



Department of Biotechnology

M. Sc. Biotechnology
M. Sc. Biotechnology

Course Contents

&

Syllabus



Hemvati Nandan Bahuguna Garhwal University

(A Central University)

Srinagar, Garhwal, 246 174, Uttarakhand



M. Sc. Biotechnology

(Effective from July 2020)

Code	Course Contents	L T P C	M.M
Semester I (July to November)			
SOLS/MBT/C0001	Biochemistry	3 0 0 3	100
SOLS/MBT/C0002	Cell Biology & Membrane Biophysics	3 0 0 3	100
SOLS/MBT/C0003	Molecular Biology & Genetics	3 0 0 3	100
SOLS/MBT/C0004	Bio-Analytical Techniques	3 0 0 3	100
SOLS/MBT/C0005	Lab Course based on course C0001 & C0002	0 0 3 3	100
SOLS/MBT/C0006	Lab Course based on course C0003 & C0004	0 0 3 3	100
Core Credits= 18			600
Semester II (December to April)			
SOLS/MBT/C0007	Immunology	3 0 0 3	100
SOLS/MBT/C0008	Microbiology & Microbial Genetics	3 0 0 3	100
SOLS/MBT/C0009	Genetic Engineering & Applications	3 0 0 3	100
SOLS/MBT/C0010	Biostatistics & Bioinformatics	3 0 0 3	100
SOLS/MBT/C0011	Lab Course based on course C0007 & C0008	0 0 3 3	100
SOLS/MBT/C0012	Lab Course based on course C0009 & C0010	0 0 3 3	100
SOLS/MBT/SS001	Epigenetics & Cancer Biology	0 0 0 3	100
SOLS/MBT/SS002	Biomedical Technology		
Core Credits = 18			600
Semester III (July to November)			
SOLS/MBT/C0013	Plant Biotechnology	3 0 0 3	100
SOLS/MBT/C0014	Intellectual Property Rights, Bioethics, Bio-Entrepreneurship	3 0 0 3	100
SOLS/MBT/C0015	Lab Course based on course C0013 & C0014	0 0 3 3	100
SOLS/MBT/E0001a	Protein engineering	3 0 0 3	100
SOLS/MBT/E0001b	Immunotechnology		
SOLS/MBT/E0001c	Nanobiotechnology		
SOLS/MBT/E0002a	Food & Beverages Biotechnology	3 0 0 3	100
SOLS/MBT/E0002b	Animal Biotechnology		
SOLS/MBT/E0002c	Enzymology & Enzyme Technology		
SOLS/MBT/E0003	Lab Course based on course E0001 & E0002	0 0 3 3	100
SOLS/MBT/SS003	Research Methodology: Tools & Techniques	0 0 0 3	100
SOLS/MBT/SS004	Science Communication & Scientific Writing		
Core Credits 09 + Elective Credits 09; Total Credits = 18			600
Semester IV (December to April)			
SOLS/MBT/C0016	Environmental Biotechnology	3 0 0 3	100
SOLS/MBT/C0017	Fermentation & Bioprocess Technology	3 0 0 3	100
SOLS/MBT/C0018	Lab Course based on course C0016 & C0017	0 0 3 3	100
SOLS/MBT/E0004a	Advanced Bioinformatics	3 0 0 3	100
SOLS/MBT/E0004b	Herbal Biotechnology		
SOLS/MBT/E0004c	Genomics & Proteomics		
SOLS/MBT/E0005	Dissertation	0 0 0 6	100
SOLS/MBT/SS005	Vaccines & Drug Development	0 0 0 3	100
SOLS/MBT/SS006	Molecular Virology		
Core Credits 09 + Elective Credits 09; Total Credits = 18			500
Grand Total Credits: Core - 54 + Elective - 18 = 72			2300

Max. Marks (MM) for each paper: 100 (Two Sessional Tests of 20 each + 60 End Term Test)

Sessional Tests:- (Mid Term Test, Assignment, Tutorials, Classroom Seminar & Lab Work, Journal Club; winter / summer training / Internship; Academic tours / visits to Industries / Institutes / Universities; training based report writing & presentation)

All 2-year Master's Programs will have the following components, viz.

- (i) Core Course (C): Minimum 54 Credits
- (ii) Electives (E): Minimum 18 Credits
- (iii) Self study (SS): Maximum 09 credits (one minimum 03Creditscourse shall be mandatory but not to be included while calculating the grades)



Paper - I: Biochemistry
(Course Code: S0LS/MBT/C0001)

No. of Credits = 3

UNIT - I

Enzymes: Classification (rationale, overview and specific examples) 0.5
 Zymogens and their activation (Protease and Prothrombin)
 Enzyme substrate complex: Concept of E-S complex, binding sites, active site, specificity, Lock and Key Hypothesis, Induced-Fit Hypothesis, Michaelis-Menten equation and its derivation, Different plots for the determination of Km and Vmax, Enzyme Inhibition

UNIT - II

Carbohydrate – Classification, structure and functions 0.75
 Carbohydrate Metabolism I: Pathway and regulation of Glycolysis, Gluconeogenesis, Glycogenolysis, Glycogenesis
 Carbohydrate Metabolism II: Citric acid cycle and its regulation, Electron transport Chain and Oxidative phosphorylation, Pentose phosphate pathway and its regulation.

UNIT - III

Amino acids – structure and functional group properties, peptides and 0.75
 covalent structure of proteins, primary and higher order structures, Ramachandran plot.
 Protein – Classification, structure and functions
 Amino Acid Metabolism: overview of amino-acid biosynthesis and degradation
 Urea cycle (Linkage between urea cycle and citric acid cycle) and its regulation.
 Conversion of nitrogen to ammonia by microorganisms

UNIT - IV

Fatty Acids - Classification and structure. 0.5
 Fatty Acid Metabolism: Fatty Acid Oxidation and regulation, β -oxidation, Oxidation of unsaturated fatty acids and odd chain fatty acids, β -oxidation in peroxisomes, Ketone bodies and their overproduction.
 Fatty Acid Biosynthesis and Regulation. Reactions of fatty acid synthase, Synthesis of triglycerols, Cholesterol biosynthesis and regulation.

UNIT - V

Nucleic Acid - structure and functions. Nucleic Acid Metabolism: Purine 0.5
 biosynthesis and its regulation, Pyrimidine biosynthesis and its regulation.
 Formation of deoxyribonucleotides. Salvage pathway for Purine and Pyrimidine nucleotides, Degradation of purines and pyrimidines into uric acid and urea.

Recommended Books: -

1. Lehninger: Principles of Biochemistry, 4th ed., Nelson & Cox, WH Freeman and Company, 2007
2. Voet & Voet: Biochemistry, 2nd ed., Wiley & Sons.
3. Berg, Tymoczko, Stryer: Biochemistry, 5th ed., WH Freeman and Company, 2003.
4. Garrett & Grisham: Biochemistry, 4th ed., Brooks/Cole Cengage learning, 2010.
5. Murray, Granner, Rodwell: Harper's Illustrated Biochemistry, 27th ed. McGraw Hill, 2006.
6. Conn & Stumpf: Outlines of Biochemistry, 5th ed., Wiley India, 2007.

**Paper - II: Cell Biology & Membrane Biophysics****(Course Code: S0LS/MBT/C0002)****No. of Credits = 3****UNIT - I**

Plasma membrane: Structure, Organisation, Lipid bilayer, Proteins and Glycoconjugates, Liposomes, lipid protein interactions, membrane rafts, hydrophobic effect. Elasticity of the membrane. Function- ionic transport, Types of transport (symport, antiport, active & passive), Channel proteins-Introduction. 0.5

UNIT - II

Intracellular compartmentalization: Structure, organization and functions of Nucleus, Mitochondria, Lysosome, Golgi body, Chloroplast, Peroxisome, Endoplasmic reticulum (Rough and smooth). Cell motility and Shape: Structure and functions, Microfilament, Microtubules and Intermediate filament. 0.5

UNIT - III

Protein Sorting: Anterograde & Reterograde mode of protein trafficking, Vesicular traffic in the secretory and Endocytic pathway: Transport from Endoplasmic reticulum through the Golgi network to Lysosome, Endocytosis, Exocytosis, Molecular mechanisms of vesicular transport and maintenance of compartments diversity. Cell signaling : General principles (Types of signaling), Cell surface receptor mediated signaling (ion channel, G protein and enzyme linked). 0.75

UNIT - IV

Cell cycle: Molecular events and regulation. Cell division: General strategy & regulation, Molecular mechanism of mitosis and meiosis. Cancer- Biology: Types of cancer, Onset of cancer, Proto-oncogenes and tumor suppressor genes, Oncogenic mutations affecting cell proliferation, Cell cycle and Genome stability, Programmed cell death, Apoptosis 0.5

UNIT - V

Membrane transport, diffusion, electro-diffusion, types of transportation, thermodynamic model, chemical potential, osmotic pressure, water permeability, structure, selectivity & permeability of channel proteins, Voltage-gated channels, Ligand-gated channels, Na⁺, K⁺ and Ca²⁺ channels, pumps as channels. Conduction of electrical activity Spread of electrical signals: passive vs. active, the action potential and its propagation through nerves, chloride channels and muscle excitability, Target cell adaptation 0.75

Recommended Books: -

1. Lodish et al.: Molecular Cell Biology (4th ed.)
2. Alberts et al.: Molecular Biology of the cell (3rd ed.)
3. Scott F. Gilbert: Developmental Biology (5th ed.)
4. Zubay, Parson & Vance: Principles of Biochemistry
5. Joshua Zimmerberg, Membrane Biophysics. Current Biology Vol 16 No 8 R272, [https://www.cell.com/current-biology/pdf/S0960-9822\(06\)01347-9.pdf](https://www.cell.com/current-biology/pdf/S0960-9822(06)01347-9.pdf)
6. Mohammad Ashrafuzzaman and Jack Tuszynski: Membrane Biophysics, Part of the Biological and Medical Physics, Biomedical Engineering book series (BIOMEDICAL), Springer

**Paper - III: Molecular Biology & Genetics****(Course Code: SOLS/MBT/C0003)****No. of Credits = 3****UNIT - I**

Chemical and physical properties of nucleic acids 0.5
 Structure and types of RNA and DNA, The Watson-Crick model. DNA as genetic material. Different forms of DNA.
 Topological properties of DNA. DNA renaturation kinetics.

UNIT - II

Mechanism of DNA replication in prokaryotes and eukaryotes. 0.75
 Mechanism of transcription in prokaryotes and eukaryotes. Reverse transcription.
 Post transcriptional processing of RNA: (capping, polyadenylation, splicing, RNA editing)
 Mechanism of translation in prokaryotes and eukaryotes.

UNIT - III

Concept of genetic code, Gene expression and regulation in prokaryotes (Lac operon and trp operon). Gene expression and regulation in eukaryotes. 0.5
 Introduction to various types of DNA damage and repair.

UNIT - IV

Mendelism: Basic principles and applications of inheritance, exceptions to Mendelian law. Chromosomal basis of Mendelism (chromosomal theory of heredity) 0.75
 The molecular structure of chromosome in eukaryotes: structure of chromatin and higher order packaging in chromosome. Centromere and Telomere,
 Giant chromosome: Polytene and Lampbrush chromosome.
 Linkage, recombination and chromosome mapping in eukaryotes. Cytoplasmic inheritance.

UNIT - V

Chromosomal Aberrations: Change in number and structure 0.5
 Allelic variation and gene function. Sex chromosome and sex determination.
 Dosage compensation of X-linked gene. Sex linked genes in human. Pedigree analysis.

Recommended Books: -

1. Lewin: Genes, Vol. VII Oxford, 1998, Indeed.
2. Snustad et al: Principles of Genetics 1997, John Wiley & Sons,
3. De Robertes & Robertis: Cell & Molecular Biology, 1987, Lee & Fabiger Philadelphia
4. Strickberger: Genetics, 1996, Prentice Hall
5. Friefelder: Molecular Biology (2nd ed.), 1996 Narosa Publ. House,
6. Alberts et al: Molecular biology of the cell (4th ed.) 1994, Garland Publ. New York.
7. Elliott & Elliott: Biochemistry and Molecular Biology, 1996, Oxford

**Paper - IV: Bio-Analytical Techniques****(Course Code: S0LS/MBT/C0004)****No. of Credits = 3****UNIT - I**

Chromatography - General principles and applications. 0.75
 Adsorption chromatography, Partition chromatography, Gas chromatography,
 Liquid chromatography, Paper chromatography, Thin layer chromatography,
 Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography,
 HPLC (High Performance/Pressure Liquid chromatography).

UNIT - II

Electrophoresis - General principle and applications 0.5
 Paper electrophoresis, Moving boundary method, Gel electrophoresis (Native,
 Denaturing & Reducing), Disc gel electrophoresis, Slab gel electrophoresis,
 Isoelectric focussing (IEF), Isotachophoresis

UNIT - III

Centrifugation: Basic principles, Common centrifuges used in laboratory, Clinical 0.5
 High speed & Ultra centrifuges. Sedimentation rate, Sedimentation coefficient, Zonal
 Centrifugation, Equilibrium density gradient centrifugation. Types of rotors (fixed angle,
 swinging bucket), Types of centrifugation: Preparative, Differential & Density gradient

UNIT - IV

Basic knowledge of the principles and applications of Microscopy: Light, Phase 0.5
 Contrast, Fluorescence and Confocal Microscopy, Scanning and Transmission Electron
 Microscopy. Biosensors: Introduction & principles, Cell based biosensors, Enzyme
 immunosensors.

UNIT - V

Spectroscopic methods: Principle and applications of UV-visible, IR, NMR, ESR 0.75
 Spectroscopy. Principle & applications of X-ray crystallography. Applications of
 radioisotopes in biology. Properties and units of radioactivity. Radioactive isotopes and
 half life. Measurement of radioactivity: GM Counter, Gamma & Liquid scintillation counter.

Recommended Books: -

1. Sharma, V.K.: Techniques in Microscopy and Cell Biology Tata McGraw Hill, 1991.
2. Alberts et al.: Molecular Biology of the cell (2nd ed.), Garland, 1989.
3. Biochemical Technique: Theory & Practical J.F. Robyt & B.J. White. Waveland Press, Inc.
4. Wilson & Walker: Practical Biochemistry (4th ed) University of Hertfordshire Cambridge University Press
5. Jayraman: Laboratory Manual in Biochemistry
6. Arnold L. Demain & Julian E. Davies: Manual of Industrial Microbio. & Biotech. 2nd ed.



Paper - V: Immunology
(Course Code: S0LS/MBT/C0007)

No. of Credits = 3

UNIT - I

Overview of the Immune system; Cells and organs of the immune system 0.5
Antigens, Antigenicity vs. Immunogenicity; Haptens & Epitopes;
Immunoglobulins: Structure and function

UNIT - II

Organization & Expression of Immunoglobulin Genes: Multigene organization of 0.75
Genes, variable- region gene rearrangements, Generation of antibody diversity,
Class switching among constant-region genes, Expression of Ig genes
Major Histocompatibility Complex; Antigen processing and presentation

UNIT - III

Structure and functions of BCR & TCR. Cytokines, Properties, General physiology, 0.75
Interferons, Application of cytokine for therapy. The complement system
Cell mediated cytotoxicity: Mechanism of T cell & NK cell mediated lysis,
Ab-dependent cell mediated cytotoxicity (ADCC)

UNIT - IV

Overview of hypersensitivity, Autoimmunity and there types 0.5
Organ transplantation: Introduction, Types and Challenges, Graft rejection
Vaccines: Active and Passive Immunization

UNIT - V

Overview of Monoclonal Antibodies and Hybridoma Technology, 0.5
Types of Antigen-Antibody Interactions: Precipitation reaction, Agglutination reactions,
RIA, ELISA, Western Blotting, Immuno-precipitation, Immuno-fluorescence

Recommended Books: -

1. Roitt, Male & Brostoff : Immunology (3rd ed).
2. Kuby : Immunology (4th ed.)
3. Elgert & Elgert : Immunology
4. Wilson & Walker: Practical Biochemistry (4th ed.)
5. Practical Immunology, 4th Ed., F.C. Hay, O.M.R. Westwood, Blackwell Publishing, 2002
6. Selected Methods for Antibody and Nucleic Acid probes, Vol. 1, S. Hockfield, S. Carlson, C. Evans, P. Levitt, J. Pintar, L. Silberstein, Cold Spring Harbor Laboratory Press, 1993.
7. Antibodies Laboratory Manual, Ed Harlow, David Lane, Cold Spring Harbor, Laboratory Press, 1988.

**Paper - VI: Microbiology & Microbial Genetics****(Course Code: SOLS/MBT/C0008)****No. of Credits = 3****UNIT - I**

Classification of living organisms and general account of microorganisms: Bacteria, Fungi and Viruses. 0.75

Introduction to bacteriology: Classification; Fine structure of bacteria;

Laboratory identification and staining techniques

Introduction to Mycology: Classification, general structure, characteristics of fungi.

UNIT - II

Media for microbial culture, Selective, Differential and Enriched media, Pure culture techniques, Sterilization techniques. 0.5

Introduction to virology: Classification, General structure and reproduction of viruses.

Cultivation of bacteriophages, Plant Viruses, Animal Viruses.

UNIT - III

Microbial growth: Synchronous & Diauxic, Factors affecting microbial growth, Measurement of microbial growth (cell number & cell count). 0.5

Modes of nutrition: Photoautotrophs, Photo-organotrophs, Chemolithotrophs, Chemo-organotrophs.

Microbial metabolism: Overview of energy production and utilization, N₂ fixation.

UNIT - IV

Modes of genetic recombination in bacteria: Conjugation, F-factor, conjugal transfer process, high frequency recombination (Hfr) strains. 0.75

Transformation – competence, DNA uptake by competent cells.

Mechanism of transformation.

UNIT - V

Transduction – General & specialized transduction. 0.5

Genetics of bacteriophages: Lytic and lysogenic cycle, expression of phage genes

In regulation of lytic and lysogenic circuit.

Recommended Books: -

1. Tortora, Funke, Case: Microbiology, (9th ed.) Pearson Education, Inc, 2009.
2. Prescott, Harley & Kliens: Microbiology (7th ed.) McGraw-Hill International Edition, 2008.
3. Michael J. Peleazar, E.C.S. Chan, Noel R. Krieg: Microbiology (5th ed.) Tata McGrall-Hill, 2008.
4. Alcamo's Jeffrey C. Pommerville: Fundamental of Microbiology (8th ed.) Jones & Bartlet Publ. 2007.

**Paper - VII: Genetic Engineering & Applications****(Course Code: SOLS/MBT/C0009)****No. of Credits = 3****UNIT - I**

Introduction to Recombinant DNA technology and applications. 0.75
 Cloning vectors: Plasmids, Phages, Cosmids, Yeast cloning vectors,
 Animal and plant viruses as vectors. BAC, PAC & YAC.
 Nucleic acid modifying enzymes. Restriction endonucleases.
 Isolation of nucleic acid from Plant, animal & bacteria.

UNIT - II

Basic steps of gene cloning: Cloning strategies. 0.75
 Synthesis of cDNA. Construction of cDNA and genomic libraries.
 Selection of r DNA clones and their expression products, Chromosome walking.
 Expression of cloned genes in heterologous host.

UNIT - III

DNA sequencing: Chemical and enzymatic methods. 0.5
 PCR: Types and applications. Real Time PCR. Site directed mutagenesis.
 Ribonuclease protection assay, Gel retardation assay,
 DNA foot printing, DNA finger printing, DNA profiling.

UNIT - IV

Genomic analysis: S-1 mapping, RFLP, RAPD, AFLP. 0.5
 Probe labeling and hybridization. Blotting techniques: Southern, Northern and
 Western blotting (Methodologies and applications)

UNIT - V

Transgenic Technology: Types, approaches & applications (Plant & Animals), 0.5
 Gene therapy: Principles, strategies and ethics of gene therapy.
 Genome editing technologies: Principles and applications.

Recommended Books: -

1. Gene cloning T.A Brown:
2. Molecular Biotechnology, Glick & Pasternak: Panima Publ. Corporation, 1994
3. Molecular biology & Biotechnology (3rded), Walker &Gingold: Panima Publ. Corporation, 1999
4. Lewin: Genes, Vol. VII Oxford, 1998, Inded.
5. Straehan & Read: Human Molecular Genetics 1999, John Wiley & Sons Pte. Ltd.
6. Gene cloning, Glover: 1984
7. Recombinant DNA, Watson et al: 1983
8. Genetic Engineering Vol. 1-4, Villiamson (ed)
9. Genetic Engineering Vol. 1-7 Setton and Bolanden (ed)

**Paper - VIII: Biostatistics & Bioinformatics****(Course Code: S0LS/MBT/C0010)****No. of Credits = 3****UNIT - I**

Importance of statistics in biological research. 0.75
 Primary and Secondary data, Methods of data collection. Mean, Mode, Median, Range, Mean deviation, Standard deviation.
 Standard error, Skewness & Kurtosis. Correlation & Regression, Probability

UNIT - II

Characteristics, Validity and Applications of Chi square test 0.5
 Test for significance- comparison of means of two samples, Comparison of means of three or more samples (f-test, t-test).
 Tabulation and Graphical representation of Statistical data.
 Data calculation in MS Excel & Power point presentation.

UNIT - III

Introduction to bioinformatics: Objectives, application and scopes, 0.5
 Information technology in biology, Bioinformatics resources on NET, Internet, Word wide web, Web Browsers.
 Biological databases-Primary, Secondary database, GEN BANK, EMBL, DDBJ, PDB, UNIPROT. Search engine-Entrez, SRS, Web Server-NCBI, EBI.

UNIT - IV

Sequence alignment and applications: Sequence similarity searching tools – 0.75
 FASTA, BLAST; Statistical and biological significance.
 Multiple sequence alignment and applications, Software and tools for MSA.
 Phylogenetic analysis, Tools for phylogenetic analysis, Applications

UNIT - V

Protein Structure Prediction Tools, Molecular Modeling (Homology modeling); 0.5
 Refinement, Validating structural model; Visualization tools, Pymol, Chimera, Ligplot.
 Annotation of proteins, Assignment of function to proteins.

Recommended Books: -

1. Lesk: Introduction to Bioinformatics, Wiley Publication.
2. ROM and Holmas EC: Molecular Evolution: a phylogenetic approach, Blackwell science.
3. Des Higgins and Willie Taylor: Bioinformatics: Sequences, structure and databanks, Oxford University Press
4. Sharma, Munjal, Shankar: A Text Book of Bioinformatics, Rastogi Publication
5. Bioinformatics: Methods and Applications Genomics Proteomics and Drug Discovery, S C Rastogi, N Mendiratta, P. Rastogi: Prentice Hall of India Private Ltd
6. Mahajan: Methods in Biostatistics (4thed.) Jaypee Bros. 1984.
7. Sokal & Rohlf: Introduction to Biostatistics, Freeman, Toppan, 1993

**Paper - IX: Epigenetics & Cancer Biology****(Course Code: S0LS/MBT/SS001)****No. of Credits = 3****UNIT - I**

Introduction: Growth characteristics of cancer cells; Morphological and ultrastructural properties of cancer cells. Types of growth: Hyperplasia, Dysplasia, Anaplasia and Neoplasia. Nomenclature of neoplasms. Differences between benign and malignant tumors. 0.75

UNIT - II

Cancer biology and biochemistry: Aberrant metabolism during cancer development; Para-neoplastic syndromes; Tumor markers; Cellular proto oncogenes- oncogene activation. Growth factors-EGF, TNF, TGF and growth factor receptors. Signal transduction in cancer. Role of transcription factors. 0.5

UNIT - III

Carcinogenesis: Radiation and chemical carcinogenesis, Stages in chemical carcinogenesis- Initiation, promotion and progression. Free radicals, Antioxidants in cancer. Cell Cycle Regulation: Tumor suppressor genes p53, p21, Rb, BRACA1 and BRACA2. Telomeres, Telomerase, and Immortality; Cell adhesion-invasion and metastasis - VEGF signaling, angiogenesis. 0.75

UNIT - IV

Epigenetics-Role of DNA methylation in gene silencing- epigenetic silencing of tumor-suppressor genes; Apoptosis in cancer-Cell death by apoptosis, Role of caspases; Death signaling pathways-Mitochondrial and death receptor pathways. 0.5

UNIT - V

Detection of Cancer, Prediction of aggressiveness of Cancer, Different forms of therapy, Chemotherapy, Radiation therapy, and Immuno therapy: Advantages and limitations. Epigenetics of cancer, Identification of targets for drug development. 0.5

Recommended Books: -

1. The Biological Basis of Cancer: R. G. McKinnell, et al 2nd Ed, Cambridge University Press, 2006.
2. The Biology of Cancer: R. A. Weinberg. Garland Science. 2006.
3. The Molecular Biology of Cancer: S. Pelengaris, M. Khan. Blackwell Publication.
4. Introduction to modern Virology, Dunmock N.J and Primrose.S.B., Blackwel Scientific Publications. Oxford, 1988.
5. An Introduction to Cellular & Molecular Biology of Cancer, Oxford Medical publications, 1991
6. Gene expression systems. Joseph M. Fernandez & James P. Hoeffler. Academic Press, 1999.
7. Cancer Biology IV Ed Volume 2 Raymond W Ruddon M.D.(2007)
8. Cancer Biology (3rd_Edition) Roger J.B. et al (2006)
9. Advances in Cancer Stem Cell Biology, Roberto Scatena, Alvaro Mordente& Bruno Giardina (Ed) – Springer (2012)

**Paper - IX: Biomedical Technology****(Course Code: S0LS/MBT/SS002)****No. of Credits = 3****UNIT - I**

Cellular Pathology: Causes of cell injury, necrosis, biochemical mechanism, Ischemic and hypoxic injury. Apoptosis (Biochemical features, mechanisms) Immunological basis of diseases: Hypersensitivity (I – IV). Autoimmune diseases Preparation of polyclonal antisera: Characterization of antisera, Immunodiagnostic techniques 0.75

UNIT - II

Mutations and Genetic disorders. Single gene disorders, Receptor proteins (hypercholesterolemia). Cytogenic disorders (Trisomy, Klinefelters). Mutation in mitochondrial genes (LHDN), Fragile X-Syndrome. 0.5

UNIT - III

Types and grading of cancer. Introduction to molecular diagnosis of cancer. (Southern & Northern blot analysis, PCR based diagnosis). Gene therapy, immunotherapy and chemotherapy of cancer cells. 0.75

UNIT IV

Chemical mutagens. Carcinogenic agents and their cellular interactions. Radiation as health hazard. (Types, measurements, effects & protective measures) Introduction to DNA damage and repair mechanism. 0.5

UNIT - V

Molecular diagnosis (genetic disease, gene diagnosis, gene tracking & other diagnostic application of RDT) MRI, CT-SCAN. Reproductive Health Technologies – Intracytoplasmic sperm injection (ICSI), In-vitro fertilization (IVF). 0.5

Recommended Books: -

1. Biomedical Technology and Devices Handbook, James E Moore, George Zouridakis, CRC Press(2004)
2. Palermo GD, O'Neill CL, Chow S, et al. Intracytoplasmic sperm injection: state of the art in humans. *Reproduction*. 2017;154(6):F93-F110. doi:10.1530/REP-17-0374
3. Alukal JP, Lamb DJ. Intracytoplasmic sperm injection (ICSI)--what are the risks?. *UrolClin North Am*. 2008;35(2):277-x. doi:10.1016/j.ucl.2008.01.004
4. Wang J, Sauer MV. In vitro fertilization (IVF): a review of 3 decades of clinical innovation and technological advancement. *TherClin Risk Manag*. 2006;2(4):355-364. doi:10.2147/tcrm.2006.2.4.355

**Paper - X: Plant Biotechnology****(Course Code: SOLS/MBT/C0013)****No. of Credits = 3****UNIT - I**

Laboratory and materials requirement for plant tissue culture technologies, 0.5
 Aseptic techniques, Plant tissue culture media-composition & preparation, Totipotency
 Clonal propagation / micropropagation, types and its applications
 Meristem culture, Callus culture, organogenesis, suspension culture,
 Conservation of plant genetic resources *in vitro*, its applications and limitations.

UNIT - II

Haploid culture: Androgenesis & Gynogenesis, Embryo culture 0.75
 & Embryo rescue, Protoplast culture & protoplast fusion – Cybrids, Symmetric &
 Asymmetric hybrid. Somatic embryogenesis and Somaclonal variation, cryo-preservation,
 production of synthetic seeds. Selection of stress tolerant cell lines: resistance to cold, high
 temperature, salt, drought, diseases and inhibitors.

UNIT - III

Transformation techniques, *Agrobacterium* mediated gene transfer, Biolistics, 0.5
 Comparison of DNA delivery techniques in plants, Integration of transgenes,
 action of transgenes, Antisense RNAi, and Overexpression approach for transgenics,
 Biotechnology related to fruit ripening, miRNA and stress response

UNIT - IV

Insect resistance, Bt crops, Cry protein and action, Molecular mechanisms- 0.75
 Flavr-savr tomato, Golden Rice and, Terminator gene technology.
 Plant pathogen interactions, strategies utilized by pathogens, genetic basis of plant
 pathogen interactions, Resistance genes (R genes) in plants, Phytohormones and
 cross talk, Molecular mechanisms of Oxidative stress and
 heat stress (HSPs etc.) in plants and genes related for stress tolerance.

UNIT - V

Plant growth promoting bacteria, PGPR traits, uses and applications, Biofertilisers, 0.5
 Phyto-priming for stress responses, Plants for cleaning contaminated soils-
 phytovolatilization, phytodegradation, phytostabilization, phytoextraction,
 Arsenic related biotechnological aspects

Recommended Books: -

1. P.K. Gupta: Elements of Biotechnology, Rastogi and Co. Meerut, 1996
2. R.J. Hanry: Practical Application of Plants Molecular Biology, Champan and Hall, 1997
3. H.D. Kumar: Modern Concepts of Biotechnology, Vikas Publ. Pvt. Ltd.
4. B.D. Singh: Biotechnology, Kalyani Publ.
5. Bhojwani SS and Razdan MK: Plant Tissue Culture: Theory and Practice- Elsevier
6. Stewart CN. Plant Biotechnology and Genetics. 2007. Wiley.

**Paper - XI: Intellectual Property Rights, Bioethics & Bio-entrepreneurship****(Course Code: S0LS/MBT/C0014)****No. of Credits = 3****UNIT - I**

Introduction to intellectual property (IP); History and evolution of patent law, types of IP: patents, trademarks, copyright & related rights, Idea-expression dichotomy, industrial design, traditional knowledge, geographical indications, Significance of IPR. Introduction & Classifications of Patents, Patentability criteria. 0.75

UNIT - II

International conventions and Treaties- History of GATT & TRIPS Agreement, World Trade Organization, Post TRIPS scenario, Madrid Agreement; Hague Agreement; Budapest Treaty; Patent Cooperation Treaty; Indian Patent Act 1970 & recent Amendments, International framework for the protection of IP, India's IPR policy, World Intellectual Property Organization (WIPO) 0.5

UNIT - III

Discovery vs Invention, concept of 'prior art', invention in context of "prior art" Complexity arising in IP of Biotechnology, Case studies- Diamond vs Chakraborty IP as a factor in R&D; IPs of relevance to biotechnology, Legal and IPR issues in Biotechnology, Different Categories of IPR Instruments to Protect a Biotechnology IP, Licensing and compulsory licensing; Patent infringement, legal action, 0.5

UNIT - IV

Introduction to bioethics- definition, scope, Principles, significance. Issues of- ownership, monopoly, biodiversity, traditional knowledge access & benefit sharing., Social ethical issues in biotechnology. Biological weapons and their social and ethical implications, Bioethical issues in GMOs, Ethical issues in human cloning 0.5

UNIT - V

Concept of entrepreneurship, Introduction and scope in Bio-entrepreneurship, Risk and Benefits. General idea of the strategy and operations of bio-sector firms, Steps involved in commercialization of a biotechnological product, Introduction to the entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), Incubation Centre, Start-Up India 0.75

Recommended Books: -

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
4. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. <http://www.ipindia.nic.in/>
5. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies, MIT Press
6. World Trade Organisation. <http://www.wto.org>
7. World Intellectual Property Organisation. <http://www.wipo.int>

**Paper - XII: Protein Engineering****(Course Code: S0LS/MBT/E0001a)****No. of Credits = 3****UNIT - I**

Protein engineering – Introduction, definition and applications; Protein engineering as a tool to alter affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc. Protein engineering with unnatural amino acids and its applications. 0.75

UNIT - II

Protein stability measurement; Spectroscopic study of physicochemical properties of proteins: Fluorescence; UV absorbance; CD & ORD; Hydrodynamic properties—viscosity, hydrogen-deuterium exchange; Introduction to NMR spectroscopy and its importance in protein studies 0.5

UNIT - III

Protein stabilizing forces – Van der Waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, etc. 0.5

UNIT - IV

Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens etc., Engineering antibody affinity by yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery. 0.5

UNIT - V

Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles vis-à-vis those from mesophiles; Protein design, Directed evolution for protein engineering and its potential. 0.75

Recommended Books: -

1. Edited by T E Creighton, (1997), Protein Structure: a Practical Approach, 2nd Edition, Oxford university press.
2. Cleland and Craik, (2006), Protein Engineering, Principles and Practice, Vol 7, Springer Netherlands.
3. Mueller and Arndt, Protein Engineering Protocols, 1st Edition, Humana Press. Ed. Robertson DE, Noel JP, (2004), Protein Engineering Methods in Enzymology, 388, Elsevier Academic Press.
4. J Kyte; (2006), Structure in Protein Chemistry, 2nd Edition, Garland publishers.



Paper - XII: Immunotechnology
(Course Code: S0LS/MBT/E0001b)

No. of Credits = 3

UNIT - I

Antigen – Antibody Interactions: Precipitation Reactions and application, 0.5
Immunological Assays: Immunodiffusion, Immunoelectrophoresis, Immunohistochemistry, Immunohistopathology; Agglutination Reactions and application, Complement Fixation, RIA, ELISA, Immunofluorescence, Western Blotting

UNIT - II

Introduction & production of monoclonal antibodies and hybridoma technology, 0.5
Advantages and limitations of monoclonal Antibodies, Characterization & storage of monoclonal Antibodies, Commercial production of monoclonal antibodies,

UNIT - III

Monoclonal Ab production by recombinant DNA technology, 0.75
Hybridoma technology vs RDT, application in diagnosis.
Engineered Monoclonal Antibodies: Chimeric and hybrid Monoclonal Antibodies, Monoclonal Antibodies constructed from Ig-gene libraries, Catalytic Monoclonal Antibodies (Abzymes). Cancer Immunotherapy

UNIT - IV

General physiology of cytokines, Application of cytokine for therapy, 0.5
Future development in cytokine therapy, Interferon colony stimulating factor, Preparation of lymphokines by r-DNA Technology.
Vaccines: Introduction and Types: Inactivated, Attenuated, Toxoid, Subunit And Multivalent vaccines, Purified macromolecules, Conjugate Vaccines.

UNIT - V

New generation vaccines: Synthetic peptide vaccines, Recombinant antigen vaccines, 0.75
DNA vaccines. Immune stimulants, Adjuvants, Novel vaccine delivery systems.
Vaccines for specific diseases: Tuberculosis, Malaria, HIV/AIDS.
New emerging diseases and vaccine development: Ebola virus disease, SARS.

Recommended Books: -

1. Practical Immunology, 4th Ed., F.C. Hay, O.M.R. Westwood, Blackwell Publishing, 2002
2. Selected Methods for Antibody and Nucleic Acid probes, Volume1, S. Hockfield, S. Carlson, C. Evans, P. Levitt, J. Pintar, L. Silberstein, Cold Spring Harbor Laboratory Press, 1993.
3. Antibodies Laboratory Manual, Ed Harlow, David Lane, Cold Spring Harbor, Laboratory Press, 1988.
4. Spicuzza L, Spicuzza A, La Rosa M, Polosa R, Di Maria G. New and emerging infectious diseases. Allergy Asthma Proc. 2007 Jan-Feb;28(1):28-34. doi: 10.2500/aap.2007.28.2870. PMID: 17390754.
5. Trovato Maria, Sartorius Rossella, D'Apice Luciana, Manco Roberta, De BerardinisPiergiusepp. Viral Emerging Diseases: Challenges in Developing Vaccination Strategies . Frontiers in Immunology 2020 Vol. 11:2130
6. The Vaccine Book (2nd Ed.), Rafi Ahmed, Roy M. Anderson et. al. Editor(s): Barry R. Bloom, Paul-Henri Lambert, Academic Press, 2016, Pages xxi-xxiv, ISBN 9780128021743.



Paper - XII: Nanobiotechnology
(Course Code: S0LS/MBT/E0001c)

No. of Credits = 3

UNIT - I

Introduction to Nanobiotechnology; Concepts, historical perspectives. 0.75
 Nanoparticles and nanotechnology, History, origin, principles.
 Chemical synthesis approach of nanoparticles, Physical synthesis of nanoparticles,
 Green synthesis approach for different nanoparticles applications and uses.
 Applications and limitations using physical and chemical approach.
 Advantages of using green synthesis using different examples

UNIT - II

Characterization of synthesized nanoparticles using XRD, SEM, TEM, HR-TEM, 0.5
 FTIR, UV spectrophotometer, Dynamic light scattering etc., Different types of
 nanoparticles and applications with examples, Safety and toxicity aspects of nanoparticles

UNIT - III

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for 0.75
 suitability of administration through various routes of delivery, advantages, strategies
 for enhanced permeation through various anatomical barriers

UNIT - IV

Nanocomposites: Properties and applications; Nanoparticles for diagnostics and 0.5
 imaging (theranostics); Clinical Applications of Nanoparticles, Nanotech and cancer,

UNIT - V

Environmental impact of nanomaterials – Exposure and risk assessment – Mechanism 0.5
 of toxicity, Toxicological impacts of Nanomaterials-Ecotoxicological impact of
 Nanomaterials, Nanotechnology in Agriculture, Nanofactories

Recommended Books: -

1. Gero Decher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials*, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); *Bionanotechnology: Lessons from Nature*; Wiley-Liss
3. Neelina H. Malsch (2005), *Biomedical Nanotechnology*, CRC Press
4. Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier
 Recent review papers in the area of Nanomedicine

**Paper - XIII: Food & Beverages Biotechnology****(Course Code: S0LS/MBT/E0002a)****No. of Credits = 3****UNIT - I**

Food and Microorganism: Microorganism in food & beverage industry, contamination of food. General principles underlying spoilage and chemical changes 0.5

UNIT - II

Contamination and spoilage of different kinds of food & beverages: 0.75
Cereals & Cereal products, sugar and sugar products,
Vegetables and Fruits, Meat, Fish, Poultry & Eggs, Sea food, Milk & Milk products,
Canned foods, Alcohol & alcoholic beverages
Fruit juices & soft drinks etc.

UNIT - III

Biotechnology of food and feed; Cultures & Fermentation, 0.5
Beverage production: Alcohol & Alcoholic beverages, Fruit juices, Soft drinks, Feed
production, SCP, Fats, Amino acid, Food additives.

UNIT - IV

Food, Beverages & Disease: Food borne illness due to bacterial food poisoning, 0.5
Infection and Intoxication.
Food-borne disease outbreaks, Disease-investigation, Materials & Equipments,
Laboratory testing, Field analysis, Interpretation of data and preventive measures.

UNIT - V

Food hygiene: Food sanitation, Bacteriology of water and food products, Food 0.75
manufacturing practice. Hazard analysis critical points.
Food control: International agencies, Federal agency and law of state agencies,
Processing industry and microbial criteria of food. Principles of food preservation,
Preservation by high temperature, low temperatures, drying, food additives and radiation.

Recommended Books: -

1. Ashok Pandey, Guocheng Du, Maria Ángeles Sanromán, Carlos Ricardo Soccol, Claude-Gilles Dussap (2016) Current Developments in Biotechnology and Bioengineering. Food and Beverages Industry [1 ed.] Elsevier
2. Food Biotechnology. S.Bielecki, et al - (Ed) Elsevier Science (2000)
3. Food Biotechnology. Kalidas Shetty et al – CRC Press (2005)
4. Guadalupe Virginia Nevárez-Moorillón (editor), Arely Prado-Barragán (editor), José Luis Martínez-Hernández (editor), Cristobal Noé Aguilar (editor) (2016) Food Microbiology and Biotechnology: Safe and Sustainable Food Production [1 ed.] Apple Academic Press
5. Johnson-Green, Perry (2018) Introduction to Food Biotechnology Ed. 1. CRC Press



Paper - XIII: Animal Biotechnology
(Course Code: S0LS/MBT/E0002b)

No. of Credits = 3

UNIT - I

Animal cell culture: History; Basic requirements; Cell culture media and reagents; 0.5
 Animal cell, tissue and organ cultures; Primary culture, secondary culture;
 Continuous cell lines; Suspension cultures; Transfection and transformation of cells;
 Stem cells and their application; Induced Pluripotency.

UNIT - II

Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation 0.75
 of sperms and ova of livestock; artificial insemination; embryo recovery and *in vitro*
 fertilization; cryopreservation of embryos; embryo transfer technology. Transgenic
 Animals: applications of transgenic animal technology; Techniques of gene transfer:
 Microinjection, Lipofection, Electroporation, Chemical based transformation, Viral Vectors.

UNIT - III

Animal Genomics: Introduction to animal genomics; Different methods for 0.75
 for characterization of animal genomes, SNP, STR, RFLP, RAPD, proteomics,
 metabolomics; Genetic basis for disease resistance; Gene knock out technology
 and animal models for human genetic disorders. Animal cloning - basic concept,
 cloning for conservation for conservation endangered species

UNIT - IV

Applications of Animal Cell Cultures: Cell Culture based products, Vaccines, 0.5
 Hybridoma technology, Monoclonal antibodies, *In vitro* testing of drugs;
 Production of pharmaceutical proteins;
 Stem Cells and their Use, Using Animals Cells for heterologous gene expression.
 Introduction to the concept of vaccines,
 conventional methods of animal vaccine production.

UNIT - V

Immunological and nucleic acid based methods for identification of animal species; 0.5
 DNA Barcoding; Detection of adulteration in meat using DNA based methods;
 Detection of food/feed adulteration with animal protein; Identification of wild animal species
 using DNA based methods.

Recommended Books: -

1. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press
2. Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
3. Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
4. Levine, M. M. (2004). New Generation Vaccines. New York: M. Dekker
5. R.E. Spier and J.B. Griffiths (1985). Animal Cell Biotechnology. Vol I and II, Academic Press.

**Paper - XIII: Enzymology & Enzyme Technology****(Course Code: S0LS/MBT/E0002c)****No. of Credits = 3****UNIT - I**

Properties of enzymes : Catalytic power, specificity, Holoenzymes, Apoenzyme, Coenzyme and Cofactor. Nomenclature and classification of enzymes, active site- Fischer and Koshland models. Collision theory, activation energy and transition state energy, the law of mass action and order reaction. 0.5

UNIT - II

Enzyme kinetics: Kinetics of single substrate enzyme catalyzed reaction, Equilibrium steady state assumption (Michaelis-Menten), transformation of Michaelis Menten equation, Lineweaver Burk, Eadie-Hofstee, Hanes plots. Determination of V_{max}, K_m, K_{cat} and their significance. Effect of pH, temperature, enzyme and substrate concentration on enzyme activity. Single displacement and double displacement reaction. 0.75

UNIT - III

Enzyme Inhibition: Reversible inhibition- competitive, uncompetitive and non competitive inhibition, allosteric and irreversible inhibitions. Assay of enzymes: Coupled kinetic assay, units of enzyme activity (IU), Turnover number, purification of enzymes and criteria of purity. 0.5

UNIT - IV

Enzyme catalysis: Tapping the enzyme -substrate complex, use of substrate analogues, enzyme modifications by chemical procedures affecting amino acid chain, treatment with protease, site directed mutagenesis, Allosteric enzymes with special reference to aspartate transcarbamylase and phosphofructokinase. Concerted and sequential models. Isozymes- special reference to lactate dehydrogenase. Ribozymes. 0.75

UNIT - V

Mechanism of enzyme action: General mechanistic principle, Factors contributing to the catalytic efficiency-proximity and orientation, nucleophilic and covalent catalysis, acid-base catalysis, metal ion catalysis. 0.5
Mechanism of reactions catalyzed by enzymes: Specific examples (Chymotrypsin, Lysozyme, Ribonuclease and Carboxypeptidase).

Recommended Books: -

1. Lehninger Principles of Biochemistry, Seventh Ed. 2017, Nelson & Cox, Macmillan Publishers.
2. Text book of Biochemistry, West, E.S., Todd, Manson & Vanbruggen. Macmillan.
3. Organic Chemistry Vol 2: Stereochemistry and the Chemistry of Natural Products, 5th, Fifth Edition
4. Biochemistry, Zubay, G. Fourth Edition, Wm.C. Brown Publishers, 1998.
5. Enzymology, Devasena T. 2010. Oxford University Press.

**Paper - XIV: Research Methodology: Tools & Techniques****(Course Code: S0LS/MBT/SS 003)****No. of Credits = 3****UNIT - I**

Importance and need of scientific research. 0.75
 Problem identification, objectives, significance, scope and limitations.
 Literature survey: Use of books, journals, libraries, online survey.
 Importance and designing of the problem to be undertaken.

UNIT - II

Field survey, site selection, source selection for data acquisition. 0.5
 Sampling techniques: Simple and random sampling,
 Systematic sampling, Stratified sampling, Multistage sampling,
 Cluster sampling, Multiphase sampling, Sample size,
 Frequency, Bias, Error.

UNIT - III

Methods: Data collection, types of data, qualitative and quantitative data. 0.75
 Primary and secondary data, data summarization
 Data representation: Tabular and diagrammatic representation of data.
 Measures of central tendency: Use of mean, mode, median. Data interpretation.

UNIT - IV

Measures of dispersion: Use of range, variance, standard deviation, standard error. 0.5
 correlation, multiple correlations,
 regression, multiple regressions, standard error of estimate.
 Test of significance: t-test, 95% confidence limit,
 Chi square test, F-test, Multivariate test.

UNIT - V

Project Report Preparation: Introduction of the problem, Materials and methods, 0.5
 Review of literature, Results, Discussion (interpretation of results),
 Referencing technique, Summary of research/Abstract etc.
 Publication of scientific data, writing research paper & report.

Recommended Books: -

1. Holmes, Moody, Dine: Research Methods for the Biosciences, 1st Indian ed., Oxford University Press, 2006.
2. N. Gurumani: Research Methodology for Biological Sciences, 1st ed., MJP Publishers, 2008.
3. Schmauder: Methods in Biotechnology, Taylor & Francis Publishers, 2003

**Paper - XIV: Science Communication & Scientific Writing****(Course Code: S0LS/MBT/SS004)****No. of Credits = 3****UNIT - I**

Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; 0.75

UNIT - II

Barriers to effective communication; power of effective listening; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; 0.5

UNIT - III

Use of ICT in Biology, Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; Keywords and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy for communication with peers and collaborators/scientists. 0.75

UNIT - IV

Importance of communicating science, problems during communication Importance of reading scientific communications 0.5
 Technical writing skills - types of reports; layout of a formal report;
 Scientific writing skills – types; importance
 Platforms for scientific reading

UNIT - V

Plagiarism, why there is need to plagiarize, Image and text plagiarism, softwares for plagiarism; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct. 0.5

Recommended Books: -

1. Valiela, I. (2001). *Doing Science: Design, Analysis, and Communication of Scientific Research*. Oxford: Oxford University Press.
2. *On Being a Scientist: a Guide to Responsible Conduct in Research*. (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. *The Science of Scientific Writing*. American Scientist, 78 (Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). *Speaking English Effectively*. Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist

**Paper - XV: Environmental Biotechnology****(Course Code: XIX:S0LS/MBT/C0016)****No. of Credits = 3****UNIT - I**

Introduction to environment; pollution types and its control; pollution indicators; sources of wastes and pollutants of water and soil, waste management: Domestic, industrial treatment of liquid waste, aerobic and anaerobic waste water treatment, Treatment of solid waste, Landfills, hazards of landfill contributions of biotechnology to waste treatment 0.5

UNIT - II

Bioremediation: Fundamentals, methods and strategies 0.5
Phytoremediation: Fundamentals and description of major methods and application
Application of bacteria and fungi in bioremediation uses, advantages vs disadvantages.
Bioremediation of metals, radionuclides, organic pollutants (PAHs, PCBs, Pesticides, TNT, xenobiotic compounds), technological aspects of bioremediation (*in situ*, *ex situ*)

UNIT - III

Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; microorganisms involved and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers 0.5

UNIT - IV

Biofungicides: Description of mode of actions and mechanisms (e.g. *Trichoderma*, *Pseudomonas fluorescens*); Biofertilizers: Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems, PGPR and heavy metals, Halotolerant PGPR and prospects, Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization), Biotechnological aspects of phytoremediation, biodegradation of xenobiotic compounds, 0.75

UNIT - V

Bioinsecticides and biopesticides: *Bacillus thuringiensis*, genetic modifications and aspects of safety in their use; Role of GMOs in environment clean-up, Dye removal using biotechnological interventions, Oil spillage and biotechnological remedies, Biosensors for environment monitoring and analysis, Nanotechnology and its applications, metallic nanoparticle uses, Green nanomaterials for environmental cleaning, Algal biotechnology- concepts, uses and applications, Use of mixed microbial populations 0.75

Recommended Books: -

1. Frederick W Pontinus, Water Quality & Treatment. American water works Association, MC Graw Hill
2. Fundamentals of Environmental Science: G. S. Dhaliwal, G. S. Sangha and P. K. Raina, Kalyani Publication
3. Perry L. McCarty; Bruce E. Rittmann (2020) Environmental biotechnology: principles & applications 2nd Ed Springer
4. Pramod Kumar; Vipin Kumar (2018) Textbook of Environmental Biotechnology. Woodhead Publishing India
5. Raman Kumar, Anil Kumar Sharma, Sarabjeet Singh Ahluwalia (eds.) (2017) Advances in Environmental Biotechnology [1 ed.] Springer Singapore

**Paper XVI: Fermentation & Bioprocess Technology****(Course Code: S0LS/MBT/C0017)****No. of Credits = 3****UNIT - I**

Introduction to fermentation and its types, Isolation, screening, improvement and preservation of Industrially important microbes; Microbial growth kinetics in batch, continuous and fed-batch processes. 0.5

UNIT - II

Media formulation for industrial fermentation, Requirement of precursors, inducers and antifoam agents as media additives; Medium optimization; Volumetric mass-transfer coefficient and its measurement, Kinetics of sterilization. 0.5

UNIT - III

Types of bioreactors (CSTR, bubble column, airlift, fluidized bed, packed bed): General configuration and applications; Scale up and scale down; Measurement and control of bioprocess parameters 0.75

UNIT - IV

Down Stream Processing: Cell disruption techniques; Separation techniques: filtration, centrifugation, sedimentation, flocculation, liquid-liquid extraction, precipitation, reverse osmosis, ultrafiltration; Drying; Crystallization; Storage and packaging. 0.5

UNIT - V

Industrial production (Microorganisms and raw material/media used, fermentation conditions and purification steps) and uses of fermentation products: Ethanol, Butanol, Antibiotics (Penicillin, Tetracycline), Alcoholic beverages, Enzymes (Glucose isomerase, Protease), Xanthan gum, Baker's yeast. Solid state fermentation and its applications 0.75

Recommended Books: -

1. Shuler, M. L., &Kargi, F. (2002). Bioprocess Engineering: Basic Concepts.Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F. & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.
4. Bailey, J. E., &Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.

**Paper - XVII: Advanced Bioinformatics****(Course Code: SOLS/MBT/E0004a)****No. of Credits = 3****UNIT - I**

Introduction, definition and history of Bioinformatics. 0.5
 Introduction to Internet, bibliographic and non bibliographic search, PubMed
 Introduction biological databases (primary, secondary and composite databases).
 Biological information system: SRS, ENTREZ (Structure and use on web).

UNIT - II

Introduction to Data mining: Classification, clustering, data collection, 0.75
 data Warehousing, data preprocessing, Applications of data mining and genomes
 mining. Databases: Nucleotide sequence information sources: GenBank, EMBL,
 EBI, DDBJ, UCSC. Protein sequence information sources: PIR, ExPASy,
 UniProt KB, SwissProt, TrEMBL,
 Protein structure information sources: PDB, SCOP, CATH, HSSP.

UNIT - III

Biocomputing : Introduction to String matching algorithms, 0.75
 Database search techniques, sequence comparison and alignment techniques,
 Use of Biochemical scoring matrices, Introduction to Graph Matching Algorithms,
 Automated genome comparison and its implication, Automated gene prediction,
 Gene arrays, Analysis of gene arrays. Introduction to signaling pathways and
 pathway regulation (KEGG), Systems biology-an introduction

UNIT - IV

Genoinformatics, Genome Annotation: Introduction, ORF's. 0.5
 Gene mapping and applications: Genetic and physical mapping,
 Transcriptome and Proteome- General account. Sequence Alignment: Pairwise and
 multiple alignment, Dynamic programming. Softwares (SSearch, BLAST, FASTA,
 CLUSTAL W), Phylogenetic analysis: Phenetic and Cladistic approach.
 Phylogenetic tree construction (rooted and unrooted method),
 Completed Genomes: Bacterium, nematode, plant and human

UNIT - V

Production of protein structure & modeling. Protein primary & secondary structure, 0.5
 prediction Methods – Introduction to various methods. Tertiary structure prediction
 (Homology & Threading Methods) Profiles, Motifs – Regular expressions. Repeat finding
 and pattern recognition. Molecular modeling, Docking and rational Drug design.

Recommended Books: -

1. Moorhouse & Barry: Bioinformatics, Biocomputing and Perl (Wiley-liss publications).
2. Jones & Prvzner: Introduction to Bioinformatics Algorithm, Anne Press.
3. Pevsner: Bioinformatics & Functional Genomics, Wiley-publication.
4. Bourne & Weissig: Structural Bioinformatics, Wiley-Liss Publication.
5. Gustafson, Shoemaker, Snape: Genome Data Mining Exploitation: the Genome.
6. Richard S Larson: Bioinformatics and drug discovery, humana press.
7. Sharma, Munjal & Shankar: A Text Book of Bioinformatics, Rastogi Publication

**Paper - XVII: Herbal Biotechnology****(Course Code: SOLS/MBT/E0004b)****No. of Credits = 3****UNIT - I**

Herbal medicines: history and scope. Local health traditions, ethnomedicines 0.5
 Important Medicinal and aromatic plants (MAPs) of Garhwal Himalayas- their diversity, distribution, traditional knowledge,

UNIT - II

Phytochemistry - active principles of herbal drugs-Biological testing, phytochemical 0.75
 screening for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds, fatty acids, tannins, glycosides and volatile oils etc.)
 Knowledge of few important MAPs, their uses etc. *Aconitum*, *Andrographis*, *Nardostachys jatamansi*, *Picrorhiza*, *Coleus*, *Rhododendron*, *Acorus calamus*, *Swertia chirata*, *Tinospora cordifolia*, *Berberis* etc.

UNIT - III

Phytometabolites of medicinal importance, Important genes and proteins related to 0.5
 metabolites, Signaling pathways, Transgenic plants- Overexpression and downregulation approach to manipulate the metabolite levels in few medicinal plants like *Andrographis paniculata* etc.

UNIT - IV

Diseases associated with raw/processed medicinal plants, and diagnostics related 0.75
 Few initiatives for cultivation and conservation of medicinal plants,
 Plant Tissue culture as an alternative for conservation of MAPs- prospects and challenges, Demand and supply, Herbal Industries at national and state levels. Ministry of AYUSH, National/ State Medicinal plant board- Organization, aims, objectives and mandate Ayurveda Biology, Role of herbal drugs at International levels

UNIT - V

Economic importance, biotechnological applications and challenges of 0.5
 herbal biotechnology. Green synthesis of nanoparticles using medicinal plants
 Phytopharmaceuticals: examples and applications
 Nutraceuticals: examples and applications

Recommended Books: -

1. B.D. Singh A textbook of biotechnology.
2. G. Patrick, Medicinal Chemistry. (2002)
3. Shah and Seth, Text book of Pharmacognosy and phytochemistry (2010) Elsevier publications

**Paper - XVII: Genomics & Proteomics****(Course Code: SOLS/MBT/E0004c)****No. of Credits = 3****UNIT - I**

Basics of genomics and proteomics, Brief overview of prokaryotic and eukaryotic genome organization; Chromatin organization; Extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast. 0.5

UNIT - II

Genome mapping, Genetic and physical maps; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, comparative gene mapping 0.5

UNIT - III

Genome sequencing projects; Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web. 0.75
Comparative genomics; Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs.

UNIT - IV

Proteomics; Aims, strategies and challenges in proteomics; proteomics technologies: MALDI-TOF, yeast 2-hybrid system, Surface Plasmon Resonance (SPR), proteomics databases. 0.5

UNIT - V

Functional genomics and proteomics; Transcriptome analysis, functional annotation of gene, Contig assembly, mining functional genes in genome, gene function- forward and reverse genetics, protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics. 0.75

Recommended Books: -

1. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
2. Liebler, D. C. (2002). *Introduction to Proteomics: Tools for the New Biology*. Totowa, NJ: Humana Press.
3. Campbell, A. M., & Heyer, L. J. (2003). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings

**Paper - XVIII: Vaccines & Drug Development****(Course Code: S0LS/MBT/ SS005)****No. of Credits = 3****UNIT - I**

Molecular Basis of Disease: Bacterial, Overview of Pathogenesis, diagnosis and treatment; Viral Overview of Pathogenesis, diagnosis and treatment, Host-virus Interaction, Progression of viral disease in host, Challenges in treatment. 0.5

UNIT - II

Biology of Parasites: Malaria, Dengue, Filariasis, Amebiasis. Parasite life cycle, Parasite-vector interactions, Parasite-Host Interactions, Pathogenesis, Diagnosis, Treatment and drug resistance. 0.5

UNIT - III

Drug Designing, Molecular Modeling, Molecular docking, Structure based Drug Designing, rational drug design, Lead Molecule Identification and optimization, validation. Drug Target Discovery, *in silico* drug discovery, Mechanism of action. Challenges 0.5

UNIT - IV

History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine, vector vaccines, anti-idiotypic vaccines; Multivalent subunit vaccines; immune stimulants. 0.75

UNIT - V

Vaccine delivery systems (liposome, microsphere and nanoparticle mediated) and immunostimulatory adjuvants, Edible vaccines. 0.75
General account of the different stages in development of new vaccines and clinical trials, Overview of the different steps in vaccine manufacture.

Recommended Books: -

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). *Immuno Biology: the Immune System in Health and Disease*. USA: Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). *Kuby Immunology*. W.H. Freeman.
3. Kaufmann, S. H. (2004). *Novel Vaccination Strategies*. Weinheim: Wiley-VCH.
4. Journal Articles (relevant issues) from: *Annual Review of Immunology*, *Annual Review of Microbiology*, *Current Opinion in Immunology*, *Nature Immunology*, *Expert review of vaccines*
5. <https://www.nature.com/subjects/structure-based-drug-design>
6. D.J. Abraham, *Structure-Based Drug Design – A Historical Perspective & the Future*, Ed(s): John B. Taylor, David J. Triggle, *Comprehensive Medicinal Chemistry II*, Elsevier, 2007, Page 65-86.
7. J.S. Mason, *Introduction to the Volume and Overview of Computer-Assisted Drug Design in the Drug Discovery Process*, Editor(s): John B. Taylor, David J. Triggle, *Comprehensive Medicinal Chemistry II*, Elsevier, 2007, Pages 1-11,

**Paper - XVIII: Molecular Virology****(Course Code: S0LS/MBT/SS006)****No. of Credits = 3****UNIT - I**

History of Virology and Biosafety: History and principles of virology, Virus taxonomy. 0.75
 Structures of animal and plant viruses and their morphology.
 Principles of biosafety, containment facilities, maintenance and handling of laboratory animals, and requirements of virology laboratory.

UNIT - II

Virus Replication: Structure and replication strategies of bacteriophages - T7, λ , Φ X174, 0.5
 and plant viruses - ss RNA virus (TMV) and ds DNA virus (CaMV). Structure and replication strategies of animal viruses - Influenza virus, Adeno virus and Retro virus.

UNIT - III

Interferon and Antiviral Agents: Viral Interference and interferons. Nature and source of 0.5
 interferons, Classification of interferons. Induction of interferon.
 Antiviral agents (chemical and biological) and their mode of actions.

UNIT - IV

Cultivation of Viruses and Viral Vaccines: Cultivation of viruses in embryonated egg, 0.5
 Tissue culture and Laboratory animals. Conventional vaccines - Killed and attenuated.
 Modern vaccines - Recombinant proteins, subunits, DNA vaccines, peptides,
 Immunomodulators (cytokines). Vaccine delivery and adjuvants, Large-scale manufacturing.

UNIT - V

Virological Methods: Methods for purification of viruses with special emphasis on 0.75
 ultracentrifugation methods. Quantitative diagnostic methods - Haemagglutination,
 Complement fixation, neutralization,
 Nucleic acid based diagnosis - PCR, microarray and nucleotide sequencing.

Recommended Books: -

1. General Virology - Luria and Darnel Virology and Immunology - Jokli
2. Text book of Virology - Rhodes and Van Royen
3. Genetics of bacteria and their viruses - W. Hayes
4. Molecular Biology of the gene - Watson, Roberts, Staitz and Weiner
5. Virological Procedures - MitchalHaskingVirology - Wilson and Topley
6. Infection and Immunity DH Davies, MA Halablab,, et al (1998) Taylor & Francis Ltd, 1, London