S.S. JAIN SUBODH P.G. COLLEGE

(Autonomous)

(Affiliated to University of Rajasthan)

Department of Biotechnology

Syllabus
For

Curriculum Framework
M.Sc. Biotechnology
Based on National Education Policy- 2020
CBCS Based

About the Department:

The Department of Biotechnology was established with the vision to accomplish new epitome in the domain of biotechnology education and research, shaping life sciences into a premier precision tool for the future and develop technologies that seek solutions to real life. Recently the department has received fund under DBT STAR Scheme for the establishment of state of art research centre. The primary responsibility of the department is to set high teaching and research standards using modern tools and technology that encourage the students to pursue new scientific knowledge and career opportunities in Biotechnology. Apart from the academic curricula the students are assigned Research institute visits, excursions, and Industrial visits and special in-plant training, genetic engineering and immunological work in industries. The students are encouraged for research through the projects, dissertations and summer trainings.

Curriculum Framework based on National Education Policy-2020

NEP-2020 has conceptualized the idea to develop well rounded competent individuals for making the nation a self-reliant and global leader. In the same spirit, we at Department of Biotechnology have developed a curriculum framework to encompass the goals of NEP 2020. To this end, we have incorporated choice of subject/disciplines of study, creating academic pathways having constructive combinations of disciplines for study with multiple entry and exit points as well as focus on experiential learning for students by introducing multidisciplinary and skill enhancement courses and actual Hand's on training in the recent and trending aspects ofBiotechnology.

M.Sc. Biotechnology

Biotechnology finds application in a variety of fields such as Animal and Plant Biotechnology, Bioinformatics, Food and dairy, Marine Biotechnology, Growth of Vaccines,

Medicines, Nanotechnology, forensic Science, Agriculture, Pollution Control, Energy Production and Conservation, Healing of Prolonged Disease and Ecological Conservation, and in development of GM food, vaccines, medicine, insecticides, fertilizers and quality of seeds. M.Sc. Biotechnology course is designed in a way that it provides adequate knowledge of Biotechnology and related subjects such as Marine Biotechnology, Immunology, Genetic Engineering, Bioinformatics, Cell biology, Molecular Biology, Microbiology, Biochemistry, Food Technology, Molecular Biotechnology, etc.

Contents:

1. Eligibility:

A candidate who has passed the B.Sc. examination from any recognized university with Zoology Chemistry, Botany and B.Sc. Biotech, BSc. Microbiology, B.Sc. Biochemistry with minimum 55% aggregate marks or CGPA of 3.5 in the UGC Seven Point scale (45% or CGPA 2.5 in the UGC Seven Point Scale for SC/ST/Non-creamy layer OBC) shell be eligible to apply for the M.Sc. program in Biotechnology. Choice based Credit System and Grade System as per Ord. 199F.The admission will be on merit basis.

2. Scheme of Examination:

- Each theory EoSE shall carry 70 marks. The EoSE will be of 3 hours duration. Part "A" of theory paper shall contain 10 short Answer Questions out of which only seven have to be attempted of 14 marks based on knowledge, understanding and applications of the topics/texts covered in the syllabus. Each question will carry two marks for correct answer.
- Part "B" of paper will be consisting of Four question with internal choice (except in cases where a different scheme is specifically specified in the syllabus) of 14 mark each. The limit of answer will be five pages.
- Each Laboratory EoSE will be of four/six hour durations and involve laboratory experiments/exercises, and viva-voce examination with weightage in ratio of 60:40.

The details of the course with code, title and the credits assign are as given below.
Abbreviations Used

Course Category

CCC: Compulsory Core Course
ECC: Elective Core Course
OEC: Open Elective Course

SC: Supportive Course
SSC: Self Study Course
SEM: Seminar
PRJ: Project Work
RP: Research Publication

Contact Hours
L: Lecture
P: Practical or Other
S: Self Study

3. Course Structure: The details of the courses with title assigned are as given below. Duration: 4 Semesters (2 Years)

Semester I	**Name of Paper and Elective Group A (Choose Any one from a group of 3 papers)**	**Course**	**Credits**	**Total Credits**
Paper 1	Cell Biology	DSC-1	4	**24**
Paper 1I	Genetics	DSC-2	4	
Paper III	Microbiology	DSC-3	4	
Paper 1V	Elective	DSE-4	4	
PR-I	*Based on Theory Papers (1 ,2 & 3)*	*DSCP-1*	*6*	
PR-II	*Based on Theory Elective Papers*	*DSEP-2*	*2*	
Semester II	**Name of Paper Elective Group B (Choose Any one from a group of 3 papers)**	**Course**	**Credits**	**Total Credits**
Paper 1	Molecular Biology	DSC-1	4	**24**
Paper 1I	Enzymology	DSC-2	4	
Paper 1II	Immunology	DSC-3	4	
Paper 1V	Elective	DSE-4	4	
PR-I	*Based on Theory Papers (1 ,2 & 3)*	*DSCP-1*	*6*	
PR-II	*Based on Theory Elective Papers*	*DSEP-2*	*2*	
Semester III	**Name of Paper and Elective Group C (Choose Any one from a group of 3 papers)**	**Course**	**Credits**	**Total Credits**
Paper 1	Genetic Engineering & System Biology	DSC-1	4	**24**
Paper 1I	Animal Biotechnology	DSC-2	4	
Paper III	Seminar, Scientific writing & PowerPoint Presentation	DSC-3	4	
Paper 1V	Elective	DSE-4	4	
PR-I	*Based on Theory Papers (1 ,2 & 3)*	*DSCP-1*	*6*	
PR-II	*Based on Theory Elective Papers*	*DSEP-2*	2	
Semester IV	**Name of Paper and** Elective Group D (Choose Any one from a group of 3 papers)	**Course**	**Credits**	**Total Credits**
Paper 1	Plant Biotechnology	DSC-1	4	**28**
Paper 1I	IPR and Bioethics	DSC-2	4	
Paper III	Applied Environmental Biotechnology	DSC-3	6	
Paper IV	Elective or MOOCS/Swayam/Coursera chosen by students	DSE-4	4	
		or DSE-4	4	
PR-I	*Based on Theory Papers (1 ,2 & 3)*	*DSCP-1*	*6*	
PR-II	*Based on Theory Elective Papers & Dissertation and Industrial training*	*DSEP-2*	6	
Total credit				**100**

Semester –I								
S.No	**Paper code**	**Course Title**	**Course Category**	**Credit**	**Contact hours per week**		**EoSE Duration (Hrs)**	
					L	P	Theory	PR
1.	MSBT101	Cell Biology	CCC	4	4	0	3	0
2.	MSBT102	Genetics	CCC	4	4	0	3	0
3.	MSBT103	Microbiology	CCC	4	4	0	3	0
4.	MSBT101A	Theory Elective -1	ECC	4	4	0	3	0
5.	MSBT104B	Theory Elective -2	ECC	4	4	0	3	0
6.	MSBT104C	Theory Elective -3	ECC	4	4	0	3	0
7.	MSBT151	General Practical lab based on Paper I, II & III	CCC	6	0	6	0	6
8.	MSBT152A	Elective Practical Lab 1	ECC	2	0	4	0	4
9.	MSBT152B	Elective Practical Lab 2	ECC	2	0	4	0	4
10.	MSBT152C	Elective Practical Lab 3	ECC	2	0	4	0	4

Semester –II								
S.No.	**Paper code**	**Course Title**	**Course Category**	**Credit**	**Contact hours per week**		**EoSE Duration (Hrs)**	
					L	P	Theory	PR
1.	MSBT201	Molecular Biology	CCC	4	4	0	3	0
2.	MSBT202	Enzymology	CCC	4	4	0	3	0
3.	MSBT203	Immunology	CCC	4	4	0	3	0
4.	MSBT201A	Theory Elective -1	ECC	4	4	0	3	0
5.	MSBT204B	Theory Elective -2	ECC	4	4	0	3	0
6.	MSBT204C	Theory Elective -3	ECC	4	4	0	3	0
7.	MSBT251	General Practical lab based on Paper I,II &III	CCC	6	0	6	0	6
8.	MSBT252A	Elective Practical Lab 1	ECC	2	0	4	0	4
9.	MSBT252B	Elective Practical Lab 2	ECC	2	0	4	0	4
10.	MSBT252C	Elective Practical Lab 3	ECC	2	0	4	0	4

Semester-III

S.No	Paper code	Course Title	Course Category	Credit	Contact hours per week		EoSE Duration (Hrs)	
					L	P	Theory	PR
1.	MSBT301	Genetic Engineering & System Biology	CCC	4	4	0	3	0
2.	MSBT302	Animal Biotechnology	CCC	4	4	0	3	0
3.	MSBT303	Seminar, Scientific writing & PowerPoint Presentation	CCC	4	4	0	3	0
4.	MSBT301A	Theory Elective -1	ECC	4	4	0	3	0
5.	MSBT304B	Theory Elective -2	ECC	4	4	0	3	0
6.	MSBT304C	Theory Elective -3	ECC	4	4	0	3	0
7.	MSBT351	General Practical lab based on Paper I,II &III	CCC	6	0	6	0	6
8.	MSBT352A	Elective Practical Lab 1	ECC	2	0	4	0	4
9.	MSBT352B	Elective Practical Lab 2	ECC	2	0	4	0	4
10.	MSBT352C	Elective Practical Lab 3	ECC	2	0	4	0	4

Semester-IV

S.No	Paper code	Course Title	Course Category	Credit	Contact hours per week		EoSE Duration (Hrs)	
					L	P	Theory	PR
1.	MSBT401	Plant Biotechnology	CCC	4	4	0	3	0
2.	MSBT402	IPR and Bioethics	CCC	4	4	0	3	0
3.	MSBT403	Applied Environmental Biotechnology	CCC	4	4	0	3	0
4.	MSBT401A	Theory Elective -1	ECC	4	4	0	3	0
5.	MSBT404B	Theory Elective -2	ECC	4	4	0	3	0
6.	MSBT404C	Theory Elective -3	ECC	4	4	0	3	0
7.	MSBT451	General Practical lab based on Paper I and II	CCC	6	0	6	0	6
8.	MSBT452A	Elective Practical Lab 1 & Dissertation	ECC	2+4	0	4	0	4
9.	MSBT452B	Elective Practical Lab 2& Dissertation	ECC	2+4	0	4	0	4
10.	MSBT452C	Elective Practical Lab 3& Dissertation	ECC	2+4	0	4	0	4

Note:- Elective core courses lab can be opted only if the respective Elective has been opted by the students. ECC Lab Examination will be based on ECC lab work of above papers wherever available.

Credits offered for 2-year PG Degree (General):

SEM I	SEM 2	SEM 3	SEM 4	
24	24	24	28	Total Credits: 100

*Project work/Dissertation is considered as a special course involving application of knowledge in solving / analyzing /exploring a real-life situation / difficult problem. A Project/Dissertation work would be of4 credits. A Project/Dissertation is mandatory for all the students of Sem IV with lab 2.

*The Medium of Instruction and Examination Shall Be English Only

Theory Elective Courses: -

Elective Course Code	Specialization	Paper Title	Prerequisite	Semester in which course will be available
MSBT104A	GEN	Analytical techniques		Sem I
MSBT104B	GEN	Protein Engineering		Sem I
MSBT104C	GEN	Proteomics and Genomics		Sem I
MSBT204A	GEN	Virology		Sem II
MSBT204B	GEN	Communication Skill		Sem II
MSBT204C	IB	Food and Dairy Technology		Sem II
MSBT304A	GEN	Bioinformatics & Biostatistics		Sem III
MSBT304B	EB	Stem Cell Biology		Sem III
MSBT304C	GEN	Vaccine Production		Sem III
MSBT404A	GEN	Bio-processing and Engineering		Sem IV
MSBT404B	IB	Plant Metabolic Engineering		Sem IV
MSBT404C	IB	Scientific Research Writing		Sem IV

Elective Core Course Lab. Work will be based on Lab. Work of above papers wherever applicable.

The medium of instruction and examination shall be English only.

SPECIALIZATION CLUSTERS

A- GEN : General
B- IB : Industrial Biotechnology
C- EB : Environmental Biotechnology
D- PE : Protein Engineering
E –PB : Plant Biotechnology

General Elective Courses:

1. Life Science Entrepreneurial Ventures
2. Economic Dynamics of Change in Biotechnology
3. Vermicomposting
4. Production of Antimicrobial Agents
5. Production of virus free Plants
6. Production of Natural Plant Products
7. Biogas Production
8. Bioresources and waste Management
9. Agriculture Biotechnology

Skill enhancement course:

1. Production of Biofertilizers, Biopesticides and insecticides
2. Biofuels production
3. Vaccine production
4. Managing and Leading Biotechnology Professionals
5. Scientific writing and Presentation
6. PCR Technology
7. Biosafety Techniques
8. Mushroom Production

4. Programme specific outcomes, Programme and course outcome of M.Sc biotechnology

After completion of M.Sc. in Biotechnology the student will be able to

POS1: Develop a foundational understanding of basic biological principles, genetics, microbiology, biochemistry, molecular biology, and cell biology, as they relate to biotechnology.

POS 2: Acquire practical laboratory skills in techniques commonly used in biotechnological research and applications, including DNA isolation and manipulation, protein purification, cell culture, and microbial techniques.

POS 3: Gain proficiency in applying biotechnological tools and methodologies to solve problems in various fields such as agriculture, medicine, pharmaceuticals, environmental science, and industrial biotechnology.

PSO4: Develop the ability to critically analyze scientific literature, experimental data, and biological systems to solve complex problems and make informed decisions in biotechnological research and industry.

PSO5: Understand the principles of bioinformatics and utilize bioinformatics tools and databases to analyze biological data, predict protein structures, annotate genomes, and conduct sequence analysis..

PSO6 : Appreciate the ethical, legal, and societal implications of biotechnological advancements and adhere to ethical standards and regulatory guidelines in research and applications.

PSO7: Demonstrate effective communication skills through written reports, oral presentations, and scientific discourse, to convey ideas, research findings, and conclusions to diverse audiences.

PSO8: Work effectively as part of interdisciplinary teams, collaborate with peers, mentors, and professionals from diverse backgrounds, and contribute positively to group projects and research endeavors.
PSO9: Develop a lifelong learning mindset, stay updated with advancements in biotechnology, engage in professional development activities, and pursue further education or careers in academia, industry, healthcare, or entrepreneurship.
PSO10: Students will be able to develop aptitude for formulating research problem and experimental planning, data collection and statistical planning.

Programme Outcome

PO 1: Cognitive Knowledge: To provide education that leads to comprehensive understanding of the principles and practices of biotechnology.

PO 2: Information and Computer Literacy: To educate and make them up to date with the current scientific literature, computer programs and web information.

PO 3: Experimental Skills: To provide broad based training in technical skills in methods of biotechnology.

PO 4: Critical Thinking: To empower students with the ability to think and solve problems in the field of biotechnology.

PO 5: Scientific Communication: To ensure students are able to effectively communicate

with biotech and other interdisciplinary professionals.

PO 6: Professional Attitude: To produce responsible biotechnologists that can work within the interdisciplinary framework of biotechnology and related fields

Couse Outcome

CO1: To provide a comprehensive understanding of the key concepts and principles of biotechnology, including molecular biology, genetics, biochemistry, and cell biology.
Research Skills:

CO2:To develop advanced research skills necessary for designing and conducting experiments in biotechnology, including proficiency in modern laboratory techniques and data analysis.

CO3:To foster innovation and problem-solving skills by applying biotechnological methods to address complex biological, medical, environmental, and industrial problems.

CO4:To ensure technical proficiency in the use of biotechnological tools and technologies, such as genetic engineering, bioinformatics, and bioprocessing.
Interdisciplinary Approach:

CO5:To promote an interdisciplinary approach, integrating knowledge from different scientific fields to develop new biotechnological applications.
Ethics and Professionalism:

CO6: To instill a deep understanding of ethical issues, regulatory frameworks, and professional standards in biotechnology research and practice.
Communication Skills:

CO7:To enhance communication skills, enabling students to effectively present their research findings and collaborate with peers, professionals, and the public.

CO8:To prepare students for careers in the biotechnology industry by providing knowledge of industry practices, trends, and innovations.
Critical Thinking and Analysis:
CO9:To develop critical thinking and analytical skills necessary for evaluating scientific literature, designing experiments, and interpreting results.
Lifelong Learning:
CO10:To encourage a commitment to lifelong learning and continuous professional development in the rapidly evolving field of biotechnology.
Global Perspective:

CO11:To provide a global perspective on biotechnological issues, preparing students to work in international and multicultural environments.
Application of Knowledge:

To apply theoretical knowledge to real-world scenarios through practical training, internships, and collaborative projects with industry partners.

By achieving these objectives, graduates of the MSc Biotechnology program will be well-equipped to contribute to advancements in biotechnology and related fields, whether in academia, industry, or regulatory sectors.

Core Paper -I Cell Biology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.
Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.
Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning Objective: The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes**.**

Unit-I: Cells and evolution
The molecules of life: DNA, RNA, ATP, proteins, water, phospholipids with emphasis on why each was chosen as the building block. How working of cell was discovered: Common experimental organisms and role of each to understand the functioning of a cell; Viruses to understand molecular cell biology; bacteria to understand fundamental functions of cell, yeast for cell cycle study.

Unit-II: The cell boundary
Overview of membrane structure: Membrane lipids, membrane proteins and glycocalyx; Physical and chemical parameters that affect membrane fluidity; Membrane rafts; Lipid movement – ABC proteins; Gated and non-gated channels; Uniporters, Symporters and antiporters; Role of cytoskeleton in maintaining cell membrane. Role of membrane in energy generation: Role of membrane in electron transport chain; Bacteriorhodopsin; ATP generation; the structure of F0-F1 complex, its assembly, movement of ATP synthase and production of ATP.

Unit-III: Regulatory molecules of the cell Introduction to signal transduction.
How signal reaches from extracellular to intracellular response. The role of signaling molecules, receptors, G-protein coupled Receptors-Structure and mechanism; secondary messengers- amplifiers, GTP-binding protein-ON/OFF switch. Tyrosine kinases- role in cell division, epidermal growth factor, cytokines mediate through it. JAK/STAT pathway.Ras/MAP kinase pathway: Down regulate the JAK/STAT pathway.

Unit-IV: Cells to multicellular organisms Germ cells and fertilization; Cellular Mechanisms of development; Morphogenetic movements and the shaping of the body plan; Differentiated cells and the maintenance of tissues; Cell diversification in the early embryo; Cell memory, cell determination and concept of positional values; Developmental control genes and the rules of cell behavior (*C. elegans*); Genesis of the body plan and homeotic selector genes and the patterning of body parts in Drosophila.

Suggested Readings
Various articles from journals Suggested Books as references:

1. Principles of Cell Biology Third Edition (2021).Edition by George Plopper, PhD; Diana BebekIvankovic, PhD, Publisher: JONES & BARTLETT

2. Karp's Cell Biology Paperback (2018)8th edition**.** Gerald Karp, Janet wasa , Wallace Marshall. Publisher : Wiley;
3. Molecular cell Biology:(2016)Lodish, Berk, Kaiser, Krieger et al. 8th ed, WH Freeman,
4. Molecular Biology of the Cell The problems Book(2014) (6ed): John Wilson and Tim Hunt
5. The Cell: Bruce Alberts, Alexander Johnson, Julian Lewis (2015), Garland Science
6. The Cell: A molecular approach , (2019)7ed, Geoffrey Cooper and Robert Hausman
7. World of the Cell(2019) (9ed): Jeff Hardin and Gregory Paul Bertini.

Core Paper –II (Genetics)

Duration: 4 hrs. per week Max. Marks: 70

Note: There will be two parts in end semester theory paper.
Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.
Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Objective of Course: The objectives of this course are to learn the students about Organization and measure of genetic variation and the understanding history of Classical and Modern Genetics.

Unit-I: Population and evolution genetics Sources responsible for changes in gene frequencies –
Mutation, selection, migration and isolation; random genetic drift; insights into human migration, natural selection and evolution. Population substructure: Hierarchical population, Isolate breaking, Inbreeding, Assortative mating, concept of heritability, artificial selection and realized heritability.

Unit-II: Organization and measure of genetic variation: Random mating population, Hardy-Weinberg principle, special cases of random mating– multiple alleles different frequencies between sexes (autosomal and X-linked). Molecular Evolution: Evolution of origin of species and theories of evolution; The basic force of evolution – Mutation, recombination and gene flow; Variation and divergence of populations; Molecular evolution of genes and proteins; Evolution of genomes; Phylogeny and systematics; Molecular clock.

Unit III: Quantitative and ethical Genetics: Johannsen pure line theory, multiple factor hypothesis, types of quantitative traits, components of phenotypic variation and genetic models for quantitative traits, Methods to study human gene diversity- Biochemical and molecular marker, VNTR, STR, microsatellite, SNP and their detection techniques RFLP, genotyping, RAPD, AFLP etc. Ethical, legal and social issues in Human genetics.

Unit IV:History of Classical and Modern Genetics: Concept and organization of Genetic material in Bacteria, Plant and Animal (*E.coli,Arabidopsis thaliana, Coenorhabditiselegans*).
Concept of gene: Allele, multiple alleles, pseudo alleles and complement test.
Cytogenetics: Human karyotype, Banding techniques, Human genetic diseases. Pedigree analysis.

Suggested Readings:

1. Alberts. (2002). Molecular Biology of the Cell –. Garland publication, Fourth Edition.
2. Principles Of Genetics 7Th Asia Edition (**2019)** by SNUSTAD DP, pub: JOHN WILEY
3. GardenerE.J,.SimmonsM.J and Snustad, D.P. (2005).Principles of Genetics – John Wiley & SonsPublications.
4. Principles of Genetics .(**2015**) by Purohit SS and Purohit S, First edition, Publisher: Agrobios (India).
5. Principles of Genetics 8Ed **(2015)** by Gardner E.J., publisher: Wiley India

6. Paul A. (2011). Text Book of Genetics- from Genes to Genomes- Books and Allied (P) Ltd, Kolkata.Third Edition.
7. Genetics, **(2015**)3Rd Edition by Strickberger, Pub:Pearson India

Core Paper-III (Microbiology)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Objective of Course: The overarching goals for the laboratory portion of this course are to teach microbiological techniques and to show students the impact of microbes on our dailylives and their central roles in nature

Unit I: Basic Microbiology

Understanding the structure and classification of Microbial cell, Archaea cell and Viruses. Classification of microbes (Bacteria) based on their optimum growth conditions; understanding their metabolism (Basic prokaryotic metabolism.).

Unit II: Cultivation of Metabolic Distinct Microbes:

Cultivation and Control of Microbes Cultivation of metabolic distinct microbes,Microbial Control (Physical and chemical methods) and Chemotherapeutics (Antibiotics and sulpha drugs); Microbial Growth and its kinetics; Understanding basics of Metagenomics for non-cultivable microbes.

Unit III: Bioprocessing and Fermentation Technology Fermentation design;

Scale-up of bioprocess (Steps of scale up, Scale-up of sterilization, aeration and agitation inoculum); Upstream processing (Solids and liquid handling, sterilization of media, air and reactors; Inoculum development; Aeration and agitation; maintenance of optimum fermentation condition); Downstream processing (Characterization of products and by-products, flocculation and conditioning of broth, Methods of cell separation, disruption, product recovery and purification).

Unit IV: Microbial Biotechnology Products Fermentation related products: Bioconversion of Steroids, Antibiotic production and modification (at-least 2 antibiotics), Production of Vitamin B12, Production of Bioplastics, Food products (Organic acids, bakery products and beverages), Microbial enzymes (Amylase, lipase, Proteases) Non-fermentation processes: MEOR (Microbial enhanced oil recovery); Bioleaching;

References:

1. Brock Biology of Microorganisms, Global Edition, 26 March (2018)by Michael Madigan, Kelly Bender, Daniel Buckley**.**
2. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7thedition, CBS Publishers and Distributors, Delhi, India.

3. Microbiology Fundamentals: (2012) A Clinical Approach by Marjorie Kelly Cowan, Pub: mac graw hill india
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
5. PelczarMJ, Chan ECS and Krieg NR. (2001). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson Education.

Elective Paper- 1of Group A(Analytical Technique)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Objective of Course: To provide students with the theory and practical experience of various instruments used in the Biotechnology.

Unit –I: Microscopy-

Principles Applications of Bright field and Dark-field Microscopy and fluorescent Microscopy, Phase contrast Microscopy, Confocal Microscopy. Electron Microscope-Principles and Applications of Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Sample preparation for Electron Microscopy.

Unit- II: Centrifugation:

Basic principles of sedimentation. Types of centrifuges:(high speed, low speed, ultracentrifuge, and density gradient).

Chromatography: General principle of chromatographic separation. Principle, instrumentation and applications of Partition Chromatography, Adsorption Chromatography, HPTLC, Ion Exchange Chromatography, Gel permeation Chromatography, Affinity Chromatography, GC, GLC and HPLC,

Unit- III: Electrophoresis

Basic principle and types of electrophoresis.Electrophoretic mobility. Factors affecting electrophoretic migration, Technique and uses of agarose gel electrophoresis, PAGE, SDS-PAGE, Two-dimensional electrophoresis and Isoelectricfocusing.

Unit –IVSpectroscopy-

Beer-Lambert law and its limitations. Light absorption and transmission. Basic design of photoelectric colorimeter and spectrophotometer.Applications of UV-visible spectroscopic techniques. Flame Photometry. Principle and application of NMR and ESR techniques.

Crystallography-Principle, instrumentation and applications of X-Ray Crystallography

Suggested Readings:

1. Boyer, R.F. (2000). Modern Experimental Biochemistry, 3rd Edition, PrenticeEdition. Wiley-Inter science, USA.
2. Biotechniques (Theory & Practice). (2018)by Prof. S.V.S. Rana (Author),Rastogi Publications

3. Hammes, G. G. (2007). Physical Chemistry for the Biological Sciences, 1stTechniques. 4th Edition, MKU, Madurai.
4. Introduction to Biotechnology (2014). 3 Edition by Thieman and William, Pub: Pearson India.
5. P.Palanivelu and M.Salihu. (2009). Analytical Biochemistry and Separation and Molecular Biology. 2nd Revised edition. W. H. Freeman, USA.

Elective2ofGroupA(Protein Engineering)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Objective of Course: Protein engineering purposes, especially in enzymes, is enlarging the active position, changes activity (change specific activity, change the characteristics of the substrate), sustainability (change thermal stability, protease stability and oxidation stability) and resistance to surfactants and detergents

Unit –I: **Structure of protein and predictions overview of protein**

Structure of protein and predictions overview of protein structure based classification database visualisation tools structure alignment domain architecture database protein legend interaction primary structure and its determination secondary structure prediction and determination of motives profile pattern fingerprints super secondary structure protein protein folding pathway.

Unit -II:Structure and modification of proteins

Tertiary structure quarterly structure method to determine tertiary and quarterly structure post translation modification introduction to protein engineering definition basic principle features and characteristics of proteins that can be engineering affinity and specificity spectroscopic property stability to change in parameters as a pH temperature and amino acid sequence aggregation methods for the protein engineering rational design.

Unit –III:Mutagenesis

Directed mutagenesis random mutagenesis DNA shuffling evolutionary methods oblique directed evolution and modelling Dino more enzyme engineering strategies and case study additional of sulphide bonds T4 lysozyme, human pancreatic ribonucleus changing aspresent to other amino acids reducing the number of free sulphur hydral residence increasing enzyme activities modifying metal.

Unit IV:Food and detergent Industry

Food and detergent industry applications environmental challenges and protein engineering theraptic proteins production antibody modelling biopolymer production applications in Nano biotechnology.

Suggested Readings:

1. Edited by T E Creighton, Protein structure: A practical approach, 2nd Edition, Oxford university press, 1997.
2. Edited by T E Creighton, Protein function. A practical approach, 2nd Edition, Oxford university press, 1997.
3. Edited by T E Creighton, Protein function. A practical approach.Oxford university press. 2004.
4. Cleland and Craik, Protein Engineering, Principles and Practice, Vol 7, Springer Netherlands 1998.
5. Mueller and Arndt., Protein engineering protocols, 1st Edition, Humana Press, 2006.
6. Ed. Robertson DE, Noel JP, Protein Engineering Methods in Enzymology, 388, Elsevier Academic Press, 2004.
7. J Kyte, Structure in protein chemistry, 2nd Edition, Garland publishers, 2006.

Elective 3of Group A (Proteomics and Genomics)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Objective of Course: The ultimate goal of proteomics is to identify or compare the proteins expressed from a given genome under specific conditions, study the interactions between the proteins, and use the information to predict cell behavior or develop drug targets

Unit-I: Structural organization of genome

Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNA-mitochondrial, chloroplast; DNA sequencing- principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD,

Unit –II:Genome sequencing projects

Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, EST's and SNP's.

Unit- III:Proteomics

Protein analysis (includes measurement of concentration, amino- acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution isoelectricfocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; Yeast two hybrid system.

Unit –IV:Pharmacogenetics

High throughput screening in genome for drug discovery- identification of gene targets, Pharmacogenetics and drug development

Suggesting Reading:

1. Voet D, Voet JG & Pratt CW, Fundamentals of Biochemistry, 2nd Edition. Wiley 2006
2. Brown TA, Genomes, 3rd Edition. Garland Science 2006
3. Campbell AM &Heyer LJ, Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings 2007

4. Primrose S &Twyman R, Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell, 2006.
5. Glick BR & Pasternak JJ, Molecular Biotechnology, 3rd Edition, ASM Press, 1998.

Lab 1 (Practicals based on Paper I, II& II): 6 Credits

1. Study of stages of cell division Mitosis (onion roots) and meiosis (Flower bud)
2. Identification of Barr body from salivary DNA.
3. Study of Polytene chromosomes in salivary glands of Chironomus larva
4. Cell counting by Heamocytometer.
5. Demonstration of RFLP.
6. Study of Various developmental stages ofchick embryo.
7. Karyotype analysis, banding pattern by G-banding method
8. Demonstration of pedigree analysis.
9. Preparation of Nutrient agar and broth media &sterilization methods,
10. Preparation and Isolation of pure culture from different sources (Air, water and soil).
11. Isolation of Plasmid from bacterial cell
12. Demonstration of Bacterial growth curve.
13. Demonstration of TDP.
14. Demonstration of Staining methods: Gram staining, spore staining, negative staining, acid fast staining.

Lab 2(Practicals based on Elective Paper): 2 Credits

1. Explain the principle and procedure of compound Microscope.
2. Separation of Plasma and serum from Blood using centrifugation.
3. Demonstration of gel electrophoresis with for DNA.
4. Demonstration of fluorescent microscopy.
5. Separation of serum proteins using agarose gel electrophoresis.
6. Factors affecting electrophoresis mobility (pore size/ voltage)
7. Separation of amino acids/ secondary metabolitesby thin layer chromatography.
8. Separation of plant pigments by column chromatography
9. Explain the Beer-Lambert law with the help of spectrophotometer.
10. Analysis of caffeine in different beverages using UV – Vis spectrophotometer

Semester II
Core Paper I -Molecular Biology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Objective of Course: To impart detailed understanding of key events of molecular biology comprising of mechanism of DNA Replication, Transcription, Translation and gene regulation in Eukaryotes.

Unit-I(DNA Replication in Eukaryotes Cell cycle and Replication)

Molecular identification of origin of replication; Formation of pre – replication complex; Initiation and elongation of replication; Regulation of pre – replication complex formation and activation; Finishing replication in eukaryotes: role of telomerase in solving end replication problem; Comparative study of replication in prokaryotes and eukaryotes; DNA repair systems in prokaryotes and eukaryotes; Repair by recombination; Translation, DNA synthesis.

Unit-II: Transcription in Prokaryotes and Eukaryotes

Transcription factors, RNA Polymerases, Regulatory sequences: enhancers, silencers; Transcription initiation and role of mediators, nucleosome modifiers and remodelers, transcriptional activators; Elongation and proof reading; Transcription termination; RNA processing: Splicing pathways. Translationin prokaryotes and eukaryotes. Mechanisms and Regulation of Translation.Co and post translational modifications of protein

Unit-III: Gene Regulation in Eukaryotes

Activation and repression of translation through m-RNA binding proteins, phosphorylation of eukaryotes initiation factor of translation. Repressor protein, Cytoplasmic control of mRNA stability.Gene regulation and Protein localization.Synthesis of secretory and membrane protein, intracellular protein traffic.

Unit-IV: Special Techniques Gene knocking and gene knock out

Eastern Blotting; Northern blotting; Reverse North Blotting; Southwestern blotting; Recombinase Polymerase amplification; Ribosome profiling; Promoter bashing; Branched DNA assay; Ligase chain reaction; Chromatin Immunoprecipitation (CHiP); Oligomer restriction; Genome editing; CRISPR/Cas systems for editing, regulating and targeting; Mutagenesis methods.

Suggested Books as references

1. Molecular Cell Biology. Lodish*et al.*(2003).5th Edition. W.H. Freeman and Company

2. Molecular Cloning – (2001). A laboratory manual.Sambrook – Russel, Vol 1, 2, 3.Third edition. CSHL Press
3. Molecular Biology of the Gene.(2003) Watson *et al.* 7th Edition.CSHL Press, Pearson and Cummings.
4. Molecular Biology of the Cell The problems Book (2015) (6ed): John Wilson and Tim Hunt
5. The Cell: Bruce Alberts 6. The Cell: A molecular approach (7ed) Geoffrey Cooper and Robert Hausman
7. World of the Cell (2013.) (8ed): Jeff Hardin and Gregory Paul Bertini.
8. Cell and Molecular Biology (2014). Concepts and Experiments (7ed): Gerald Karp
12. Molecular Biology (2013):David P. Clark, Nanette J. Pazdernik · 2nd edition (Elsevier Science).
13. Cell And Molecular Biology (2006) : S. C. Rastogi, 2nd edition · ; New Age International (P) Limited.

Core PaperII-(Enzymology)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning Objective: To build upon undergraduate level knowledge of biochemical principles with specific emphasis on Enzyme working and regulation.

Unit-I: Enzymes working

Acid-base catalysis, covalent catalysis, proximity, orientation effect, role of metal ion in enzyme catalysis.Strain & distortion theory.Measurement of enzyme activity - two-point assay, kinetic assay, using radiolabeled substrates.Determination of active site amino acids - chemical probe, affinity label, and site-directed mutagenesis, intrinsic and extrinsic regulations.Investigation of 3- D structure of active site. Mechanism of action of lysozyme, carboxypeptidase, serine proteases, nitrogenizes and examples from other classes of enzymes.

Unit-II: Enzyme regulation

General mechanisms of enzyme regulation, product inhibition. Reversible (glutamine synthase &phosphorylase) and irreversible (proteases) inhibition; Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics, determination of Ki and numerical based on these. Importance of Kcat/Km; Suicide inhibitors; Covalent modifications of enzymes. Mono cyclic and multicyclic cascade systems with specific examples; feed forward stimulation.Allosteric enzymes, its physiological significance, qualitative description of “concerted” & “sequential” models for allosteric enzymes.

Unit-III: Kinetics and drug designs for enzymes

Use of initial velocity, Review of unisubstrate enzyme kinetics, multisubstrate enzyme kinetics, Co-operatively phenomenon, MWC and KNF models, Hill and Scatchard plots, protein-ligand binding and its measurement, analysis of binding isotherms, inhibition and exchange studies to differentiate between multi substrate reaction mechanism, Drug discovery, delivery and mechanism of action, specific emphasis on designing of drugs which can block the action of an enzyme or can activate it, catalytic antibodies, Ribozymes and DNAzymes, methods to improve biocatalysts.

Unit-IV: Industrial and clinical uses of enzymes

Industrial uses of enzymes - sources of industrial enzymes, thermophilic enzymes, amylases, glucose isomerases, cellulose degrading enzymes, lipases, proteolytic enzymes in meat and leather industry, detergents and cheese production, enzymes in textile industry, paper industry, food industry etc. biofuel cells, Bio refinery, Biosensors.Immobilized enzymesmethods, kinetics and their industrial applications.Nanomaterials for Enzyme immobilization.

Suggested Books as references:

1. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry-(2008). Trevor Palmer, 11th edition. Est west publisher.
2. Principles of Biochemistry- (2017). Lehninger, David L. Nelson and Michael M. Cox. 7 th edition.
3. Biochemistry-(2010).Donald Voet, Judith G. Voet.4th edition. John Wiley publication.
4. Fundamentals of Enzyme Kinetics: (2004)Athel Cornish and Bowden, Portland Press,
5. Understanding the control of metabolism: (1996) David Fell, Portland Press,
6. Fundamentals of Enzymology: (1999)Price and Stevens, OUP,
7. Industrial Enzymology: (1998)Tony Godfrey, Jon Reichel, 2 edition
8. Enzymology :(2010).T.Devsena ; Oxford higher education, 3nd edition ,.
9. Enzymology and Enzyme Technology :(2014) S. M. Bhatt , Pub: S.Chand.

Core Paper III–Immunology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning Objective: Identify, access, and visualize immune system proteins playing key roles in innate and acquired immunity and describe how the structures of immune system molecules facilitate their functions.

Unit-I

Molecules of immune system Antigens: Antigenicity vs immunogenicity, Factors that influence immunogenicity, B and T – cell epitopes, haptens. Antibodies: Structure, Antibody classes and biological activities, the immunoglobulin superfamily, organization and expression of immunoglobulin genes. Camelids; Cytokines: Properties, cytokine receptors, Cytokine-related diseases, therapeutic uses of cytokines. MHC: General organization and inheritance of MHC, cellular distribution of MHC molecules.

Unit-II

Cells of immune system Granulocytes: Eosinophils, Basophils, Neutrophils; Natural killer cells, Macrophages; Antigen Processing and presentation pathways - the cytosolic and endocytic pathway, presentation of non-peptide antigens. B cells: Maturation, activation and proliferation, antigen induced B- cell differentiation, regulation of B-cell development. T cells: T cell maturation, Thymic selection of T cells, TH cell activation, T cell differentiation, Role of T – cells in cell death.

Unit-III

The immune response: Thehumoral response - primary and secondary response. Role of TH cells in humoral response. The complement system: The components and functions of complements. Activation of complement, regulation of the complement pathways, complement deficiencies. Cell mediated response: Effector responses, General properties of effector T cells. Response to infectious agents: Virus, bacteria, protozoa; emerging infectious disease. Leukocyte migration and inflammation; Damage associated molecular mechanisms/platforms (DAMS); Pathogen associated molecular mechanisms/platforms (PAMS).

Unit-IV

Diseases related to immune system: Hypersensitive reactions- Gel and Coombs classification. Types of hypersensitive reactions.Primary immunodeficiencies- Severe combined immunodeficiency. Autoimmunity: Organ specific, systemic autoimmune disease, proposed mechanisms for autoimmunity; Treatment, Antibody Drug Conjugate (ADC), Immunotherapy.

Suggested Books as references:

1. Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A., W.H Freeman and Company (New York),
2. Immunology: A Short Course (2009) 6th ed., Coico, R and Sunshine, G., John Wiley& sons, Inc (New Jersey),
3.Janeway'sImmunobiology (2012) 8th ed., Murphy, K., Mowat, A., and Weaver, C.T., Garland Science (London & New York).
4. Immunology: (1997). Jan Klain, 2 ndadition. Blackwell scientific
5. Immunology (2010). Ivan Roitt, (10th ed), Blackwell Scientific Press,
6. Microbiology(2008) Willey, Sherwood, Woolverton, Microbiology 7th ed. McGraw Hill

Elective Paper 1 of Group B (Virology)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning Objectives:

Distinguish characteristics of normal cells and virus-infected cells. Explain and apply methods used in research and diagnosis of viral diseases. Describe cellular and therapeutic antiviral strategies. Explore social stigmas against infected individuals.

Unit –I: History and principles of Virology

Virus taxonomy, introduction to replication strategies.Virus structure and morphology.Viruses of veterinary importance.Principles of bio-safety, containment facilities, maintenance and handling of laboratory animals and requirements of virological laboratory.Plant viruses, plant virus propagation.

Unit II: Virological Methods

In vivo, in vitro and in vivo systems for virus growth, estimation of yields, methods for purification of viruses with special emphasis on ultracentrifugation methods. Introduction to PCR,ELISA,RIYA, IFAand Immunohistochemistry.

Unit III: Virus Cell Structure

Interaction**:** Definition, structure and methods of discovery of viral receptors (herpes, HIV). Kinetics of receptor binding. Cellular interactions—clathrin coated pits, lipid rafts, caveolae, endocytosis and virus uncoating mechanisms. Nuclear localization signals and nuclear pore transit, virus –cytoskeletal interactions, chaperons.

Unit IV: Applied epidemiology

Types and methods of public health and infectious disease surveillance, establishing surveillance system.Case control and cohort studies. Needs and steps to be taken for outbreak investigations, collaboration with State and National health authorities.

Suggested Books as references:

1.Fields Virology Vol 1 and 2. B.N. Fields, D.M. Knipe, P.M. Howley, R.M. Chanock, J.L. Melnick, T.P. Monath, B. Roizman, and S.E. Straus, eds.), (1999). 3rd Edition.Lippincott-Raven, Philadelphia, PA.

2. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka.Latest edition / Pub. Date: December (2003) Publisher: American Society Microbiology.

3. Laboratory Animal Medicine: Principles and Procedures. Margi Sirois. Latest edition / Pub. Date: November (2004). Publisher: Elsevier Health Sciences.
4. Guides for the Care and Use of Laboratory Animals. National Research Council.Latest edition / Pub. Date: January (1996). Publisher: National Academy Press.
5.Laboratory Biosafety Manual,(2020).$thadition. WHO,
6. Virology: (1994). 3rd ed. FrankelConrat et al, Prentice Hall.
7. Introduction to Modern Virology. (2001)5th ed. Dimmock et al., Blackwell Scientific Publ.
8. Basic Virology,(1999). By Waginer and M. Hewlett, Blackwell Science Publ.it II.

Elective paper 2of Group B (Communication Skills)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Objective of Course: The primary objective of communication in management is to convey information—instructions, policies, procedures, decisions, etc., so the listener will hear.

Unit -I: Process of communication

Concept of effective communication- Setting clear goals for communication; Determining outcomes and results; Initiating communication; Avoiding breakdowns while communicating; Creating value in conversation; Barriers to effective communication; Non verbal communication- Interpreting non verbal cues; Importance of body language, Power of effective listening; recognizing cultural differences

Unit –II: Presentation skills

Formal presentation skills; Preparing and presenting using Over Head Projector, Power Point; Defending Interrogation; Scientific poster preparation & presentation; Participating in group discussions.

Unit –III: Technical Writing Skills

Types of reports; Layout of a formal report; Scientific writing skills: Importance of communicating Science; Problems while writing a scientific document; Plagiarism; Scientific Publication Writing: Elements of a Scientific paper including Abstract, Introduction, Materials & Methods, Results, Discussion, References; Drafting titles and framing abstracts

Unit IV:Computing Skills for Scientific Research

Web browsing for information search; search engines and their mechanism of searching; Hidden Web and its importance in Scientific research; Internet as a medium of interaction between scientists; Effective email strategy using the right tone and conciseness

Suggested Reading

1. Mohan Krishna and N.P. Singh, Speaking English effectively, Macmillan, 2003.

Elective paper 3 of Group B (Food and Dairy)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Objective of Study: The Dairy Standard Agency executes its current statutory and non-statutory activities through the implementation of the following scientifically grounded and predetermined objectives, strategies and processes.

Unit I: Industrial and Food Biotechnology;

Introduction; History; Importance; Applications of biotechnology in food processing; Significant advances; Recent developments; Risk factors; Safety regulations etc.

UnitII: Industrial use of Microorganisms

Microbes exploited commercially- *Saccharomyces, Lactobacillus, Penecillium, Acetobactor, Bifidobacterium, Lactococcus, Streptococcus*etc; Fermentation-process, media and systems; Upstream and down stream processing; Product development; Dairy fermentation and fermented products.

Unit III: Microbial enzymes in food processing

Industrial production of enzymes - proteases and cellulases; Food and beverage fermentation-alcoholic and nonalcoholic beverages; Food additives and supplements – probiotics, health care products, vitamins and antibiotics; Fuels and industrial chemicals- Alkanes, industrial ethanol etc.

Unit IV:**Modification of microbial enzymes**

Modification in microbial enzymes production – Strain improvement, enzyme cofactor engineering, Technologies for microbial inactivation.Applications in product development and improvement.

Suggested Reading:

1. Gautam, N. C., Food Biotechnology in Comprehensive Biotechnology, Vol. 6., Shree Publishers, New Delhi, 2007
2. Gutierrez – Lopez, G. F. et. al., Food Science and Food Biotechnology. CRC Publishers, Washington, 2003
3. Maheshwari, D. K. et. al., Biotechnological applications of microorganisms, IK . International, New Delhi, 2006
4. Stanbury, P. F. et. al., Principles of Fermentation Technology, 2nd Edition, Elsevier, UK, 1995.
6. Waites, M. J. et. al., Industrial Biotechnology: An Introduction, Blackwell publishing, UK, 2007.

Lab 1 (Practicals on the basis of theory Paper I, II& III) : 6 Credits

1. Demonstration of Southern Transfer technique.
2. Restriction digestion of Plasmid DNA.
3. DNA Ligation.
4. RNA Isolation
5. Estimation of Riboflavin by Arnold's fluorimetric method
6. Effect of environmental factors such as pH, and temperature inhibitors on emylase
7. Preparation of Buffer (Acetate buffer/ phosphate buffer).
8. Isolation and purification of peroxidase.
9. Immobilization studies: Preparation of peroxidase entrapped in alginate beads and determination of percent entrapment
10. Study the immunodiffusion technique by Single Radial Immunodiffusion.
11. Study the reaction pattern of an antigen with a set of antibodies by Ouchterlony Double Diffusion method.
12. To learn the technique of Dot ELISA for the detection of an antigen.
13. Rocket immunoelectrophoresis.

Lab 2 (Practicals on the basis of Elective TheoryPaper): 2 Credits

1. Demonstrate the morphology of different types of viruses(photographs).
2. Study of any two viral diseases of plant / animal/ human (Specimens/ photographs).
3. Study any four diseasesymptoms produced in plant due to viral infection.
4. LJ media preparation for Mycobacterium tuberculosis
5. Identification of Mycobacterium.
6. Isolation of Lambda phage
7. Prepare a list of conventional and new vaccines.
8. Any other practical based on theory papers

Semester III

Core Paper I-Genetic Engineering and System Biology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Objective of course: To define 'genetic engineering' explain the process of gene manipulation to produces GM food and applications of genetic engineering.

Unit- I: Basics of gene manipulation

Introduction to Recombinant DNA (rDNA) technology, Isolation of DNA, RNA and Plasmids, Techniques used in rDNA technology.Types of PCR, DNA Sequencing and different techniques.FISH, Gene construction, Transformation.Applications ofRecombinant DNA technology

Unit-II:DNA manipulation in Prokaryotes

Plasmids as cloning vehicles, Types of Plasmid vectors, Bacteriophage, specialized vectors like cosmids, phagemidsBAC and YAC.Construction of genomic and c-DNA libraries, recombinant selection and screening, Expression of cloned genes in *E. coli*.

Unit-III: DNA manipulation in Eukaryotes

Cloning in *S. cerevisiae* and other microbial eukaryotes, Gene transfer in plants, Double Termination, Technique of Gene transfer in animal cells, transferring genes into animal eggs, embryos. Targeted gene replacement; Generation of novel plants and animals, Disadvantages of rDNA technology, ethical concerns of rDNA technology.

Unit-IV: Omics in Biotechnology

Historical perspective and applications of system biology, Understanding of biological systems, metabolic network, measurements for system biology, system behavior analysis. Importance of metabolic engineering, Methods for metabolic characterization, Regulation of metabolic networks, Regulation of at the whole cell level, Metabolic control analysis, the theory of flux balances (Cell Capability Analysis &Genome Scale Flux Analysis).

Suggested Books as references:

1. Recombinant DNA: Genes and genomes (2017).Watson, James D., Caudy, Amy A., Myers, Richard M., and Witkowski, Jan A., W.H. Freeman and Company, Gordonsville.
2. Genome Science: A Practical and Conceptual Introduction to Molecular Genetic Analysis in Eukaryotes.(2012). David Micklos (Author), UweHilgert, Bruce Nash
3. From genes to Genomes: Concepts and applications: Jeremy Dale and Malcolm von Schantz.Publisher : Cold Spring Harbor Laboratory Press,U.S.; 1st edition.
4. Principles of Gene manipulation and Genomics (2006). SB Primrose and RM Twyman, 7th ed, Blackwell Scientific.
5. Advanced Genetic analysis: (2009).Philip Meneely, Oxford University Press,
6. Genome science: A practical and conceptual introduction to molecular genetics analysis in eukaryotes: David Micklos, Bruce Nash and UweHilgertSambrook and Manniatis.
7. Genetic engineering and horticulture crops. (2018).R.K.Gaur.first edition. Academic press publication.

Core Paper II- Animal Biotechnology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Objective of course: Explain and apply methods usedinAnimalCell/ Tissue Culture, Evolution of Cell Lines and Production of transgenic animals.

Unit- I: Historical Background

History, Definitions,laboratory equipmentsand terminology of animal tissue culture, Advantagesand Limitations,of Tissue Culture, Origin and Instability of animal Cells.Biology of Cultured Cells,choice of materials in animal cell culture. Problems associated with tissue culture.Application of animal cell culture in broad level.

Unit –II: Media and CellCultured

Media composition, types, preparation and consideration for designing of media.Initiation of the Culture, Primary Culture; Subculture and Cell Lines.Evolution of Cell Lines, Transformation and the Development of Continuous Cell Lines. Standardization of Culture Conditions:Use of Antibiotics.Organ Culture, Histotypic culture.Maintenance and records.Cryopreservation and Banking.

Unit –III: Cell Line and Derivation of Drug-Resistant Cell Strains

Cell Line Characterization,authentication validationand routine maintenance.Expression in the In-vivo conditions. Phenotype Stages of Differentiation, Proliferation and Differentiation, Commitment and Lineage, Stem Cell Plasticity, Markers of Differentiation, Induction of Differentiation, Differentiation and Malignancy, Three-Dimensional Culture: Cell Interaction and Phenotypic Expression;

Unit –IV:Genetic manipulations in animal cells (Transgenic Animals)

Introduction, basic method, typesgenetic manipulations, screening of recombinant cellsProduction of transgenic mice and sheep. Transgenic animals as bioreactors-recombinant proteins produced by animal bioreactors.Transgenic animals as models of human diseases. Xenotransplantation, Applications of transgenic animals.

Suggested Books as references:

1. DubeyR. C., (2018). A Text Book of Biotechnology. S. Chand& Co Ltd, NewDelhi.
2. Gangal S., (2010). Animal Tissue culture. Second edition. University Press (India)PvtLtd. Hyderabad.
3. Ranga,M. (2006). Animal Biotechnology, Studam publishers.
4. Sasidhara, R. (2006). Animal Biotechnology, MJP Publishers.

5. Satya and Das (2005). Essential Biotechnology for students.PeePee Publishers. NewDelhi
6. ShivangiMathur (2012). Animal cell and tissue culture. Agrobios Publisher, India
7. Sverdrup H.U. (1942). Oceans & their Physics, Chemistry & Biology – Johns & R.H.Fleming, Prentice Hall Inc.
8. Satyanarayana, U. (2008). Biotechnology, Books and Allied (p)Ltd, Kolkata.

Paper III- Seminar and Their Presentation:

Semester III

Paper III (Seminar, Scientific Writing & PowerPoint Presentation)

Duration: 4 hrs. Per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry two mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 14 marks.

Learning Objective: The aim of this course is to equip students with the skills to effectively communicate scientific research and findings, both orally and in writing. The course will help them understand the principles of scientific writing, hone presentation skills, and use tools like PowerPoint to visualize complex scientific information. It will also emphasize the importance of proper structuring, logical reasoning, and critical evaluation of research.

Unit-I

Introduction to Scientific Communication: Overview: Importance of communication in science; understanding scientific literature. **Structure of a Scientific Paper**: Abstract, Introduction, Methods, Results, Discussion, and Conclusion. **Writing Abstracts**: Summarizing scientific research briefly and effectively.

Unit-II

Writing a Scientific Paper: Scientific Writing Styles: Formal writing vs. informal writing; differences between research articles, review papers, and thesis. **Common Writing Errors**: Avoiding grammatical errors, improving sentence structure, and maintaining clarity. **Data Presentation in Writing**: Incorporating tables, graphs, and figures into research writing.

Unit-III

PowerPoint Presentations in Science: Principles of Effective Presentation: Structure, clarity, and flow; the importance of a clear message. **Visual Aids**: Using charts, graphs, and images to complement data presentation; avoiding overcrowding slides. **Presentation Skills**: Body language, tone of voice, audience engagement, and managing questions.

Unit-IV

Preparing and Delivering a Seminar: Seminar Structure: Organizing scientific content; transitioning from one part to another smoothly. **Time Management**: Preparing content according to time constraints and prioritizing key messages. **Dealing with Q&A**: Handling audience questions confidently and effectively. **Feedback and Improvement**: Receiving feedback to refine both scientific writing and presentation skills.

Course outcome: Students will develop the skills to deliver scientific seminars, manage time, and handle audience interactions confidently.

Suggested Readings

1. *How to Write and Publish a Scientific Paper* – Barbara Gastel and Robert A. Day (2021)
2. *The Craft of Scientific Writing* – Michael Alley (2018)
3. *Made to Stick: Why Some Ideas Survive and Others Die* – Chip Heath & Dan Heath (2007)
4. *Presentation Zen: Simple Ideas on Presentation Design and Delivery* – Garr Reynolds (2019)

Elective Paper 1 of Group C (Bioinformatics and Biostatistics)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning Objectives: To get introduced to the basic concepts of Bioinformatics and its significance in Biological data analysis and Explain about the methods to characterize and manage the different types of Biological data.

Unit -I: **Elementary idea about Bioinformatics**:

Definition, introduction, application and scopes.Databanks – Gen Bank, DataBanks – PubMed. BLAST, FASTA, and NCBI.Applications of Bioinformatics in relation to Biotechnology.

Unit –II: Basic Bioinformatics

Introduction to databases-Primary, secondary, composite, Databases related to human diseases: OMIM, HGMD, Sequence similarity search: local, global, multiple and pairwise, Comparison of bacterial genome, Protein structure: protein structure prediction, Human genome variation, Functional genomics.

Unit –III: Applied Bioinformatics

Bioinformatics approach to RNA: Understanding the Genetic basis of Variation in Gene expression, Protein analysis and proteomics, Molecular phylogeny & evaluation, Protein - protein interaction, DNA-Drug interaction, Gene prediction, Analysis of gene expression by microarray, Homology Modelling.

Unit –IV: Biostatistics Probability and statistics

Population, variables, collection, tabulation and graphical representation of data, frequency distribution, central tendency, binomial, concept and correlation; regression; methods of least square; chi-square tests, random number generation- testing and use; probability density and cumulative distribution function; systematic and random sampling.

Suggested Books as references:

1. Lesk, A. Introduction to Bioinformatics (2019), 5th edition, published by OUP Higher Education Division
2. Attwood.Introduction to Bioinformatics(2020).
3. Instant notes in Bioinformatics---Westhead, Parish &Twyman.
4. Bioinformatics: A practical guide to the analysis of genes and proteins-Baxevanis, Qoellette, John Wiley & Sons, NY.
5. Mount David: Bioinformatics
6.Xiong, J. (2006). Essential bioinformatics.Cambridge University Press. [Primary Book]
7.Dan E Krane and M. L Raymer. Fundamental Concepts of Bioinformatics.Pearson Publications. 2003

Elective Paper 2 of Group C(Stem Cell Biology)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning Objectives: Student will understand the types and uses of embryonic stem cells.

Unit –I: Stem Cell Biology

Introduction to Stem CellsDefinition, Classification, Properties and Sources. Detail application of Stem cells in biotechnology.

Unit -II: Embryonic **Stem Cells**

Embryonic Stem Cells: Blastocyst and inner cell mass cells; Organogenesis; Mammalian Nuclear Transfer Technology; Stem cell differentiation; Stem cells cryopreservation.

Unit –III:Application of Stem Cells

Overview of embryonic and adult stem cells for therapy Neurodegenerative diseases; Parkinson's, Alzheimer, Spinal Code Injuries and other Brain Syndromes; Tissue systems Failures Diabetes Cardiomyopathy; Kidney failure; Liver failure; Cancer; Hemophilia etc.

Unit –IV :Human Embryonic Stem Cells and Society

Human stem cells research: Ethical considerations; Stem cell religion consideration; Stem cell based therapies: Pre clinical regulatory consideration and Patient advocacy.

Suggested Readings:

1.Ann A. Kiessling, Human Embryonic Stem Cells: An Introduction to the Science and Therapeutic Potential, Jones andBartett, 2003.
2.Peter J. Quesenberry, Stem Cell Biology and Gene Therapy, 1st Edition, Willy-Less, 1998.
3.Robert Lanja, Essential of Stem Cell Biology, 2nd Edition, Academic Press, 2006.
4.A.D.Ho., R.Hoffiman, Stem Cell Transplantation Biology Processes Therapy, Willy-VCH, 2006.
5. C.S.Potten, Stem Cells, Elsevier, 2006

Elective Paper 3 of Group C (Vaccine Production)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning Objectives: To understand the production, risks, management and uses of different types of vaccines

Unit –I: Innate Immunity

Activation of the Innate Immunity through TLR mediated signaling; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Protective immune response in bacterial; Viral and parasitic infections; Correlates of protection

Unit II: Vaccination and immune response; Appropriate and inappropriate immune response during infection: CD4+ and CD8+ memory T cells; Memory B cells; Generation and Maintenance of memory T and B cells; Dendritic cells in immune response

Unit III: Adjuvants in Vaccination; Induction of Th1 and Th2 responses by using appropriate adjuvants; Microbial, Liposomal and Microparticles as adjuvant; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and mucosal Immunity.

Unit IV: Conventional vaccines; Bacterial vaccines; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine. Vaccines for specific targets; Tuberculosis Vaccine; Malaria Vaccine; HIV vaccine.

Suggested Readings:

1. Edited by Stefan H.E. Kaufmann, Novel Vaccination Strategies, Wiley-VCH Verlag GmbH & Co. KgaA, 2004 or later edition.

2 Topley& Wilson's, Microbiology and Microbial Infections Immunology Edited by Stefan H.E. Kaufmann and Michael W Steward Holder Arnold, ASM Press, 2005 or later edition.

3 Edition Charles A Janeway. Jr, Paul Travers, Mark Walport and Mark J Shlomchik, Immuno Biology, The Immune system in health and Disease, 6th Edition, Garland Science, New York, 2005 or later edition.

4 Annual Review of Immunology: Relevant issues

5 Annual Review of Microbiology: Relevant issues

Lab 1 (Practicals on the basis of theory Paper I, II & II)6 Credits

1. Preparation of animal cell culture media and Membrane filtration.
2. Preparation & sterilization of balanced salt solution and DBSS.
3. Preparation of single cell suspension from spleen.
4. Cell viability test and cell counting from animal blood.
5. Trypsinization of monolayer and subculture.
6. Measurement of doubling time.
7. Role of serum in cell culture.
8. Isolation of genomic DNA from animal tissue.
9. Qualitative and Quantification estimation of genomic DNA
10. Amplification of DNA by PCR
11. Demonstration of RFLP
12. Demonstration RAPD
13. Seminar preparation and presentation.

Lab 2 (Practicals on the basis of ElectivePaper)2 Credits

1. Introduction to Bioinformatics database (any three): NCBI/ PubMed. BLAST, FASTA
2. Sequence alignment
3. Protein Structure Prediction
4. Prediction of different features of a functional group.Representation of Statistical data by
    a. Histograms , b) Pie diagrams
5. Determination of Statistical averages/ central tendencies.
    a. a)Arithmetic mean, b) Median, c) Mode
6. Test of significance-
    a) Chi-Square test
    b) t-Test
    c) Slandered error

Semester IV
Core Paper I- Plant Biotechnology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning Objectives: Explain plant biotechnology and the techniques used in plant conservation area and perform experiment.

Unit I: Introduction to Plant Biotechnology

Definition.History, application and development of plant Biotechnology.Modern trends in plant biotechnology.Various techniques of plant cell and tissue culture, culture media, preparation, stock solutions, growth factors and laboratory facilities.

Unit II: Plant cell tissue and organ cultures

Introduction to cell and tissue culture techniques; Toti potency; Organogenesis and somatic embryogenesis; Micropropagation.Synthetic seeds production.Production of haploids and triploids (anther, and endosperm culture).Protoplast culture and somatic hybridization; nuclear and cytoplasmic hybrids.Somaclonal variation in plant cell culture and regenerated plants.Cryopreservation and germplasm conservation.

Unit III: **Transgenic plant technology:** Gene transfer (vertical) by classical methods; horizontal gene transfers; methods of genetic transformation in plants; methods of nuclear transformation; Organelle transformation; advantages; Direct transformation of plant systems using physical methods; Agrobacterium mediated plant transformation. Comparison of methods for transfer of DNA to plants, manipulation of gene expression in plants; production of transgenic plants without reporter or marker genes.

Unit IV: Application of plant transformation for productivity and performance

Herbicide resistance; Insect resistance; Bt genes; long shelf life of fruits and flowers; molecular farming, benefits and risks; Transgene stability and gene silencing; Strategies to avoid gene silencing and improve gene expression in transgenic plants; ethics and plant genetic engineering; metabolic engineering and industrial products.

Suggested Books as references:

1. Chrispeel M.J, Sadava D.E, (2017). Revised edition, Plants, Genes and Agriculture(Sustainability through Biotechnology), Jones and Barlett Publication, Boston.
2. R. KeshavaChandran and K.V. Peter. (2008).Plant Biotechnology. First edition. University Press (India) Pvt. Ltd, Hyderabad.

3. BishunDeo Prasad, SangitaSahni, Prasant Kumar, Mohammed WasimSiddiqui.2018, Plant Biotechnology, Volume 1 Principles, Techniques, and Applications. Pub: Apple Academic Press
4. M.A. Deepa.(2011) Recent Advances in Agricultural Biotechnology, Publisher : Himalaya Publishing House
5. Satyanarayana . U, (2020). Biotechnology, 5 th edition. Books and Allied (p) Ltd.
6. Aneja. K.R. (2007). Laboratory Manual of Microbiology and Biotechnology, New Age International Publisher.
7. Ashwani Kumar, Shikha Roy (2006).Plant Biotechnology and its Applications in Tissue Culture. I K International Publishing House Pvt. Ltd

Semester IV
Paper II- IPR & Bioethics

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives:

To discuss the ethical and safety concerns in the Biotechnology field with respect to Global and Indian standards and to highlight the current trends and issues of intellectual property rights

Unit I: Bioethics

The legal and socioeconomic impact of biotechnology, public education of the process of biotechnology involved in generating new forms of life for informed decision making, biosafety regulation and national and international guidelines, r-DNA guidelines, experimental protocol approvals, levels of containment, regulatory bodies in biotechnology, biosafety committee.

Unit II: Economics, Biosafety

Patent rights and Biotechnology R & D and industry: Business aspects of biotechnology, research and market place, Finance and human resources, Intellectual property right: patents, R & D partnership, license agreement and joint venture.Biosafety: Prevention and management of chemical and biological hazards associated with research.

Unit III: Entrepreneurship

Evaluation and interpretation of data sheets, labels etc. for pre-assessment of biological and chemical hazards. Entrepreneurship**:** Starting an enterprise, stage in setting up an enterprise, business idea, Setting a business plan. Management team, Marketing, market research, market strategies (4p strategies) financial planning, Balance sheet, profit and loose statement.

Unit IV: Innovation Management

Technology transfer tools, Industry-Academia collaborations, Bio-incubators, Bio-accelerators, Finishing schools.; Bioethics: Role of bioethics in research. Prevention and management of plagiarism, fabrication/manipulation of data, conflict of interest,Bioethical norms governing research related to animals and humans.

Suggested Books as references:

1. Goel andParashar(2013). IPR, Biosafety and Bioethics.Pearson Education India
2. Nambisan, P. (2017). An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology, Academic Press.

3. Joshi R. (2007). Biosafety and Bioethics. Isha Book Publisher.
4. Sateesh M.K. (2010). Bioethics and Biosafety, I. K. International Pvt Ltd.
5. Sree Krishna V. (2007). Bioethics and Biosafety in Biotechnology, New Ageinternational publishers.

Semester IV

M.Sc. Biotech Sem IV

Paper III (Applied Environmental Biotechnology)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.
Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.
Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Course Objectives: Understand Core Concepts: Develop a solid understanding of environmental biotechnology principles and their applications in waste management, resource recovery, and bioenergy production.

Unit I:

Fundamentals of Environmental Biotechnology: Overview of Environmental Biotechnology: Definition and scope**,** Historical development and applications**,** Role in sustainable development**.** Microbial interactions (symbiosis, competition, predation)**.** Biodegradation and Bioremediation: Mechanisms of biodegradation (aerobic vs. anaerobic)**,** Bioremediation technologies (in situ vs. ex situ)**,** Phytoremediation and mycoremediation**..**

Unit II:

Waste Management and Treatment Technologies: Waste Types and Sources: Municipal, industrial, and agricultural waste**.** Hazardous vs. non-hazardous waste**.** E-waste and its environmental impact**.** Biological Treatment Methods: Anaerobic digestion. Composting and vermicomposting. Advanced Wastewater Treatment: Activated sludge process, Membrane bioreactors and advanced oxidation processes.

Unit III:

Bioenergy and Resource Recovery

Biomass as a Renewable Resource: Types of biomass (agricultural, forestry, municipal), Biomass production systems and sustainability. Resource Recovery from Waste:Nutrient recovery technologies (nitrogen, phosphorus), Circular economy concepts and applications, Recovery of metals and other valuable materials from waste.

Unit IV:

Environmental Monitoring and Policy

Monitoring Techniques: Environmental impact assessment (EIA), Microbial indicators of pollution (fecal coliforms, etc.), Remote sensing and GIS applications in environmental monitoring. Regulatory Frameworks**:** Environmental laws and policies (local, national, international), Role of governmental and non-governmental organizations, Sustainable development goals (SDGs) and biotechnology.

Suggested Reading List

1. *Environmental Biotechnology: Principles and Applications* by Gareth M. Evans and Judith C. F. A. Smith
2. *Biotechnology for Waste and Wastewater Treatment* by C. M. Srivastava
3. *Bioremediation: Principles and Applications* by E. J. C. Bradshaw and H. L. Allen
4. *Biofuels: A Solution for the Energy Crisis* by P. L. K. Chaudhary and K. G. C. K. Patil
5. *Microbial Ecology: Fundamentals and Applications* by Paul H. B. B. Allen and J. E. C. Overman
6. *Waste Management: A Complete Guide* by K. M. S. R. K. Rao
7. *Biotechnology for Environmental Sustainability* by R. K. Gupta and A. K. S. Chaturvedi
8. *Environmental Biotechnology: Theory and Application* by R. E. H. G. H. G. M. Flórez and D. A. C. Rodriguez

Semester IV

Elective Paper1 of Group D (Bio-processing and Engineering)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objective:

To provide the strong foundation in the areas of food engineering, post-harvest practices and value addition of food materials.

Unit I: Introduction to Bioprocess Engineering

Bioreactors and membrane Bioreactors and Membrane Bioreactors, Isolation Preservation and Maintenance of Industrial Microorganisms, Types of fermentation processes. Analysis of batch, Fedbatch and continuous bioreactors, analysis of mixed microbial populations, specialized bioreactors (pulsed fluidized, photobioreactorsetc).

Unit II: Downstream processing

Introduction, Removal of microbial cells and solid matter, foam reparation, precipitation, filtration, centrifugation, cell disruptions, liquid-liquid extraction, chromatography, membrane process.Drying and crystallization, Treatment and disposal of effluents.Whole cell Immobilization and their Industrial Applications, bioconversion and Biotransformation.

Unit III: Industrial Production of chemicals

Alcohol (ethanol). Acids (citric, acetic), Solvents (acetone, butanol), Antibiotics (penicillin, tetracy6cline), Amino acids (lysine, glutamic acid), Single Cell Protein, Introduction to Food technology elementary idea of canning and packin-Fat-Based Edible products, Typical Food/ food products (bread, cheese, idli, Agro-products (oilseeds) Food preservation.

Unit IV:Biology of Industrial Microorganisms:

(*Saccharomyces*, *Aspergillus*, *Penicillia*).Idea of Fermentation, Cell growth, Regulation of Metabolism, Substrate Assimilation/Product Secretion.Different fermentative system; Fermentor Design, Surface and submerged liquid substrate fermentation.Bio-mass production (lactic acid, cheese making, health care products (antibiotics, steroids, vaccines), Production of Industrial solvents (alcohol, acetone, butanol), Industrial Enzymes (amylase, proteases, lipases).

Suggested Books as references:

1. Aneja. K.R. (2007). Laboratory Manual of Microbiology and Biotechnology, New Age International Publisher.
2. GoelAndParashar(2013). IPR, Biosafety and Bioethics.Pearson Education India
3. Nambisan, P. (2017). An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology, Academic Press.

4. Joshi R. (2007). Biosafety and Bioethics. Isha Book Publisher.
5. Sateesh M.K. (2010). Bioethics and Biosafety, I. K. International Pvt Ltd.
6. Sree Krishna V. (2007). Bioethics and Biosafety in Biotechnology, New Age international publishers.

Elective Paper 2 of Group D (Plant Metabolite Engineering)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objective: To understand the metabolism and biological oxidation reduction reactions.

Unit I:**Metabolism and Metabolic Engineering**

Carbon Assimilation; Light absorption and energy conversion; Calvin Cycle; Hatch-slack pathway; Reductive pentose phosphate pathway; Carbon dioxide uptake and assimilation; Photorespiration; Glycolate metabolism.

Unit II: **Biological Oxidation and release of Energy**

Enzyme Kinetics and analysis of Sequences of Reactions; Glycolate pathway; Kreb's cycle; High energy compounds; Oxidative phosphorylation; Chemiosmotic hypothesis; pentose phosphate shunt pathway.

Unit III: **Metabolism of Macromolecules**

Biosynthesis and inter-conversion of carbohydrates; Biosynthesis, inter-conversion and degradation of lipids; Regulation of Metabolic Networks, Metabolic Flux Analysis; Metabolic Control analysis.

Unit IV:Secondary Metabolism

Importance of Secondary Metabolites; Biosynthesis of phenolic compounds, isoprenoids, alkaloids and flavonids;

Elective Paper 3 of Group D (Pharmaceutical Biotechnology)

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 7 marks. Each question will carry one mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Unit I: Biotechnology in pharmaceutical perspective:

Biology in drug discovery; Traditional drug discovery vs. rational drug discovery, rational drug discovery pipeline, concept of target based drug design and target discovery, role of plant biotechnology in edible vaccine development. Definition: Generics and its advantages; Biogenerics and Biosimilar; Why biosimilar are not (bio) generics; The advent of Biosimilar.

Unit II: Biotechnology in pharmaceutical industry

Major areas for biotechnology in the pharmaceutical industry such as antibiotics, vaccines, diagnostics, antibodies,biopharmaceuticals (insulin, interferon, GSF, CSF & therapeutic proteins etc.);Commercial aspects, priorities for future biotechnological research

Unit III:Industrial enzymes in drug development.

Penicillin amidase, lipase, oxidoreductase, nitrilase, protease etc.Use of all these enzymes for enantioselective synthesis of pharmaceutically important drugs / drug intermediates, future directions.

Unit IV: **Approved follow-on proteins/Biosimilar**

Characteristics of high-selling peptides and proteins; Products with expired patents; Challenging originator's patents; Target products for FOB (follow-on biologicals)/ Biosimilars development peptides; Recombinant nonglycosylated proteins; Recombinant glycosylated proteins; Industries dealing with biogenerics and its market value; World scenario; Indian scenario.

Suggested Readings:

1. Pharmaceutical Biotechnology (2016) Helmer E, Syrawood Publishing House, ISBN: 978- 1682861066.
2. Pharmaceutical Biotechnology (2014) Sreenivasulu V, Jayaveera KN and Adinarayana K, S Chand & Company, ISBN: 978-8121942478.
3. Pharmaceutical Biotechnology Fundamentals and Application (2013) Kokare C, NiraliPrakashan, Educational Publishers, ISBN: 978-8185790688.

4. Pharmaceutical Biotechnology: Concepts and Applications (2011) Walsh G, Wiley India Pvt Ltd, ISBN: 978-8126530250.
5. Pharmaceutical Biotechnology (2002) 2nd ed. Cromelin DJA and Sindelar RD, Taylor and Francis Group, ISBN: 978-3-527-65125-2.

Lab 1 (Practicals on the basis of theory Paper I, II & II) 6 Credits

1. Preparation of stock solutions for MS medium.
2. Preparation & sterilization of MS medium.
3. Surface sterilization and organ/ nodal/shoot tip culture.
4. Isolation of genetic DNA from planttissue.
5. Anther cultureor Ovary culture.
6. Establishment of shoot tip culture using MS medium
7. Isolation of protoplasts using enzymatic/mechanical method.
8. Establishment and maintenance of somatic embryogenesis.
9. Cytological examination of regenerated Plant.
10. Preparation of synthetic seeds (Entrapment method).
11. Extraction & Separation of Chlorophyll A & B using Column Chromatography.
12. Write various steps to Setupa Biotechnological industry plan.
13. Students have to present power point presentation of their project in front of the external and internal examiners.

Lab 2 (Practicals on the basis of Elective Theory Paper IV) 2 Credits

1. Assay of any two common enzymes (amylase, protease, pactinase, lipase).
2. Production of ginger wine
3. Production of grape wine.
4. Estimation of lactic acid percentage by Saurcouret production
5. Immobilization of enzymes/ whole cells by adsorption, covalent linkage
6. Industrial visit and report have to submit in college by student.

Note: Dissertation is mandatory for all the students with Lab 2 of Sem IV

Students have to prepare Dissertation report and their PPT of their project and present in front of the external and internal examiners. 4 Credits