Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar

(Autonomous)

(Affiliated to Savitribai Phule Pune University, Pune)

Choice Based Credit System (CBCS)

Master of Science (M.Sc.)

Syllabus of

M. Sc. (Biotechnology) Part-I

Implemented from

Academic year 2021 -22

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar (Autonomous)

Board of Studies in Biotechnology

Sr. No.	Name	Designation
1.	Dr. Shubhangi S. Moharekar	Chairman
2.	Dr. Sanjay T. Moharekar	Member
3.	Dr. Sarika R. Deshmukh	Member
4.	Mr. Ashish S. Wani	Member
5.	Prof. Dr. Bimalendu B. Nath	Vice-Chancellor Nominee
6.	Prof. Dr. Nitin S. Desai	Academic Council Nominee
7.	Dr. Jyoti P. Jadhav	Academic Council Nominee
8.	Mr. Nitin Shirole	Industry Expert
9.	Mr. Sachin R. Adsare	Alumni
10.	Dr. Aparnna A. Kulkarni	Member (co-opt)
11.	Mr. Girish P. Kukreja	Member (co-opt)

1. Prologue/ Introduction of the programme:

Biotechnology has grown, extensively in last couple of decades. This advanced 'interdisciplinary' life science branch encompasses areas viz. molecular biology, genetics, biochemistry, microbiology, immunology, virology, plant and animal tissue culture, chemistry and engineering. It is a fast emerging "cutting edge" science with distinctive advantages as it finds applications in practically all aspects of life.

The subject offers exciting opportunities in various fields from basic research to industry oriented career. Global and local focus has slowly shifted to using knowledge of life Science for innovative technology development that is being used for betterment of human life. Many fundamental research fields from cell biology to molecular biology, from biochemistry to biophysics, from genetic engineering to stem cell research, from bioinformatics to genomics-proteomics, from environmental biology and to biodiversity, from microbiology to bioprocess engineering, from bioremediation to Insilco drug discovery etc. comes under the umbrella of Biotechnology.

The proposed choice based credit curriculum and grading system will cater to the existing interdisciplinary nature of biotechnology can also offer many courses to the other branches of life science. The generative power of biological data is effectively harnessed by biotechnology like no other field. Economic and social renaissance is staged on biotechnology especially, since it's biomedical and cutting edge technological applications are tremendously powerful in shaping this century and exciting future. Keeping in view the expanse and applications of Biotechnology in every field, there is going to be a perpetual demand for resource personnel with Biotechnology specialization. The post graduate program is aimed to cater to this ever increasing demand and to groom the students to excel in their future career. Education and research sectors require such interdisciplinary trained workforce to develop future generations of science leaders.

2. Programme Outcomes (POs)

After successfully completing this course, the student should be able to:

- Understand the basic knowledge and concepts of biotechnology and other related areas.
- Understand the ability to apply their knowledge for practical which they can conduct independently.
- Apply their knowledge in other advanced subject area like bioinformatics, immunotechnology and animal and plant biotechnology for the betterment and advancement of their professional career.
- Learn the theoretical and practical exposure to the basic and the advanced fields of biotechnology.

Programme Structure and Course Titles

Sr. No.	Class	Semester	Course Code	Course Title	Credits
1.	M.Sc.-I	I	MSC-BT 111T	Advanced Biological Chemistry	04
2.	M.Sc.-I	I	MSC-BT 112T	Cell and Molecular Biology	04
3.	M.Sc.-I	I	MSC-BT 113T	Immunology	02
4.	M.Sc.-I	I	MSC-BT 114P	Practicals in Advanced BiologicalChemistry	02
5.	M.Sc.-I	I	MSC-BT 115P	Practicals in Cell and Molecular Biology	02
6.	M.Sc.-I	I	MSC-BT 116P	Practicals in Immunology	02
7.	M.Sc.-I	I	MSC-BT 117 T (A) MSC-BT 117 T (B)	Environmental Biotechnology **OR** Food Biotechnology	02
8.	M.Sc.-I	I	MSC-BT 118 P (A) MSC-BT 118 P (B)	Practicals in Environmental Biotechnology **OR** Practicals in Food Biotechnology	02
9.	M.Sc.-I	I	MSC-BT 119 T	Genetics	02
10.	M.Sc.-I	II	MSC-BT 211T	Genetic Engineering	04
11.	M.Sc.-I	II	MSC-BT 212T	Plant Biotechnology	04
12.	M.Sc.-I	II	MSC-BT 213T	Bacteriology	02
13.	M.Sc.-I	II	MSC-BT 214P	Practical in Genetic Engineering	02
14.	M.Sc.-I	II	MSC-BT 215P	Practicals in Plant Biotechnology	02
15.	M.Sc.-I	II	MSC-BT 216P	Practicals in Bacteriology	02
16.	M.Sc.-I	II	MSC-BT 217 T(A) MSC-BT 217 T(B)	Clinical Research **OR** Biostatistics	02
17.	M.Sc.-I	II	MSC-BT 218 P(A) MSC-BT 218 P(B)	Practical in Clinical Research **OR** Practical in Biostatistics	02

18.	M.Sc.-I	II	MSC-BT 219 T	Virology	02
19.	M.Sc.-II	III	MSC-BT 311T	Animal Biotechnology and Stem Cell Technology	04
20.	M.Sc.-II	III	MSC-BT 312T	Bioprocess Engineering	04
21.	M.Sc.-II	III	MSC-BT 313T	Bioinformatics	02
22.	M.Sc.-II	III	MSC-BT 314P	Practicals in Animal Biotechnology	02
23.	M.Sc.-II	III	MSC-BT 315P	Practicals in Bioprocess engineering	02
24.	M.Sc.-II	III	MSC-BT 316P	Practicals in Bioinformatics	02
25.	M.Sc.-II	III	MSC-BT 317T(A) MSC-BT 317T(B)	Agricultural Biotechnology **OR** Nanobiotechnology	02
26.	M.Sc.-II	III	MSC-BT 318 P(A) MSC-BT 318 P(B)	Practicals in Agricultural Biotechnology **OR** Practicals in Nano biotechnology	02
27.	M.Sc.-II	III	MSC-BT 319 T	Pharmaceutical Biotechnology	02
28.	M.Sc.-II	IV	M SC-BT 411T	Genomics and Proteomics	04
29.	M.Sc.-II	IV	MSC-BT 412T	Advanced Bio analytical Techniques	04
30.	M.Sc.-II	IV	MSC-BT 413T	Research Methodology and Scientific Communication	02
31.	M.Sc.-II	IV	MSC-BT 414P	Practicals in Bioanalytical Techniques	02
32.	M.Sc.-II	IV	MSC-BT 415P	Review and research article writing	02
33.	M.Sc.-II	IV	MSC-BT 416 T(A) MSC-BT 416 T(B)	Medical Biotechnology **OR** Entrepreneurship and Business Administration	02
34.	M.Sc.-II	IV	MSC-BT 417 P(A) MSC-BT 417 P(B)	Animal and Plant Physiology **OR** Ecology and Evolution	02
35.	M.Sc.-II	IV	MSC-BT 418 Pr.	Project	04
				Total Credits	88

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New Arts, Commerce and Science College, Ahmednagar
(Autonomous)

Syllabus of M.Sc. Biotechnology
under
Faculty of Science & Technology

Semester – I	
Course Code: MSC-BT 111 T	**Title of the Course: Advanced Biological Chemistry**
Credits: 04	**Total Lectures: 60**

Course Outcomes (Cos)

1. Learn concept of advanced biological chemistry.
2. Recall and correlate specific biomolecules their structure and function.
3. Understand significance of proteins, enzymes in diagnostics.
4. Understand the concept of secondary metabolites and phytochemical investigation.
5. Able to infer basic concept of metabolomics, nutritional disorders, Inborn errors of metabolism
6. Learn to apply the basic knowledge of advance biological chemistry.

Detailed Syllabus:

Unit I: (03)

- Overview of Biomolecules: Carbohydrate, lipid, nucleic acid, protein

Unit II: (14)

- Protein Chemistry: Structure of proteins - Primary, Secondary, Tertiary, Quaternary.
- Study of protein motifs, domain, fold and protein families.
- Protein folding mechanisms and Pathways - Molten globule, chaperons. protein misfolding and diseases
- Protein –protein interaction and protein –DNA interaction
- Protein Engineering and its applications, Peptides and Therapeutic Proteins

Unit III: (14)

- Enzymes: Concept of active site, binding sites, stereospecificity of enzyme and ES complex formation
- Enzyme activity & various factors influencing enzyme activity, enzyme inhibition
- Mechanism of enzyme action, enzyme regulation- allosteric enzyme, Isoenzymes, Ribozyme and abzyme, Multienzyme complexes

- Enzyme kinetics, rate of reactions, steady state enzyme kinetics, Michaelis-Menten equation form and derivation, significance of Vmax and Km, K/cat, bisubstrate reactions, graphical procedures in enzymology - Lineweaver Burke's Plot, Ediee Hofstee plot
- Clinical and industrial applications of enzymes, enzyme engineering and its applications

Unit IV: (07)

- Disorders of metabolism-Introduction,
- Nutritional disorder- Protein-energy malnutrition (PEM) (Kwashiorkar and Marasmus), obesity metabolic disorders- Diabetes
- Inborn errors of metabolism- i) Protein-PKU, Alkaptonuria, Maple syrup and Gaucher's disease ii) Carbohydrates - glycogen storage disorders, Cori's disease and Pome's disease iii) Lipids- Atherosclerosis, iv) Nucleic acids- Gout, Lesch-Nyhan syndrome

Unit V: (07)

- Metabolomics: Overview of metabolism, Integration of metabolism
- The Metabolome – Metabolic flux, metabolic flux analysis, Metabolic engineering – 2 eg. Polyketides synthesis, Xenobiotics

Unit VI: (15)

- Phytochemistry: Introduction to secondary metabolism, primary metabolite as precursors of secondary metabolite
- Biosynthetic pathways for secondary metabolite: 1. Mevalonate pathways 2. Shikimate Pathway 3. Malonic pathway
- Study of secondary Metabolite- 1. Alkaloids, 2.Phenolics, 3.Terpenoids
- Extraction methods: qualitative & quantitative analysis

Suggested Readings:

1. Proteins: Biotechnology and Biochemistry, 1st edition (2001), Gary Walsch,Wiley, USA
2. Phytochemical Method, 3rd edition (1998), A.J. Harborne, Springer, UK.
3. Pharmacognosy, 14th edition, (2008), Dr. C. K. Kokate, A. P. Purohit, S. B. Gokhale, NiraliPrakashan, India.
4. Trease and Evans' Pharmacognosy, 16th edition (2009), William Charles Evans, Saunders Ltd. USA.
5. Introduction to Practical Biochemistry, (2000), S. K. Sawhney, RandhirSinghNarosa, 2000. Practical Enzymology, 2nd edition (2011),HansBissWanger, Wiley-Blackwell, USA.
6. Biochemical Calculations, 2nd Ed., (1997) Segel Irvin H., Publisher: John Wiley and Sons, New York.
7. Enzymes: Biochemistry, Biotechnology & Clinical chemistry, (2001) Palmer Trevor, Publisher: Horwood Pub. Co., England.
8. Metabolic Engineering: Principles and Methodologies. (1998). Gregory N

Stephanopoulos, Aristos A Aristidou, Jens Nielsen. Publisher: Academic Press, San Diego, US

9. Outlines of Biochemistry: 5th Edition, Erice Conn & Paul Stumpf ; John Wileyand Sons, USA
10. Fundamentals of Biochemistry. 3rd Edition (2008), Donald Voet& Judith Voet ,John Wiley and Sons, Inc. USA
11. Lehninger, Principles of Biochemistry. 5th Edition (2008), David Nelson& MichaelCox, W.H. Freeman and company, NY.
12. Outlines of Biochemistry: 5th Edition, (2009), Erice Conn & Paul Stumpf ; JohnWiley and Sons, USA
13. Biochemistry: 7th Edition, (2012), Jeremy Berg, LubertStryer, W.H.Freeman and company, NY
14. An Introduction to Practical Biochemistry.3rd Edition, (2001), David Plummer,Tata McGraw Hill Edu.Pvt.Ltd. India
15. Biochemical Methods.1st , (1995), S.Sadashivam, A.Manickam, New Age International Publishers, India

Semester – I	
Course Code: MSC-BT 112 T	**Title of the Course: Cell and Molecular Biology**
Credits: 04	**Total Lectures: 60**

Course Outcomes (Cos)

1. Understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
2. Learn the cellular components which are used to generate and utilize energy in cells.
3. Learn DNA replication, recombination and repair, transcription and translation.
4. Understand the modern tools and techniques of genomics and isolation and identification of genes.
5. Learn the biology and application of antisense technologies and biology of cancer.

Detailed Syllabus:

Unit I: (08)

- Cellular Transport- Transport across plasma membrane, Mechanism of vesicular transport
- Organelles and membrane trafficking: Protein sorting and transport: Endoplasmic Reticulum, Golgi apparatus and Lysosome, Mitochondria, Chloroplast
- Mechanism of nerve transmission- electrical and chemical transmission

Unit II: (12)

- Cell signaling: signaling molecules and their receptors
- Second messengers, signaling through G-protein coupled receptors
- Signal transduction pathways: JAK STAT, RAS-MAP Kinase TGF-β, NF-kB Pathway.
- Cell–matrix interactions: matrix structural protein; collagen
- Matrix polysaccharide; glycosaminoglycans (GAGs), adhesion protein; fibronectin
- Cell–cell Interactions: Cell adhesion molecules: selectins, integrins, immunoglobulin (Ig) superfamily cadherins
- Cell junctions: tight communication, anchoring junction

Unit III: (10)

- Cell cycle and its regulation
- Cell differentiation, cell transformation in plants and animals
- An over view of mechanics of cell division (mitosis and meiosis)
- Cell cycle checkpoints: role of cyclins, cyclin dependent kinases inhibitors.
- Assembly and disassembly of cytoskeletal elements, role in cell division
- Cell death pathways: Types of cell death, necrosis, programmed cell death
- Apoptosis: role of Caspases , Pro-apoptotic and antiapoptotic proteins
- Extrinsic and intrinsic pathway and Granzyme mediated pathway

- Etiology of cancer: the development and causes of cancer
- Oncogenes and tumor suppressor genes

Unit IV: (10)

- Chromatin organization and remodeling, chromosome, eukaryotic and prokaryotic DNA polymerases
- DNA-replication, recombination (homologous and site-specific recombination, NHEJ, Rec BCD pathway), mutations and DNA repair (photo reactivation, excision repair, posttranscriptional repair, mismatch repair and SOS repair)
- Transposable genetic elements in prokaryotes and eukaryotes

Unit V: (10)

- Transcription: eukaryotic and prokaryotic RNA polymerases
- Transcriptional initiation, elongation and termination
- Inhibitors of transcription; post-transcriptional modifications: capping, tailing and splicing, Gene Silencing: RNAi

Unit VI: (10)

- Translation: protein translation machinery (ribosomes, mRNA, tRNA, rRNA, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase)
- Mechanism of initiation, elongation and termination, and translational proof-reading, genetic codes,
- Co- and post-translational modifications, translational inhibitors, post translational modifications, protein turnover and degradation

Suggested Readings:

1. Molecular Cell Biology. 7th Edition, (2012) Lodish H., Berk A, Kaiser C., KReiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P. Scott M.P., W.H. Freeman and Co., USA
2. Molecular Biology of the Cell, 5th Edition (2007) Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Garland Science, USA
3. Cell Biology, 6th edition, (2010) Gerald Karp. John Wiley & Sons., USA 4. The Cell: A Molecular Approach, 6th edition (2013), Geoffrey M. Cooper, Robert E. Hausman, Sinauer Associates, Inc. USA 5. Genes XI, 11th edition (2012), Benjamin Lewin, Publisher - Jones and Barlett Inc. USA
6. Molecular Biology of the Gene, 6th Edition (2008), James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick. Pearson Education, Inc. and Dorling Kindersley Publishing, Inc. USA
7. Molecular Biology, 5th Edition (2011), Weaver R., McGrew Hill Science. USA
8. Fundamentals of Molecular Biology, (2009), Pal J.K. and SarojGhaskadbi, Oxford University Press. India
9. Molecular Biology: genes to proteins, 4th edition (2011), Burton E Tropp, Jones & Bartlett Learning, USA

Semester – I	
Course Code: MSC-BT 113 T	**Title of the Course: Immunology**
Credits: 02	**Total Lectures: 30**

Course Outcomes (Cos)

1. Understand the basic concept of innate and acquired immunity.
2. 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.
3. Understand the basic mechanisms of hypersensitivity responses and their associations with different diseases.
4. Provide basic understanding of immunology and immune responses in response to various infectious and non-infectious diseases.

Detailed Syllabus:

Unit I: (07)

- Immunology: fundamental concepts and overview of the immune system
- Overview of innate and acquired immune system and phagocytosis, complement system and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP).
- Concept of antigens and immunogens, primary and secondary lymphoid organs.
- Immunogenetics: Major histocompatibility complex: MHC genes, MHC and immune responsiveness and disease susceptibility
- Multigene organization of immunoglobulin genes, immunoglobulin super family
- Inflammation and autoimmunity

Unit II: (05)

- B cell immune response:
- Immunoglobulins -basic structure, classes & subclasses of immunoglobulins
- Antigenic determinants, B-cellreceptor
- Principles of cell signaling; basis of self& non-self-discrimination; memory;
- B cell maturation, activation and differentiation; generation of antibody diversity

Unit III: (06)

- T Cell immune response:
- T-cell maturation, activation and differentiation
- T-cellreceptors; functional T Cell subsets;
- Cell-mediatedimmune responses (ADCC), Components of ADCC cytokines: properties, receptors and therapeuticuses.

- Antigen processing and presentation- endogenous antigens,exogenous antigen hypersensitivity and it's types, immune response during Bacterial(TB) and Viral (HIV) infections

Unit IV: (06)

- Techniques in immunology:
- Difference between precipitation and agglutination
- Advanced immunological techniques: Radio Immuno Assay (RIA), Enzyme Linked Immunosorbent Assay (ELISA), Enzyme Linked Immunosorbent Spot assay (ELISPOT), Western blotting. Immune fluorescence microscopy, Immunoelectron microscopy, Flow cytometry- FACS, FISH and GISH

Unit IV: (06)

- Vaccinology:
- Historical background of Vaccine development, Active and passive immunization
- Live, killed, attenuated, subunit vaccines.
- Vaccine technology: recombinant DNA, protein based vaccines and peptide vaccines, plant-based vaccines, , conjugate vaccines; T cell based vaccine,(With one example of each)
- Generation of monoclonal antibodies, hybridoma technology

Suggested Readings:

1. Roitt's Essential Immunology
2. Immunobiology:The immune system in health and disease by Charles Janeway et al
3. Kuby Immunology

Semester – I	
Course Code: MSC-BT 114 P	**Title of the Course: Practicals in Advanced BiologicalChemistry**
Credits: 02	**Total Hours: 60**

Course Outcomes (Cos)

1. Understand Isolation and purification of Enzyme from crude source.
2. Learn to perform purification of protein by column chromatography.
3. Understand methods of protein separation by SDS PAGE
4. Learn to extract phytochemicals from different plant sources.
5. Understand the qualitative and quantitative estimation of phytochemicals.

Detailed Syllabus:

S.No.	Title	Number of Practicals (15)
1	Extraction of protein/enzyme, determination of enzyme activity and specific activity	1
2	Precipitation of protein/enzyme (salt and solvent)	1
3	Desalting by dialysis	1
4	Purification of protein/enzyme by column chromatography (Gel filtration/ Ion exchange/Affinity)	1
5	Characterization of protein/enzyme by Native & SDS-PAGE	2
6	Effect of pH and temperature on enzyme activity	1
7	Effect of incubation time and inhibitor on enzyme activity	1
8	Effect of various substrate concentration on enzyme activity and determination of Km and Vmax by LB plot	2
9	Extraction of phytochemicals (aqueous & organic solvents)	1
10	Soxhlet extraction of phytochemicals	1
11	Qualitative detection – analysis of phytochemicals by TLC	1
12	Quantitative estimation of alkaloid and phenolic	1

Semester – I	
Course Code: MSC-BT 115 P	**Title of the Course: Practicals in Cell and Molecular Biology**
Credits: 02	**Total Hours: 60**

Course Outcomes (Cos)

1. Learn to isolate nuclei and chromatin
2. Determine the Mononucleosome size by agarose gel electrophoresis.
3. Analyze the histones of genetic material
4. Interpretation of Electron micrographs
5. Learn to isolate mitochondria and lysosomes.
6. Understand and perform methods of maceration and programmed cell death.

Detailed Syllabus:

S.No.	Title	Number of Practicals (15)
1	Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation	1
2	Isolation of nuclei and chromatin, analysis by agarose gel electrophoresis	2
3	Extraction and Analysis of Histones	2
4	Isolation of RNA and analysis by agarose gel electrophoresis	1
5	Demonstration of PCR/RT-PCR using suitable genes	1
6	Isolation of mitochondria and assay of SDH activity	1
7	Isolation of lysosomes and assay of acid phosphatase activity	1
8	Programmed cell death during limb development In Chick	1
9	Separation of leucocytes by dextran method.	1
10	Staining of animal cells (Histone by Fast green; DNA by Fuelgen; RNA by Methyl green Pyronin).	2
11	Karyotyping and Ideogram construction in onion roots using Colchicine treatment	1
12	Visit to animal house or any Research Laboratory and Industry, Report writing.	1

Semester – I	
Course Code: MSC-BT 116 P	**Title of the Course: Practicals in Immunology**
Credits: 02	**Total Hours: 60**

Course Outcomes (Cos)

1. Learn to perform ELISA and immunodiffusion.
2. Understand the concepts and procedures of Immunoelectrophoresis and Rocket immunoelectrophoresis.
3. Demonstrate the technique of Western blotting and perform Widal's test.

Detailed Syllabus:

S.No.	Title	Number of Practicals 14
1	Widal test	1
2	Radial lmmuno diffusion	1
3	Ouchterlony double diffusion	1
4	lmmuno-electrophoresis	2
5	Rocket immuno-electrophoresis	1
6	DOT ELISA	1
7	Antibody titer by ELISA method	2
8	Western blotting	2
9	Case study on Flow cytometry analysis	1
10	Immunofluorescence microscopy(case study)	2

Semester – I	
Course Code: MSC-BT 117 T(A)	**Title of the Course: Environmental Biotechnology**
Credits: 02	**Total Lectures: 30**

Course Outcomes (Cos)

1. The student will be able to evaluate the potential of biodegradation of organic pollutants, taking microbial and physical/chemical environments, as well as the chemical structure of the compound itself, into consideration.
2. Students will understand the phenomenon of phytoremediation for the decontamination of soil and water, wetlands as treatment processes, biofilms/biofilters for vapor-phase wastes, and composting.
3. Students will learn about the environmental quality evaluation, monitoring, and remediation of contaminated environments.
4. Students will learn about the use of biosensors in environmental analysis, environmental engineering.

Detailed Syllabus:

Unit I: (03)

- Energy and Environment
- Introduction to environmental Science
- Bio-energy resources and their exploitation: Overview of biomass as an energy source, Thermal characteristics of biomass as fuel.
- Scientific aspects and prospects of biofuel production (Biodiesel, bioethanol, biogas)

Unit II: (09)

- Threats to Environment
- Global and regional threats to the environment
- Environmental Pollution (Air, Water and Soil) and its impact on environment (biotic & abiotic), transport, diffusion and monitoring of pollutants
- Future scenarios of the global environment, causes and consequences of climate change (greenhouse effect and global warming, Ozone hole, Sea level rise)
- Carbon foot prints, Carbon sequestration (biological) and Carbon credit
- Role of biotechnology in biodiversity conservation

Unit III: (05)

- Waste management
- Waste water (Sewage) management: Sources of waste water and its impact on environment
- Biological waste water treatment methods
- Solid waste management: Sources and types, impact of solid waste disposal, recycle, reuse and recovery solutions (Solid waste management with composting, vermicomposting)

Unit IV: (05)

- Bioremediation: removing pollutants from environments
- Introduction to use of biological agents in pollution control, advantages, limitations and applications
- Types of bioremediation and factors affecting: natural, engineered, *Ex-situ* and *in-situ* principles and methods in: Bio-augmentation, Bio-stimulation, phytoremediation
- Xenobiotic degradation, Biomining/Bioleaching, Biomethanation

Unit V: (03)

- Environment monitoring
- Applications of remote sensing and GIS in environmental monitoring
- Environmental impact assessment: introduction, objectives, classification, guidelines, case study
- International and indian eco-standards
- ISO 14000 series overview

Unit VI: (05)

- Environmental Laws and Policies
- International: In the view of global concerns, objectives of laws/regulations, importance: Stockholm conference, Montreal protocol, Rio conference and Kyoto protocol
- India: In the view of national concerns, objectives of laws/regulations, importance etc.
- The Environment Protection Act 1986, the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules

Suggested Readings:

1. Advanced Renewable Energy Sources (2012) Gopal Nath Tiwari and R K Mishra, RSC Publishing, London.
2. Agenda 21: Guidelines for Stakeholders Patwardhan & Gunale, Pune.
3. Air Pollution (2004) HVN Rao and M N Rao Tata McGraw-Hill, , New Delhi
4. Air Pollution Control CP Mahajan, Capital Publishing Co, New Delhi
5. Air Pollution Engineering Manual (2000) Wayne T Davis (editor), Air and Waste Management Association, Wiley Interscience,, New Jersey
6. An Introduction To Geographic Information Technology (2009) Suchandra Choudhury I K International Pvt Ltd., New Delhi
7. Bioremediation (1994) Baker, K.H and Herson, D.S.Mc Graw Hill, Inc. New York
8. Biotreatment of Industrial & Hazardous Waste (1993) M.V.Levin and Gealt, M.A McGraw Hill. Inc, New York
9. Concepts and Techniques of Geographic Information Systems (2009) C.P.Lo.Albert and K.W.Yeung 2nd edition, Prentice Hall, Inc., New Jersey
10. Ecology and environmental biology (2011) Saha T K Books & Allied (p) Ltd, Delhi
11. Environment Problems & Solutions (2001) Asthana & Asthana S. Chand Limited, New Delhi

Semester – I	
Course Code: MSC-BT 117 T(B)	**Title of the Course: Food Biotechnology**
Credits: 02	**Total Lectures: 30**

Course Outcomes (Cos)

1. Students shall become aware of fundamentals of food biotechnology
2. Critically evaluate and solve issues or problems pertaining to food science.
3. Students should be able to gain in-depth understanding of biotechnology of fermented foods.
4. Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

Detailed Syllabus:

Unit I: (10)

- Microbes in food spoilage & control:
- Types of microorganism normally associated with food: mold, yeast, and bacteria and their control
- Biochemical changes caused by microorganisms, in spoilage of various types of food products.
- Food poisoning and microbial toxins, food borne intoxicants and mycotoxins.
- Microbial biotechnology:
- Fermentation technology- use of microbes in the production of alcoholic beverages (Beer, Wine), bread, yogurt, organic acid (Lactic acid), pigments, flavors, sweeteners
- Applications of Amylases, Proteases, Lipases, Cellulases, Pectinases enzymes in food processing

Unit II: (10)

- Nutrigenomics:
- Applications of nutrigenomics in the food industry
  Ethical concerns, Safety and Regulatory issues of biotechnological products
- Prebiotics and Probiotics: Food Sources- Prebiotics [Dietary fiber, Oligosaccharides (Galacto-oligosaccharides, Fructo-oligosaccharides), Resistant Starch, Sugar alcohols] and probiotics
- Strains of microorganisms used as probiotics
- Role in health and disease, Mechanism of action, levels of probiotics required for therapeutic efficacy

Unit III: (10)

- Nutraceuticals:
- Concept of nutraceuticals and functional foods
- Major nutraceuticals and their health applications- Bioactive peptides, Curcumin, Conjugated Linoleic acid, Glucosamine, Carnitine, Creatine
- Quality Improvement: concepts of quality control and quality assurance in food industries
- TQM, principals of TQM

- Food Laws and Regulations: Food laws and standards: National and International food laws, Mandatory and voluntary food laws.
- Indian Food Regulations and Certifications: Food Safety and Standards Act, FSSAI Rules, Duties and responsibilities of Food Safety Authorities

Suggested Readings:

1. Anthony Pometto (2005). Food Biotechnology, 2nd Edition. CRC Press
2. Byong H Lee (2014). Fundamentals of Food Biotechnology, 2nd Edition, Wiley- Blackwell
3. Goldberg, I 1994. Functional Foods: Designer Foods, Pharma foods, Nutraceuticals Chapman & Hall
4. Gibson, GR and William, CM. 2000. Functional foods - Concept to Product. Woodhead publishing.
5. Aluko, R.E. (2012). Functional Foods and Nutraceuticals. Springer
6. InteazAlli. 2004. Food Quality Assurance: Principles and Practices. CRC Press, Boca Raton, FL, USA.
7. Ronald H. Schmidt and Gary E Rodrick. 2003. Food Safety Handbook. John Wiley & Sons, Inc.,Hoboken. New Jersey, USA.

Semester – I	
Course Code: MSC-BT 118 P(A)	**Title of the Course: Practicals in Environmental Biotechnology**
Credits: 02	**Total Hours: 60**

Course Outcomes (Cos)

1. Learn to isolate the microorganism from polluted soil.
2. Estimate TSS, DO, BOD and COD of waste water.
3. Interpretation of "Google Earth" images for the known and unknown area for land use.
4. Understand the method of estimation of biodegradation of pesticide/ insecticide/fungicide.

Detailed Syllabus:

S.No.	Title	Number of Practicals 14
1	Genotoxicity assay on polluted water- Onion root tip and pollen germination assay.	2
2	Isolation of microorganisms from different habitats/niches and enumeration of its bioremediation potential	2
3	Removal/estimation of pollutant from soil/water samples by biostimulation/bioaugmentation/phytoremediation	2
4	Qualitative estimation of biodegradation of pesticide/insecticide/fungicide.	1
5	Estimation of Total suspended solids of waste water	1
6	Determination of dissolved oxygen concentration of water sample	1
7	Determination of chemical oxygen demand (COD) of sewage sample.	1
8	Determination of biological oxygen demand of sewage sample	1
9	Acquisition of "Google Earth" images for the known and unknown area for land use - land cover mapping.	1
10	Review on EIA case study.	2

Semester – I	
Course Code: MSC-BT 118 P(B)	**Title of the Course: Practicals in Food Biotechnology**
Credits: 02	**Total Hours: 60**

Course Outcomes (Cos)

1. Students should be able to understand various aspects of food processing and different processes used for different type of food products.
2. They should also be able to analyse quality of processed and raw food products.
3. Students should be able to perform various biotechnological practicals important in food industry

Detailed Syllabus:

S.No.	Title	Number of Practicals 15
1	Determination of Gluten content in wheat flour samples	1
2	Determination of adulterant ($NaHCO_3$) in wheat flour/ maida	1
3	Microbial pigment production using fermentation technology	2
4	Preservation of food: Pasteurization Preservation of pickles/jam/jelly	2
5	Production of beer/flavor	2
6	Production of enzyme and its application	2
7	Production and evaluation of probiotic food	1
8	Estimation of salt content in butter	1
9	Proximate analysis of food sample: Determination of moisture, carbohydrate and protein content of food	2
10	Visit to food processing industry like distilleries and breweries	1

Semester – I	
Course Code: MSC-BT 119 T	**Title of the Course: Genetics**
Credits: 02	**Total Lectures: 30**

Course Outcomes (Cos)

1. On successful completion of this course, student will be able to describe fundamental molecular principles of genetics
2. Understand relationship between phenotype and genotype in human genetic traits
3. Describe the basics of population genetics
4. Understand the human genetic disorders and methodologies for its detection

Detailed Syllabus:

Unit I: (06)

- Basics of Genetics - Mendelian Genetics: Laws of heredity and modifications of monohybrid interactions (incomplete dominance, codominance and over dominance, multiple alleles, lethal genes), dihybrid cross, back-cross and test- crosses
- Gene interactions - dominant and recessive epistasis, duplicate genes, complementary genes and dominant & recessive interactions, pleiotropy

Unit II: (06)

- Population genetics- Hardy –Weinberg principle and its applications
- Factors affecting Hardy Weinberg equilibrium (selection, mutation, migrations and genetic drift)
- Population bottlenecks effect, founders effect, inbreeding and estimation of inbreeding coefficient, In-breeding depression, heterosis

Unit III: (10)

- Genetic disorders- chromosomal aberrations and syndromes
- Changes in chromosomal number: euploidy, aneuploidy, polyploidy, mosaics, trisomy and monosomy.
- Changes in chromosomal structure: translocation, inversion, duplication, deletion.
- Mendelian disorders : Autosomal and sex-linked disorders, pedigree analysis

Unit IV: (08)

- Human genetics and methodologies- clinical genetics, diagnostic tools and techniques for human genetic disorder
- Genetics of complex genetic diseases- hypertension, diabetes and Alzheimer’s
- Genetics of cancer (oncogenes and tumor suppressor genes)

Suggested Readings:

1. Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett.
2. Pierce, B. A. (2005). Genetics: a Conceptual Approach. New York: W.H. Freeman.
3. Tamarin, R. H., & Leavitt, R. W. (1991). Principles of Genetics. Dubuque,IA: Wm. C. Brown.
4. Smith, J. M. (1998). Evolutionary Genetics. Oxford: Oxford University Press

Semester – II	
Course Code: MSC-BT 211 T	**Title of the Course: Genetic Engineering**
Credits: 04	**Total Lectures: 60**

Course Outcomes (Cos)

1. Familiarize 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
2. Learn the applications of genetic engineering in biological research.
3. Understand to perform basic genetic engineering experiments at the end of course.
4. Acquire the knowledge of advances in biotechnology- healthcare, agriculture and environment cleanup via recombinant DNA technology.

Detailed Syllabus:

Unit I: (12)

- Introduction to recombinant DNA Technology, general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing
- Labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes,
- Hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.

Unit II: (12)

- Different types of vectors- Plasmids and Bacteriophages vectors: M13 mp vectors, pUC and phagemids, Lambda vectors, Insertion and Replacement vector, Cosmids
- Artificial chromosome vectors (YACs; BACs)
- Expression vectors: pMal; GST; pET-based vectors;
- Mammalian expression and replicating vectors, Baculovirus vectors system, yeast vectors, shuttle vectors

Unit III: (12)

- Principles of PCR, primer design; fidelity of thermostable enzymes; DNA polymerases
- Types of PCR – multiplex, nested; reverse- transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; PCR based site specific mutagenesis; PCR in molecular diagnostics for viral and bacterial detection;
- Sequencing methods: enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing
- Mutation detection: SSCP, DGGE, RFLP.

Unit IV: (12)

- Gene manipulation and protein-DNA interaction
- Insertion of foreign DNA into host cells; transformation, electroporation, transfection
- Construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries
- Study of protein-DNA interactions: electrophoretic mobility shift assay; DNase foot printing; methyl interference assay, chromatin immunoprecipitation.

Unit V: (08)

- Gene silencing, genome editing and applications
- Gene silencing techniques; introduction to siRNA; siRNA technology; construction of siRNA vectors; principle and application of gene silencing; gene knockouts, Genome editing by CRISPR-CAS with examples
- Gene therapy – ex vivo, in vivo, gene delivery systems, viral and non-viral. DNA fingerprinting, genetically engineered biotherapeutics and vaccines and their manufacturing, transgenic animals and Bio-pharming.

Suggested Readings:

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: An Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
4. Selected papers from scientific journals, Particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab

Semester – II	
Course Code: MSC-BT 212 T	**Title of the Course: Plant Biotechnology**
Credits: 04	**Total Lectures: 60**

Course Outcomes (Cos)

1. Learn the principles and technical advances behind the in vitro culture of plant cells and rDNA techniques
2. Learn the applications of plant transformation for improving the productivity and performance of plants under biotic and abiotic stresses
3. Understand the concept of antisense technologies for improvement of crop plants.
4. Learn the concept and applications of transgenic plants.

Detailed Syllabus:

Unit I: (20)

- Plant tissue culture and its applications
- Overview of plant tissue culture
- Micropropagation- concept, stages of micropropagation (stage 0 to stage 4),
- Methods/approaches of micropropagation: a) Axillary bud/shoot proliferation, b) Adventitious bud formation, c) Organogenesis and d) Somatic embryogenesis and artificial seeds
- Application of micropropagation
- Somaclonal variations
- *In vitro* androgenesis and its applications,
- Protoplast isolation, somatic hybridization, cybridization and their applications
- Suspension culture: Production of bio active secondary metabolites by plant tissue culture.
- Plant tissue culture for production of disease/virus free plants and superior plant varieties (embryo rescuing) seedless plants (endosperm culture).
- Methods and techniques of preservation of plant cultures and its revival

Unit II: (06)

- Algal and fungal biotechnology
- Qualitative/Quantitative improvement in economically important Algae with one example (Biofuels, Pigments, Single cell proteins)
- Qualitative/Quantitative improvement in industrially important Fungi like yeast, mushrooms

Unit III: (12)

- Methods of transformation in plants
- Direct methods of transformation: 1. Physical methods of plant Transformation 2. Chemical methods of plant Transformation 3. In planta

- Indirect Methods of transformation: Agrobacterium mediated gene transfer: Ti plasmid & Ri Plasmid vectors
- Mechanism of T-DNA transfer to plants
- Agro infection, plant viral vectors
- Selectable markers, reporter genes and promoters used in plant vectors and their role in genetic transformation

Unit IV: (14)

- Transgenic plants
- Transgenic plants for biotic (weeds, insects, viruses, fungi and bacteria) and abiotic stress (drought, salt, temperature, and oxidative stress) tolerance
- Increase in productivity by manipulation of photosynthesis and nitrogen fixation,
- Concept of synthetic biology for production of bioactive secondary metabolites
- Molecular farming (improvement in protein, lipids, carbohydrates), vaccines, antibodies, therapeutic proteins
- Approaches to marker-free transgenics
- Debate over GM crops

Unit V: (08)

- Marker assisted plant breeding and QTL mapping
- Overview of markers
- QTL mapping and techniques
- Important properties of ideal markers for MAS and practical applications of MAS.
- Marker-assisted backcrossing
- Marker-assisted gene pyramiding

Suggested Readings:

1. Chawla HC (2004) – Introduction to plant biotechnology (Science Publ)
2. Davies K (Ed) (2004) – Plant pigments and their manipulation – Annual plant reviews, vol 14 (BlackwellPubl)
3. Altman A, Hasegawa PM (Ed) (2012) – Plant Biotechnology and agriculture. Prospects for the 21st century (Academicpress).
4. Bhojwani SS. & Razdan MK (1996). - Plant Tissue Culture: Theory & Practice(Elsevier).
5. Slater A, Scott NW, Fowler MR (2008) – Plant Biotechnology: the Genetic Manipulation of plants (Oxford Press)
6. Vasil IK, Thorpe TA (1994) – Plant cell and tissue culture(Springer)
7. H K Das Textbook of Biotechnology 4th edition
8. Plant Cell and Tissue Culture. A Laboratory manual 1994. Reinert J andYeoman MM Springer
9. Biotechnology in Crop Improvement, H S Chawla. International BookDistributing Company1998
10. Practical Application of Plant Molecular Biology. RJ Henry. Chapman and Hall1997

11. Elements of Biotechnology, P.K. Gupta. Rastogi and Co., Meerut1996
12. A Text Book of Biotechnology, HD Kumar (WEpub.)
13. Gene transfer to Plants 1995, Polykus I and Spongernberg, G. Ed. Springer Scam.
14. Molecular Approaches to Crop Improvement1991. Dennis Liwelly Eds. PP16
15. Plant Biotechnology 1994, Prakash and Perk, Oxford & IBH Publishers Co
16. Plant Cell and Tissue Culture. A Laboratory manual 1994. Reinert J and Yeoman MM Springer.
17. Plant Biotechnology: An Introduction to Genetic Engineering by Adrian Slater, Nigel W. Scott, Mark R. Fowler. Oxford University Press, 2008.
18. Anderson, J.A., S. Chao, and S. Liu, 2007: Molecular breeding using a major QTL for Fusarium head blight resistance in wheat. Crop Sci.4.
19. Rai M (2009) – Fungal Biotechnology (IK International)
20. Handbook of Microalgal Culture: Applied Phycology and Biotechnology, Second Edition Editor(s): Amos Richmond Ph.D., Prof. Emeritus,, Qiang Hu Ph.D.,
21. Algae Biotechnology Products and Processes Editors: Bux, Faizal, Chisti, Yusuf (Eds) Springer
22. Advances In Algal Cell Biology by Heimann K, De Gruyter
23. Heffner, E.L., M.E. Sorrells, and Jannink, J.-L. 2009. Genomic selection for crop improvement. Crop Sc. 49:1-12.

Semester – II	
Course Code: MSC-BT 213 T	**Title of the Course: Bacteriology**
Credits: 02	**Total Lectures: 30**

Course Outcomes (Cos)

1. Describe bacterial cell structure and function.
2. Learn the various methods in Bacteriology to isolate and maintain the bacteria.
3. Understand the applications of bacteriology in environment and industries.

Detailed Syllabus:

Unit I: (13)

- Taxonomy and Diversity of Bacteria: Taxonomy, binomial nomenclature, types of bacterial classification systems
- New approaches to bacterial taxonomy (numerical taxonomy, ribotyping, rRNA sequencing, fatty acid profile)
- Ribosomal RNA analyses for tracing microbial evolution, genetic basis of evolution, evolution of physiological diversity
- The measurement of microbial diversity, Measures and indices of diversity
- Concept of 'unculturable' bacterial diversity
- Strategies for culture of 'unculturable' bacteria
- Taxonomic significance of protoplast, spheroplast, Lforms, mycoplasma
- Extremophiles: Molecular adaptations
- Metabolic diversity in bacteria (nutritional classification and metabolic diversity of bacteria with specific examples)

Unit II: (06)

- Ultrastructure of bacteria
- Cell wall (Gram positive, Gram negative and Archea),
- Cell membrane (Gram positive, Gram negative and Archea),
- Endospore (formation, germination, genetic basis and structure),
- Flagella, axial filament and Motility (assembly, chemotaxis mechanism)
- Fimbriae, Pilli, Capsule, S layer, Cell inclusions

Unit III: (11)

- Applied Bacteriology: Bacteriology and Public health
- Antibacterial agents with mode of action (natural and synthetic), multidrug resistance in bacteria (cause and effect), mechanisms of development of drug resistance of Methicillin Resistant Staphylococcus aureus (MRSA). plasmid curing a possible approach for overcoming drug resistance

- Current trends in bacteriology, Threats of bioterrorism
- Quorum sensing in bacteria, biofilms: Significance in bacterial virulence and antibiotic resistance (one example each)
- Bacteriology and agriculture: Plant growth promoting bacteria (nitrogen fixation, phosphate solubilization, auxin production etc.)
- Siderophores – structure, function and significance
- Bacteriology and environment: Applications of extremophiles in biotechnology, Microbial Fuel Cells (MFCs), bioluminescence, biosurfactants
- Current topics/ recent developments of bacteriology

Suggested Readings:

1. Introduction to Microbiology. 3rd Edition, (2004), Ingraham JL and Ingraham CA. Thomson Brooks / Cole.
2. Brock's Biology of Microorganisms. 11th Edition, (2006). Madigan MT, Martinko JM.
3. Pearson Education Inc., USA
4. Fundamental Principles of Bacteriology. 7th Edition, (1971) Salle AJ. Tata MacGraw Publishing Co. India
5. Microbiology: An introduction, 5th edition,(1992), Tortora, G.J., Funke B.R., Case C.L, Benjamin Pub.Co. NY
6. Microbiology, 4th edition (1990), Davis B.D. ,Debacco, J.B. Lippincott Co. NY
7. Zinsser, W , 1976, Microbiology Edition, W .K Joklik, NY
8. Medical Bacteriology, 14th edition, (1988), Dey, N.C and Dey, TK., Allied Agency, India
9. Text book of microbiology 5th edition (1996), Ananthnarayana, R. and C.E, Jayaram Panakar, Orient Longman.
10. General Microbiology, 5th edition (1987), Stanier R.Y., Adelberg E.A. and Ingraham J.L..Macmillan Press Ltd.
11. Prescott L.M., Harley J.P., and Klein D.A. (2005). Microbiology, 6th Edition. Mac Graw Hill Companies Inc.
12. Principles of Virology 3rd edition, (1999), Flint Jane. S., ASM (American Society of Microbiology) Press Publisher, USA.
13. Field's Virology - 2 volumes, 5th edition, (2006), Bernard.N. Fields, Lippincott and Williams Wilkins, USA
14. Microbiology: An introduction, 5th edition,(1992), Tortora, G.J., Funke B.R., Case C.L, Benjamin Pub.Co. NY

Semester – II	
Course Code: MSC-BT 214 P	**Title of the Course: Practical in Genetic Engineering**
Credits: 02	**Total Hours: 60**

Course Outcomes (Cos)

1. Learn to isolate plasmid DNA, its digestion and ligation.
2. Understand to perform transformation of *E.coli*.
3. Learn to perform southern blotting and hybridization, Northern blotting.
4. Learn the DNA amplification by PCR
5. Understand the amplification by RAPD/AFLP Markers

Detailed Syllabus:

Sr. No.	Title	No of Practicals 15
1	Plasmid DNA isolation and DNA quantitation	1
2	Restriction enzyme digestion of Lambda DNA	1
3	Vector and Insert DNA ligation	1
4	Preparation of competent cells	1
5	Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency	2
6	GFP Cloning	1
7	Primer Design and Polymerase Chain Reaction	2
8	Restriction fragment length polymorphism	1
9	Southern blotting and hybridization	2
10	Northern blotting and hybridization	2
11	Amplification by RAPD/AFLP markers	2

Semester – II	
Course Code: MSC-BT 215 P	**Title of the Course: Practicals in Plant Biotechnology**
Credits: 02	**Total Hours: 60**

Course Outcomes (Cos)

1. Acquire the knowledge about the techniques of Plant Tissue Culture, Lab. organization & measures adopted for aseptic manipulation and nutritional requirements of cultured tissues.
2. Learn the techniques of culturing tissues, single cells, protoplasts & anther culture, germplasm conservation and cryobiology.
3. Understand the large scale clonal propagation of plants through various micro propagation techniques, Production of secondary metabolites under in vitro conditions.
4. Learn the concepts of r-DNA technology, methods of gene transfer, molecular markers and marker assisted selection.
5. Develop transgenic plants resistant to biotic & abiotic stresses & quality characteristics and their role in crop improvement

Detailed Syllabus:

Sr. No.	Title	No of Practicals 14
1	*Chlorella* or *Spirulina* culture establishments and study of its growth using suitable parameters and biochemical analysis of it	2
2	Effect of plant growth regulators on in vitro response of explants.	2
3	Induction of Androgenises *in vitro*	1
4	Preparation of artificial seeds	1
5	Protoplast isolation and Fusion from plant material	2
6	Micro propagation: initiations, multiplication and subculture	2
7	Initiation of suspension culture and identification of common secondary metabolites production	2
8	Initiation maintenance and confirmation of Hairy root culture	2
9	Visit to tissue culture laboratory/seed company and report writing	Compulsory

Semester – II	
Course Code: MSC-BT 216 P	**Title of the Course: Practicals in Bacteriology**
Credits: 02	**Total Hours: 60**

Course Outcomes (Cos)

1. Learn to handle and maintain cleanliness, good laboratory practices, media preparation and sterilization.
2. Learn to perform various staining techniques which include Monochrome, Negative, Gram, Endospore, Capsule staining.
3. Understand the methods of isolation of pure cultures of bacteria from air/soil/water.

Detailed Syllabus:

Sr. No.	Title	No of Practicals 14
1	Preparation of selective, differential media and enriched media and Isolation, purification of microorganisms by pure culture techniques a. Streak plate method. b. Pour plate method. c. Spread plate method.	2
2	Isolation, Enumeration and Identification of microorganisms by Bergey's Manual up to genus level	3
3	Isolation, cultivation and morphological study of Actinomycetes	2
4	Isolation, cultivation of endophyte and production primary/secondary metabolite	3
5	Isolation of antibiotic resistant mutants by physical/chemical mutagenesis	1
6	Determination of MIC, LD 50 of Beta-lactam/aminoglycoside/ tetracycline/kanamycin	1
7	Determination of antimicrobial activity of a chemical compound (Phenol, resorcinol, thymol, formaldehyde)	1
8	Culture preservation techniques (agar slants, stabs and glycerol stocks)	1

Semester – II	
Course Code: MSC-BT 217 T(A)	**Title of the Course: Clinical Research**
Credits: 02	**Total Lectures: 30**

Course Outcomes (Cos)

1. Explain the regulatory requirements for conducting clinical trials
2. Explain the responsibilities of key players involved in clinical trials
3. Describe the documentational requirements for Clinical trials
4. Describe basic concepts, and establishment of Pharmacovigilance

Detailed Syllabus:

Unit I: (05)

- Introduction to Clinical Research: History of clinical research.
- Drug development process: Overview of drug development process; definitions of lead and hit compounds
- Clinical trials, Placebo (Blind trials vs Un-blind trials) and their phases
- Lead discovery: general approaches

Unit II: (05)

- Protocol design: Definition of protocol, its importance and purpose
- Protocol format: Chapters (Headings) and broad contents of protocol
- Important scientific and administrative aspect included in protocol
- Protocol writing team and role of each member
- Clinical trial design: Types of study designs
- Statistics in Clinical trials
-

Unit III: (06)

- Good Clinical Practice (GCP): ethical principles and their origin
- Ethics in clinical research: As per ICMR & GCP guidelines
- Ethics committees: roles & responsibility of IEC and IRB
- Responsibilities of sponsors, investigators & regulators
- ICH: purpose, regulations & guidelines
- Essential and non-Essential documents

Unit IV: (04)

- Drug regulatory affairs (clinical trial)
- Regulatory authority in India (DCGI & CDSCO)
- Schedule Y of Drugs & Cosmetics Act
- National and international scenario of regulatory aspects for clinical safety: National drug policy, FDA-21CFR,

Unit V: (04)

- Pharmacovigilance: Concepts and applications of pharmacovigilance
- Adverse event, adverse drug reactions
- Serious (Severe) adverse event, Recording & reporting: Objectives and importance
- Yellow Card Scheme, Drug information centers

Unit VI: (03)

- Monitoring of clinical trials: Monitoring and its role in clinical trials
- CRF and CRF designing
- Source documentation relevant to monitoring

Unit VII: (03)

- Introduction to clinical database management system
- Concept and designing of database
- Data management and role of information in clinical research

Suggested Readings:

1. Katzung, B.G. Basic and Clinical Pharmacology, (2010) Prentice hall, International
2. National Ethical Guidelines for Biomedical and Health Research Involving Human Participants (2017)
3. E6 Good Clinical Practice. Code, Document Title, Previously coded. E6(R2) Good Clinical Practice(GCP). Finalised Integrated Addendum: November 2016.
4. New Drugs and Clinical Trials Rules 2019
5. Website: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearchm

Semester – II	
Course Code: MSC-BT 217 T(B)	**Title of the Course: Biostatistics**
Credits: 02	**Total Lectures: 30**

Course Outcomes (Cos)

1. On completion of this course, students should be able to understand how to summarize statistical data
2. Apply appropriate statistical tests based on an understanding of study question, type of study and type of data
3. Interpretation of results and application in biological systems.

Detailed Syllabus:

Unit I: (06)

- Introduction to Statistics: Measures of central tendency – mean, mode, median and their properties
- Measures of dispersion – variance, standard deviation, coefficient of variance symmetry and skewness, measures of skewness, kurtosis
- Sampling and sampling distributions – concept of sample and population, statistic, methods of sampling, standard error

Unit II: (09)

- Correlation and regression
- Bivariate correlation, positive correlation, negative correlation
- Measures of correlation – scatter diagram, Karl-Pearson's coefficient of correlation, Spearman's rank correlation coefficient
- Regression – Equations of regression lines using least square method, regression estimate and its standard error

Unit III: (06)

- Experimental statistics - Design of experiments
- Principles of design – randomization, replication, local control, treatment group and control group
- Guidelines for designing the experiments, size of plot, number of replications Completely randomized design (CDR), randomized block design (RBD)

Unit IV: (09)

- Testing of hypothesis and analysis of variance
- Hypothesis, statistical hypothesis, critical region, level of significance, p-value, normal distribution
- T-test: t-test for mean, equality of two means, paired t-test, unpaired t-test

- chi-square test: chi square test for goodness of fit, independence of attributes,
- Analysis of variance table (ANOVA)
- Introduction to statistical analysis software- e.g. SPSS

Suggested Readings:

1. Billingsley, P. (1986). Probability and Measure. New York: Wiley.
2. Rosner, B. (2000). Fundamentals of Biostatistics . Boston, MA: Duxbury Press
3. Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley.
4. P.S.S. Sunderrao and J. Richards-An introduction to Biostatistics, Prentice Hall Pvt. Ltd. India
5. Campbell R.C.- Statistics for Biologists, Cambridge University Press, Cambridge.

Semester – II	
Course Code: MSC-BT 218 P(A)	**Title of the Course: Practical in Clinical Research**
Credits: 02	**Total Hours: 60**

Course Outcomes (Cos)

1. Demonstrate competency in biopharmaceutical clinical trial research designs and regulatory affairs management to meet the health and medical needs of current and future biopharmaceutical product consumers
2. Evaluate critical domestic and global regulatory and health care issues that challenge and influence biopharmaceutical product development
3. Demonstrate competencies in evaluating clinical research data and communicating results

Detailed Syllabus:

Sr. No.	Title	No of Practicals 14
1	Pre-clinical study of existing drug compound on cell line	1
2	Kidney function tests	1
3	Essential In-Vitro diagnosis-Hematology –a)Haemoglobin counting b)CBC	1
4	Clinical chemistry assay-Alanine amino transferase (ALT)	1
5	Clinical chemistry assay—Albumin testing	1
6	Study of phases of clinical trial and metadata analysis of CT's	1
7	Case study of any one already established medicine-Survey and report writing	2
8	Case study of any one banned medicine and its data related to post marketing surveillance- Survey and report writing	1
9	Case study of any one already established Vaccine-Survey and report writing	1
10	Development of clinical research documents: SOPs development CRFs & ICFs Preparation Dummy clinical research and bioequivalence protocols etc.	2
11	A visit to Clinical Research Organization (CRO).	1
12	Statistical analysis of clinical data-Up and Down designs	1

Semester – II	
Course Code: MSC-BT 218 P(B)	**Title of the Course: Practical in Biostatistics**
Credits: 02	**Total Hours: 60**

Course Outcomes (Cos)

1. Recognize the definition of statistics, its subject and its relation with the other sciences.
2. Collect data relating to variable/variables which will be examined and calculate descriptive statistics from these data.
3. Apply hypothesis testing via some of the statistical distributions.

Detailed Syllabus:

Sr. No.	Title	No of Practicals 14
1	Measurement of central tendency (mean, mode and median)	1
2	Measure of variance, standard deviation, coefficient of variance and standard error	1
3	Measures of skewness and measures of Kurtosis	1
4.	Determination of Karl-Pearson's coefficient of correlation from the given data	2
5	Determination of Spearman's rank correlation coefficient from the given data	2
6	Determination of regression lines and calculation of correlation coefficient – grouped and ungrouped data	1
7	Examples based on t – test	2
8	Drawing a simple random sample with the help of table of random numbers	1
9	Chi-square test for goodness of fit and independent attributes	1
10	Analysis of variance on the given data (ANOVA)	2

Semester – II	
Course Code: MSC-BT 219 T	**Title of the Course: Virology**
Credits: 02	**Total Lectures: 30**

Course Outcomes (Cos)

1. Students will gain knowledge about the basic concepts of virology
2. Students will learn the virological techniques for diagnosis
3. Students will gain knowledge about various viral groups and viral treatment

Detailed Syllabus:

Unit I: (06)

- Introduction to viruses
- General properties of viruses: Morphology and ultrastructure of viruses,
- Concept of viroid and prions
- Classification of viruses: ICTV system, Baltimore system
- Bacteriophages: Lambda phage, T phage, M13 Phage, Phi X174 phage
- Lytic and Lysogenic life cycle

Unit II: (06)

- Replication of viruses
- Mechanism of virus adsorption and entry into host cell
- Genome replication, transcription and Translation of viral proteins
- Genome packaging, Assembly, exit and maturation of progeny virions

Unit III: (05)

- Cultivation of viruses
- In ovo: using embryonated chicken eggs
- In vivo: using experimental animals
- Ex vivo / In vitro: using various cell cultures - primary culture and secondary cell lines, suspension cell cultures and monolayer cell culture

Unit IV: (10)

- Viral Diagnosis:
- Microscopy, Serological and Molecular methods, Infectivity assays
- Antivirals: Physical and chemical agents, therapeutic agents
- Interferons, Nature and source of interferons, classification of interferons.
- Vaccines and types of Vaccines (Live attenuated, Head killed Subunit)

Unit V: (03)

- Animal, Plant and Poultry viruses
- Re-emerging and New emerging viral diseases with example (Influenza, H1N1, SARS: Covid 19, Nipah and Marburg), Current outbreaks

Suggested Readings:

1. Flint Jane. S. (1999), Principles of Virology 3rd edition, ASM (American Society of Microbiology) Press Publisher, 2 volumes. USA.
2. Bernard.N. Fields, Lippincott and Williams Wilkins, USA Field's Virology - 2 volumes, 5th edition, (2006)
3. John B. Carter and Venetia A. Saunders, Virology, Principles and applications, John Wiley & Sons Ltd (2007)
4. Alan J. Cann, University of Leicester, UK, Principles of Molecular Virology 4th Edition
5. Edward K. Wagner, Basic Virology Third Edition, Blackwell publishing