S.S. Jain Subodh P.G. College, (Autonomous)

Jaipur

SYLLABUS

TWO YEAR POSTGRADUATE PROGRAMME IN SCIENCE

I & II SEMESTER EXAMINATION 2023-24

III & IV SEMESTER EXAMINATION 2024-25

As per NEP -2020

S.S. Jain Subodh P.G. College, (Autonomous)

Jaipur

FACULTY OF SCIENCE

Programme Name: TWO YEAR POSTGRADUATE PROGRAMME IN SCIENCE

Subject/Discipline: Biotechnology

(Syllabus as per NEP-2020 and Chaise Based Credit System)

Medium of Instruction: Hindi/ English

w.e.f. Academic Session 2023-24

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 of Biotechnology.

M.Sc. Biotechnology

M.Sc. Biotechnology course is designed in a way that it provides adequate knowledge of Biotechnology and related subjects such as Industrial Biotechnology, Immunology, Genetic Engineering, Bioinformatics, Cell biology, Molecular Biology, Microbiology, Biochemistry, Food Technology, Molecular Biotechnology, etc. Biotechnology finds application in a variety of fields such as Production and Conservation, Healing of Prolonged Disease and Ecological Conservation, and in development of GM food, vaccines, medicine, insecticides, fertilizers and quality of seeds. Biotech is applying on the technical skills learnt to establish nurseries for horticultural and agricultural crops. It also illustrates the various aspects of Biotechnological applications in Fermentation Industries. Subject Integrates scientific and technological knowledge on the use of bioprocesses for industrial products and applying for the practical skills for entrepreneurial development.

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:

Sr. No.	Paper	ESE	CIA	Total
1.	Theory	70%	30%	100
2.	Practical	60%	40%	100

Each theory paper syllabus is divided into four units. Each theory paper 3 hours duration.
Each Practical /Lab work 6 hours duration.

The number of papers and the maximum marks for each paper/ practical shall be shown in the syllabus for the paper concerned. It will be necessary for a candidate to pass in theory part as well as practical part of a subject separately.

Note: Maximum marks for a theory paper is 100 marks which include 70 marks for ESE and 30marks for internal assessment.

Examination Question Paper Pattern for all semester Exams

I 08 Questions (very short answer questions. Any 7 from 8 questions) 7 x 2 Mark - 14
II 04 Questions (1 question from each unit with internal choice) 4 x 14 Marks - 56
Total of End Sem. Exam - 70
Internal Assessment - 30
Maximum Marks - 100
Minimum Marks – 40

1. Each theory paper carries 100 marks. The internal assessment will be 30 marks and EoSE shall carry 70 marks. The EoSE will be of 3 hours duration. There will be a practical examination of 200 marks in all Semester.
2. There will be two parts in EoSE theory paper. Part A of theory paper shall contain 10 Short Answer Questions of 14 marks, based on knowledge, understanding and applications of the topics/texts covered in the syllabus. Candidate has to attempt seven questions out of 10 and each question will carry two marks for correct answer.
3. Parts "B" of EoSE theory paper will consisting of four questions from each unit with internal choice of 14 mark each. The limit of answer will be five pages.
4. Each Laboratory EoSE will be of four hour durations and involve laboratory experiments/exercises/ Seminar presentation / Synopsis presentation/Project work or field study / Industrial Training/ consultancy training and viva-voce examination consisting of 200Marks.
5. The aim of Project work or field study /Research laboratories/ Hospital training is to introduce students to research methodology in the subject and prepare them for pursuing research in theoretical or experimental or computational areas of the subject. The project work or Field Study is to be undertaken under guidance jointly by Head of the Department and a senior faculty or a Scientist or any other suitable person with proven research excellence in the concerned field of study. Project work or field study /Hospital Training/ can also be taken up in an outside institution of repute Department. The guide will make continuous internal assessment of the Project work or field study / Hospital Training. EoSE for Project work or field study / Hospital Training and seminar will be held at department of the college by a board of three examiners consisting of HOD, two senior faculties of the department or expert from interdisciplinary department of the institution.
6. Supplementary/ due paper/ special examinations will be resolute as per the institutions autonomous rules.
7. Grade/CGPA/percentage/division will be decided as per the autonomous guidelines of the institution.

- 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.

3. Course Structure:

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

Abbreviations Used

Course Category

DSC: Discipline Specific Course

DSE: Discipline Specific Elective

SEM: Seminar

PRJ: Project Work

Contact Hours

L: Lecture

T: Tutorial

P: Practical or Other

S: Self Study

M. Sc. Biotechnology

Semester Subject 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 I	Cell Biology	DSC-1	4	24
Paper II	Genetics	DSC-2	4	
Paper III	Microbiology	DSC-3	4	
Paper IV	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 I	Molecular Biology	DSC-1	4	24
Paper II	Enzymology	DSC-2	4	
Paper III	Immunology	DSC-3	4	
Paper IV	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 I	Genetic Engineering & System Biology	DSC-1	4	24
Paper II	Animal Biotechnology	DSC-2	4	
Paper III	Seminar, Scientific writing & PowerPoint Presentation	DSC-3	4	
Paper IV	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 I	Plant Biotechnology	DSC-1	4	26
Paper II	IPR and Bioethics	DSC-2	4	
Paper III	Dissertation and Industrial training	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*	*DSEP-2*	2	
Total credit				98

Semester –I		Maximum theory marks- 400			Maximum Practical marks-200			
S.No	Paper code	Course Title	Course Category	Credit	Contact hours per week		EoSE Duration (Hrs)	
					L	P	Theory	PR
1.		Cell Biology	DSC	4	4	0	3	0
2.		Genetics	DSC	4	4	0	3	0
3.		Microbiology	DSC	4	4	0	3	0
4.		Theory Elective -1	DSE	4	4	0	3	0
5.		Theory Elective -2	DSE	4	4	0	3	0
6.		Theory Elective -3	DSE	4	4	0	3	0
7.		General Practical lab based on Paper I, II & III	DSCP	6	0	6	0	6
8.		Elective Practical Lab 1	DSEP	2	0	4	0	4
9.		Elective Practical Lab 2	DSEP	2	0	4	0	4
10.		Elective Practical Lab 3	DSEP	2	0	4	0	4

Semester –II		Maximum Theory marks-400			Maximum practical marks -200			
S.No.	Paper code	Course Title	Course Category	Credit	Contact hours per week		EoSE Duration (Hrs)	
					L	P	Theory	PR
1.		Molecular Biology	DSC	4	4	0	3	0
2.		Enzymology	DSC	4	4	0	3	0
3.		Immunology	DSC	4	4	0	3	0
4.		Theory Elective -1	DSE	4	4	0	3	0
5.		Theory Elective -2	DSE	4	4	0	3	0
6.		Theory Elective -3	DSE	4	4	0	3	0
7.		General Practical lab based on Paper I,II &III	DSCP	6	0	6	0	6
8.		Elective Practical Lab 1	DSEP	2	0	4	0	4
9.		Elective Practical Lab 2	DSEP	2	0	4	0	4
10.		Elective Practical Lab 3	DSEP	2	0	4	0	4

Semester-III	Maximum theory marks -400				Maximum practical marks-200			
S.No	Paper code	Course Title	Course Category	Credit	Contact hours per week		EoSE Duration (Hrs)	
					L	P	Theory	PR
1.		Genetic Engineering & System Biology	DSC	4	4	0	3	0
2.		Animal Biotechnology	DSC	4	4	0	3	0
3.		Seminar, Scientific writing & PowerPoint Presentation	DSC	4	4	0	3	0
4.		Theory Elective -1	DSE	4	4	0	3	0
5.		Theory Elective -2	DSE	4	4	0	3	0
6.		Theory Elective -3	DSE	4	4	0	3	0
7.		General Practical lab based on Paper I,II &III	DSCP	6	0	6	0	6
8.		Elective Practical Lab 1	DSEP	2	0	4	0	4
9.		Elective Practical Lab 2	DSEP	2	0	4	0	4
10.		Elective Practical Lab 3	DSEP	2	0	4	0	4

Semester-IV	Maximum Theory Marks-450				Maximum Practical marks-200			
S.No	Paper code	Course Title	Course Category	Credit	Contact hours per week		EoSE Duration (Hrs)	
					L	P	Theory	PR
1.		Plant Biotechnology	DSC	4	4	0	3	0
2.		IPR and Bioethics	DSC	4	4	0	3	0
3.		Dissertation and Industrial training	DSC	6	4	0	3	0
4.		Theory Elective -1	DSE	4	4	0	3	0
5.		Theory Elective -2	DSE	4	4	0	3	0
6.		Theory Elective -3	DSE	4	4	0	3	0
7.		General Practical lab based on Paper I and II	DSCP	6	0	6	0	6
8.		Elective Practical Lab 1	DSEP	2	0	4	0	4
9.		Elective Practical Lab 2	DSEP	2	0	4	0	4
10.		Elective Practical Lab 3	DSEP	2	0	4	0	4

Note: - Discipline specific Elective Practical can be opted only if the respective Elective has been opted by the students. DSEP Lab Examination will be based on DSE 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	26	Total Credits: 98

*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 of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific core paper.

***The Medium of Instruction and Examination Shell Be English Only**

Nomenclature for Discipline Specific Elective (DSE)

Discipline Specific Elective Code	Specialization	Paper Title	Prerequisite	Semester in which course will be available
	.GEN	Analytical techniques		Sem I
	GEN	Protein Engineering		Sem I
	GEN	Proteomics and Genomics		Sem I
	GEN	Virology		Sem II
	GEN	Agriculture Biotechnology		Sem II
	IB	Food and Dairy Technology		Sem II
	GEN	Bioinformatics & Biostatistics		Sem III
	EB	Stem Cell Biology		Sem III
	GEN	Vaccine Production		Sem III
	GEN	Bio-processing and Engineering		Sem IV
	IB	Plant Metabolic Engineering		Sem IV
	IB	Pharmaceutical Biotechnology		Sem IV

Abbriviations For Specialization Discipline Specific Elective

GEN : General
IB : Industrial Biotechnology
EB : Environmental Biotechnology
PE : Protein Engineering
PB : Plant Biotechnology
AB :Agriculture Biotechnology

4. Programme Specific Outcomes:

By the end of the course, a student should be able to:

- Students develop global competencies in the area of basic and applied biological sciences.
- Enhancing the subject knowledge of students by using traditional and modern ICT based teaching methods and learning by doing.
- As Biotechnology is an interdisciplinary course, empower the students to acquire technological knowhow by connecting disciplinary and interdisciplinary aspects of biotechnology.
- To enrich students' knowledge and train them in various branches of Biotechnology such as genetics, molecular biology, biochemistry, immunology, fermentation technology, environmental biotechnology and tissue culture techniques. As Biotechnology is an interdisciplinary course, empower the students to acquire technological knowhow by connecting disciplinary and interdisciplinary aspects of biotechnology.
- To groom the students to meet futuristic challenges and national interests
- To bestow the students with all the research skills required to work independently
- To develop scientific temperament and social responsibilities in the students.
- To inculcate nature care by imparting knowledge of advance modern techniques
- Acquire knowledge in students of biotechnology enabling their applications in industry and research.
- To provide a platform for education of global standards in Biotechnology and Bioinformatics using advanced methods and techniques.
- To carry out discovery-oriented research of international standards towards biotech product development.
- To establish academic and research collaborations with the industries and Health care institutions at both National and International levels.
- To produce bio-entrepreneurs and human resources for biotech industries.

5. Course Details

Semester -I

Theory 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 behaviour (*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 Bebek Ivankovic, 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.

Semester I

Theory 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.

Learning Objectives: 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 –

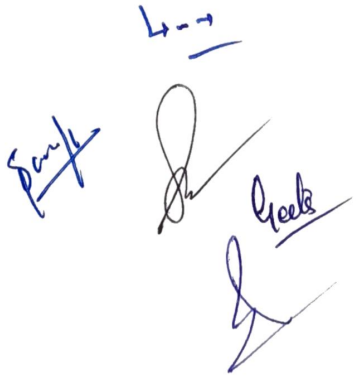
Mutation, selection, migration and isolation; random genetic drift; insights into human migration, natural selection and evolution. Population substructure: Hierarchical population, Isolate breaking, Inbreeding, Assortative mating, concept of heritability, artificial selection and realized heritability.

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, Coenorhabditis elegans*). **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. Gardener E.J.. Simmons M.J and Snustad, D.P. (2005). Principles of Genetics – John Wiley & Sons Publications.
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

Semester I

Theory 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.

Learning Objectives: 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 daily lives 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;

Suggested readings:

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. Pelczar MJ, 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.

Semester I

Elective Paper- 1 of 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.

Learning Objectives: 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 Isoelectric focusing.

Unit –IV Spectroscopy-

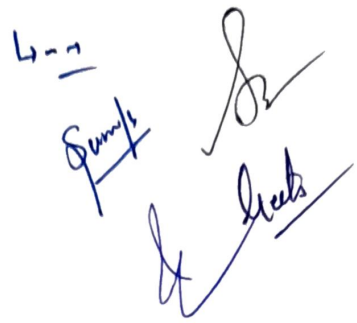
Beer-Lambert law and its limitations. Light absorption and transmission. Basic design of photoelectric colorimeter and spectrophotometer. Applications of UV-visible spectroscopic techniques. Flame Photometry. Principle and application of NMR and ESR techniques.

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

Suggested Readings:

1. Boyer, R.F. (2000). Modern Experimental Biochemistry, 3rd Edition, Prentice Edition. 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.



Semester I

Elective 2 of Group A (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.

Learning Objectives: 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 as present 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 therapeutic 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.

Semester -I

Elective 3 of 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.

Learning Objectives: 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 of chick 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 on the basis of Elective Theory Paper 1(Analytical techniques): 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 metabolites by 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

Or

Practicals on the basis of Elective Theory Paper 2 (Protein engineering): 2 Credits

1. To study the denaturation and renaturation of egg white albumin protein.
2. To examine the solubility of different proteins under various pH and temperature conditions.
3. To test catalase enzyme activity on hydrogen peroxide.
4. To measure protein concentration in a sample using the Bradford assay.
5. Protein gel electrophoresis using SDS-PAGE
6. To analyze the folding patterns of different proteins and their stability using in-silico approach.
7. Analyze publicly available proteomics data to identify trends or patterns in protein expression across different conditions or tissues.

Or

Practicals on the basis of Elective Theory Paper 3 (Proteomics and Genomics): 2 Credits

1. To analyze genetic variation by digesting genomic DNA with restriction enzymes and visualizing the resulting fragments on a gel.
2. To identify conserved regions and variations in DNA sequences by comparing the DNA sequences of related species.
3. To study the genetic diversity and demographic history of human populations using population genetics tools and datasets.
4. To extract proteins from a complex sample (e.g., cell lysate) and fractionate them based on their properties, such as solubility.
5. To estimate the molecular weight of a protein by running it through a gel filtration chromatography column.
6. To explore different protein staining methods, such as Coomassie Blue or silver staining, to visualize proteins on gels.
7. To investigate genetic variants associated with drug response and toxicity.

Semester II

Theory 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.

Learning Objectives: 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. Translation in 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.

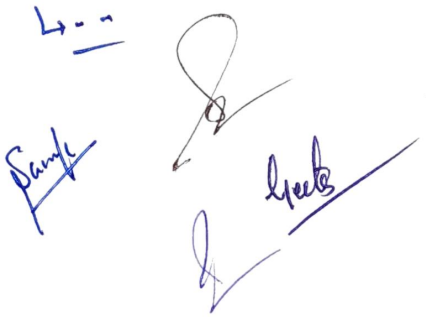
Unit-IV: Special Techniques Gene knocking and gene knock out

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 Readins

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
9. Molecular Biology (2013) : David P. Clark, Nanette J. Pazdernik · 2nd edition (Elsevier Science).
10. Cell And Molecular Biology (2006) : S. C. Rastogi, 2nd edition · ; New Age International (P) Limited.



Semester -II

Theory Paper II- (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 enzymes methods, kinetics and their industrial applications. Nanomaterials for Enzyme immobilization.

Suggested Readings:

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 Techno logy : (2014) S. M. Bhatt , Pub: S. Chand.

Semester II

Theory 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: Students can 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: The humoral 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 Reading:

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's Immunobiology (2012) 8th ed., Murphy, K., Mowat, A., and Weaver, C.T., Garland Science (London & New York).
4. Immunology: (1997). Jan Klain, 2 nd adition. Blackwell scientific
5. Immunology (2010). Ivan Roitt, (10th ed), Blackwell Scientific Press,
6. Microbiology (2008) Willey, Sherwood, Woolverton, Microbiology 7th ed. McGraw Hill

Semester II

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, IFA and 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).$th adition. 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.

Semester II

Elective paper 2 of Group B (Agriculture 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: The primary objective of Agriculture Biotech is to provide research-oriented study,solving problems in current farming practice,the acquisition of international expertise and the promotion of creativity and innovation, attention to the need to identify and assess the impact of technological processes.

UNIT-I: Agriculture Biotechnology

Definition and scope of Agriculture biotechnology, Application of biotechnology in agriculture, N2 fixation, transfer of pest resistance genes to plants, Application of biotechnology in forensic science: e.g. solving violent crimes such as murder and rape; solving claims of paternity and theft etc. using various methods of DNA finger printing.

UNIT-II: Elementary Crop Physiology

Role of plant physiology in agriculture. Cell structure and function. Plant tissues. Physio-chemical phenomenon-diffusion, osmosis and imbibition. Essential nutrient elements, their role, deficiency symptoms, mineral salt, absorption. Photosynthesis - light and dark reactions. Mechanism of respiration, transpiration.

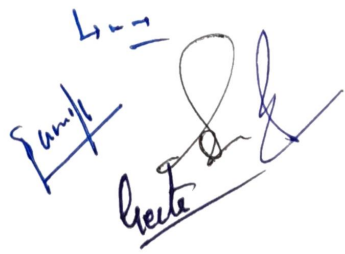
UNIT-III: Production Technology Of Medicinal And Aromiatic Plants

Importance and scope of medicinal, aromatic plants and spices. Cultivation of Mentha, Citronella, Khus, Ocimum, Rauvolifia and Dioscoria.Cultivation of Turmeric, Zinger, Coriander, Cumin and Saunf in the North Indian conditions.

UNIT-IV: Vegetable Crops Production

Importance and scope of vegetable production. Classification of vegetables. Types of vegetable gardens. Cultivation and seed production of major vegetables like Potato, Brinjal, chillies, tomato, Cauliflower, Cabbage, knol khol, Onion, gourds, Musk melon, Watermelon, Okra, Radish, Carrot and Pea.

Suggested Reading:



1. Alfonso, A. 2007. Rice Biotechnology. Presentation during PhilRice R&D. March 13-15, 2007. China sets new record in hybrid rice. 19 September 2012 http://www.chinadaily.com.cn/ business/2011-09/19/content_13735947.htm
2. Eckart N. A. 2006. Cytoplasmic male sterility and fertility restoration, The Plant Cell 18 (515517)
3. Food and Agriculture Organization. 2002. Crop Biotechnology: A working paper for administrators and policy makers in sub-Saharan Africa
4. Historical corn Grain Yields for Indiana and the US. 2012. http://www.agry.purdue.edu/ext/ corn/news/timeless/YieldTrends.html.
5. Agricultural Biotechnology At a Glance by Dr. K.H. Singh Dr. Ajay Kumar Thakur, Dr. Nehanjali Parmar | 8 January 2019.
6. Textbook Of Agricultural Biotechnology By Nag, Ahindra, Edition : SECOND EDITION, Pages : 366, Print Book ISBN : 9789391818166

Semester II

Elective paper 3 of Group B (Food and Dairy Technology)

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: 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. Microbial flora and source of contamination of food in general. Factors affecting microbial growth in food- extrinsic and intrinsic factors..

Unit II: 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, 2ndEdition, Elsevier, UK, 1995.
5. 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 Theory Paper 1(Virology) : 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 disease symptoms 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

Or

Practicals on the basis of Elective Theory Paper 2 (Agriculture Biotechnology):

1. Isolation of *Azotobacter* from soil.
2. Demonstration of methods of DNA finger printing.
3. Experiments on diffusion, osmosis and imbibition.
4. Experiments on factors affecting rate of photosynthesis (CO2, light and temperature).
5. Identification of medicinal and aromatic plants.
6. Visit to orchards, nurseries, research centers of fruits, plantation crops, commercial growing places research stations of the medicinal and aromatic crops.
7. Determination of Biological Oxygen Demand (BOD) of waste water samples.
8. Physico-chemical testing of soil.

Or

Practicals on the basis of Elective Theory Paper 3 (Food and Dairy Technology) :

1. Bacterial contamination in milk.
2. Determination of bacteria in spoiled canned foods.
3. Determination of bacteria number: Direct microscopic count and Standard plate count.
4. Determination of casein hydrolysis in milk.
5. Isolation of casein protein from milk sample.
6. Determination of microbiological quality of milk sample by MBRT.
7. Identification of microbes in fermented milk.
8. Isolation and Identification of food spoilage microorganisms from bread / fruits /vegetables.
9. Preparation of fermented food & beverages: Sauer Kraut, Koji & Soya sauce.

Semester III

Theory 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.

Learning Objectives: 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 of Recombinant DNA technology

Unit-II: DNA manipulation in Prokaryotes

Plasmids as cloning vehicles, Types of Plasmid vectors, Bacteriophage, specialized vectors like cosmids, phagemids BAC 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 Reading:

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), Uwe Hilgert, 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 Uwe Hilgert Sambrook and Manniatis.
7. Genetic engineering and horticulture crops. (2018). R.K.Gaur. first edition. Academic press publication.

Semester III

Theory 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.

Learning Objective: Explain and apply methods used in Animal Cell/ Tissue Culture, Evolution of Cell Lines and Production of transgenic animals.

Unit- I: Historical Background

History, Definitions, laboratory equipments and terminology of animal tissue culture, Advantages and 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 Cell Cultured

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 validation and 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, types genetic manipulations, screening of recombinant cells Production 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 Reading:

1. Dubey R. C., (2018). A Text Book of Biotechnology. S. Chand& Co Ltd, New Delhi.
2. Gangal S., (2010). Animal Tissue culture. Second edition. University Press (India) Pvt Ltd. 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. Pee Pee Publishers. New Delhi
6. Shivangi Mathur (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:

Proposal Seminar Format:

- Introduce your advisor and committee members (who should be in attendance).
- Give an introduction and background information on your topic.
- State the problem(s) that remain unanswered.
- Clearly state your objectives and give the specific hypotheses you wish to test.
- Describe the methodology you will use to test your hypotheses. Be sure you fully understand your chosen methods. Give reasons why you chose these methods over other approaches.
- Present any data you have collected thus far.
- Describe what remains to be done, and what you expect to find.
- Explain the significance of your findings (or potential future findings).

*Preparation of seminar with seminar report and present in front of Classmates and Teachers. A Recent Peer-reviewed Journal paper will be presented (with Power Point slides) in front of Examiners

Semester III

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, Data Banks – Pub Med. 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.

Semester III

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: At the completion of this paper students will be able to Define stem cells. Identify types of stem cells. Describe the medical uses for stem cells.

Unit –I: Stem Cell Biology

Introduction to Stem Cells biology. History of Stem Cells: Definition, 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 and Bartett, 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

Semester III

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 Elective Theory Paper 1(Bioinformatics) : 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

Or

Practicals on the basis of Elective Theory Paper 2 (Stem Cell Biology) : 2 Credits

1. Demonstrate the Blastocyst and inner cell mass cells.
2. Demonstrate Mammalian Nuclear Transfer Technology.
3. Demonstrate Stem cells cryopreservation.
4. Study the Neurodegenerative diseases;
5. Study the Parkinson's, Alzheimer,
6. Study the Spinal Code Injuries and other Brain Syndromes.
7. Explain different types of Stem cell based therapies.

Or

Practicals on the basis of Elective Theory Paper 3 (Vaccine Production): 2 Credits

1. Study of T Cell B cell.
2. Perform antigen antibody reaction by single diffusion.
3. Demonstrate Vaccine production methods.
4. Study the various viral and parasitic infections.
5. Demonstrate the production of Tuberculosis Vaccine;
6. Demonstrate the production of Malaria Vaccine;
7. Demonstrate the production of HIV vaccine.

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: Plant Biotechnology aims to impart understanding of the basic principles of the plant sciences and molecular biology, as well as the integration of these disciplines, to provide healthy plants in a safe environment for food, non-food, feed and health applications

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. Keshava Chandran and K.V. Peter. (2008).Plant Biotechnology. First edition. University Press (India) Pvt. Ltd, Hyderabad.
3. Bishun Deo Prasad, Sangita Sahni, Prasant Kumar, Mohammed Wasim Siddiqui. 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

Theory 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 I: 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.

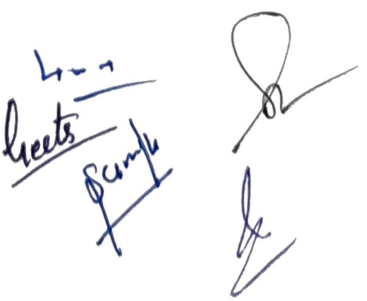
Unit III: Entrepreneurship

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 and Parashar (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 Age international publishers.

Semester IV

Paper III-Dissertation and Industrial Training - **6 credits**

Six weeks' research project in a renewed National/International Research Institute/University.

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

Semester IV

Elective Paper 1 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, Fed batch and continuous bioreactors, analysis of mixed microbial populations, specialized bioreactors (pulsed fluidized, photobioreactors etc).

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

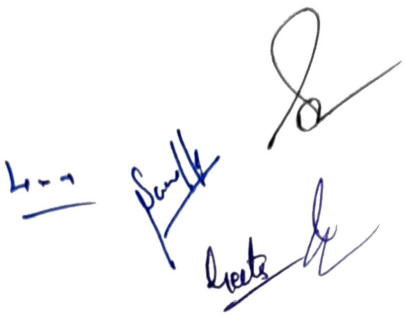
Alcohol (ethanol). Acids (citric, acetic), Solvents (acetone, butanol), Antibiotics (penicillin, tetracy6cline), Amino acids (lysine, glutamic acid), Single Cell Protein, Introduction to Food technology elementary idea of canning and packin-Fat-Based Edible products, Typical Food/ food products (bread,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



Semester IV

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;

Semester IV

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, Nirali Prakashan, 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 plant tissue.
5. Anther culture or 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 Setup a 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 1 (Bio-processing and Engineering): 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 sauerkraut production
5. Immobilization of enzymes/ whole cells by adsorption.
6. One Industrial visit.
7. Industrial visit report has to prepare and submit in college by students.

Or

Practicals on the basis of Elective Theory Paper 2 (Plant Metabolite Engineering): 2 Credits.

1.Physicochemical analysis of Plant primary metabolites Carbohydrate, proteins, lipids

2. Physicochemical analysis of plant Secondary metabolites Alkaloid, steroids, flavonoids
3. Isolation and identification of natural plant products (secondary metabolites) using TLC
4. Demonstrate HPLC for analysis of pharmaceutical utilizable natural plant products,
5. Demonstrate GCMS for for analysis of pharmaceutical utilizable natural plant products
6. Quantitative analysis of secondary metabolites using TLC
7. In vitro production of secondary metabolites using cell culture:
8. Agrobacterium rhizogenes-mediated transformation (Hairy root culture) for production of plant secondary metabolites.

Or

Practicals on the basis of Elective Theory Paper 3 (Pharmaceutical Biotechnology): 2 Credits

1. Extract DNA from any biological sources
2. Understand that DNA extraction is the routine step in biotechnology procedures.
3. Extract, amplify and analyze their own DNA.
4. Demonstrate the transformation and its applications in biology.
5. Demonstrate the regulation of gene expression by arabinose operon.
6. Counting cells and assessment of viability with haemocytometer.
7. Penicillin production in laboratory.