Rev: 04

SYLLABUS

For

2 YEARS MSC BIOTECHNOLOGY PROGRAMME

(Revised Syllabus Approved by Academic Council)

Dept. of

Applied Biology

JUNE, 2019

UNIVERSITY OF SCIENCE &TECHNOLOGY, MEGHALAYA

Techno City, 9th Mile, Baridua, Ri-Bhoi, Meghalaya, 793101

SEMESTER WISE DISTRIBUTION OF COURSE

Course Code: MBT **School Code: SOBS**

SEMESTER-I

Course Code	Title	Credit	Nature of the Course	Marks Allotted		
				Internal	End Semester	Total
MBT 101	Cell and Developmental Biology **(CC-1)**	**4**	**T**	**30**	**70**	**100**
MBT 102	Biochemistry **(CC-2)**	**4**	**T**	**30**	**70**	**100**
MBT 103	Microbiology **(CC-3)**	**4**	**T**	**30**	**70**	**100**
MBT 104	Bioinstrumentation **(SEC-1)**	**4**	**T**	**30**	**70**	**100**
MBT 105	Practical on Cell Biology, Biochemistry & Microbiology **(CC-4)**	**4**	**P**	**30**	**70**	**100**
	Total	**20**	**-**	**150**	**350**	**500**

SEMESTER-II

Course Code	Title	Credit	Nature of the Course	Marks Allotted		
				Internal	End Semester	Total
MBT 201	Molecular Biology **(CC-5)**	**4**	**T**	**30**	**70**	**100**
MBT 202	Immunology **(CC-6)**	**4**	**T**	**30**	**70**	**100**
MBT 203	Genetics **(CC-7)**	**4**	**T**	**30**	**70**	**100**
MBT 204	Biostatistics, Bioethics and IPR **(SEC-2)**	**4**	**T**	**30**	**70**	**100**
MBT 205	Practical on Molecular Biology **(CC-8)**	**4**	**P**	**30**	**70**	**100**
	Total	**20**	**-**	**150**	**350**	**500**

SEMESTER-III

Course Code	Title	Credit	Nature of the Course	Marks Allotted		
				Internal	End Semester	Total
MBT 301	Genetic Engineering **(CC-9)**	**4**	**T**	**30**	**70**	**100**
MBT 302	Plant and Animal Biotechnology **(CC-10)**	**4**	**T**	**30**	**70**	**100**
MBT 303	Omics and Bioinformatics **(DSE-1)**	**4**	**T**	**30**	**70**	**100**
MBT 304	Food and Industrial Biotechnology **(CC-11)**	**4**	**T**	**30**	**70**	**100**
MBT 305	Practical on Genetic Engineering, Plant, Food and Industrial Biotechnology (**CC-12)**	**4**	**P**	**30**	**70**	**100**
MBT 306	Pharmacology **(MDC-1)**	**4**	**T**	**30**	**70**	**100**
	Total	**20**	**-**	**150**	**350**	**500**

SEMESTER-IV

Course Code	Title	Credit	Nature of the Course	Marks Allotted		
				Internal	End Semester	Total
MBT 401	Environmental Biotechnology **(CC-13)**	**4**	**T**	**30**	**70**	**100**
MBT 402	Research Methodology **(DSE-2)**	**4**	**T**	**30**	**70**	**100**
MBT 403	Practical on Environmental Biotechnology **(CC-14)**	**4**	**P**	**30**	**70**	**100**
MBT 404	Dissertation Work and Lab. Visit Report **(CC-15)**	**8**	**P**	**60**	**140**	**200**
HVP-740	Human Values and Professional Ethics	**NCM***	**T**			
	Total	**20**	**-**	**150**	**350**	**500**

*NCM: Non Credit Mandatory
CC: Core Courses;
MDC: Multidisciplinary Course:
SEC: Skill Enhancement Courses;
DSE: Discipline Specific Elective

CORE COURSES

1. Cell and Developmental Biology
2. Biochemistry
3. Microbiology
4. Molecular Biology
5. Immunology
6. Genetics
7. Genetic Engineering
8. Plant and Animal Biotechnology
9. Food and Industrial Biotechnology
10. Environmental Biotechnology

MULTIDISCIPLINARY COURSE (any one in semesters-III; to be opted by other Department under the School)

1. Pharmacology
2. Food Processing and Preservation Technique

SKILL ENHANCEMENT COURSES (any one per semester in semesters 3-4)

1. Bioinstrumentation
2. Biostatistics, Bioethics and IPR
3. Industrial Fermentations

DISCIPLINE SPECIFIC ELECTIVES (Any paper per semester in semesters 3-4)

1.Omics Bioinformatics
2. Research Methodology
3. Intellectual Property Rights
4. Evolutionary Biology

Programme Specific Outcomes (PSOs) of M. Sc. BIOTECHNOLOGY

PSO1. The objective of the Master's Programme in Biotechnology is to equip the students to apply knowledge of living organisms and their cellular processes, classification and interaction among themselves, with physical and chemical agents and higher order organisms.

PSO2. The laboratory training in addition to theory is included to prepare them for careers in the industry, agriculture, and applied research where biological system is increasingly employed.

PSO3. Basics and current molecular updates in the areas of Industrial Biotechnology, Fermentation Technology, Agriculture and Environmental Biotechnology are included to train the students and also sensitize them to scope for research.

PSO4. The Masters in Biotechnology Programme will address the increasing need for skilled scientific manpower with an understanding of research ethics involving living organisms to contribute to application, advancement and impartment of knowledge in the field of Biotechnology.

PO5. The study of Master of Biotechnology will impart in-depth understanding of basic aspects of Biotechnology pertaining to industrial applications that will make the students ready to contribute to:

- better awareness of the major issues at the forefront of the discipline.
- will possess an in-depth understanding of the area of Biotechnology chosen for research emphasis.
- Awareness of ethical issues in Medical, clinical and animal research and careers options.

develop inclination towards own professional goals over a wide range of carrier options expanding from R & D, industrial or Govt. Sector or as an Entrepreneur.

SEMESTER-I

MBT 101 Cell and Developmental Biology Theory Credit: 4

After successful completion, this course enables students

CO1. To get the historical basis and concept of cell and developmental Biology.

CO2. To understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
It also gives an idea how these cellular components are used to generate and utilize energy in cells.

CO3. To find answer to the question "how continuity of life is maintained from one generation to another?"

CO4. To explore the biomedical research involving tissue engineering that aims to grow and replace tissue *in-vitro* using stem cell technology.

CO5. To understand the mechanism of plant development/improvement using breeding processes that contribute to the efforts of achieving sustainable food security in times of over population.

Course Content **No. of Classes**

Unit – I: **25**

1. Ultra structure of prokaryotic and eukaryotic cells; Cell organelles structure and functions; ATP synthase and generation of ATP; Chloroplast DNA and its significance.
2. Cell communication, Cell – ECM junction, adhesion molecules; Transport of ions; Mechanism and stages of secretory pathways; Cell cycle (Yeast), regulation of cell cycle.
3. Cell signaling – Cellular response to environmental signals in plants and animals; Mechanism of signal transduction.

Unit –II: **15**

1. Organization and role of microtubules and microfilaments; Cell shape and motility.
2. Action-binding proteins and their significance; Muscle organization and function; Molecular motors; Intermediate filaments; Extra cellular matrix in plants and animals.

Unit –III: **25**

1. Potency of embryonic cells, Commitment, Specification (Autonomous and Conditional), Determination and Differentiation, Morphogenetic gradients, Cell fate, cell lineages and development control genes in *Caenorhabditis*
2. Cellular movements and Pattern Formation – Differentiation of germ layers; Cellular polarity; Maternal gene effect; Homeotic gene effect in Drosophila; Embryogenesis and early pattern formation in plants, phase change in salmonella, mating cell types in yeast, Heterocyst

Unit –IV **25**

1. Metamorphosis of Amphibians and Insects; Hormonal control of metamorphosis, regeneration-different types of regeneration; Histological processes during regeneration; Polarity andmetaplasia in regeneration; Lens regeneration in amphibian.
2. Organization of shoot and root apical meristem, pollen germination and pollen tube
guidance, phloem differentiation, Self incompatibility and its genetic control, embryo andendosperm development, heterosis and apomixes.
3. Infertility, *In vitro* fertilization and embryo transfer, Stem cell differentiation, fibroblasts and itsdifferentiation. Stem cell and its applications. Ethical Issues in Stem cells.

SUGGESTED READINGS:

1. Bruce Alberts *et al* .Molecular Biology of cell, Garland Publications
2. Daniel, Molecular Cell Biology, Sceintific American Books.
3. Jack D. Bruke, Cell Biology, The William Twilkins Company.

4. Old and Primrose, Principles of Gene Manipulations, Black Well Scientific Publications.
5. Sharp, Mc Graw Fundamentals of Cytology, Hill Company
6. Wilson and Marrision, Cytology, Reinform Publications
7. Smith Molecular Biology, Faber and Faber Publications
8. EDPRoberties and EMF Roberties , Cell Biology and Molecular Biology, Sauder College.
9. E.J.Gardener, M.J.Simmons and D.P.Snustad, Principles of Genetics, John Wiley and Sons Publications.

MBT 102 **Biochemistry** **Theory** **Credit: 4**

After successful completion, this course enables students

CO1. To understand the actual chemical concepts of biology through the functioning of various body processes and physiology using bio-molecules.

CO2. To understand the chemical basis of cellular life as well as the internal chemistry of biological systems of animals and plants.

CO3. The study of biochemistry helps one to understand the actual chemical concepts of biology. That is the functioning of various body processes and physiology by uses of bio-molecules.

CO4. To understand the concept of enzymes, its kinetics and importance in metabolism and other physiological reactions inside the cell.

CO5. To understand the underlying concept of physiological processes occuring in plants and animals and their regulations. It also deals with the regulation and synthesis of plant and animals and animal hormones.

Course Content	No. of Classes
Unit 1: Basics of Biochemistry	**15**
1. Ionization of water, Concept of pH and pK. Buffer solutions, action of buffers.Henderson-Hasselback equation. Preparation of weak acids and bases. 2. Bioenergetics: Concept of energy, First and Second Law of thermodynamics. Free Energy Change, relation between standard free energy change and equilibrium constant, exergonic and endergonic reactions.	
Unit 2: Biomolecules	**20**
1. Structures and properties (chemical and physical) of carbohydrate, protein, amino acids, nucleic acids, and lipids. 2. Prediction of protein structure, Ramachandran plot; helix-coil transltion. 3. Enzyme nomenclature, enzyme kinetics, MM, LB, EH plots. Allosteric interactions and product inhibition. Enzyme immobilization. Co enzymes and prosthetic groups.	
Unit 3: Metabolism	**30**
1. Anabolism and catabolism of carbohydrate, amino acids, nucleotides, lipids. 2. Inborn metabolic errors of carbohydrates, proteinsand nucleic acids.	
Unit 4: Physiological processes in plants and animals	**25**
1. Photosynthesis, light reaction and dark reaction, photosynthesis in C3 and C4 plants. 2. Animal and plant hormones (types, function, regulation and synthesis). 3. Applications of enzymes in food, pharmaceutical, textile and leather industries.	

SUGGESTED READINGS:

1. Albert L. Lehninger Principles of Biochemistry- CBS Publishers & Distributors
2. LubertStryer Biochemistry –Freeman International Edition.
3. Keshav Trehan Biochemistry Wiley Eastern Publications
4. Dr.A.C.Deb Fundamental of Biochemistry –
5. U. Satyanarayana Biochemistry Books and Allied Pvt. Ltd.

6. Conn and Stump, Outlines of Biochemistry, Wiley Eastern Ltd., New Delhi.
7. Voet and Voet, Biochemistry- John Wiley and Sons.

MBT 103 **Microbiology** **Theory** **Credit: 4**

After successful completion, this course enables students

CO1. To explore the fascinating world of microorganism and their role (both beneficial and harmful) in day to day life. It imparts knowledge on the various phases and contribution of different Scientists how Microbiology established itself as a separate branch of Science.

CO2. To understand the different categories of microbes and sub-microbial groups with their position in the tree of life (classification), their characteristic features and importance.

CO3. To become familiarize with the different technical aspects [isolation, cultivation, observation (microscopy), and identification] of studying microbes.

CO4. To get an insight on the existence of microbes in different spheres of the environment and how the microbes are affected/induced in these environments or *vice versa*.

CO5. To get the basic idea about the food substrate, microorganisms involved in food spoilage and food preservation methods. It also deals with the basic concept on food borne diseases in humans.

Course Content	**No. of Classes**
Unit I: Fundamentals of Microbiology 1. History of Microbiology, medical microbiology & immunology, agricultural & environmental microbiology, food & industrial microbiology and astrobiology. 2. Microscopy-principle and application of light, phase contrast and electron microscope. Sterilization and disinfection- physical and chemical methods, disinfectants and mode of action, Culture Techniques- types and importance of culture media, pure culture methods, preservation of pure culture.	**30**
Unit II: Microbial Diversity 1. Bacteriology: general properties of bacteria, morphology and ultra structure of bacteria. Gram-positive and Gram-negative bacteria. Recombination in bacteria. 2. Virology: discovery of viruses. Nature, properties and general morphology of virus. Transmission of plant virus. Lytic, lysogenic cycles, sub-viral particles (Viroids, Virusoids and Prions. Concept of antiviral compounds, interferons and viral vaccines. 3. Phycology and mycology: General characteristics and classification of algae. Algae cell ultra-structure. Types of life cycle in algae. Importance and associations. General characteristics and classification of fungi. Fungal cell wall ultra- structure. Heterothallism and parasexuality in fungi	**20**
Unit III: Microorganisms and their natural habitats 1. Terrestrial Environment: Soil as a natural habitat of microbes. Soil microflora and their interactions in soil (symbiosis, mutualism, commensalism, competition, synergism and parasitism). Microbes in the Rhizosphere and their importance. Role of microbes in nutrient cycling (Nitrogen, Phosphorus and Sulfur). 2. Aquatic Environment: Microflora of Freshwater & Marine habitats. Microbial assessment of water quality and water purification. Eutrophication. Potability of water. A brief account of water born diseases in man. 3. Aerial Environment: Aeromicroflora. Source and dispersal of Microbes in air. Microbes in the Phyllosphere and their importance.	**20**
Unit IV: Microbes in Food 1.Foods as a substrate for microorganisms: natural flora and source of contamination offoods.Microbial spoilage of various foods: principles and spoilage of vegetables, fruits, meat, eggs, milk and canned foods. 2. Principles and methods of food preservation: physical and chemical methods of food preservation. Food	

preservatives.

3. Basic concept of Fermented foods and food borne diseases in man.

Suggested Readings:

Textbooks-

1. Pelczar MJ, Chan ECS and Krieg NR. (2010). *Microbiology*. 8th edition. McGraw Hill Book Company.
2. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.

References-

1. Adams MR and Moss MO. (1995). *Food Microbiology*. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
2. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). *Introductory Mycology*. 4th edition. John and Sons, Inc.
3. Atlas RM. (2005). *Principles of Microbiology*. 4th edition. WMT.Brown Publishers.
4. Dimmock, NJ, Easton, AL, Leppard, KN (2007). *Introduction to Modern Virology*. 6th edition (First Indian reprint 2007), Blackwell Publishing Ltd.
5. Frazier WC and Westhoff DC. (1992). *Food Microbiology*. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
6. Maier RM, Pepper IL and Gerba CP. (2009). *Environmental Microbiology*. 2nd edition, Academic Press.
7. Martin A. (1977). *An Introduction to Soil Microbiology*. 2nd edition. John Wiley & Sons Inc. New York & London.
8. Madigan MT, Martinko JM and Parker J. (2009). *Brock Biology of Microorganisms*. 12th ed. Pearson/Benjamin Cummings.
9. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2009). *General Microbiology*. 7th ed. McMillan.
10. Stolp H. (1988). *Microbial Ecology: Organisms Habitats Activities*. Cambridge University Press, Cambridge, England.
11. Subba Rao NS. (1999). *Soil Microbiology*. 4th edition. Oxford & IBH Publishing Co. New Delhi.
12. Tortora GJ, Funke BR, and Case CL. (2013). *Microbiology: An Introduction*. 11th edition. Pearson Education.
13. Vashishta BR and Sinha AK. (2008). *Fungi*. 5th edition. S. Chand and Company Ltd.
14. Vashishta BR. (2008). *Algae*. 5th edition. S. Chand and Company Limited, New Delhi.

MBT 104 Bioinstrumentation Theory Credit: 4

After successful completion, this course enables students

CO1. To develop concept on the important techniques necessary for the study and prediction of different processes occurring in microbes and other cellular organisms.

CO2. To familiarize with the importance, principle and types of chromatography and centrifugation techniques and their role in the study of biological system.

CO3. To familiarize with the importance, principle and types of electrophoretic techniques and their role in the study of biological system.

CO4. To get an insight into the concept of radioactivity and its application in biochemical and immunological processes.

CO5. To familiarize with a***dvanced techniques like*** Protein Crystallization, MALDI-TOF, Mass Spectrometry, Enzyme and Cell Immobilization which are extensively used in Industrial and R & D sectors.

Course Content **No. of Classes**

Unit I:

Basic Techniques-

1. Buffers; Methods of cell disintegration; Enzyme assays and controls; Detergents and membraneproteins; Dialysis, Ultrafiltration and other membrane techniques

Spectroscopy Techniques

2. Principles and Applications of UV, Visible Spectroscopy; Circular Dichroism; Fluorescence; Mass Spectroscopy, NMR Spectroscopy

Unit II:

Chromatography Techniques-

3. TLC and Paper chromatography; Gel permeation, Ion exchange, Hydrophobic, Reverse-phase andAffinity chromatography; HPLC and FPLC

Electrophoretic techniques-

4. Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillaryelectrophoresis; 2D Electrophoresis

Unit III:

Centrifugation

5. Basic principles & theory (RCF, Sedimentation coefficient etc); Types of centrifuge - Microcentrifuge, High speed & Ultracentrifuges; Differential & density gradient centrifugation;
6. Applications (Isolation of cell components); Analytical centrifugation; Determination of molecularweight by sedimentation velocity.

Unit IV

Radioactivity

7. Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurementof radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle,instrumentation & technique); Autoradiography;
8. Applications of isotopes in biochemistry; Radiotracer techniques; Radioimmunoassay

Unit V

Advanced Techniques

9. Protein crystallization; Theory and methods; API-electrospray and MALDI-TOF; Mass spectrometry; Enzymeand cell immobilization techniques; DNA & Peptide Synthesis.

MBT 105 Cell Biology, Biochemistry and Microbiology Practical Credit: 4

This course enhances the practical application of the concept on Microbiology, Biochemistry and Cell Biology. After successful completion, this course enables students

CO1. To understand the different phases of cell-cycle during mitosic and meiosic cell division.

CO2. To learn the principle and process for quantitative estimation (spectrophotometry) of DNA using (Diphenylamine method), RNA (Orcinol method) and protein analysis (vertical slab gel electrophoresis).

CO3. To get an insight into the laboratory techniques for the isolation and enumeration of microorganisms from fro different environmental spheres like soil, water and air with special reference to
-antibiotic producing microbes from soil
-the effect of physical factors (temperature and pH) on growth

CO4. To learn the principle and the process concerned with the study of bacteria including:
-isolating bacteria in pure cultures by streaking method
-determination of growth-phases in bacteria with the help of growth curve
-identification of unknown bacteria with the help of specific biochemical activity and staining techniques (Gram's, capsule and flagella staining)
-determination of sensitivity/resistance in bacteria against different antibiotic substances

CO5. To get an insight into the biochemical methods for the estimation of carbohydrates, proteins and amino acids- both quantitatively and qualitatively.

It also helps students to develop the idea of separation of plant pigments and amino acids using chromatographic methods of TLC/ Paper chromatography.

Course Content	No. of Classes
Cell Biology (Any 4)	**40**
1. Study of mitosis and meiosis in dividing cells 2. Spectrophotometric quantification of DNA using Diphenylamine method. 3. Spectrophotometric quantification of RNA using Orcinol method. 4. Isolation and quantification of DNA from bacteria, plant and animal. 5. Agarose gel electrophoresis. **6.** Protein analysis by vertical slab gel electrophoresis and characterization by standard protein marker.	
Biochemistry (Any 5)	**50**
1. Determination of reducing sugars by Nelson Somogye method. 2. Determination of total carbohydrate by anthrone method. 3. Estimation of starch by anthrone method. 4. Determination of free acid of oil. 5. Determination of saponification value of oil. 6. Estimation of protein by Lowry's method. 7. Separation of pigments using paper chromatography. 8. Separation of amino acids using thin layer chromatography.	
Microbiology (Any 4)	**90**
1. Isolation and enumeration of microorganisms from soil (rhizosphere and rhizoplane), water and air (phyllosphere and phylloplane). 2. Isolation of antibiotic producing microbes from soil. 3. Study of effect of physical factors (temperature and pH) on growth of microbes. 4. Study of bacteria: a) Study of bacterial growth curve. b) Biochemical characterization of bacteria. c) Staining techniques in bacteria (Gram's, capsule and flagella staining). d) Antibiotic sensitivity test of bacteria. 5. Study of the vegetative and reproductive structures of *Aspergillus, Saccharomyces, Penicillium, Agaricus*and *Alternaria* through temporary and permanent slides.	

Reference:

1. S. Sadasivam and A. Manickam Biochemical Methods-, New Age International Publishers, New-Delhi.
2. Cappucino J and Sherman N. (2010). *Microbiology: A Laboratory Manual*. 9th edition. Pearson Education limited.

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SEMESTER II

MBT 201: Molecular Biology THEORY Credit: 4 Full Marks: 100

After successful completion, this course enables students

CO1. To understand the molecular basis of biological activity between biomolecules in the various systems of a cell.

CO2. To familiarize with the basics of DNA, RNA, and proteins structure and their interactions within the cell to promote growth, division and development.

CO3. To have the concept on the responses to environmental or physiological changes, or alterations of cell function brought about by mutation.

CO4. To get an insight in to the wide range of mechanisms required for gene regulation in different organisms.

CO5. To understand the molecular basis of cancer and other diseases and the pattern of interaction of animal cells with micro-organisms and viruses.
It also deals with the application of recombinant DNA techniques to problems in basic science and biotechnology.

Course Content **No. of Classes**

Unit-1: Organization of genetic materials

1. Various models to explain the structure of the nucleus and chromosomes, Special type of chromosomes: lamp brush, salivary and B chromosomes.
2. Packaging of DNA as nucleosomes in eukaryotes, Chromosomal DNA contents and Cvalue paradox. Structural changes in the chromosomes
3. Multigene families in eukaryotes; Genomic organization in prokaryotes and Archaebacteria

Unit-II: DNA replication and repair

1. Enzymes & accessory proteins involved in DNA replication
2. Replication process in prokaryotic & Eukaryotic DNA. Regulations of Eukaryotic replication
3. DNA Repair:- Types of DNA Repair, Mechanism of DNA Repair

Unit-III: Transcription

1. Importance of DNA binding Proteins, RNA polymerase
2. Mechanism of Transcription in prokaryotes & Eukaryotes
3. Processing of RNA:- m-RNA processing, 5' capping, 3' polyadenylation, splicing r-RNA & t- RNA processing

Unit-IV: Translation

1. The translation machinery, role of t RNA & ribosome; Mechanism, of translation
2. Post translational modification of proteins such as phosphorylation, adenylation, acylation andglycosylation

Unit-V: Regulation & gene expression in Prokaryotes & eukaryotes

1. Operon concept (Lac operon, trp operon, his operon and arabinose operon), Structural basis ofDNA-Protein interaction; Attenuation & termination
2. Gene silencing:- DNA methylation,
3. Chromatin modification & gene expression. Histone acetylation & deacetylation; Environmental regulation of gene expression

MBT 202: Immunology THEORY Credit: 4 Full Marks: 100

After completion, this course enables students

CO1. To familiarize with the concept of non-specific (innate) and specific (acquired) resistance mechanism developed in man against pathogens and other non-self factors which is the basis of this course.

CO2. To get an insight into the formation, types, organization and functional specificity of different cellular and organ level components conferring resistance in man.

CO3. To understand the nature, types and function of antigens that induce immunological response in man and how the product of this response (antibody, B and T cells) help in neutralizing them (agglutination and precipitation reactions).

CO4. To have the concept of different mediators/cell signaling molecules (complement, cytokines: interferons, Interleukins, heamatopoetins and chemokines) associated with immunological responses as well as their biological consequences.

CO5. To deal with the different diagnostic and serological approaches for the study of interaction between an antigen and its specific antibody including Widal Test, immunodiffusion, Immuno-electrophoresis, ELISA and RIA.
It also gives an idea on immune-disorders (hypersensitivity, autoimmune disorders, oncogenesis etc.) and induced immunity (vaccination) to overcome such abnormalities.

Course Content	**No. of Classes**
Unit – I	**10**
1. Introduction: Physiology of immune system,Innate and acquired immunity. Clonal nature of immune response,Artificial immunity.	
Unit – II	**15**
1. Cells of immune system: Lymphoid lineage (producing B and T lymphocytes) and myeloid lineage (Phagocytes: macrophages, neutrophils and eosonophils and auxillary cells; basophils, mast cells and platelets. 2. Organs of immune system: primary and secondary lymphoid organs.	
Unit – III	**25**
1. Antigens: Nature, function and types (Haptens, super antigens and cluster of differentiation molecules (CDs), Processing and presentation of antigens. 2. Immunoglobulins – structure and types, Antigen antibody reactions. Major histo-compatibility complex, MHC gene organization; Class I and Class II MHC molecules, thin structure & functions. 3. B - cell and T- cell receptors, Organization of Immunoglobulin gene, Class switching.	
Unit – IV	**10**
1. Complement: Pathways of complement activation; biological consequence of complement activation, Cytokines: interferences (α, β and γ), TNF, Inter leukins, heamatopoetins and chemokines.	
Unit- V	**15**
1. Monoclonal antibodies–hybridoma technology; antigen–antibody reactions; agglutination reactions (Widal, haemaglutination); Precipitation reactions (immunodiffusion, Immuno-electrophoresis), Immunoblotting, ELISA, RIA; immunoelectron-microscopy.	
Unit- VI	**15**
1. Immunization by vaccines: Vaccine types & functions, Immune disorder; hypersensitivity; autoimmune diseases. 2. Organs transplantation reaction; immunodeficiency, Tumour Immunology (Basic idea).	

Suggested Readings:

1. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman,2002.
2. Janeway et al., Immunobiology, 4th Edition, Current Biology publications., 1999.Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002.
3. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999.
4. Goding, Monoclonal antibodies, Academic Press. 1985.
5. F.C. Hay, O.M.R. Westwood, Practical Immunology, 4th Edition-, Blackwell Publishing, 2002.
6. S. Hockfield, S. Carlson, C. Evans, P. Levitt, J. Pintar, L. Silberstein, Selected Methods forAntibody and Nucleic Acid probes, Volume1, Cold Spring Harbor Laboratory Press, 1993.
7. Ed Harlow, David Lane, Antibodies Laboratory Manual, Cold Spring Harbor, Laboratory Press, 1988.

MBT 203: Genetics Theory Credit: 4

After successful completion, this course enables students

CO1. To understand basic principles of Mendelian inheritance.

CO2. To study cell division and chromosome segregation during the process.

CO3. To explore the multifactorial inheritance and understand the chromosome structure, chromatin organization and variation.

CO4. To learn the concepts of Linkage, concept of sex determination and sex linked inheritance which help to understand about different sex influenced human diseases.

CO5. To gain knowledge about the organellar inheritance, genome evolution, mutation and basis of several hereditary diseases.

Course Content	No. of Classes
UNIT-I: Bacterial mutants and mutations 1. Isolation; Useful phenotypes (auxotrophic, conditional, lethal, resistant) 2. Mutation rate; Types of mutations(base pair changes; frameshift; insertions; deletions; tandem duplication) 3. Reversion vs. suppression 4. Mutagenic agents; Mechanisms of mutagenesis; Assay of mutagenic agents (Ames test)	**20**
UNIT-II: Mendelian genetics 1. Introduction to human genetics; Background and history 2. Types of genetic diseases; Role of genetics in medicine; 3. Human pedigrees 4. Patterns of single gene inheritance-autosomal recessive; Autosomal dominant; X linked inheritance 5. Hemoglobinopathies -Genetic disorders of hemoglobin and their diseases.	**20**
UNIT-III: Non Mendelian inheritance patterns 1. Mitochondrial inheritance 2. Genomic imprinting; Lyon hypothesis 3. Isodisomy; Complex inheritance 4. Genetic and environmental variation; Heritability; Twin studies 5. Behavioral traits; Analysis of quantitative and qualitative traits	**20**
UNIT-IV: Introduction to genomics 1. Introduction to genomics-Structural organization of genomes in prokaryotes and eukaryotes. 2. OrganelleleDNA- Mitochondria and Chloroplast 3. Tools for genome analysis 4. Genome sequencing projects- Human genome project	

Suggested Readings:

1. N. Trun and J. Trempy, Fundamental Bacterial Genetics, Blackwell publishing, 2004.
2. Strachan T and Read A P, Human molecular genetics, 3rd Edition Wiley Bios, 2006.
3. Glick BR & Pasternak JJ, Molecular Biotechnology, 3rd Edition, ASM Press, 1998.
4. Campbell AM &Heyer LJ, Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings 2007.

MBT 204: Biostatistics, Bioethics and IPR THEORY Credit: 4

After successful completion, this course enables students

CO1. To understand the ethical and safety issues concerned with Biotechnological experiments.

CO2. To understand the basics of intellectual property rights including the concept, types, importance and legal issues related to patents, trademarks, copyright, industrial design and rights, traditional knowledge and geographical indicators.

CO3. To get the idea about the process of granting patent by patenting authorities with reference to types of patent applications, patent filing procedures, patent licensing and agreement and rights and duties of patent owner.

CO4. To have knowledge on the agreements, treaties and international recognition in connection to protect innovations and novel works; It also gives an idea on Indian Patent Act (1970) and recent amendments.

CO5. To understand the guidelines in using radioisotopes in laboratories, safety measures and disposal mechanism.

Course Content	**No. of Classes**

Unit – I Biostatistics **35**

1. Application of statistics in biological science; measurement of central tendency and dispersion. Mean variance, standard deviation, standard error, co-efficient of variance.
2. Concept of probability and probability laws; standard probability distribution – binomial, poisson and normal distributions.
3. Test of hypothesis. Test of significance based on z, $\chi 2$, t and F statistics; correlation and regression.Analysis of variance and co-variance; one-way and two-way ANOVA.
4. Random sampling; principles of design of experiments; CRD, RBD, LSD; transformation of data; comparison of mean.

Unit –II Biothics **35**

Foundation of Bioethics

1. Definition, historic evolution, codes and guidelines, universal principles.
2. Bioethics: Necessity of Bioethics. Different paradigms of Bioethics-National & International.
3. Ethical issues against the molecular technologies.

Clinical ethics **20**

1. Sanctity of human life and the need to preserve human life; issues related to prenatal screening, clinical trials (Phase I/II/III/IV) studies.
2. Medical error and medical negligence; remedies against medical negligence, protection and compensation related to it.
3. Ethical use of animals in the laboratory

Unit –III IPR

1. Introduction to IPR: History, Importance and scope.
2. Forms of IPR- Patent, trademark, copyright, traditional knowledge, geographical indicators, tradesecrets.
3. TRIPS, WIPO, WTO.
4. Farmers rights, Plant variety- suigeneris.
5. Indian Patent Act (Brief idea).
6. Case studies: Turmeric, Superbug, Basmati rice.

Suggested Readings and Important Links:

1. Biostatics: A foundation for analysis in the health science – W.W.Daniel; John Wiley.
2. Statistical methods for Agricultural workers – Panse and Sukhetme; ICAR.
3. A text Book of Agricultural Statistics – Rangaswami; New Age International.
4. Instrumental Methods of analysis – Willare, Mermitt& Dean.
5. Bioinformatics: Sequence & Genome analysis – D.W. Mount.
6. Physics for Biology and premedical students – D.M. Burns & Mac Donald; Addision Wesley.
7. http://www.w3.org/IPR/
8. http://www.wipo.int/portal/index.html.en

9. http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html
10. www.patentoffice.nic.in

BT 205: Practical on Immunologyand Molecular Biology **Practical** **Credit: 4**

This practical course enhances the applicability of the concept on Molecular Biology and Immunology. After successful completion, this course enables students

CO1. To understand the principle and process of
-blood group determination following slide agglutination test,
-blood cell count and identification following blood film preparation and
-immuno-diagnostic methods like Radial immunoassay and ELISA

CO2. To acquaint with the principle and process of the immunodiffusion techniques like ODD, SRID, Immuno-electrophoresis and counter-current electrophoresis.

CO3. To learn the principle and process for the isolation DNA from bacterial, plant and animal sources and their quantification using agarose gel electrophoresis

CO4. To learn the principle and process of restriction digestion analysis by agarose and polyacrylamide gel electrophoresis (over-expression of proteins by SDS-PAGE.

CO5. To learn the principle and process for the isolation and cloning of plasmid DNA and their amplification by PCR (RAPD analysis).

Course Content	**No. of Classes**
Immunology:	**60**
1. Blood film preparation and identification of cells.	
2. Preparation of antigen.	
3. Immunization, serum collection and preservation.	
4. Purification of IgG from serum.	
5. SGOT – PT test; agglutination.	
6. Immunodectrophoresis, Immuno-peroxidase test; Immunoflurescence test, ELISA.	
7. Isolation of lymphoid cells (mouse) from spleen.	
8. Separation of mononuclear cells.	**30**
Molecular Biology	
1. Spectrophotometric quantification of DNA using Diphenylamine method.	
2. Spectrophotometric quantification of RNA using Orcinol method.	
3. Isolation and quantification of DNA from bacteria, plant and animal.	
4. Agarose gel electrophoresis.	
5. Protein analysis by vertical slab gel electrophoresis and characterization by standard protein marker.	

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SEMESTER III

MBT 301: GENETIC ENGINEERING THEORY Credit: 4

After completion, this course enables students

CO1. To have the basic concept of genetic engineering and r-DNA technology laying the basis of genetic modification of cellular organisms.

CO2. To develop the concept about the types, nature and functions of restriction enzymes that act as the mediators of DNA modification during genetic manipulation process.

CO3. To get an insight into the concept of different vectors (plasmids, cosmids, phagemids, artificial chromosome vectors) that act as carrier of DNA fragment between cellular organisms during genetic modification.

CO4. To understand the different blotting techniques (Southern, Northern and Western) hybridization process as well as the construction and screening genomic and c DNA libraries.

CO5. To have concept about the most versatile molecular technique of Polymerized Chain Reaction (PCR); its types, applications and different PCR based and PCR independent marker (RAPD, RFLP, AFLP) methods in Molecular Biology.

Course Content	No. of Classes
Unit- I	**20**
1. Genetic engineering and its applications: Restriction enzymes, DNA Ligases, Klenow fragment, polymerases and other modifying enzymes.	
2. Cohesive and blunt end ligation, linkers, adaptors and homopolymeric tailing, Restriction digestion and mapping of clone genes	
Unit- II	**25**
1. Important vectors- plasmid , bacteriophages , M13,insertion and replacement vectors, cosmids, YAC, BAC, Expression vectors and shuttle vectors,Plants based vectors – Ti and Ri vectors	
2. Regulation of copy number in plasmid, iterons, Construction and screening of genomic and cDNA libraries	**20**
Unit- III	
1. PCR, types and its application	
2. DNA sequencing- Maxam and Gilbert's method, Sanger's method, Pyrosequencing, automated DNA sequencing.	
3. DNA fingerprinting, RFLP, RAPD, AFLP, ISSR, SNP.	**25**
Unit- IV	
1. Hybridization techniques- Northern, Southern and Western Hybridization, Nick translation, random priming and probes, Marker genes and reporter genes	
2. Introduction of DNA into mammalian cells, transfection techniques	
3. Methods for creation of transgenic plants and animals, Uses of transgenics.	

Suggested Readings:

1. J Sambrook, E F Fritsch and T Maniatis, Molecular Cloning: a Laboratory Manual, Cold Spring Harbor Laboratory Press, New York, 2000.
2. SL Berger and AR Kimmel, Methods in Enzymology Vol.152, Guide to Molecular Cloning Techniques, Academic Press, Inc. San Diego, 1998.
3. M R Walker and R Rapley, Route Maps in Gene Technology, Blackwell Science Ltd, Oxford, 1997.
4. SM Kingsman and A J Kingsman Genetic Engineering, An Introduction to gene analysis & exploitation in eukaryotes, Blackwell Scientific Publications, Oxford, 1998.
5. S B Primrose,Molecular Biotechnology (2nd Edn.), Blackwell Scientific Publishers, Oxford, 1994.

MBT 302: PLANT AND ANIMAL BIOTECHNOLOGY THEORY Credit:4

After successful completion, this course enables students

CO1. To familiarize with the techniques of plant and animal cell culture, mechanisms of gene transfer and various molecular marker assisted methods in improvement of live-stocks and crop plants.

CO2. To have knowledge on different tissue and cell culture media and their preparation methods.

CO3. To explore the biomedical research involving tissue engineering that aims to grow and replace tissue *in-vitro* using stem cell technology.

CO4. To understand the various vectorless and vector mediated gene transfer methods used in plant and animal cell cloning.

CO5. To have the basic understanding of plant and animal tissue culture and its maintenance as well as to get the insight in to the concept of callus and suspension culture, somaclonal variation, callus cultur, totpotency, hybrid and cybrids.

Course Content	**No. of Classes**
Unit- I 1. Tissue Culture Methodology, Culture media, Initiation and maintenance of cultures. 2. Micropropagation- Multiple shoot proliferation, rooting of the micro-shoots and transfer to soil, hardening, acclimatization and final transfer of whole plant to field. Applications- Clonal propagation, Production of disease free plants.	**10**
Unit- II 1. Culture media and culture conditions, preparation of cell suspension, maintenance of suspension culture Callus culture media, culture and callus induction, organogenesis and somatic embryogenesis 2. 2. Shoot development, rooting and transfer of plantlets to soil, Somaclonal variation. Artificial seed production- synthetic seeds. Induction of secondary metabolite production, acceleration and inhibition of the products and elicitors.	**10**
Unit- III 1. Haploid production- importance of haploids, progress in the development of haploid technology, Culture media and culture conditions, source materials for haploid culture. Anther and ovary culture, organogenesis, haploid plant regeneration, Embryo culture and embryo rescue 2. Protoplast technology- Prospects of protoplast technology. Media and solutions, Protoplast isolation techniques, purification of protoplasts, viability of protoplast, Culture of protoplasts and regeneration of plants, Somatic hybridization- protoplast fusion, cybrids and their utilization	**15**
Unit- IV 1. Animal Biotechnology: historical background, scope and possible applications. 2. Requirements in an animal cell culture laboratory.	**10**
Unit- V 1. Transgenic technology- gene transfer in nuclear genome and chloroplasts, direct and *Agrobacterium* mediated gene transfer, gene silencing. 2. Transgenic production for insect resistance, disease resistance, male sterility and longer shelf life, male sterility. Scenario of transgenic technology, success of gene transfer in economically important crop plants.	**15**
Unit- VI 1. Animal cell and tissue culture: Culture media, Culture procedures, Primary cultures and cell lines. 2. Stem cell technology: origin and types of stem cells; Therapeutic cloning for embryonic stem cells.*In-vitro* fertilization in human and live stocks.	**15**

Suggested Readings:

1. M. K. Razdan An Introduction to Plant Tissue Culture: Tata Mc Graw Hill Publishing Co. Ltd. 2004.

2. J. Hammond, P. MaGarvey and V.Yusibov (Eds).,Plant Biotechnology: Springer Verlag. 2000.
3. T-J Fu, G. Singh and W. R. Curtis (Eds.)Plant Cell and Tissue Culture for the production of Food Ingredients:, Kluwer Academic /Plenum Press.1999.
4. H. S. Chawla, Introduction to Plant Biotechnology: (Second edition), Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2004.
5. P. K. Gupta, Rastogi and Co Elements of Biotechnology:Meerut,2007

MBT 303: OMICS AND BIOINFORMATICS THEORY Credit: 4

After successful completion, this course enables students

CO1. To understand the contents and properties of bioinformatics databases; perform text- and sequence-based searches, and analyze and discuss the results in light of molecular biological knowledge.

CO2. To learn about the major steps in pair wise and multiple sequence alignment, and execute pair wise sequence alignment by dynamic programming.

CO3. To learn the techniques of predicting the secondary and tertiary structures of protein sequences.

CO4. To become familiar with the use of a wide variety of internet applications, biological database that can be applied in solving research problems.

CO5. To understand the theoretical and practical development of useful tools for automation of complex computer jobs, and making these tools accessible on the network from a Web browser.

Course Content **No. of Classes**

UNIT I: INTRODUCTION

1. History of Omics world, Branches of Omics, Scope, Applications and Limitations, Omics resources.

UNIT II: GENOMICS

1. Genome and genomics, Comparative, Functional and Structural Genomics, Genome sequencing projects, Genome sequencing technologies, Big Data.
2. Genome annotation, Genome databases, Genome browsers and Data retrieval, Applications of genomics in agriculture, human health andindustry.

UNIT III: TRANSCRIPTOMICS

1. Concept on transcriptomics, Analysing gene expression – Northern blot, Real Time-PCR, subtractive hybridization, differential display, SAGE, Microarrays, NGS technologies.
2. Analysis & Annotation of transcriptome-ORF, Exon–Intron boundaries, Transcript assembly, BLAST, Gene ontologies (GO),Transcript databases-EST, SRA.

UNIT IV: PROTEOMICS

1. Proteome and proteomics, General scheme to proteomics analysis, Qualitative and quantitative proteome analysis, Shotgunproteomics for proteome profile.
2. Identification of differentially expressed proteins, Protein motif and conserved domain, Protein Information resources-PDB, Swissprot, pfam, Data retrieval and comparative proteomics.

UNIT V: METABOLOMICS

1. Introduction to Metabolites, Analytical technologies in metabolomics: separation methods and detection methods, Nuclear Magnetic Resonance Spectroscopy and Mass Spectrometry in metabolomics. Metabolic pathway resources: KEGG, Metabolomics and ionomics for elucidating metabolic pathways.

UNIT VI: BIOINFORMATICS APPLICATIONS

1. Concept in sequence alignment, Pairwise and Multiple sequence

alignment, Phylogenetics analysis, BioEdit, ClustalW, MEGA, Restriction mapping, Genome mapping.

2. Secondary structure prediction of nucleic acids and proteins,

Homology modeling, Ramachandran plot, Visualisation of proteins 3D structure-RASMOL, Protein-protein interaction and pathways analysis.

Suggested Readings:

1. Current Protocols in Bioinformatics, Edited by A.D. Baxevanis et al, Wiley Publishers, 2005.
2. Bioinformatics by David W. Mount, Cold Spring Harbor Laboratory Press, 2001.
3. Fundamental concepts of Bioinformatics by D.E. Krane and M.L Raymer, Pearson Education, 2003.
4. Metabolome Analysis: An Introduction. Silas G. Villas-Boas, Jens Nielsen, JornSmedsgaard, Michael A. E. Hansen, Ute Roessner-Tunali, John Wiley & Sons, 320 pages, 2007.
5. Handbook of Comparative Genomics: Principles and Methodology by Cecilia Saccone, GrazianoPesole. Wiley-LISS Publication, 2003.
6. Discovering Genomics, Proteomics &Bioinfo, A.M. Campbell, C.S.H. Press, 2003.
7. Comparative Genomics by Melody S. Clark. Kluwer Academic Publishers, 2001.

MBT 304: FOOD AND INDUSTRIAL BIOTECHNOLOGY THEORY Credit- 4

After successful completion, this course enables students

CO1. To understand the role of biotechnology in food production, food processing, and food security.

CO2. To learn about the conditions under which the organisms responsible for the deterioration of food can be inactivated, killed or made harmless.

CO3. To understand the principles involving food preservation via fermentation processes.
It also acquaints with various kinds of Bioreactor and fermenters used in Industries for food production.

CO4. To have knowledge for improving the industrially useful microorganisms genetically and to understand the process and role of enzyme immobilization in food industries.

CO5. To get an insight in to the principles and current practices of processing techniques and the effects of processing parameters on product quality.
It also deals with the pre- and probiotic microorganisms and their importance.

Course Content

Unit-I Fundamentals of food **15**

1. Basics of food, Types and Classification of food.
2. Microbes involved in food spoilage, Food preservation – Physical and Chemical and biological methods.

Merits and drawbacks of different methods of food preservation, Food packaging.

Unit-II Fermented food **20**

1. Food and beverage fermentation: of cabbage, soybean (miso, soyu, natto, sofu), milk (kumiss, yoghurt, kefir), fish and meat.
2. Pre- and pro-biotic microorganism: GRAS microorganism, Starter culture, Industrial production of alcohols and organic acids (acetic acid, citric acid and lactic acid) and SCP.

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Unit- III Commercialization of fermented food and food laws

1. Commercialization of fermented food.
2. Benefits of fermented food products; Nutritional values and safety aspects.
3. Enzymes in food processing industries. Immobilized enzymes and their applications.
4. Genetic improvement of industrially important micro organism.

Unit- IV Bioreactor **25**

1. Bioreactor: types, structure and design.

2. Automation in bioreactor. Bioreactor for animal cell culture.

Suggested Readings:

1. Bisen P.S (1994) Frontiers in Microbial Technology, 1st Edition, CBS Publishers.
2. Glaser A.N and Nilaido.H (1995) Microbial Biotechnology, W.H Freeman and Co.
3. Prescott and Dunn (1987) Industrial Microbiology 4th Edition, CBS Publishers & Distributors.
4. Prescott and Dunn (2002) Industrial Microbiology, Agrobios (India) Publishers.
5. Crueger W. and Crueger A. (2000) A Text of Industrial Microbiology, 2nd Edition, PanimaPublishing Corp.
6. Stanbury P.F, Ehitaker H, Hall S.J (1997). Priciples of Fermentation Technology, Aditya Books (P) Ltd.
7. Adams and Moss Food Microbiology
8. Fraizer and Werthoff Food Microbiology –
9. Joshi and Pandey.Food Fermentation – Microbiology, Biochemistry & Technology, Vol. I & II.

MBT 305:Practical on Genetic Engineering, Plant & Animal Biotechnology, Bioinformatics and Food & Industrial Biotechnology Practical Credit: 4

This practical course gives the idea of industrial production of important material using fermenter, improvement of crop using the concept of Genetic Engineering and methods like microprpagation. After successful completion, this course enables students

CO1. To acquaint with methods for the isolation of chromosomal DNA from plant and microbial cells, their qualitative and quantitative analysis as well as to become familiar with the technical process of PCR.
It also helps in learning the technique of restriction digestion of DNA and its separation by Gel Electrophoresis and Protein profiling using SDS PAGE.

CO2. To learn the preparation of medium used in plant tissue culture and carry out the process like micropropagation and artificial seed preparation.

CO3. To understand the design and working principle of a fermenter and its use in the industrial production of solvent, enzymes etc.).

CO4. To learn the different laboratory methods to determine quality of food products (MBRT and Alkaline phosphatase test to check the efficiency of pasteurization of milk).

CO5. To understand the practical aspects of Bioinformatics including
a. operating systems like UNIX, LINUX and Windows;
b. bioinformatics databases systems like NCBI/ PDB/ DDBJ, Uniprot, PDB;
c. sequence retrieval using BLAST and sequence alignment & phylogenetic analysis using clustalW & phylip;
d. protein structure prediction using psipred, homology modeling using Swissmodel, and molecular visualization using jmol.

Course Content	No. of Classes
Genetic Engineering (Any 4) 1. Isolation and quantification of plant genomic and plasmid DNA. 2. Agarose gel electrophoresis of DNA. 3. PCR Amplification of DNA. 4. Construction of restriction map- Plasmid DNA. 5. Cloning of DNA fragments in plasmid vactor. 6. Colony hybridization for screening of libraries using probe.	**40**
Plant Biotechnology (Any 4) 1. Preparation of media for plant tissue culture. 2. Micropropagation using apical/nodal explants. 3. Callus culture using apical meristem, embryo/cotyledon. 4. Preparation of artificial seeds. 5. Anther and embryo culture.	**50**

6. Establishment of suspension culture.

Animal biotechnology (Any 2)

1. Study of equipments and materials for animal cell culture.
2. Demonstration of the process and techniques of animal cell culture.
3. Induced ovulation in mouse/ rats.
4. Visit to reputed animal biotechnology laboratory, study on areas of research being continued therein and preparation of a report on IVF and / or success and failure rate.

Bioinformatics (Any 4)

1. **Accessing Biological databases:**

Retrieving protein and nucleic acid sequences, structures, EST sequences, SNP data using database browsers and genome browsers. Converting sequences between different formats using sequence editors. Sequence assembly.

2. **Nucleic acid sequence analysis:**

Detecting ORF's, identification of translational and transcriptional signals, gene predictions, codon usage, RNA folds analysis.

3. **Sequence alignment and applications:** pair wise alignment-dot

matrix comparisons, global and local alignment, Database searching-different pair wise methods. Use of scoring matrices and gap penalties.

4. **Multiple sequence alignment and applications:** Use of multiple sequence editors. Progressive alignment and iterative alignment approaches. Use of profile methods formation detection. Clustering and Phylogeny approaches.

7. **Protein Sequence analysis:**

Composition, Hydrophobicity and prediction of trans-membrane proteins.

Food & Industrial Biotechnology: (Any 4)

1. Grape juice fermentation by *Saccharomyces cerevisiae*.
2. Sauerkraut fermentation and study of microbial profile during fermentation.
3. Study of microbial of starter culture ('bakhar'). ?
4. Screening of food – borne molds for amylase production.
5. Immobilization of *S. cerevisiae* for study of bioconversion of glucose. ?
6. Microbial biomass production using pleurotussajor-caju / P. cringii etc.
7. Extraction of casein from milk.
8. Determination of milk quality by methylene blue reductase test.

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SEMESTER IV

MBT 401: ENVIRONMENTAL BIOTECHNOLOGY THEORY Credit: 4

After successful completion, this course enables students

CO1. To understand the environment around us and the organisms living in normal and extreme conditions of the environment.

CO2. To learn the utilization of the unique properties microorganisms living in the extreme habitats to remediate degraded environment: such as solid and liquid waste management.

CO3. To get the information on the ethical and safety issues concerned with Biotechnological experiments.

CO4. To get an insight into how microbes affecting aquatic health and what are the different approaches for monitoring and maintaining potability of water.

CO5. To familiarize with the important environmental roles played by microbes specifically in the light of sewage treatment, litter decomposition, maintenance of soil health and at the same time in metal recovery process (bioleaching).

Course Content	No. of Classes
Unit- I:Fundamentals ofEnvironmental Biotechnology 1. Environmental Biotechnology: definition, achievements, opportunities and challanges. Microbial process involvement in bio-composting, bio-fertilizers, bio-pesticides, and bio-weedicides. Bio-plastic and biosensors for environmental monitoring. 2. Microbes in normal (soil, water and soil) and extreme (thermophiles, acidophiles, alkaliphiles, psycrophiles, halophiles and xerophiles) environment. 3. Methanogens and their applications. Biochemical process of methanogenesis.	**15**
Unit- II:Microbes in Environmental Management 1. Involvement of microbes in domestic and industrial waste-water treatment: Solid Waste Management: Sources and types of solid waste, methods of disposal of solid waste (incineration, composting and sanitary landfill) Liquid Waste Management: Composition of sewage; strength of sewage (BOD and COD); Primary, secondary (aerobic–oxidation pond, trickling filter, rotating biological contractor/ biodisc system, activated sludge process and anaerobic–septic tank, imhoff tank, anaerobic digester) and tertiary sewage treatment. 2. Bioleaching: Concept and application of microbes in bioleaching of copper and gold, Microbial enhanced oil recovery (MEOR) technique.	**30**
Unit III: Bioremediation of Hazardous Waste 1. Bioremediation: Concept (*in situ* and *ex situ* bioremediation) and role of bioremediation in controlling various pollution problems (industrial and medical effluents,). Basic concept of phyto-remediation and myco-remediation. 2. Bioremediation of heavy metals, oil spills, plastics, cellulose and paper, xenobiotics.	**30**
Unit IV: Basic Techniques in Environmental Biotechnology 1. Environmental genomics/ metagenomics: a general account. 2. Environmental bio-safety: a general account. 3. Culture dependant and culture independent techniques in Environmental Biotechnology: ARDRA, DGGE, FAME profile analysis, G+C analysis.	**15**

Suggested Readings:

Textbooks-

3. Dubey, R.C. (1998). *A Textbook of Biotechnology*. S. Chand and Company Ltd. New Delhi.
4. Evans, G.M. and Furlong, J.C. (2003). *Environmental Biotechnology: Theory and Application*. John Wiley and Sons.
5. Jogdand, S.N.(2006). *Environmental Biotechnology*. Himalaya Publishing House.

6. Lohar, P.S.(2005). *Biotechnology*. MJP Publishers, Chennai.
7. Satyanarayan. *Biotechnology*.
8. Singh, B. D. (1998). *Biotechnology*. Kalyani publishers.

References-

1. Das, M.K. (2008). *Environmental Biotechnology and Biodiversity Conservation*. Daya Publishing House, New Delhi.
2. Harrison, R.M. (1992). *Understanding our Environment: Introduction to Environmental Chemistry and Pollution.* The Royal Society of Chemistry.
3. Liu, D.H.F. and Liptak, B. G. (2000). *Wastewater Treatment*. CRC Press.
4. Manahan, S.E. (1997). *Environmental Science and Technology*. Lewis, New York.
5. Metcalf and Eddy (Eds). (2003). Wastewater Engineering. Treatment and Reuse, Tata McGraw-Hill, New Delhi.
6. Nelson, G.C. (2001). *Genetically Modified Organisms in Agriculture: Economics and Politics*. Academic Press.
7. Ramakrishnan, P.S.; Campbell, J.; Demierre, L.; Gyi, A.; Malhotra, K.C.; Mehndiratta, S.; Rai, S.N. and Sashidharan, E.M. (1994). *Ecosystem Rehabilitaion of the Rural Landscape in South and Central Asia: An Analysis of Issues.* UNESCO Regional Office, New Delhi.
8. Singh, J.S. (1993). *Restoration of Degraded Lands: Concepts and Strategies*. Rastogi Publication.
9. Singh, O.P. (2005). *Mining Environment: Problems and Remedies*. Regency Publications.
10. Sharma, P.D. (1996). *Ecology and Environment*. Rastogi Publication.
11. Soetaert, W. and E.J. Vabdanne (2009). *Biofuels*.John Wiley and Sons.
12. Thomas, J.A. and Fuchs, R. (2002). *Biotechnology and safety Assessment*. Academic Press.
13. Wang, L.K., Hung, Y.T. and Shammas, N.K. Eds). (2006). *Advanced Physiochemical Treatment Processes*. Springer-Verlag New York. LLC.
14. Wise, D. L. (Eds). (1997). *Global Environmental Biotechnology*. Proceedings of the third international symposium on the international society for environmental biotechnology. Kluwer Academic Publishers, London.

MBT 402: Research Methodology THEORY Credit: 4

After successful completion, this course enables students

CO1. To understand the concept, types and criteria of research, addressing the identification of a research problem, objectives, designs and methodology to carry out a research work.

CO2. To get the basic knowledge on qualitative research techniques and on the collection and analysis quantitative data.

CO3. To get an insight in to formulating a hypothesis, data analysis for hypothesis-testing as well as formulation of research synopsis and report.

CO4. To have adequate knowledge on measurement and scaling techniques for analyzing research outcomes thereby enabling them in justifying their findings.

CO5. To develop data analytics skills and meaningful interpretation to the data sets so as to solve the business/ Research problem.

Course Content **No. of Classes**

Unit I: Fundamentals of Research Methodology **15**

1. Definition and Objectives of Research.
   Types (Descriptive, Analytical, Applied, Fundamental, Qualitative, Quantitave, Conceptual and Empirical) and Significance of Research.
2. Research Approaches. Research Methods versus Methodology.
   Criteria of a Good Research.

Unit II: Research Problem **10**

1. Definition of Research Problem. Necessity of defining Research Problem.Techniques involved in Defining

a Research Problem.

Unit III: Research Design **10**

1. Meaning and Need of Research Design, Important concepts related to Research Design. Features of a Good Design.

Unit IV: Data Collection **10**

1. Collection of Primary Data: Observation and Interview Methods, Collection of Data through questionnaires, Collection of Secondary Data.
2. Selection of Appropriate Methods for Data Collection.

Unit V: Data Analysis **15**

1. Processing and Analysis of Data; processing operations, problems in processing, simple regression, multiple correlation and regression analysis, T-test, Analysis of variation and co-variations; what is ANOVA, basic principle of ANOVA

Unit VI: Hypothesis Testing **15**

1. Concept of hypothesis and hypothesis testing, Important parametric tests; hypothesis testing of means.

Unit VII: Data Interpretation and Report Writing **15**

1. Meaning and Importance of Interpretation.Techniques of Interpretation, Significance of Report Writing.

Suggested Reading:

1. Kothari, C. R. (2004), Research Methodology: Methods and Techniques, New Age International Publishers.

MBT 403:

Practical on Environmental Biotechnology **Credit: 06** **Full Marks 100**

This practical course gives the idea of analytical methods used in biological laboratories, application such methods in solving issues related to the environment. After successful completion, this course enables students

CO1. To understand the quality/potability of water through bacteriological analysis of water samples.

CO2. To learn the laboratory methods for the estimation of Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) through which the condition of a water body can be determined.

CO3. To learn the estimation of nitrate/phosphate/silicate content of waste water which can make an aquatic system eutrophic.

CO4. To study of different physico-chemical parameters (pH, water holding capacity, soil moisture content, soil organic carbon, soil organic matter) of soil thereby to assess the nature of a particular soil.

CO5. To study different enzymatic processes carried out by microbes in soil including amylase and cellulase activity during decomposition of litter.

Course Content	**No. of Classes**
1. Qualitative analysis of water by MPN counts (for fecal coliforms) method. 2. Bacteriological analysis of water (presumptive, confirmed and completed test) 3. Study of amylase and cellulase activity of microbes. 4. Determination of Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) of water body. 5. Study of physico-chemical parameters (pH, water holding capacity, soil moisture content, soil organic carbon, soil organic matter) of soil 6. Estimation of nitrate/phosphate/silicate content of waste water.	**90**

MBT 404:

Dissertation Work and lab Visit Report

Credit: 4 **Full Marks 60 + 140**

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