthcare, agriculture and environment cleanup via recombinant DNA technology.

Detailed syllabus:

Unit I: Basics Concepts
Basics Concepts DNA Structure and properties; Restriction Enzymes; DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase; Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions- Electromobility shift assay; DNaseI footprinting; Methyl interference assay.

Unit II: Cloning Vectors
Cloning Vectors Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; vaccinia/bacculo & retroviral vectors; Expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to reduce formation of inclusion bodies; Baculovirus and pichia vectors system, Plant based vectors, Ti and Ri as vectors, Yeast vectors, Shuttle vectors
Unit III: Cloning Methodologies
Cloning Methodologies Insertion of Foreign DNA into Host Cells; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Expression cloning; Jumping and hopping libraries; Southwestern and Far-western cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression
Unit IV: PCR and Its Applications
PCR and Its Applications Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; Tvectors; Proof reading enzymes; PCR in gene recombination; Deletion; addition; Overlap extension; and SOEing; Site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection; PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test)
Unit V: Sequencing methods
Sequencing methods; Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing; Chemical Synthesis of oligonucleotides; Introduction of DNA into mammalian cells; Transfection techniques; Gene silencing techniques; Introduction to siRNA; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing; Gene knockouts and Gene Therapy; Creation of knock out mice; Disease model; Somatic and germ-line therapy- *in vivo* and *ex-vivo*; Suicide gene therapy; Gene replacement; Gene targeting; Transgenics; cDNA and intragenic arrays; Differential gene expression and protein array.

Suggested Readings:

1. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
3. Brown TA, Genomes, 3rd ed. Garland Science 2006
4. Selected papers from scientific journals.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc

M.Sc. Microbiology: Semester-II MMB204: IPR & BIOSAFETY	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: Biochemistry, Molecular Biology, Microbiology & Industrial Applications, Genetic Engineering.

Course Objectives:

To give a background on the history of science, emphasizing the methodologies used to do research - To use the framework of these methodologies for understanding effective lab practices and scientific communication - To use the framework of these methodologies to understand and appreciate scientific ethics.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Students will gain knowledge about the basics of the four primary forms of intellectual property rights, the right of ownership, scope of protection as well as the ways to create and to extract value from IP.

CO2: Students will able to compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.

CO3: Students will gain knowledge to analyze the effects of intellectual property rights on society as a whole.

CO4: This course will provide complete package to the students to identify activities and constitute IP infringements and the remedies available to the IP owner and describe the precautious steps to be taken to prevent infringement of proprietary rights in products and technology development**.**

Detailed Syllabus:

Unit I: Introduction to Intellectual Property
Introduction to Intellectual Property Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS

Unit II: Concept of 'prior art'
Concept of 'prior art' Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation
Unit III: Basics of Patents
Basics of Patents Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application
Unit IV: Patent filing and Infringement
Patent filing and Infringement Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US Patenting by research students, lecturers and scientists-University/organizational rules in India and abroad, credit sharing by workers, financial incentives Patent infringement- meaning, scope, litigation, case studies and examples
Unit V: Biosafety
Biosafety Introduction; Historical Backround; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

Important Links for reference:

http://www.w3.org/IPR/
http://www.wipo.int/portal/index.html.en
http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html www.patentoffice.nic.in
www.iprlawindia.org/ - 31k - Cached - Similar page
http://www.cbd.int/biosafety/background.shtml
http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm
http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html

Suggested Readings:

1. The law and strategy of Biotechnological patents by Sibley. Butterworth publications.
2. Intellecutla property rights – Ganguli – Tata McGrawhill
3. Intellectual property right – Wattal – Oxford Publishing House.

M.Sc. Microbiology: Semester-II MMB205: ENVIRONMENTAL MICROBIOLOGY	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: - Microbial Biodiversity, Biochemistry, Microbiology & Industrial Applications.

Course Objectives:

1. To understand the basics of environmental microbiology.

2. To learn the Culture-dependent and culture-independent approaches for understanding microbial diversity in the environment

3. To learn and have complete knowledge of biodegradation.

4. To understand how global warming problem could be solved.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Understand microbiology of environment.

CO2: Analyze the effect of various fermentation and downstream processes involved in the synthesis of products.

CO3: Understand the Microbial diversity in extreme environments

CO4: Understand the process of wastewater treatment and solid waste management.

CO5: Lignin degradation by Lignocellulolytic microorganisms.

CO6: Understand the process of bioleaching & global warming.

Detailed syllabus:

UNIT I: Brief history and development of environmental microbiology
Brief history and development of environmental microbiology: History and development of microbial ecology highlighting significant contributions of microbiologists and emergence of environmental microbiology, and significant applications of microbes in solving environmental pollution problems.

UNIT II: Culture-dependent and culture-independent approaches for understanding microbial diversity in the environment
Culture-dependent and culture-independent approaches for understanding microbial diversity in the environment:by DNA heterogeneity by reannealing denatured environmental DNA, ARDRA, analysis of FAME profiles, measuring metabolic capabilities using BIOLOG microtitre plates, using DNA probes and PCR primers, G+C analysis, slot-blot hybridization of community DNA, and fluorescent in situ hybridization of intact cells.
UNIT III: Microbial diversity in normal environments
Microbial diversity in normal environments: Diversity of microbes in terrestrial (agricultural and desert soils), aquatic (fresh water and marine), atmospheric (stratosphere) and animal (cattle, termites, pests such as cockroach and nematodes, and human being) and their potential applications ***Microbial diversity in extreme environments:*** Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, barophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles
UNIT IV: Liquid waste management
Liquid waste management*:* Treatment of sewage (Primary, Secondary and Tertiary treatments) and Treatment of Industrial effluents (distillery, textile, pulp and paper).**Solid waste management:** Waste types & their possible usages, landfill development and composting.
UNIT V: Lignin degradation
Lignin degradation: Lignocellulolytic microorganisms, enzymes and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles (iv) biofules, (v) animal feed production. Microbes and mineral recovery: ***Bioleaching***: of metals like copper, gold and uranium. **Bioremediation of environmental pollutants:** Petroleum hydrocarbons and pesticides. **Global warming:**its causes, effectsand remedial measures.

Suggested Readings:

1. Microbial Ecology By Atlas R.M., Bartha R., Benjamin Cummings Publishing Co, Redwood City, CA., 1993.
2. Environmental Microbiology by A.H. Varnam& M.G. Evans, Manson Publishing Ltd., 2000.
3. Manual of Environmental Microbiology by Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, ASM Press, 2007.
4. Environmental Microbiology by W.D. Grant & P.E. Long, Kluwer Academic Publishers, 1981.
5. Environmental Microbiology by R. Mitchel (2nd edition), Wiley-Blackwell, 2009.

M.Sc. Microbiology: Semester-II MMB206: ADVANCEMENTS IN APPLIED BIOTECHNOLOGY	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: Basic Knowledge of Biotechnology and Its applications.

Course Objectives: The objectives of this course are to provide knowledge about advancement of applied Biotechnology.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: The student will be aware the application of biotechnology in different field such as health, medicine and conservation of biodiversity.

CO2: The student will able to understand advance knowledge in different field of biotechnology.

Detailed Syllabus:

Unit I: Genetically modified organisms
Genetically modified organisms: Genetically modified microbes, crop plant and animals with example and applications. Genetically modified commercial products: Insulin, Golden rice, BT Cotton, BT Brinjal, Mustard, Status of genetically modified crops, commercialization and regulation in India
Unit II: Stem cells
Stem cells: Definition, properties, classification, culture of stem cells, hematopoietic and non hematopoietic stem cells, applications of stem cells, organogenesis and organ transplant, legal and ethical issues of stem cells. Importance of Biotechnology, Concept of Recombinant DNA technology and Gene Cloning. Microbial Biotechnology: A brief account of microbes in industry and agriculture, Metabolic engineering for over production of metabolites.
Unit III: Nano- biotechnology
Nano-biotechnology: Introduction, definition, nano-fluids, application in medicine, agriculture, Biotechnology in medicine, vaccine, Gene therapy, drug delivery and tissue engineering.
Unit IV: Biotechnology in bioremediation
Biotechnology in bioremediation, restoration of degraded land and conservation of ex situ and in situ biodiversity, improvement of soil fertility by microbes, application of selected and engineered microbes for heavy metal removal, development of abiotic stress plant (salinity, temperature and aluminum toxicity).

Suggested Readings:

1. The Cell - A molecular Approach, Geoffrey M. Cooper and Robert E. Hausman, ASM Press
2. Molecular Biology and Biotechnology, 4th Edn, J.M Walker and R. Rapley, Panima Books
3. Cell Biology, David. E. Sadava, Panima Books, Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour Laboratory Press
4. Environmental Microbiology, 2nd Edition, Ian L .Pepper and Charles P. Gerba, Elsevier Pub.
5. Environmental Biotechnology – Concepts and Application, Hans – Joachim Jordening and Jesefwinter – Wiley – VCH

M.Sc. Microbiology: Semester-II MMB251: ENZYME TECHNOLOGY AND BIOCHEMISTRY LAB	
Teaching Scheme	**Examination Scheme**
Practicals: 4 hr/Week	Internal Assessment -15Marks
Credits: 2	External Assessment - 35Marks

Prerequisite: Enzyme Technology, Biochemistry, Molecular Biology.

Course Objectives:

1. To understand the basics of Enzyme functioning.
2. To learn the enzyme kinetics.
3. To learn and have complete knowledge of enzyme inhibition.
4. To understand how enzyme and substrate reaction occurs.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Isolate enzymes from various sources.

CO2: Determine the Km and Vmax of the enzymatic reactions.

CO3: Perform ELISA & Blotting techniques.

CO4: Purify and preserve enzymes.

Detailed syllabus:

1. Preparation of buffers for protein isolation.
2. Study of mitosis by microscopic technique.
3. Quantitative estimation of proteins by spectrophotometer.
4. Spectrophotometric estimation carbohydrate.
5. Determination of molecular weight of protein sample by SDS-PAGE.
6. Characterization of protein samples by coomasiebrilliant blue and silver staining
7. Analysis of affinity difference by paper chromatography.
8. Dot blot and Western blotting techniques – demonstration
9. Hormone estimation by ELISA.

M.Sc. Microbiology: Semester-II MMB252: INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY LAB	
Teaching Scheme	**Examination Scheme**
Practicals: 4 hr/Week	Internal Assessment -15Marks
Credits: 2	External Assessment - 35Marks

Prerequisite: Microbiology.

Course Objectives:

The objective of this laboratory course is to provide the students practical skills on basic microbiological techniques.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Ability to isolate, characterize and identify common bacterial organisms.

CO2: Determine bacterial load of different samples.

CO3: Perform antimicrobial sensitivity test.

CO4: Preserve bacterial cultures.

Detailed Syllabus:

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Identification and culturing of various microorganisms.
3. To study antimicrobial susceptibility testing using an octadisc.
4. To determine minimal inhibitory concentration (MIC) of an antibiotic using an E-test.
5. To perform sterility testing of a sample.
6. To isolate fungi present in soil samples and calculate their relative abundance and frequency of occurrence.
7. To determine BOD and COD of water samples from different sources.

M.Sc. Microbiology: Semester-II MMB253: GENETIC ENGINEERING LAB	
Teaching Scheme	**Examination Scheme**
Practicals: 4 hr/Week	Internal Assesssment -15Marks
Credits: 2	External Assessment - 35Marks

Prerequisite: Molecular Biology & Genetic Engineering.

Course Objectives:

The objectives of this course are to provide students with the experimental knowledge of molecular biology & genetic engineering.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Students should be able to gain hands on experience on gene cloning, protein expression and purification.

CO2: This experience would enable them to begin a career in industry that engages in genetic engineering as well as in research laboratories conducting fundamental research.

Detailed syllabus:

1. Isolation of genomic DNA from *Bacillus subtilis** genome.
2. PCR amplification of *scoC* gene and analysis by agarose gel electrophoresis
3. Preparation of plasmid, pET-28a from *E.coli* and gel analysis.
4. Restriction digestion of vector (gel analysis) and insert with NcoI and XhoI
5. a. Vector and Insert ligation
   b. Transformation in *E.coli* DH5.
6. Plasmid isolation and confirming recombinant by PCR and RE digestion.
7. Transformation of recombinant plasmid in *E.coli* BL21 (DE3) strain.
8. Induction of ScoC protein with IPTG and analysis on SDS-PAGE
9. Purification of protein on Ni-NTA column and analysis of purification by SDS-PAGE
10. a. Random Primer labeling of scoC with Dig-11-dUTP
    b. Southern hybridization of *B. subtilis* genome with probe and non-radioactive detection.

- *Any other bacterial strain can be used.

M.Sc. Microbiology: Semester-II MMB 255: SEMINAR II	
Teaching Scheme	**Examination Scheme**
Lectures: 2 hrs/Week	Internal Assessment -15 Marks
Credits: 2	External Assessment - 35 Marks

Course Objectives:

The objectives of this course are to train the students to evaluate research papers, to assess quality of the papers and how the papers are refereed and published as well as learn how to get the papers published.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Critically analyse the research papers from different upcoming topics.

CO2: Understand the weaknesses and strengths of the paper and what additional experiments could have been done to strengthen the research study.

CO3: Understand the context of the paper and identify important questions.

CO4: Acquire the skills in paper writing and getting it published.

Detailed Syllabus:

It's compulsory for all the students to give a seminar on the topic assigned by the Department of Microbiology in the staring of the semester, in the supervision of the assigned supervisor. If the discussion session of seminar / presentation is not found satisfactory then the next date for the said presentation will be given immediately.		
Presentation Time duration	:	30 - 45 minutes
Discussion duration	:	15 - 20 minutes

M.Sc. Microbiology: Semester-III MMB 301: FERMENTATION TECHNOLOGY	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: - Knowledge of basic Biochemistry, Industrial Microbiology, Enzymology.

Course Objectives:

1. To understand Fermentation technology.
2. To understand microbial growth kinetics.
3. To develop insights about bioreactor processes.
4. To understand media preparation and sterilization.

Course Learning Outcomes

After completing the course, students will be able to:

CO1: Students will be able design, conduct experiments, analyze and interpret data for investigating problems in Microbiology and allied fields.

CO2: Higher studies (M.Phil, Ph.D) can be pursued in order to attain research positions. Various examinations such as CSIR-NET, ARS-NET GATE, ICMR, DBT and many other opens channels for promising career in research.

CO3: Students can become Junior Production Officer and Technical Assistant in biotechnology, pharmaceutical Companies, bio fertilizer industry, aquaculture industries, environmental units, crop production units & food processing industries.

Detailed Syllabus:

Unit I: An introduction to fermentation processes
An introduction to fermentation processes- Range of fermentation process, microbial biomass, Microbial metabolites, Microbial growth kinetics- Batch culture, continuous culture, comparison of batch and continuous culture in industrial applications, fed-batch culture, variable and fixed volume fed batch culture,

Unit II: Isolation, preservation and improvement of industrially important microorganisms
Isolation, preservation and improvement of industrially important microorganisms, Screening methods, Isolation methods, enrichment liquid culture, enriched culture, Industrial fermentationtypical media, media formulation, water, energy and carbon sources, nitrogen sources, minerals, vitamin sources, nutrient recycle, buffers, precursors and metabolic regulators, oxygen requirement.
Unit III: Sterilization Methods
Media sterilization, sterilization of fermenter, sterilization of the feed. Inocula for industrial fermentation- development of inocula for yeast, bacteria, fungi and actinomycetes, the inoculation of fermenters, the use of spore inoculums, inoculation from a laboratory and plant fermenter .
Unit IV: Downstream processing
Downstream processing: Bioseparation - filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal, anaerobic and aerobic treatment of effluents.
Unit V: Bioreactor
Bioreactor: Types of reactor: Batch culture bioreactor, plug flow reactor (PFR), continuous stirred tank reactor (CSTR), Fixed and Fluidized bed, bubble column, air lift fermenter. Design of fermenter, basic functions, construction, aeration and agitation, oxygen requirements of industrial fermentation, Instrumentation and control of process parameters, Scale up and scale down process.

Suggested Readings:

1. Principles of Fermentation Technology by Stanbury, P.F., Whitekar A. and Hall. 1995., Pergaman, McNeul and Harvey.
2. Biochemical Reactors by Atkinson B., Pion, Ltd. London.
3. Fermentation Biotechnology: Industrial Perspectives by Chand.
4. Biotechnology- A textbook of Industrial Microbiology by Creuger and Creuger, Sinaeur Associates.
5. Bioprocess Engineering Kinetics, Mass Transport, Reactors, and Gene expressions by Veith, W.F., John Wiley and Sons.
6. Bioprocess Engineering Principles by Doran, Acad. Press, London.
7. Fermentation, Biocatalysis and bioseparation, Encyclopedia of Bioprocess Technology by Chisti, Y., Vol. 5, John Wiley and Sons, N, Y.

M.Sc. Microbiology: Semester-III MMB 302: MEDICAL MICROBIOLOGY	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: - Knowledge of basic and Industrial Microbiology.

Course Objectives:

1. To understand basic of Medical microbiology.
2. To understand koch's postulate and pathogenesis.
3. To develop insights about systematic microbiology.
4. To understand diseases caused by microbes and their pathophysiology with respect to different organisms.

Course Learning Outcomes

After completing the course, students will be able to:

CO1: Students will be able design, conduct experiments, analyze and interpret data for investigating problems in Microbiology and allied fields.

CO2: Higher studies (M.Phil, Ph.D) can be pursued in order to attain research positions. Various examinations such as CSIR-NET, ARS-NET GATE, ICMR, DBT and many other opens channels for promising career in research.

CO3: Students can become Junior Production Officer and Technical Assistant in biotechnology, pharmaceutical Companies, bio fertilizer industry, aquaculture industries, environmental units, crop production units & food processing industries**.**

Unit I: General topics on Medical Microbiology
General topics on Medical Microbiology: History and development, Koch's postulates, classification of medically important bacteria. Infection: source, modes of transmission, portal of entry into the susceptible host and prevention.
Unit II: Bacterial pathogenicity, identification of bacteria
Bacterial pathogenicity, identification of bacteria: staining methods, culture methods, biochemical tests and other recent methods. Sterilization and disinfection. Normal microbial flora, antimicrobial agents, drug resistance and drug sensitivity test.

Unit III: Systematic Microbiology
Systematic Microbiology: Diseases caused by Gram positive cocci - sore throat, pneumonia etc., Diseases caused by Gram negative cocci - meningitis, gonorrhoea etc. Diseases caused by Gram positive bacilli - Tuberculosis, Diphtheria, Tetanus, Gas gangrene etc., Diseases caused by Gram negative bacilli of Entrobacteriaceae - Enteric fever, Bacillary dysentery, UTI etc.
Unit IV: Diseases caused by other Gram negative bacilli
Diseases caused by other Gram negative bacilli - Cholera, Plague, Whooping cough, Wound infection, Septicemia etc. Sexually Transmitted Diseases. Diseases caused by mycoplasma, Chlamydia, Rickettsia. Overview of Medical Mycology, Important Fungal Diseases – Superficial, Subcutaneous, Systemic and Opportunistic Mycosis.
Unit V: Overview of Medical Parasitology
Overview of Medical Parasitology, Important Protozoan Diseases- Malaria, Leishmaniasis, Amoebiasis, Giardiasis etc. Important Helmenthic Diseases- Ascariasis, Ankylostomiasis, Filariasis, Taeniasis, Echinococcosis, Schistosomiasis etc. Overview of Medical Virology, Important Viral Diseases– Herpesvirus, Poliovirus, Rabies virus, Arboviruses Hepatites, HIV etc. Opportunistic Microbial Infection, Water, Milk and Food borne diseases, Microbial Vaccine.

Suggested Readings:

1. Greenwood D (2007). Medical Microbiology. I.K. International.
2. Murray PR, Pfaller MA, Tenover FC and Yolken RH (2007). Clinical Microbiology. ASM Press.
3. Talaro KP and Talaro A. (2006). Foundations in Microbiology. McGraw-Hill College Dimensi.
4. Willey J, Sherwood L. and Woolverton C (2007). Prescott/Harley/Klein's Microbiology, McGraw Hill.
5. Atlas RM (1997). Principles of Microbiology. McGraw Hill.
6. Nester E.W, Anderson DG and Nester MT (2006). Microbiology. A Human Perspective. McGraw Hill.
7. Harvey, R.A., Champe, P.C. and Fisher, B.D. 2007. Lippincott's Illustrated Reviews : Microbiology. Lippincott Williams and Wilkins, New Delhi/New York.

M.Sc. Microbiology: Semester-III MMB 303: MICROBIAL GENETICS	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: Basic concepts of genetics, microbiology and genomics

Course Objectives:

1. To give an overviewof basic principles of genetics, inheritance and the hypothesis testing to study heredity.
2. To give overview of genes and the allelic variations.
3. To describe the inheritance pattern of genes to chromosomes and the genetic disorders.
4. To explain the chromosome mapping techniques and the genetic distance.
5. To explain the allelic frequency and concepts of population genetics and genetic drift.
6. To explain the effects of inbreeding and the genetic analysis of inbreeding and measuring the genetic relationships.

Course Learning Outcomes

After completing the course, students will be able to:

CO1: Understand the concepts of genetics and the role of inheritance and the genetic variations. CO2: Analyze the effect of crosses and the principles in heredity.

CO3: Identify the allelic variation and the gene functions such as of multiple alleles. CO4: Understand normal and abnormal combustion gene and gene functions.

CO5: Evaluate the linkages and the chromosomes mapping and evaluations.

CO6: Understand the population genetics, genetic influences and the mutation drift.

Detailed Syllabus:

Unit- I: Bacterial mutants and mutations
Bacterial mutants and mutations Isolation; Useful phenotypes (auxotrophic, conditional, lethal, resistant);Mutation rate; Types of mutations(base pair changes; frameshift; insertions; deletions; tandem duplication); Reversion vs. suppression; Mutagenic agents; Mechanisms of mutagenesis; Assay of mutagenic agents (Ames

test) Gene transfer in bacteria History; Transduction – generalized and specialized; Conjugation – F, F', Hfr; F transfer; Hfr

Unit-II: Bacteriophages and Plasmids
Bacteriophages and Plasmids Bacteriophage–structure; Assay; Lambda phage – genetic map, lysogenic and lytic cycles; Gene regulation; Filamentous phages such as M13; Plasmids – natural plasmids; their properties and phenotypes; Plasmid biology - copy number and its control; Incompatibility; Plasmid survival strategies; Antibiotic resistance markers on plasmids (mechanism of action and resistance); Genetic analysis using phage and plasmid **Restriction-modification systems** History; Types of systems and their characteristics; Methylation-dependent restriction systems; applications.
Unit-III: Mendelian Genetics
Mendelian Genetics Introduction to human genetics; Background and history; Types of genetic diseases; Role of genetics in medicine; Human pedigrees; Patterns of single gene inheritance-autosomal recessive; Autosomal dominant; X linked inheritance; Complicating factors - incomplete penetrance; variable expression; Multiple alleles; Co dominance; Sex influenced expression; Hemoglobinopathies - Genetic disorders of hemoglobin and their diseases. **Non Mendelian inheritance patterns** Mitochondrial inheritance; Genomic imprinting; Lyon hypothesis; isodisomy; Complex inheritance-genetic. Heritability; Twin studies; Behavioral traits; Analysis of quantitative and qualitative traits
Unit-IV: Cytogenetics
Cytogenetics Cell division and errors in cell division; Non disjunction; Structural and numerical chromosomal abnormalities – deletion; duplication; translocation; Sex determination; Role of Y chromosome; Genetic recombination; Disorders of sex chromosomes and autosomes; Molecular cytogenetics – Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH). **Developmental genetics** Genes in early development; Maternal effect genes; Pattern formation genes; Homeotic genes; Signaling and adhesion molecules. **Immunogenetics** Major histocompatibility complex; Immunoglobulin genes - tissue antigen and organ transplantation; Single gene disorders of immune system.
Unit-V: Genetic variation
Genetic variation Mutations; kinds of mutation; agents of mutation; genome polymorphism; uses of polymorphism. **Gene mapping and human genome project** Physical mapping; linkage and association **Population genetics and evolution** Phenotype; Genotype; Gene frequency; Hardy Weinberg law; Factors distinguishing Hardy Weinberg equilibrium; Mutation selection; Migration; Gene flow; Genetic drift; Human genetic diversity; Origin of major human groups.

Suggested Readings:

1. S.R. Maloy, J.E. Cronan, D. Friefelder, Microbial Genetics, 2nd Edition, Jones and Bartlett Publishers, 1994.
2. N. Trun and J. Trempy, Fundamental Bacterial Genetics, Blackwell publishing, 2004.
3. Strachan T and Read A P, Human molecular genetics, 3rd Edition Wiley Bios, 2006.
4. Mange E J and Mange A. P., Human genetics, 2nd Edition, Sinauer Associates publications, 1999.

M.Sc. Microbiology: Semester-III MMB304: BIOINFORMATICS	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: Computer fundamentals, Computer Applications & Biostatistics, Concepts on biomolecules and function, Molecular Biology, MMB103, MMB105.

Course Objectives:

1. To give an overview on computing methods and the bioinformatics tools commonly used for analyzing the sequencing data.
2. To provide basics knowledge on unix and the fundamentals in networking.
3. To describe the importance of phylogenetic analysis and the mathematical models as a prerequisite to calculate the evolutionary linkages.
4. To explain the computing models and concepts to understand the computational techniques
5. To explain the annotation to the study proteins, protein coding genes and DNA and genomes.
6. To understand the structure prediction methods for the proteins and nucleic acids.

Course Learning Outcomes

After completing the course, students will be able to:

CO1: Understand the importance of bioinformatics and the computational techniques.

CO2: Analyze the sequencing data generated and available in the databases and to interpret these results.

CO3: Identify the important mathematical models and techniques for biological data analysis.

CO4: Understand importance of techniques for structure and function prediction of proteins and genes.

CO5: Understand the nucleic acid and protein structure prediction tools.

CO6: Understand the genome annotation methods and some of the techniques.

Detailed Syllabus:

Unit-1: Introduction to computers and bioinformatics
Introduction to computers and bioinformatics- Types of operating systems, concepts of networking and remote login, basic fundamentals of working with unix/Linux. Biological databases- Introduction to NCBI, NCBI data bases, BLAST, BLASTn, BLASTp, PSI-BLAST, modes of database search, mode of data storage (Flat file format, db-tables), flatfile formats of GenBank, EMBL, DDBJ, PDB. Sequence alignment –Concept of local and global sequence alignment, Pairwise sequence alignment, Structure alignment, STAMP: structural alignment of multiple proteinsscoring an alignment, substitution matrices, multiple sequence alignment.. Principle of Protein structure and conformational space, pfam (Protein family prediction).

Unit-II: Phylogenetic analysis
Phylogenetic analysis- Basic concepts of phylogenetic analysis, rooted/uprooted trees, approaches for phylogenetic tree construction (UPGMA, Neighbor joining, Maximum parsimony, Maximum likelihood). Cluster analysis; Phylogenetic clustering by simple matching coefficients; Sequence Comparison; Sequence pattern; Regular expression based pattern; Theory of profiles and their use in sequence analysis; Hidden Markov models; Concept of HMMS; Baum-Welch algorithm; Use of profile HMM for protein family classification; Pattern recognition methods.
Unit-III: Methods for modeling
Methods for modeling: Homology modeling; Loop modeling, Comparative modeling, Threading, Refinement of model,Protein structure prediction; Structure comparison of macromolecules with reference to proteins; Force fields; Molecular energy minimization; Monte Carlo and molecular dynamics simulation, Protein Modeling, Molecular Simulations_basic information.
Unit-IV: Generation and analysis of high throughput sequence data
Generation and analysis of high throughput sequence data- Assembly pipeline for clustering of HTGS data, format of ".ace" file, quality assessment of genomic assemblies, International norms for sequence data quality, Clustering of EST sequences, concept of Unigene. Annotation procedures for high through-put sequence data- Identification of various genomic elements (protein coding genes, repeat elements, strategies for annotation of whole genome, functional annotation of EST clusters, gene ontology (GO) consortium.
Unit-V: Structure predictions for nucleic acids and proteins
Structure predictions for nucleic acids and proteins- Approaches for the prediction of RNA secondary and tertiary predictions, energy minimization and base covariance models, Basic approaches for protein structure predictions, comparative modeling, fold recognition/threading and ab-initio prediction. Drug Designing- Molecular Docking, Virtual Screening, ADMET analysis, click chemistry.

Suggested Readings:

1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins by Baxevanis A.D. and Ouellette, Third Edition. John Wiley and Son Inc., 2005.
2. Bioinformatics Sequence and Genome Analysis by Mount D.W., CSHL Press, 2004.
3. Introduction to Bioinformatics by Tramontano A., Chapman & Hall/CRC, 2007.
4. Understanding Bioinformatics by Zvelebil, M. and Baum, Chapman & Hall/CRC, 2008.

M.Sc. Microbiology: Semester-III MMB305: Plant Pathogen Interaction	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: MMB101, MMB-302**,** Basic concepts of microbiology, plant and the functional role of microorganism, plant pathology.

Course Objectives:

1. To give an overview on disease, disease triad and the plant physiology and microbial interaction with plants.
2. To give overview of pathogen infecting the plants, interaction and infection and progression.
3. To describe the biochemical basis of plant disease and the pathogen infecting various plant.
4. To explain the genetic basis of plant disease, disease resistance or susceptibility concept and genes and mechanisms in disease controls.
5. To explain approaches for plant protection and the disease forecasting.

Course Learning Outcomes

After completing the course, students will be able to:

CO1: Understand plant and microorganism interaction and pathogenesis.

CO2: Understand the current agriculture practices and factors and basis for the diseases.

CO3: Understand the genetic basis of disease, its progression and the basis to control.

CO4: Identify the techniques that are useful to control some the common diseases in plants.

CO5: Identifying the plant biocontrol and the strains or microorganisms for effective and plant growth promotion and the chemical and physical control methods.

CO6: Understand the disease forecasting methods and its relevance in Indian farming.

Detailed Syllabus:

Unit-I: Concepts and physiology of plant diseases
Concepts and physiology of plant diseases: What is a disease, its causes, pathogenesis in relation to environment, effect of microbial infections on plant physiology, photosynthesis, respiration, transpiration, translocation.
Unit-II: Biochemical basis of plant diseases
Biochemical basis of plant diseases: Enzymes and toxins in plant diseases, phytoalexins. **Some important plant diseases and their etiological studies:** Crown gall, symptoms of viral diseases and their control, diseases of some important cereals, vegetables and crops.

Unit-III: Genetically basis of plant diseases and molecular approach
Genetically basis of plant diseases and molecular approach: Genetics of host-pathogen interactions, resistance mechanism and resistance genes in plants. Molecular diagnosis, its futuristic vision, applications and constraints. Transgenic approach for plant protection.
Unit-IV: Disease control
Disease control: Principles of plant disease control, physical and chemical methods of disease control, biocontrol, biocontrol agents - concepts and practices, fungal agents, Trichoderma as biocontrol agent, biocontrol agents – uses and practical constraints.
Unit-V: Disease forecasting
Disease forecasting: History and important milestones in disease control, disease forecasting and its relevance in Indian farming.

Suggested Readings:

1. Plant pathology by George N. Agrios: 4th ed., Academic press, New York, 1969.
2. Bacterial plant pathology, cell and molecular aspects by David C. Sigee, Cambridge University Press,1993.
3. Bacterial plant pathology, cell and molecular aspects by David C. Sigee, Cambridge University Press,1993.
4. Molecular plant pathology by M. Dickinson: BIOS Scientific Publishers, London, 2003.
5.The essentials of Viruses, Vectors and Plant diseases by A.N. Basu & B.K. Giri: Wiley Eastern Limited,1993.
6.Biocontrol of Plant Diseases (Vol. I) by K.G. Mukerji & K.L. Garg: CRC Press, Inc., Boca Raton,Florida,1988.

M.Sc. Microbiology: Semester-III MMB306: MOLECULAR DYNAMICS & BIOENERGETICS	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/Week	Class Test -12 Marks
Tutorials: 1 hr/Week	Teachers Assessment – 6 Marks
Credits: 4	Attendance – 12 Marks
	End Semester Exam – 70 marks

Prerequisite: MMB101 Biochemistry.

Course Objectives:

1. To understand the basic and molecular level of the biochemistry.
2. To learn concept of enthalpy entropy and Gibbs free energy.
3. To explore the basic knowledge of amino acid and its biosynthetic pathways.
4. To understand the knowledge of high energy energy molecules such as ATP, GTP, NADP and FAD.

Course Outcomes:

After completing the course, students will be able to:

CO1: This course will familiarize the students with the major thermodynamic principles in biology and basic metabolic pathways of the living systems.

CO2: This course will helpful for beginner learners in biochemistry.

CO3: Students are coming from various fields at this initial semester, they all must be made introduced to the basic concepts of metabolism and bioenergetics.

CO4: This course of metabolism and bioenergentic studies will cover maximum part of bioenergetics.

Detailed Syllabus:

Unit-I: Carbohydrates
Carbohydrates –Glycolysis, citric acid cycle, its function in energy production and biosynthesis of energy richbond, pentose phosphate pathway.Gluconeogenesis, glycogenesis and glycogenolysis, glyoxylate and Gamma aminobutyrate shunt pathways, Coricycle, anaplerotic reactions, Entner-Doudoroff pathway, glucuronate pathway.Metabolism of disaccharides.Hormonal regulation of carbohydrate metabolism.Energetics of metabolic cycle.

Unit-II: Amino Acids

Amino Acids –General reactions of amino acid metabolism -Transamination, decarboxylation, oxidative andnon-oxidative deamination of amino acids. Special metabolism of methionine, histidine, phenylalanine, tyrosine,tryptophan, lysine, valine, leucine, isoleucine and polyamines.Urea cycle and its regulation.

Intermediary Metabolism –Approaches for studying metabolism

Coenzymes and Cofactors –Role and mechanism of action of NAD+/NADP+, FAD, lipoic acid, thiaminepyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 coenzymes and metal ions with examples.

Unit-III: Bioenergetics

Bioenergetics –Concept of free energy, standard free energy, determination of ΔG for a reaction. Relationshipbetween equilibrium constant and standard free energy change, biological standard state & standard free energychange in coupled reactions. Biological oxidation-reduction reactions, redox potentials, relation betweenstandard reduction potentials and free energy change (derivations and numericals included). High energyphosphate compounds –introduction, phosphate group transfer, freeenergy of hydrolysis of ATP and sugarphosphates alongwith reasons for high ΔG. Energy charge.

M.Sc. Microbiology: Semester-III

MMB351:FERMENTATION TECHNOLOGY LAB

Teaching Scheme	Examination Scheme
Practicals: 4 hr/Week	Internal Assessment -15 Marks
Credits: 2	External Assessment - 35 Marks

Prerequisite: MMB101, MMB-302, Basic concepts of microbiology and functional role of microorganism, plant pathology**.**

Course Objectives:

The objectives of this laboratory course are to make students develop an understanding about practical aspects of fermentation technology lab.

Course Learning Outcomes

After completing the course, students will be able to:

CO1: Students will be able design, conduct experiments, analyze and interpret data for investigating problems in Microbiology and allied fields.

CO2: Higher studies (M.Phil, Ph.D) can be pursued in order to attain research positions. Various examinations such as CSIR-NET, ARS-NET GATE, ICMR, DBT and many other opens channels for promising career in research.

CO3: Students can become Junior Production Officer and Technical Assistant in biotechnology, pharmaceutical Companies, bio fertilizer industry, aquaculture industries, environmental units, crop production units & food processing industries.

Detailed Syllabus:

1. Determination of oxygen transfer rate and volumetric oxygen mass transfer coefficient (KLa) under variety of operating conditions in shake flask and bioreactor.
2. Determination of mixing time and fluid flow behaviour in bioreactor under variety of operating conditions.
3. Rheology of microbial cultures and biopolymers and determination of various rheological constants.
4. Production of microbial products in bioreactors.
5. Studying the kinetics of enzymatic reaction by microorganisms.
6. Production and purification of various enzymes from microbes.
7. Comparative studies of Ethanol production using different substrates.
8. Microbial production and downstream processing of an enzyme, e.g. amylase.
9. Various immobilization techniques of cells/enzymes, use of alginate for cell immobilization.

M.Sc. Microbiology: Semester-III MMB352: MEDICAL MICROBIOLOGY LAB	
Teaching Scheme	**Examination Scheme**
Practicals: 4 hr/Week	Internal Assessment -15 Marks
Credits: 2	External Assessment – 35 Marks

Prerequisite: MMB101, MMB202 MMB302, Basic concepts of microbiology and functional role of microorganism pathology**.**

Course Objectives: The objectives of this laboratory course are to make students develop an understanding about practical aspects of microbiology lab.

Course Learning outcomes:

After completing the course, students will be able to:

CO1: Students will be able design, conduct experiments, analyze and interpret data for investigating problems in Microbiology and allied fields.

CO2: Higher studies (M.Phil, Ph.D) can be pursued in order to attain research positions. Various examinations such as CSIR-NET, ARS-NET GATE, ICMR, DBT and many other opens channels for promising career in research.

CO3: Students can become Junior Production Officer and Technical Assistant in biotechnology, pharmaceutical Companies, bio fertilizer industry, aquaculture industries, environmental units, crop production units & food processing industries.

Detailed Syllabus:

1. To study cultural characteristics of pathogenic bacteria on following selective / differential media: TCBS agar; Hektoen Enteric agar; XLD agar; Endo agar; *Salmonella-Shigella* agar; Deoxycholate citrate agar
2. Isolation of soil-borne pathogens from plant tissue and soil.
3. Molecular methods for detection and identification of pathogens in plants and soil. By monoclonal antibody based tests and PCR.
4. Quantification of population of pathogens in soil and estimation of inoculum potential by MPN and Dilution End Point methods.
5. To study cultural and microscopic characteristics of selected pathogenic fungi viz. *Microsporum* sp.*Candida albicans*, and *Aspergillus* sp.

M.Sc. Microbiology: Semester-III MMB353: BIOINFORMATICS LAB	
Teaching Scheme	**Examination Scheme**
Practicals: 4 hr/Week	Internal Assessment -15 Marks
Credits: 2	External Assessment – 35 Marks

Prerequisite: Computer fundamentals, Computer Applications & Biostatistics, Concepts on biomolecules and function, Molecular Biology, MMB103, MMB105, MMB 304.

Course Objectives: The objectives of this laboratory course are to make students develop an understanding about practical aspects of bioinformatics lab.

Course Learning Outcomes:

After completing the course, students will be able to:

CO1: Students will be able design, conduct experiments, analyze and interpret data for investigating problems in Microbiology and allied fields.

CO2: Higher studies (M.Phil, Ph.D) can be pursued in order to attain research positions. Various examinations such as CSIR-NET, ARS-NET GATE, ICMR, DBT and many other opens channels for promising career in research.

CO3: Students can become Junior Production Officer and Technical Assistant in biotechnology, pharmaceutical Companies, bio fertilizer industry, aquaculture industries, environmental units, crop production units & food processing industries.

Detailed Syllabus:

1. Construction of database for specific class of proteins / enzymes, genes/ORF/EST/Promoter sequences/ DNA motifs or protein motifs using oracle.
2. Access and use of different online protein and gene alignment softwares
3. Gene finding related search for a given nucleotide sequence in order to predict the gene
4. ORF prediction for different proteins out of some given nucleotide sequences.
5. Exon identification using available softwares for a given nucleotide sequences.
6. Secondary structure prediction for amino acid sequences of a given protein.

M.Sc. Microbiology: Semester-III MMB 355: SEMINAR III	
Teaching Scheme	**Examination Scheme**
Practicals: 4 hr/Week	Internal Assessment -15 Marks
Credits: 2	External Assessment – 35 Marks

Prerequisite: - MMB101 Biochemistry, MMB103 Molecular Biology, MMB202 Microbiology & Industrial Applications, MMB203 Genetic Engineering, MMB301 Bioprocess Engineering etc.

Course Objectives:

1. To understand and learn the concepts of any topic.
2. To learn how to present a scientific topic in front of examiner.
3. To understand basic principle of the technique.
4. To learn and explain the application of the methods.
5. To enhance the computational skills.
6. To get to know the various technical objective and conclusion of topic.

Course Learning outcomes:

After completing the course, students will be able to:

CO1: Will enhance his communication and computational skills.

CO2: Will leads to enhance the confidence and personal aptitude.

CO3: Analyze the procedure and instrumentation required for proving his hypothesis.

CO4: Will teach him to boldly accept the outcomes and conclusion of topic.

CO5: Will teach him how to represent a data.

CO6: Will learn to present research data.

Detailed Syllabus:

It's compulsory for all the students to give a seminar on the topic assigned by the Department of Microbiology in the staring of the semester, in the supervision of the assigned supervisor. If the discussion session of seminar / presentation is not found satisfactory then the next date for the said presentation will be given immediately.		
Presentation Time duration	:	30 - 45 minutes
Discussion duration	:	15 - 20 minutes

MMB 451: PROJECT WORK		
Teaching Scheme	**Examination Scheme**	
Tenure: 12 to 16Week/	Dissertation	200
	Presentation and Viva Voce	150
Credits: 28	**Maximum Marks**	**300**

Every student will be required to undertake a research project (minimum tenure three months) based on any of the areas of virology, proteomics, genomics, animal, plant, medical microbiology, and bioinformatics or preferably related to major biotechnology/microbiology research. The project report will be submitted in the form of dissertation duly certified by the supervisor of the dissertation by any research organization, industry, national institutes and/or Universities in India, by seeking the placement. The student then shall have to appear for the viva voce examination.

GUIDELINES FOR DISSERTATIONS REPORT LAYOUT:
The report should contain the following components:

Title or Cover Page: The title page should contain the following information: Project Title; Student's Name; Course; Year; Supervisor's Name.

Acknowledgements (optional): Acknowledgment to any advisory or financial assistance receive in the course of work may be given.

Abstract: It should be straight to the point; not too descriptive but fully informative. First paragraph should state what was accomplished with regard to objectives. The abstract have to be concise summary of the scope and results of the project.

Table of Contents: Titles and subtitles are to correspond exactly with those in the text.

Introduction: A brief introduction to the problem that is central to the project and it should aim to catch the imagination of the reader, so excessive details should be avoided.

Materials and Methods: This section should aim at experimental designs, materials used. Methodology should be mentioned in details including modifications if any.

Results and Discussion: Present results, discuss and compare these with those from other workers, etc. In writing these section, emphasis should be given on what has been performed and achieved in the course of the work, rather than discuss in detail what is readily available in text books. Avoid abrupt changes in contents from section to section and maintain a lucid flow throughout the thesis. An opening and closing paragraph in every chapter could be included to aid in smooth flow.

Note during writing, all figures & tables should as far as possible be next to the associated text, in same orientation as main text, numbered, & given appropriate titles.

Conclusion: This is the final section in which outcome of the work is mentioned briefly.

Future prospects (if applicable)

References / Bibliography: This should include papers and books referred to in the body of the report. These should be ordered alphabetically on the author's surname.

Appendices: This contains material which is of interest to reader but not an integral part of the thesis and may be useful to document for future reference.

Assessment of the Project File:
Essentially, marking will be based on the following criteria: the quality of the report, the technical merit of the project and the project execution. Technical merit attempts to assess the quality and depth of the intellectual efforts put into the project.