Department of Biotechnology

M.Sc. Biotechnology

(Two-year P.G. Program) as per NEP-2020

Course Contents

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Syllabus

(Effective from 2025-26)

Hemvati Nandan Bahuguna Garhwal University
(A Central University)
Srinagar, Garhwal, 246 174, Uttarakhand

Syllabus for M.Sc. Biotechnology

Two-year P.G. Program as per NEP (Effective from 2025-26)

First semester

Entry Requirement	3-year Bachelor's degree (minimum 120 credits and candidates who have met the entrance requirements, including specified levels of attainment, in the admission regulations**.**					
Semester	**Course Category**	**Course Code**	**Course Title**	**Credits**		**Total Credits**
				T	**P**	
I	Discipline Specific Core (DSC)	SOLS/MBT/DSC-1	Biochemistry and Metabolism	5	-	5
		SOLS/MBT/DSC-2	Advanced Molecular Biology	5		5
		SOLS/MBT/DSC-3	Microbes and Microbial Technology	5	-	5
		SOLS/MBT/DSCP-1	DSC Practical (Lab Course based on SOLS/MBT/DSC-1, DSC-2 & DSC-3)	-	3	3
	Discipline Specific Elective (DSE) (Any one)	SOLS/MBT/DSE-1a	Genomics and Proteomics	4		4
		Or				
		SOLS/MBT/DSE-1b	Biofuels and Biopolymers			
		SOLS/MBT/DSEP-1	DSE Practical (Lab Course based on SOLS/MBT/DSE-1a or DSE-1b)	-	2	2
Total				**19**	**5**	**24**

Second semester

Semester	**Course Category**	**Course Code**	**Course Title**	**Credits**		**Total Credits**
				T	**P**	
II	Discipline Specific Core (DSC)	SOLS/MBT/DSC-4	Bio-Analytical Techniques	5	-	5
		SOLS/MBT/DSC-5	Immunology	5		5
		SOLS/MBT/DSC-6	Genetic Engineering and Applications	5	-	5
		SOLS/MBT/DSCP-2	DSC Practical (Lab Course based on SOLS/MBT/DSC-4, DSC-5 & DSC-6)	-	3	3
	Discipline Specific Elective (DSE) (Any one)	SOLS/MBT/DSE-2a	Nanobiotechnology	4	-	4
		Or				
		SOLS/MBT/DSE-2b	Epigenetics and Cancer Biology			
		SOLS/MBT/DSEP-2	DSE Practical (Lab Course based on SOLS/MBT/DSE-2a or DSE-2b)	-	2	2
Total				**19**	**5**	**24**
NHEQF level-6	Student on exit after successfully completing first year of 2-year PG (i.e., securing minimum required 48 credits will be awarded "Postgraduate Diploma" of one year, in Biotechnology					

Third semester

Semester	Course Category	Course Code	Course Title	Credits		Total Credits
				T	P	
III	Discipline Specific Core (DSC)	SOLS/MBT/DSC-7	Molecular Genetics	5	-	5
		SOLS/MBT/DSC-8	Bioinformatics and Biostatistics	5		5
		SOLS/MBT/DSC-9	Molecular Cell Biology	5	-	5
		SOLS/MBT/DSCP-3	DSC Practical (Lab Course based on SOLS/MBTDSC-7, DSC-8 & DSC-9)	-	3	3
	Discipline Specific Elective (DSE) (Any one)	SOLS/MBT/DSE-3a	Plant Biotechnology	4	-	4
		Or				
		SOLS/MBT/DSE-3b	Protein Engineering			
		Or				
		SOLS/MBT/DSE-3c	Biomedical Technology			
		SOLS/MBT/DSEP-3	DSE Practical (Lab Course based on SOLS/MBT/DSE-3a, DSE-3b or DSE-3c	-	2	2
Total				**19**	**5**	**24**

Fourth semester

Semester	Course Category	Course Code	Course Title	Credits		Total Credits
				T	P	
IV	Discipline Specific Core (DSC)	SOLS/MBT/DSC-10	Intellectual Property Rights, Bioethics and Bio-Entrepreneurship	5	-	5
		SOLS/MBT/DSC-11	Environmental Biotechnology	5		5
		SOLS/MBT/DSC-12	Industrial Biotechnology	5	-	5
		SOLS/MBT/DSCP-4	DSC Practical (Lab Course based on SOLS/MBTDSC-10, DSC-11 & DSC-12)	-	3	3
	Discipline Specific Elective (DSE) (Any one)	SOLS/MBT/DSE-4a	Immunotechnology	4	-	4
		Or				
		SOLS/MBT/DSE-4b	Animal Biotechnology			
		SOLS/MBT/DSEP-4	DSE Practical (Lab Course based on SOLS/MBT/DSE-4a or DSE-4b	-	2	2
		SOLS/MBT/DSE-4c	Dissertation (In place of SOLS/MBT/DSE-4a or DSE-4b and SOLS/MBT/DSEP-4		6	6
Total				**19/15**	**5/9**	**24**
NHEQF level-6.5	Student on successfully completing 2-year PG (i.e., securing minimum required 96 credits will be awarded "Postgraduate Degree" in Biotechnology					

M.Sc. Biotechnology 1st Sem.

Paper-I Biochemistry and Metabolism

(Course Code: SOLS/MBT/DSC-1)

No. of Credits: 5

UNIT-I (Cr- 1)

Carbohydrates: Classification, structure, and functions.

Carbohydrate metabolism I: Pathway and regulation of glycolysis, gluconeogenesis, glycogenolysis, and glycogenesis.

Carbohydrate metabolism II: Citric acid cycle and its regulation, electron transport chain and oxidative phosphorylation, pentose phosphate pathway, and its regulation.

UNIT- II (Cr-1.25)

Fatty acids: Classification and structure.

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- III (Cr-1)

Nucleic acids: Structure and functions.

Nucleic acid metabolism: Purine biosynthesis and its regulation, pyrimidine biosynthesis, and its regulation, formation of deoxyribonucleotides, Salvage pathway for purine and pyrimidine nucleotides, degradation of purines and pyrimidines.

UNIT-IV (Cr-1.25)

Amino acids: Structure and functional group properties, peptides and covalent structure of proteins, primary and higher-order structures, and 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, and conversion of nitrogen to ammonia by microorganisms.

UNIT-V (Cr-0.5)

Enzymes: Introduction and classification, concept of E-S complex, binding sites, active site, specificity, lock and key hypothesis, induced-fit hypothesis, zymogens, Michaelis-Menten equation, enzyme inhibition.

Recommended Books:

1. Garrett R.H., Grisham C.M. Biochemistry. 2024. 7th ed. Cengage.
2. Berg J.M., Tymoczko J.L., Gatto G.J.Jr., Stryer L. Biochemistry. 2023. 10th ed. Macmillan Learning.
3. Kennelly P.J., Botham K.M., McGuinness O.P., Rodwell V.W., Weil P.A. Harper's Illustrated Biochemistry. 2022. 32nd ed. McGraw-Hill.
4. Voet D., Voet J.G., Pratt C.W. Fundamentals of Biochemistry: Life at the Molecular Level. 2023. 6th ed. John Wiley & Sons.
5. Nelson D.L., Cox M.M., Hoskins A.A. Lehninger Principles of Biochemistry. 2021. 8th ed. W.H. Freeman.
6. Conn E., Stumpf P. Outlines of Biochemistry. 2009. 5th ed. John Wiley & Sons.

M.Sc. Biotechnology 1st Sem.

Paper-II Advanced Molecular Biology

(Course Code: SOLS/MBT/DSC-2)

No. of Credits: 5

UNIT-I (Cr- 1)

Chemical and physical properties of nucleic acids: Structure and types of RNA and DNA, Watson-Crick model, different forms of DNA, topological properties of DNA, and DNA renaturation kinetics; DNA as genetic material

UNIT- II (Cr-1)

DNA replication and mechanism: Enzymes and proteins involved in DNA replication, mechanism of DNA replication in prokaryotes and eukaryotes, molecular mechanism of the regulation process of DNA replication in prokaryotes and eukaryotes.
DNA damage: Types and repair mechanisms.

UNIT- III (Cr-1)

Mechanism of transcription: Promoter, *cis* and *trans* elements, and consensus sequences, mechanism of transcription in prokaryotes and eukaryotes, reverse transcription.
Post-transcriptional processing of RNA: Capping, polyadenylation, splicing, and RNA editing.

UNIT-IV (Cr-1)

Mechanism of translation in prokaryotes and eukaryotes: Genetic code, wobble hypothesis, Aminoacyl-t RNA synthetase and its role, steps of initiation, elongation and termination of translation process and the proteins and enzymes involved. Post-translational modifications and its relevance.

UNIT-V (Cr-1)

Regulation of gene expression in prokaryotes and eukaryotes: Positive and negative regulation, *lac* operon, and *trp* operon, regulatory proteins and DNA binding, chromatin modifications associated with gene expression, and regulatory modules for eukaryotic promoters.

Recommended Books:

1. Brown T.A. Genomes 5. 2023. 5th ed. CRC Press.
2. Nelson D.L., Cox M.M. Lehninger Principles of Biochemistry. 2021. 8th ed. W.H. Freeman & Co.
3. Krebs J.E., Goldstein E.S., Kilpatrick S.T. Lewin's Genes XII. 2018. 12th ed. Jones & Bartlett Learning.
4. Watson J.E. Molecular Biology of the Gene. 2014. 7thed. Pearson Publishers.

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M.Sc. Biotechnology 1st Sem.

Paper-III Microbes and Microbial Technology

(Course Code: SOLS/MBT/DSC-3)

No. of Credits: 5

UNIT-I (Cr- 1.5)

Microorganisms: General structure, characteristic features and classification of bacteria, fungi and viruses.

Laboratory culture and methods to study microbes: Concept of pure culture, aseptic conditions, sterilization and staining methods. microbial culture media and its types.

UNIT– II (Cr- 0.5)

Bacterial growth: Monoauxic, diauxic, and synchronous growth, growth phases, and growth curve. Factors affecting bacterial growth, modes of bacterial nutrition, methods to control microbial growth.

UNIT– III (Cr- 1)

Microbial applications in food & health: Microbial processes and their application in food and healthcare industries, food processing and food preservation, Single cell proteins (*Spirulina*, and Yeast), and microbial production of organic acids, vitamins, and amino acids.

UNIT–IV (Cr- 1)

Microbial cell factories: Definition and concept, advantages over traditional chemical synthesis, and applications.

Plant growth promoting bacteria: Types and their applications.

Microbial production of nanoparticles.

UNIT–V (Cr- 1)

Metagenomics: Definition and concept, applications in studying unculturable microorganisms, metagenomic library construction and functional screening in suitable hosts, amplicon and genome sequencing to study microbial diversity and functions, general overview of bioinformatics methods for studying metagenomics sequence data.

Recommended Books:

1. Willey, J., Sherwood, L., Woolverton, C.J. Prescott's Microbiology. 2023. 10th ed. New York, McGraw Hill Education.
2. Wood, D., Joanne, W., Sandman, K. Prescotts Microbiology. 2023.McGraw Hill Education.
3. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M., Stahl, D.A. Brock Biology of Microorganisms. 2021. 16th ed. Pearson Education Ltd.
4. Tortora, G.J., Funke, B.ll R., Case, C.L. Microbiology: An Introduction. 2019. 13th ed. Chicago, Pearson.
5. Pelczar, M.J., Chan, E.C.S., Krieg, N.R. 2001. Microbiology, McGraw Hill Education.

M.Sc. Biotechnology 1st Sem.

Lab-I DSC Practical (Lab Course based on SOLS/MBT/DSC-1, DSC-2 & DSC-3)

(Course Code: SOLS/MBT/DSCP-1)

No. of Credits: 3

Practicals based on DSC (Biochemistry and Metabolism)

1. Quantitative estimation of protein.
2. Quantitative estimation of carbohydrate.
3. Quantitative estimation of cholesterol.
4. Determination of the acid value of fats.

Practicals based on DSC (Advanced Molecular Biology)

1. Isolation of genomic DNA.
2. Qualitative and quantitative estimation of DNA.
3. Determination of the melting temperature of DNA.
4. Preparation of the absorption spectra of DNA.

Practicals based on DSC (Microbes and Microbial Technology)

1. Enumeration of microorganisms.
2. Preparation of pure culture of microorganisms.
3. Staining of microbial cells.
4. Preparation of agar slant and glycerol stock for microbial culture preservation.

Any other practical based on the facility.

M.Sc. Biotechnology 1st Sem.

Paper-IV Genomics and Proteomics
(Course Code: SOLS/MBT/DSE-1a)

No. of Credits: 4

UNIT-I (Cr- 0.75)
Introduction to genomics: A brief overview of prokaryotic and eukaryotic genome organization, chromatin organization, and characteristics. Comparative and functional genomics.
Extra-chromosomal DNA: Bacterial plasmids, mitochondrial and chloroplast DNA, their significance and evolutionary importance.

UNIT- II (Cr- 0.75)
Genome mapping: Its importance and characteristics, genetic and physical maps, methods and techniques used for gene mapping, linkage analysis.
Definition, concept and applications of transcriptomics and metabolomics and their integration with genomics.

UNIT- III (Cr- 1)
High throughput DNA sequencing: NGS, Genome sequencing projects.
Genome Analysis & Variation: Genome annotation, phylogeny, cluster of orthologous groups, and single nucleotide polymorphisms.
Expression profiling: Expressed sequence tags, serial analysis of gene expression, and total gene expression analysis.

UNIT-IV (Cr- 0.75)
Proteomics: Aims, strategies and challenges in proteomics, and functional and structural proteomics.
Proteomics technologies: Protein sequencing techniques, 2D gel electrophoresis, MALDI-TOF, Surface Plasmon resonance (SPR), and mass spectrometry.

UNIT-V (Cr- 0.75)
DNA-protein interactions: DNA binding motif, and methods for detecting DNA-protein interactions, protein motifs and domains, methods for protein-protein interactions detection, protein chips, clinical and biomedical applications of proteomics.

Recommended Books:
1. Rastogi, S.C., Rastogi, P., Mendiratta, N. Bioinformatics Methods and Applications: Genomics, Proteomics and Drug Discovery. 2022. 5th ed. PHI.
2. Rudolph, M. Genomics and Proteomics: Functional and Computational Aspects. 2019. 1st ed. Syrawood Publishing House.
3. Keerthikumar, S., Mathivanan, S. Proteome Bioinformatics. 2017. 1st ed. Springer, Humana, New Yark.
4. Kussmann, M., Stover, P.J. Nutragenomics and Proteomics in Health and Disease. 2017. 2nd ed. John Wiley & Sons Ltd.
5. Campbell, A.M., Heyer, L.J. Discovering Genomics, Proteomics, and Bioinformatics. 2007. 2nd ed. San Francisco, CSHL Pearso/Benjamin Cummings.

M.Sc. Biotechnology 1st Sem.

Paper-IV Biofuels and Biopolymers
(Course Code: SOLS/MBT/DSE-1b)

No. of Credits: 4

UNIT-I (Cr- 0.75)
Introduction to biofuels: Generation of biofuels (first, second, third and fourth generations) and their historical development, various types of biofuels and their properties and characteristics.

UNIT- II (Cr- 0.5)
Microbial metabolism to produce biofuels: Producers of key biofuels such as biohydrogen, biomethane, biomethanol, bioethanol, biodiesel, and biobutanol, and their metabolism.

UNIT- III (Cr- 1)
Anaerobic digestion and waste management: Biotechnological aspects in biofuels production from biowaste(s).
Genetic engineering of biofuel producers: Bioprocess management in major biofuels production such as biohydrogen and bioethanol, present status and future development in dark-fermentative, and photo-fermentative biohydrogen production technology.

UNIT-IV (Cr- 1)
Natural biopolymers: Types of natural biopolymers and their benefits over synthetic plastics.
Polyhydroxyalkanoates (PHA): Microbial biodiversity of PHA-producers, and their metabolism, microbial production of PHA co-polymers and their physicochemical characteristics.

UNIT-V (Cr- 0.75)
PHA application: Biotechnological advancement in application of PHA as biocontrol agents, drug carriers, medical implants, and tissue engineering.
Commercialization of PHA: Updates on commercial production of microbial PHA.

Recommended Books:
1. Soccol, C.R., Brar, S.K., Permaul, K., Pakshirajan, K., de Carvalho, J.C. Biohydrogen - Advances and Processes. 2024. 1st ed. Springer Cham.
2. Rena, Kumar S. Biofuels – Technologies, Policies and Opportunities. 2023. 1st ed. CRC Press.
3. Koller, M. The Handbook of Polyhydroxyalkanoates. 2023. 1st ed. CRC Press.
4. Sahay, S. Handbook of Biofuels. 2021.1st ed. Academic Press.
5. Kalia, V.C. Biotechnological Applications of Polyhydroxyalkanoates. 2019. 1st ed. Springer Singapore.

M.Sc. Biotechnology 1st Sem.

Lab-II- DSE Practical (Lab Course based on SOLS/MBT/DSE-1a or DSE-1b)

(Course Code: SOLS/MBT/DSEP-1)

No. of Credits: 2

Anyone of the following depending on the DSE taken in Theory course

Practicals based on DSE (Genomics and Proteomics)

1. Multiple sequence alignment using CLUSTALW.
2. Phylogenetic analysis of bacteria and fungi based on rRNA gene.
3. Prediction of subcellular localization of given protein sequences.
4. Retrieval and analysis of protein sequences from public databases.
5. Conserve domain analysis of a protein sequence.

Any other practical based on the facility.

Practicals based on DSE (Biofuels and Biopolymers)

1. Determination of the composition of biowaste(s).
2. Demonstration of dark fermentative biohydrogen production.
3. Determination of dry cell mass of bacterial culture.
4. Estimation of polyhydroxyalkanoate accumulation by bacteria
5. Characterization of polyhydroxyalkanoate.

Any other practical based on the facility.

M.Sc. Biotechnology 2nd Sem.

Paper-I Bio-Analytical Techniques

(Course Code: SOLS/MBT/DSC-4)

No. of Credits: 5

UNIT-I (Cr- 1)

Chromatography: General principles and applications of chromatography, paper chromatography, thin layer chromatography, gel filtration chromatography, ion exchange chromatography, affinity chromatography, gas chromatography and HPLC.

UNIT- II (Cr- 1)

Electrophoresis: General principle and applications, paper electrophoresis, moving boundary method, gel electrophoresis (Native, denaturing & reducing), isoelectric focussing (IEF), and isotachophoresis.

UNIT- III (Cr- 1)

Centrifugation: Basic principles and applications, types of rotors, common centrifuges used in laboratory, clinical, high speed & ultracentrifuges. Differential centrifugation, density gradient centrifugation-zonal and isopycnic.

UNIT–IV (Cr- 1)

Basic knowledge of the principles and applications of microscopy: Light, phase contrast, fluorescence microscopy, confocal laser scanning microscopy, scanning electron microscopy, transmission electron microscopy, and atomic force microscopy.

UNIT-V (Cr- 1)

Spectroscopic methods: Principle and applications of UV-visible, IR and fluorescence spectroscopy. Introduction to FTIR, NMR and X-ray crystallography and applications.

Recommended Books:

1. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., Walter, P. Molecular Biology of the cell. 2022. 7th ed. WW Norton & Co.
2. Egbuna, C., Patrick-Iwuanyanwu, K.C., Shah, M.A., Ifemeje, J.C., Rasul, A. Analytical Techniques in Biosiences: From Basics to Applications. 2021. 1st ed. Academic Press.
3. Ghosal, S., Avasthi, A.S. Fundamentals of Bioanalytical Techniques and Instrumentation. 2018. 2nd ed. PHI.
4. Hofmann, A., Clokie S. Wilson & Walker's: Principles and Techniques of Biochemistry and Molecular Biology. 2018. 8th ed. Cambridge Univ. Press.
5. Jayaraman, J. Laboratory Manual in Biochemistry. 2011. 1st ed. New Age International Private Ltd.

M.Sc. Biotechnology 2nd Sem.

Paper-II Immunology
(Course Code: SOLS/MBT/DSC-5)

No. of Credits: 5

UNIT-I (Cr- 1)
Historical development in Immunology.
Overview of the immune system: Innate and adaptive immunity, Cells and organs of the immune system, Hematopoiesis.
Antigens, antigenicity and immunogenicity, haptens & epitopes.
Immunoglobulins: Structure and function.

UNIT- II (Cr- 1)
Organization & expression of immunoglobulin genes: Multigene organization of 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 (Cr- 1)
Structure and functions of BCR & TCR.
Cytokines: Properties, general physiology, interferons, application of cytokine for therapy.
Complement system.
Cell mediated cytotoxicity: Mechanism of T cell & NK cell mediated lysis, Ab-dependent cell mediated cytotoxicity (ADCC).

UNIT–IV (Cr- 1)
Hypersensitivity: Types of hypersensitivity
Autoimmunity and their types.
Organ transplantation: Introduction, types and challenges, and graft rejection.
Vaccines: Types & applications, Active and passive Immunization.

UNIT-V (Cr- 1)
Monoclonal antibodies: Overview of monoclonal antibodies and hybridoma technology.
Types of antigen-antibody interactions: Precipitation reaction, agglutination reactions, RIA, ELISA, western blotting, immuno-precipitation, and immuno-fluorescence.

Recommended Books:
1. Stranford, S., Owen, J.A., Punt, J., Jones, P. Kuby: Immunology. 2022. 8th ed. W.H. Freeman.
2. Male, D., Peebles, R.S.Jr., Male, V. Immunology. 2020. 9th ed. Elsevier.
3. Hofmann, A., Clokie S. Wilson & Walker's: Principles and Techniques of Biochemistry and Molecular Biology. 2018. 8th ed. Cambridge Univ. Press.
4. Elgert, K.D. Immunology: Understanding the Immune System. 2009. 2nd ed. Wiley-Blackwell.
5. Hay, F.C., Westwood, O.M.R. Practical Immunology. 2002. 1st ed. Wiley-Blackwell.

M.Sc. Biotechnology 2nd Sem.

Paper-III Genetic Engineering and Applications
(Course Code: SOLS/MBT/DSC-6)

No. of Credits: 5

UNIT-I (Cr- 1)
Recombinant DNA technology: Introduction to Recombinant DNA technology and applications.
Nucleic acid modification: Nucleic acid modifying enzymes, and restriction endonucleases.
Cloning vectors: Plasmid and phage based vectors, cosmid, phagemid, yeast cloning vectors, animal and plant viruses as vectors. BAC, PAC & YAC.

UNIT- II (Cr- 1)
Nucleic acid isolation: Isolation of nucleic acid from plant, animal & bacteria.
Basic steps of gene cloning and heterologous expression: Cloning strategies, genomic library, selection of rDNA clones and their expression products, cDNA and cDNA library, expression of cloned genes in heterologous hosts.

UNIT- III (Cr- 1)
DNA sequencing: Chemical and enzymatic methods, NGS.
PCR: Types and applications, and real-time PCR,
Nucleic acid analysis techniques: Gel retardation assay, DNA foot-printing, DNA finger-printing.

UNIT–IV (Cr- 1)
Probe labeling, and hybridization.
Blotting techniques: Southern, northern, and western blotting (Methodologies and applications).
Site directed mutagenesis.

UNIT-V (Cr- 1)
Transgenic technology: Types, approaches & applications (plants & animals).
Gene therapy: Types and applications.
Genome editing technologies: Principles and applications, and CRISPR technology.

Recommended Books:

1. Glick, B.R., Pasternak, C.L. Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology. 2022. 6th ed. Wiley-Blackwell.
2. Grover, D.M. Gene Cloning and DNA Analysis. 2021. 8th ed. John Wiley & Sons Ltd.
3. Brown, T.A. Gene Cloning and DNA Analysis: An Introduction. 2020. 8th ed. Wiley-Blackwell.
4. Williamson, R. Genetic Engineering 3. 2012. 2nd ed. Springer.
5. Watson, J.D., Caudy, A.A., Myers, R., Witkowski, J.A. Recombinant DNA. 2007. 3rd ed. W H Freeman & Company.

M.Sc. Biotechnology 2nd Sem.

Lab- I DSC Practical (Lab Course based on SOLS/MBT/DSC-4, DSC-5 & DSC-6)
(Course Code: SOLS/MBT/DSCP-2)

No. of Credits: 3

Practicals based on DSC paper (Bio-Analytical Techniques)

1. Separation of compounds through paper chromatography.
2. Separation of cells from a suspension/biological sample by centrifugation.
3. Protein separation by SDS-PAGE.
4. Preparation of standard curve and determination of the concentration of unknown compound using UV-Visible spectroscopy

Practicals based on DSC paper (Immunology)

1. Blood group detection.
2. Precipitation test and ouidin tube test.
3. Outcherlony double diffusion test.
4. Dot-ELISA test for detection of antigen.

Practicals based on DSC paper (Genetic Engineering and Applications)

1. Genomic DNA isolation from bacteria or other organisms
2. Restriction digestion of DNA sample
3. Ligation of fragmented DNA
4. Demonstration of PCR.

Any other practical based on the facility.

M.Sc. Biotechnology 2nd Sem.

Paper-IV Nanobiotechnology
(Course Code: SOLS/MBT/DSE-2a)

No. of Credits: 4

UNIT-I (Cr-0.5)
Introduction to nanobiotechnology: Concepts, historical perspectives, types and various applications and uses of nanomaterials.

UNIT- II (Cr- 1)
Synthesis of nanoparticles: 'Top-Down' and 'Bottom-Up' approaches, physical, chemical, and biological approach of nanoparticle synthesis, limitations of physical and chemical approaches, and advantages of using the green synthesis approach.
Characterization of nanoparticles: Using UV spectrophotometer, XRD, SEM, TEM, HR-TEM, FTIR and dynamic light scattering, etc.

UNIT- III (Cr- 1)
Biological activities and applications of nanoparticles: Antimicrobial activity, antioxidant activity, anticancer activity, anti-inflammatory activity, dye degrading potential, and nano-fertilizers, application of nanoparticles in the treatment of Industrial wastewater, and pollution control.

UNIT–IV (Cr- 0.75)
Nanomedicine: Nanoparticles within a biological environment, nanoparticle dynamics in biological media.
Nanoparticles for therapy: Drug delivery, gene delivery, protein delivery, and uptake.

UNIT-V (Cr- 0.75)
Environmental impact of nanomaterials: Exposure and risk assessment, mechanism of toxicity, toxicological impacts of nanomaterials, cytotoxicity of nanomaterials, and phytotoxicity of nanoparticles.

Recommended Books:
1. Visakh, P.M., Bayraktar, O. Recent Progress in Nanobiotechnology: Modern Techniques in Biomedical Applications. 2024. 1st ed. Springer, Singapore.
2. Tomar, R.S., Jyoti, A., Kausik, S.K. Nanobiotechnology. 2020. 1st ed. Apple Academic Press Inc.
3. Hermanson, G.T. Bioconjugate Techniques. 2013. 3rd ed. Elsevier.
4. Summers, H.D. Nanomedicine. 2013. 1st ed. Elsevier.
5. Decher, G., Schlenoff, J.B. Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials. 2012. 2nd ed. Wiley-VCH Verlag GmbH.
6. Ramsden, J.J. Nanotechnology: An Introduction. 2011. 1st ed. Elsevier.

M.Sc. Biotechnology 2nd Sem.

Paper-IV Epigenetics and Cancer Biology
(Course Code: SOLS/MBT/DSE-2b)

No. of Credits: 4

UNIT-I (Cr- 0.75)
Introduction: Basic characteristics of cancer cells, morphological and ultrastructural properties of various types of cancer cells,
Types of growth: Hyperplasia, dysplasia, anaplasia and neoplasia, nomenclature of neoplasms, and differential characteristics of benign and malignant tumors.

UNIT- II (Cr- 0.5)
Cancer biology and biochemistry: Aberrant metabolism in cancer development, para-neoplastic syndromes, tumor markers, cellular proto-oncogenes, and their activation mechanism.
Growth factors: EGF, TNF, TGF and growth factor receptors, signal transduction in cancer, and the mechanism of transcription factors.

UNIT- III (Cr- 1)
Carcinogenesis: Radiation and chemical carcinogenesis and their mechanism.
Stages in chemical carcinogenesis: Initiation, promotion, and progression.
Role of free radicals, and 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, and angiogenesis.
Role of microbiomes in cancer.

UNIT–IV (Cr- 1)
Epigenetics: Role of DNA methylation in gene silencing, epigenetic silencing of tumor-suppressor genes and its benefits.
Apoptosis in cancer: Cell death by apoptosis, detailed mechanism, and the role of caspases.
Death signaling pathways: Mitochondrial and death receptor pathways.

UNIT-V (Cr- 0.75)
Detection methods of cancer: Type of detection and prediction of aggressiveness of cancer.
Different forms of therapy: Chemotherapy, radiation therapy, and immunotherapy and their brief mechanism, advantages, and limitations, epigenetics of cancer, and identification of targets for developing potential drugs.

Recommended Books:
1. Kumar, D.U. An Introduction to Epigenetics of Cancer. 2025. 1st ed. B P Internation.
2. Kalkan, R. Cancer Epigenetics. 2024. 1st ed. Springer Cham.
3. Gray, S.G. Epigenetic Cancer Therapy. 2023. 2nd ed. Academic Press.
4. Qazi, A.S., Tariq, K. Therapeutic Approaches in Cancer Treatment. 2023. 1st ed. Springer Cham.
5. Tollefsbol, T.O. Cancer Epigenetics. 2019. 1st ed. CRC Press.
6. Sarkar, F.H. Epigenetics and Cancer. 2013. 1st ed. Springer Dordrecht.

M.Sc. Biotechnology 2nd Sem.

Lab-II DSE Practical (Lab Course based on SOLS/MBT/DSE-2a or DSE-2b)

(Course Code: SOLS/MBT/DSEP-2)

No. of Credits: 2

Anyone of the following depending on the DSE taken in theory course

Practicals based on DSE (Nanobiotechnology)

1. Preparation of plant extract for nanoparticle synthesis
2. Green synthesis of nanoparticles using plant extract.
3. Characterization of nanoparticles.
4. Evaluation of the antioxidant activity of nanoparticles.
5. Evaluation of the antimicrobial activity of nanoparticles.

Practicals based on DSE (Epigenetics and Cancer Biology)

1. Protein sequence analysis of cancer related genes.
2. Homology search for cancer related genes.
3. *In silico* determination of physicochemical properties and 3-D structure analysis of a cancer related protein.
4. Demonstration of DNA methylation through *in silico* methods.
5. Demonstration of histone modification through *in silico* methods.

Any other practical based on the facility.

M.Sc. Biotechnology 3rd Sem.

Paper-I Molecular Genetics

(Course Code: SOLS/MBT/DSC-7)

No. of Credits: 5

UNIT-I (Cr- 1)

Chromatin: Structure of chromatin and higher order packaging in chromosome.

Principles of Genetic Inheritance: Mendelian law of Inheritance and its variations, linkage and crossing over, gene mapping, recombination, complementation, and extrachromosomal inheritance.

UNIT- II (Cr- 1)

Mutations: Types, mutation rate, reversion vs. suppression, mutagenic agents, molecular mechanism of mutagenesis.

Chromosomal aberrations: Change in number and structure.

Ploidy: Types & genetic implications.

UNIT- III (Cr- 1)

Transposons: Transposable genetic elements, insertion sequences, composite and complex transposons, replicative and non-replicative transposition, and genetic analysis using transposons.

UNIT–IV (Cr- 1)

Bacterial Conjugation: F-factor, conjugal transfer process, high frequency recombination (Hfr) strains.

Bacterial transformation: Competence, DNA uptake by competent cells and mechanism of transformation.

UNIT-V (Cr- 1)

Transduction: General & specialized transduction.

Genetics of bacteriophages: Lytic and lysogenic, cycle, expression of phage genes in regulation of lytic and lysogenic circuit.

Recommended Books:

1. Shergojry, S.A., Nisham, M.U. Introduction to Molecular Genetics. 2024. 1st ed. Lambert Academic Publisher.
2. Bhat, T.A., Shakoori, R., Al-Khayri, J.M. Molecular Genetics, Structure, Mechanism, and Functions. 2024. 1st ed. CRC Press.
3. Andres, A., Parafianowicz, P., Lantz, K. Molecular Genetics. 2021. 1st ed. Kendall/Hunt Publishing Company.
4. Snustad, D.P., Simmons, M.J. Principles of Genetics. 2015. 7th ed. John Wiley & Sons.
5. Joshi, D. Molecular Genetics of Bacteria. 2011. 1st ed. Oxford Book Company
6. Maloy, S.R., Cronan, J.E., Freifelder, D. Microbial Genetics. 1994. 2nd ed. Jones and Bartlett Publishers, Inc.

M.Sc. Biotechnology 3rd Sem.

Paper-II Bioinformatics and Biostatistics

(Course Code: SOLS/MBT/DSC-8)

No. of Credits: 5

UNIT-I (Cr- 1)

Introduction to bioinformatics: Objectives, applications and scopes of information technology in biology, bioinformatics resources, Word wide web, and web browsers.
Biological databases: Primary, secondary database, GENBANK, EMBL, DDBJ, PDB, and UNIPROT.
Search engines: Entrez, SRS, web server-NCBI, and EBI.

UNIT- II (Cr- 1)

Sequence alignment: Definition and applications,
Sequence similarity searching tools: FASTA, and BLAST, multiple sequence alignment (MSA) and applications, software and tools for MSA, phylogenetic analysis, tools for phylogenetic analysis and their applications.

UNIT- III (Cr- 1)

Protein structure: Prediction tools, molecular modeling (Homology modeling), visualization tools, protein-protein interactions and online tools for prediction.

UNIT–IV (Cr- 1)

Biostatistics and its importance in biological research.
Types of data and analysis: Qualitative vs. quantitative, discrete vs. continuous, primary and secondary data, methods of data collection, graphical representation of data.

UNIT-V (Cr- 1)

Statistical methods: Mean, mode, median, standard error, standard deviation, basics of probability theory, skewness & kurtosis, correlation & regression.
Statistical data calculation using computational tools.

Recommended Books:

1. Pasha, C., Swathi, Rajan A. Bioinformatics & Biostatistics. 2021. 1st ed. Divya Lakshmi Publishers.
2. Arumugam, N., Gopi, A. Mumaresan, V., Meena, A., Sundaralingam, R. Biostatistics, Computer Application and Bioinformatics. 2019. 4th ed. Saras Publication.
3. Lesk, A.M. Introduction to Bioinformatics. 2019. 5th ed. Wiley Publications
4. Rastogi, S.C., Mendiratta, N., Rastogi, P. Bioinformatics: Methods and Applications—Genomics, Proteomics, and Drug Discovery. 2013. 4th ed. Prentice Hall of India Private Ltd.
5. Balagurusamy, E. Fundamentals of Computers. 2008. 1st ed. Tata McGraw Hill.
6. Pevsner, J. Bioinformatics and functional genomics (3rd ed.), 2015. Wiley-Blackwell.

M.Sc. Biotechnology 3rd Sem.

Paper-III Molecular Cell Biology

(Course Code: SOLS/MBT/DSC-9)

No. of Credits: 5

UNIT-I (Cr- 1.5)

Prokaryotic and eukaryotic cell: Cell structure and organization, cell organelles, and cell wall.
Cell organelle's structure and function: Nucleus, mitochondria, Golgi body, endoplasmic reticulum, chloroplast, lysosome, peroxisome, ribosome and plasma membrane.
Cytoskeleton and its components.

UNIT- II (Cr- 1)

Membrane transportation: Membrane proteins, principle of membrane transport, types of cellular transport, channel proteins and their types, carrier proteins and functions, ion channels (Ion selective and voltage-gated ion channels) and membrane potential.

UNIT- III (Cr- 1)

Protein Sorting: Anterograde & retrograde mode of protein trafficking, vesicular transport, secretory and endocytic pathways, protein folding, unfolded protein response, cell signaling and their types, crosstalk in signaling pathways, and secondary messengers.

UNIT–IV (Cr- 0.5)

Cell growth: Cell division and differentiation, cell cycle and its regulation (Cyclins, CDK, and checkpoints), necrosis and its implications.

UNIT-V (Cr- 1)

Autophagy: Process and regulation, role in aging and neurodegenerative diseases.
Programmed cell death: Definition, significance, and types (overview).
Proto-oncogenes, and tumor suppressor genes.

Recommended Books:

1. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., Walter, P. Molecular Biology of the Cell. 2022.7th ed. WW Norton & Co.
2. Lodish, H., Berk, A., Kaiser, C.A. Molecular Cell Biology. 2021. 9th ed. W. H. Freeman & Co.
3. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry. 2021. 8th ed.). W. H. Freeman & Co.
4. Cooper, G.M., Hausman, R.E. The Cell: A Molecular Approach. 2019. 7th ed. Sinauer Associates Inc.
5. Watson, J.D., Tania, A.B., Stephen, P.B. Molecular Biology of the Gene. 2017. 7th ed. Pearson Education.

M.Sc. Biotechnology 3rd Sem.

Lab-I DSC Practical (Lab Course based on SOLS/MBT/DSC-7, DSC- 8 & DSC-9)

(Course Code: SOLS/MBT/DSCP-3)

No. of Credits: 3

Practicals based on DSC (Molecular Genetics)

1. Preparation of Master and Replica Plates.
2. Study of the effect of mutagens on bacterial cells
3. Observation of different conformations of plasmid DNA through Agarose gel electrophoresis
4. Demonstration of bacterial conjugation.
5. Demonstration of bacterial transformation

Practicals based on DSC (Bioinformatics and Biostatistics)

1. Study of the MS-office package and its applications.
2. Study of NCBI, PubMed databases.
3. Retrieval of nucleotide or protein sequences from the NCBI database.
4. Localization prediction of a protein sequence using the CELLO server.
5. Use of statistical methods (mean, mode, median etc.)

Practicals based on DSC (Molecular Cell Biology)

1. Measurement of cell size
2. Study of mitosis and meiosis.
3. Study of the osmosis process.
4. Chlorophyll estimation using a spectrophotometer.
5. Study of STRING tool to visualize and analyze PPI network signaling.

Any other practical based on the facility.

M.Sc. Biotechnology 3rd Sem.

Paper-IV Plant Biotechnology

(Course Code: SOLS/MBT/DSE-3a)

No. of Credits: 4

UNIT-I (Cr- 1)

Plant tissue culture: Laboratory and materials requirement, Aseptic techniques, media-composition & preparation,

Clonal propagation/micropropagation: Concept of Totipotency, types and applications of clonal propagation–(Meristem culture, Callus culture, suspension culture, Embryo culture & Embryo rescue). Secondary metabolites and its production.

Conservation of plant genetic resources *in vitro*, its applications and limitations.

UNIT- II (Cr- 0.75)

Haploid culture: Androgenesis & Gynogenesis

Protoplast culture & protoplast fusion – Cybrids, Symmetric & Asymmetric hybrid.

Somatic embryogenesis and Somaclonal variations

Cryo-preservation, production of synthetic seeds.

UNIT- III (Cr- 0.5)

Plant Transformation: *Agrobacterium* mediated gene transfer, Electroporation, Biolistics, etc.

Transgenic technology: Integration of transgenes, action of transgenes

UNIT–IV (Cr- 1)

Stress tolerance: Abiotic (Heat, salt, drought) and biotic stress tolerance (Insect resistance, Bt crops, Cry protein and action) in plants using biotechnological tools

Applications of plant transgenics: Flavr-savr tomato, Golden Rice and, Terminator gene technology.

UNIT-V (Cr- 0.75)

Phytohormones: Introduction of phytohormones, cross talk and signaling.

Plant growth promoting bacteria, PGPR traits, uses and applications, Biofertilisers, Phyto-priming for stress responses.

Recommended Books:

1. Singh B.D. A Textbook of Biotechnology. 2021. 6th ed. Kalyani Publishers.
2. Patrick G.L. An Introduction to Medicinal Chemistry. 2023. 7th ed. Oxford University Press.
3. Buchanan, B. B., Gruissem, W., & Jones, R. L. Biochemistry and molecular biology of plants. 2015. 2nd ed. John Wiley & Sons.
4. Dubey, R. C. A textbook of Biotechnology. 2022. 5th ed. (Reprint). S. Chand Publishing.
5. Stewart, C. N., Jr. (2008). Plant biotechnology and genetics: Principles, techniques, and applications. Wiley-Blackwell.

M.Sc. Biotechnology 3rd Sem.

Paper-IV Protein Engineering

(Course Code: SOLS/MBT/DSE-3b)

No. of Credits: 4

UNIT-I (Cr- 0.75)

Protein structure and engineering: Overview of protein engineering, structure and properties of amino acids, structures of proteins, analysis of protein structure by NMR, X-ray diffraction crystallography, hydrodynamic properties of protein.

UNIT- II (Cr- 0.75)

Unnatural Amino Acids and Protein Stability: Introduction and use of unnatural amino acids in protein engineering and their applications, methods of protein stability measurement, and stabilizing forces in proteins (Van der Waals, electrostatic interactions, hydrogen bonding, weak polar interactions, and hydrophobic effects).

UNIT- III (Cr- 0.75)

Protein thermodynamics: Entropy and enthalpy compensation in protein stability.
Experimental methods of protein engineering: Directed evolution like gene site saturation mutagenesis, module shuffling and guided protein recombination, etc.

UNIT–IV (Cr- 0.75)

Combinatorial Protein Engineering: Chemical mutagenesis, error-prone PCR, synthetic peptide combinatorial libraries, and selection and screening approaches for folding and function.
Principles and applications of phage display and bacterial display.

UNIT-V (Cr- 1)

Computational approaches to protein engineering: Sequence and 3D structure analysis, and data mining, Ramachandran plot analysis in protein structure assessment, computational peptide design.

Recommended Books:

1. Rao Y. Protein Engineering. 2024. 1st ed. AIP.
2. Park, S.J., Cochran, J.R. Protein Engineering and Design. 2024. 1st ed. CRC Press.
3. Zhao, H., Lee, S., Y., Nielsen, J., Stephanopoulos, G. Protein Engineering: Tools and Applications. 2021, Wiley Online Library
4. Bornscheuer, U., T. and Hohne, M. Protein Engineering: Methods and Protocols. 2018, Humana Press (Springer Nature Link).
5. Ogawa, T. Protein Engineering: technology and Applications, 2013, IntechOpen
6. Kyte, J. Structure in Protein Chemistry. 2006. 2nd ed. Garland Science.
7. Robertson, D.E., Noel, J.P. Protein Engineering: Volume 388 (Methods in Enzymology). 2004. 1st ed. Academic Press.

M.Sc. Biotechnology 3rd Sem.

Paper-IV Biomedical Technology

(Course Code: SOLS/MBT/DSE-3c)

No. of Credits: 4

UNIT-I (Cr- 1)

Cellular pathology: Causes of cell injury, necrosis, ischemic and hypoxic injury, apoptosis biochemical features, significance and mechanisms.

Hypersensitivity and autoimmune diseases.

Preparation of polyclonal antisera: Characterization of antisera, and immunodiagnostic techniques and their limitations.

UNIT- II (Cr- 1)

Mutations and genetic disorders: Single gene disorders, receptor proteins and hypercholesterolemia, cytogenic disorders (Trisomy and Klinefelter's), mutation in mitochondrial genes (LHDN), and fragile X-syndrome and its biochemical features.

UNIT- III (Cr- 1)

Cancer: Mutagens, Carcinogens, and DNA Damage, Types and grading of cancer,

Introduction to molecular diagnosis techniques in the detection of cancer: Southern & Northern blot analysis, and PCR-based methods.

UNIT–IV (Cr- 0.5)

Diagnostic methods for genetic diseases, MRI and CT-SCAN and their applications in disease diagnosis.

UNIT-V (Cr- 0.5)

Diagnostic methods and tools: Therapeutic Methods: Overview of radiotherapy, immunotherapy, drug therapy, gene therapy and applications.

Recommended Books:

1. Ramanujam, N., Criuch, B. Biomedical Engineering for Global Health. 2024. 1st ed. Cambridge University Press.
2. Lai, K.W., Yeoh, P.S.Q. Biomedical Engineering: AI and Technological innovations. 1st ed. Springer Singapore.
3. Feng, D.D. Biomedical Information Technology. 2020. 2nd ed. Academic Press.
4. Wriggers, P., Lenarz, T. Biomedical Technology. 2018. 1st ed., Springer Cham.
5. Moore, Jr.J.E., Maitland, D.J. Biomedical Technology and Devices. 2014. 2nd ed. CRC Press.
6. Baran, G.R., Kiani, M.F., Samuel, S.P. Healthcare and Biomedical Technology in the 21st Century. 2014. 1st ed. Springer, New York.

M.Sc. Biotechnology 3rd Sem.

Lab-II Elective Practical (Lab Course based on SOLS/MBT/DSE-3a, DSE-3b or DSE-3c)
(Course Code: SOLS/MBT/DSEP-3)

No. of Credits: 2

Anyone of the following depending on the DSE taken in theory course

Practicals based on DSE (Plant Biotechnology)
1. Aseptic methods in plant tissue culture.
2. Preparation of MS stock reagents.
3. Preparation of MS media
4. Surface sterilization of seeds

Any other practical based on the facility.

Practicals based on DSE (Protein Engineering)
1. Conserved domain analysis of proteins.
2. Protein modeling and 3D structure analysis.
3. Protein-docking and energy calculation.
4. Study of the secondary structure analysis of proteins.

Any other practical based on the facility.

Practicals based on DSE (Biomedical Technology)
1. Analysis of antisera.
2. Gene amplification through PCR.
3. Southern blot analysis
4. Western blot analysis.

Any other practical based on the facility.

M.Sc. Biotechnology 4th Sem.

Paper-I Intellectual Property Rights, Bioethics and Bio-Entrepreneurship
(Course Code: SOLS/MBT/DSC-10)

No. of Credits: 5

UNIT-I (Cr- 1)
Intellectual property (IP): Introduction, history and evolution of patent laws.
Types of IP: Patents, trademarks, copyright & related rights, Idea-expression dichotomy, industrial design, traditional knowledge, geographical indications, significance of IPR.

UNIT- II (Cr- 1)
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, India's IPR policy, and World intellectual property organization (WIPO).

UNIT- III (Cr- 1)
Discovery vs invention: A concept of 'prior art', invention in context of 'prior art', introduction & classifications of patents, and patentability criteria. Diamond vs Chakraborty case study, IP as a factor in R&D, legal and IPR issues in biotechnology, licensing and compulsory licensing, patent infringement and legal action.

UNIT–IV (Cr- 1)
Introduction to bioethics: Definition, scope, principles, and significance, issues of ownership, monopoly, biodiversity, traditional knowledge access & benefit sharing, social ethical issues in biotechnology, bioethical issues in GMOs and human cloning.

UNIT-V (Cr- 1)
Concept of entrepreneurship: Introduction and scope in bio-entrepreneurship, risk and benefits, general idea about bio-sector firms and commercialization of a biotechnological product, introduction to the entrepreneurship development programs (MSME, DBT, BIRAC, and Make in India), incubation centre, and start-up India.

Recommended Books:
1. Gurnani, S.R. Intellectual Property Rights. 2024. 1st ed. C. Jamnadas & Co.
2. Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy. 2017. 1st ed. McGraw Hill Education.
3. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Government of India (http://www.ipindia.nic.in).
4. World Trade Organisation (http://www.wto.org).
5. World Intellectual Property Organisation (http://www.wipo.int).

M.Sc. Biotechnology 4thSem.

Paper-II Environmental Biotechnology
(Course Code: SOLS/MBT/DSC-11)

No. of Credits: 5

UNIT-I (Cr- 1)
Environment and pollution: Introduction to environment, pollution and its control, and pollution indicators.
Waste management: Domestic, industrial, solid & hazardous waste, wastewater treatment, contributions of biotechnology to waste treatment and environmental management.

UNIT- II (Cr- 1)
Bioremediation: Fundamentals, methods & strategies of bioremediation, application of bacteria and fungi in bioremediation of various pollutants (heavy metals, radionuclides, organic pollutants, and xenobiotic compounds), use of nanoparticles in bioremediation.

UNIT- III (Cr- 1)
Environmental biotechnology and biofuels: Biogas, bioethanol, biodiesel, and biohydrogen, microorganisms involved and biotechnological interventions for optimizing production, microbiologically enhanced oil recovery (MEOR), bioleaching of metals, production of bioplastics, production of biosurfactants and bioemulsifiers.

UNIT–IV (Cr- 1)
Biofertilizers: Symbiotic systems between plants and microorganisms (nitrogen-fixing symbiosis, and mycorrhiza fungi symbiosis).
Phytoremediation: Fundamentals and description of major methods of applications (Phytoaccumulation, phytovolatilization, rhizofiltration, and phytostabilization).

UNIT-V (Cr- 1)
Bioinsecticides, biopesticides & biofungicides: Introduction and applications.
Role of GMOs in environment clean-up and biotechnological interventions for dye removal and oil spillage. biosensors for environment monitoring.

Recommended Books:
1. Verma, P. Biotechnology for Environmental Sustainability. 2024. 1st ed. Springer Nature.
2. McCarty, P.L., Rittmann, B.E. Environmental Biotechnology: Principles & Applications. 2021. 2nd ed. McGraw Hill
3. McCarty, P.L., Rittmann, B.E. Environmental Biotechnology: Principles & Applications. 2020. 2nd ed. Springer.
4. Kumar, P., Kumar, V. Textbook of Environmental Biotechnology. 2018. 1st ed. Woodhead Publishing.
5. Kumar, R., Sharma, A.K., Ahluwalia, S.S. Advances in Environmental Biotechnology. 2017. 1st ed. Springer, Singapore.

M.Sc. Biotechnology 4thSem.

Paper-III Industrial Biotechnology
(Course Code: SOLS/MBT/DSC-12)

No. of Credits: 5

UNIT-I (Cr- 1)
Fermentation: Introduction and its types, Isolation, screening, improvement, and preservation of industrially important microbes, and microbial growth kinetics in batch, continuous and fed-batch processes. Solid state fermentation and its applications.

UNIT- II (Cr- 1)
Media formulation and applications: Media/raw material for Industrial fermentation, requirement of precursors, inducers and antifoam agents as media additives, medium optimization, volumetric mass-transfer coefficient and its measurement, and kinetics of sterilization.

UNIT- III (Cr- 1)
Bioreactors: types, general configuration and applications (CSTR, bubble column, airlift, fluidized bed, packed bed), scale up and scale down, measurement and control of bioprocess parameters.

UNIT–IV (Cr- 1)
Downstream processing: Cell disruption techniques, separation techniques (Filtration, centrifugation, sedimentation, flocculation, liquid-liquid extraction, precipitation, reverse osmosis, ultrafiltration), drying, crystallization, storage and packaging.

UNIT-V (Cr- 1)
Fermentation products: Microorganisms and raw material/media used, fermentation, conditions and purification steps for production of ethanol, antibiotics (Penicillin, and tetracycline), alcoholic beverages, enzymes, xanthan gum, and Baker's yeast.

Recommended Books:

1. Verma, P. Industrial Microbiology and Biotechnology: An Insight into Current Trends. 2024. 1st ed. Springer Singapore.
2. Benvenuto, M.A. Industrial Biotechnology. 2024. 2nd ed. De Gruyter.
3. El-Mansi, M., Bryce, C.F. Fermentation Microbiology and Biotechnology. 2018. 4th ed. Boca Raton.
4. Bailey, J.E., Ollis, D.F. Biochemical Engineering Fundamentals. 2017. 2nd ed. McGraw Hill Education.
5. Casida, J.R. Industrial Microbiology. 2016. 2nd ed. New Age International Publishers.
6. Stanbury, P.F., Whitaker, A. Principles of Fermentation Technology. 2010. 3rd ed. Oxford Pergamon Press.
7. Blanch, H.W., Clark, D.S. Biochemical Engineering. 1997. 2nd ed. CRC Press.

M.Sc. Biotechnology 4thSem.

Lab- I DSC Practical (Lab Course based on SOLS/MBT/DSC-10, DSC-11 & DSC-12)
(Course Code: SOLS/MBT/DSCP-4)

No. of Credits: 3

Practicals based on DSC (Intellectual Property Rights, Bioethics and Bio-Entrepreneurship)
1. IP-related case studies.
2. Study of the salient features of a patent document.
3. Exploring web portals for IPR in India
4. Biopiracy related case studies.
5. Exploring web portals for Start-up in India.

Practicals based on DSC (Environmental Biotechnology)
1. Determination of various physicochemical parameters in polluted water samples.
2. Coliform test for water quality analysis.
3. Study of bioremediation by microorganisms.
4. Production of biofertilizers.
5. Determination of soil quality parameters.

Practicals based on DSC (Industrial Biotechnology)
1. Bacterial growth curve preparation.
2. Screening of soil microflora for enzyme production.
3. Demonstration of bioreactor
4. Production of enzyme/organic acid/solvent through fermentation
5. Purification of a fermentation product

Any other practical based on the facility.

M.Sc. Biotechnology 4thSem.

Paper-IV Immunotechnology
(Course Code: SOLS/MBT/DSE-4a)

No. of Credits: 4

UNIT-I (Cr- 0.5)
Antigen-antibody interactions: Precipitation reactions and application, agglutination reactions and applications,
Immunological assays: Immunodiffusion, immunoelectrophoresis, RIA, ELISA, immunofluorescence, and western blotting.

UNIT- II (Cr- 0.75)
Monoclonal antibodies: Introduction, polyclonal antibody versus monoclonal antibody, advantages, and limitations of monoclonal antibodies,
Monoclonal antibody production: Hybridoma technology, phage display technology, single B-cell technology.

UNIT- III (Cr- 1)
Recombinant monoclonal antibody production: Development of engineered monoclonal antibodies, murine, chimeric, humanized and fully human antibody. Hybrid monoclonal antibodies and catalytic monoclonal antibodies (Abzymes), Storage and applications of monoclonal antibodies.

UNIT–IV (Cr- 1)
Cytokines: General physiology, application of cytokine for 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, and conjugate vaccines.

UNIT-V (Cr- 0.75)
New generation vaccines: Synthetic peptide vaccines, recombinant antigen vaccines, DNA vaccines, immune stimulants, adjuvants, novel vaccine delivery systems.
Vaccines for specific diseases: Tuberculosis, malaria, and HIV/AIDS.
New emerging diseases and vaccine development: Ebola virus disease, and SARS.

Recommended Books:
1. Mohapatra, A.D., Sahu, P.S. Advances in Immunology and Immunotechniques: Updates Concepts and Recent Applications. 2024. 1st ed. Springer Singapore.
2. Punt, J., Stranford, S., Jones, P., Owen, J. Kuby: Immunology. 2022. 8th ed. W.H. Freeman.
3. Ghosh, S. Immunology and Immunotechnology. 2021. 1st ed. Books & Allied.
4. Delves, P.J., Martin, S.J., Burton, D.R., Roitt I.M. Essential Immunology, 2017. 13th ed. Willey Blackwell.
5. Bloom, B., Lambert, P.-H. The Vaccine Book. 2016. 2nd ed. Academic Press.
6. Greenfield, E.A. Antibodies: A Laboratory Manual. 2014. 2nd ed. Cold Spring Harbor Laboratory Press.
7. Hay, F.C., Westwood, O.M.R. Practical Immunology. 2002. 1st ed. Wiley-Blackwell.
8. Male, D.K., Champion, B., Cooke, A. Advanced Immunology. 1998. 1st ed. Mosby.

M.Sc. Biotechnology 4thSem.

Paper-IV Animal Biotechnology
(Course Code: SOLS/MBT/DSE-4b)

No. of Credits: 4

UNIT-I (Cr- 0.75)
Animal cell culture: History, basic requirements, cell culture media and reagents, animal cell culture methods, primary culture, secondary culture, suspension cultures, cell lines, continuous cell lines .

UNIT- II (Cr- 1)
Transgenic animals: Applications of transgenic animal technology.
Techniques of gene transfer: Microinjection, lipofection, electroporation, chemical-based transformation, and viral vectors.

UNIT- III (Cr- 1)
Animal genomics: Introduction to animal genomics, different methods for characterization of animal genomes, SNP, STR, RFLP, RAPD, genetic basis for disease resistance, gene knock out technologies.
Animal cloning: Basic concept and cloning for conservation of endangered species.

UNIT–IV (Cr- 0.75)
Applications of animal cell cultures: Cell culture-based products, vaccines, hybridoma technology, *in vitro* testing of drugs, production of pharmaceutical proteins, stem cells and their use.

UNIT-V (Cr- 0.5)
Immunological and nucleic acid-based methods: Identification of animal species, DNA barcoding, detection of food/feed adulteration with animal protein.

Recommended Books:
1. Kumar, P.H.P., Soumya, C., Shobha, G. Animal Biotechnology. 2024. 1st ed. Scientific International Publication.
2. Glick, B.R., Patten, C.L. Molecular Biotechnology: Principle and Applications of Recombinant DNA. 2022. 6th ed. ASM Press.
3. Verma, A.S., Singh A. Animal Biotechnology (Models in Discovery and Translation). 2020. 2nd ed. Elsevier, Academic Press.
4. Singh, B., Gautam, S.K., Chauhan, M.S. Text book of Animal Biotechnology. 2014. 1st ed. TERI Press.
5. Pörtner, R. Animal Cell Biotechnology: Methods and Protocols. 2007. 2nd ed. Humana Press.

M.Sc. Biotechnology 4th Sem.

Lab-II DSE Practical (Lab Course based on SOLS/MBT/DSE-4a or DSE-4b)
(Course Code: SOLS/MBT/DSEP-4)

No. of Credits: 2

Anyone of the following depending on the DSE taken in theory course

Practicals based on DSE (Immunotechnology)

1. Identification of leukocyte subsets and total count.
2. Immunoelctrophoresis.
3. Rocket immunoelectrophoresis.
4. Western blotting.

Any other practical based on the facility.

Practicals based on DSE (Animal Biotechnology)

1. Preparation and filter sterilization of animal tissue culture medium.
2. Quantification of cells by haemocytometer.
3. Determination of viable and non-viable cells by trypan blue dye exclusion method.
4. Demonstration of electroporation

Any other practical based on the facility.