PANSKURA BANAMALI COLLEGE

(AUTONOMOUS COLLEGE: 2018-2019 to 2027-2028)
UNDER VIDYASAGAR UNIVERSITY
Largest Rural Based, NAAC Re-accredited 'A' Grade (2016-2021)
DST-FIST (Govt. of India), BOOST-DBT (Govt. of West Bengal) sponsored College
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Learning Outcomes based Curriculum Framework (LOCF)

for

B. Sc. Biotechnology (Honours)

(Undergraduate Programme – 2018)

CONTENTS

Preamble

The learning outcomes are contemplated to help students understand the goals of studying B.Sc. Biotechnology that is, to analyze, understand, appreciate the use of living systems, their products and by-products for various beneficial purposes to the environment as well as for the mankind. The organization of the courses under CBCS help the learners to choose courses of their choice of interest and also considers the credit load in a given semester with the ultimate endof outcomes of the course and learners also can gather knowledge from old to new migrating institutions. In one hand, it makes sense to include papers or courses that demand more attention to improve the job opportunities for students; on the other hand, the courses help the learner to introduce the real application of biotechnology in their daily life to the society.

1. Introduction

Biotechnology is an immixture of biology and technology and is a rapidly growing and evolving field in the science. The recent development in the field of Biotechnology as applied science has been recorded in a rapid growthand establishment in the field of research, industries and academics and so on. That is why it is a major demand to build trained and skillful students in the diverse fields in biotechnology. That in turn also open new career opportunities for the young generation. For this purpose, the College has been started the degree programme B.Sc. Biotechnology since 2003. Since its establishment, the department is functioning efficiently with the help of well- established laboratory and hardworking staffs.

The discipline of Biotechnology involves the study of the structure and function of biomolecules and the vital processes that occur in living organisms. It is regarded as Mother of all Biological Sciences disciplines because it unveils the chemical basis of life in all living organisms including plants, animals and microorganisms. Biotechnology has contributed enormously to the growth of modern medical and health science and agriculture. Biotechnology has applications in clinical diagnosis, understanding pathology of diseases, treatment of diseases, designing of drugs and understanding their metabolism and manufacture of various biological products like amino acids, proteins, antibiotics, hormones, enzymes, nutrients, etc. Understanding the biochemical basis of vital processes of plants such as photosynthesis, respiration, hormonal regulation, nutrient assimilation has helped in developing superior varieties of crop plants with better growth attributes and yield.

2. Objectives of B.Sc. Biotechnology Programme

The overall objectives of B.Sc. Biotechnology programme are to provide students with Core courses in Biochemistry, Cell Biology, Mammalian Physiology, Plant Physiology, Microbiology, Genetics, Microbiology, Inorganic Chemistry, Molecular Biology, Immunology, Organic Chemistry, Bioprocess Technology, Recombinant DNA Technology, Bioanalytical Tools and Genomics and Proteomics. Also, each course has a practical component where students achieve hands-on techniques and experience of the experiments based on concept of theory. Apart from that, department also prepare the students for various competitive examination such as IIT JAM, JNU Entrance, Central Universities Entrance examination etc. for admission to post graduate course. Along with reference books department also provides advance biology notes based on basic theory, conceptual question, subject based problem, analytical question and application.

3. Overview of Department

It is almost 15 years old department; since 2003, it is developing day by day till now. There are five (5) well qualified experienced faculty having expertise in various fields of biotechnology such as, Microbiology, Immunology, Molecular Biology, Biochemistry, Genetic Engineering, Industrial Biotechnology, Bioinformatics, Plant and Animal cell culture, etc. There are also two (2) experienced laboratory technicians to help and boost the students at any time.

The department has well equipped laboratories with sophisticated instruments such as **a**utoclave, BOD Incubators, Hot Air Oven, Bacteriological Incubators, Digital balance, Microscopes, Phase Contrast Inverted Microscope, Laminar Air Flow, Vortex Mixers, Water Bath Shaker, Freezer and Deep Freezer, Colorimeter, Spectrophotometer, Vertical and Horizontal Slab Gel System, Gel Documentation System, PCR Machine, pHMeter, Centrifuge, Micro centrifuge, Water distillation unit, Small scale fermenter, Magnetic Stirrer, Dancing Shaker, Sonicator etc. Department also received grant from BOOST- Programme from department of science and technology; West Bengal.

4. Graduate Attributes

Program Learning Outcomes	Short Title of the PLOs	Description of the PLO_s will be earned by Graduate
PLO 1	Analysis of Problem with Technology	Think critically, identify, analyze the problems and then attempt to design solutions that meet with specified goals. Apply appropriate tools efficiently in learners, and daily activities of academics and communication.
PLO 2	Environmental sustainability and Bioethics	Analyze with solutions to environmental issues and commit the problems to sustainable development in the environment. Understand the human in term of bioethics.
PLO 3	Work, Training, Gaining Skill and Communication	Function significantly at various problem and situations. Communicate proficiently (written or oral) as a responsible member of modern biotechnologist.
PLO 4	Role of Research and Social responsibility	Understand the research methods and able to analyze, interpret and derive a real conclusion. Recognize the need, and have the ability to engage in independent and life-long learning in the broadest context of domain specific changes.
PLO 5	Critical thinking, Analysis and Problem Solving	Demonstrate in quantitative reasoning critically and analytically. Also, be able to use these skills to analyze and solve scaling up related problems, thus preparing the learner for a successful career globally.
PLO 6	Understanding the role for sustainable solutions	Be able to realize the need of biotechnological solutions on organism to environment and vice-versa.
PLO 7	Practical skills development	Weaponized with practical skills and the caliber to apply their theoretical knowledge to design, perform experiments, detach and interpret data and thus exhibit proficiency in laboratory management.
PLO 8	Developing of fidelity towards research	Develop an aptitude towards research through the internship in various fieldwhich promote and infuse professional ethics and code of practice among learners, empowering them to work within team with a multidisciplinary perspective.

5. Qualification descriptors

The key qualification descriptor for undergraduate Biotechnology shall be clarity of concepts, experimentation, critical thinking and ethical awareness. The students of biotechnology will be able to demonstrate systematic approach to the experimental and theoretical aspects; expand the knowledge of the subject from the classroom/laboratory to industry and society as they will be able to recognize the scope of Biotechnology in terms of career opportunities.

The courses such as Microbiology, Biomolecules, Cell biology and Genetics, Basics of plant and animal sciences, Immunology, Molecular Biology, Genetic engineering will enrich students with conceptual knowledge. The courses such as Tools and techniques in Biotechnology, Food and Environmental Biotechnology, Plant and Animal Biotechnology, Industrial Biotechnology and Bioinformatics includes understanding of fundamentals, acquiring practical training and application of the subject knowledge in diversified areas of Biotechnology with a clear understanding that this knowledge will equip the students to make them suitable for various Biotech, Pharma, Medicine, Agri-Biotech, Biochemical related laboratories/industries. The courses such as Biostatistics, Molecular genetics and Molecular medicine will enable a student in having a critical thinking approach towards the various fields of biotechnology. Bioethics and Biosafety course encompass the ethical awareness amongst the students related the various fields in biotechnology.

6. Programme Learning Outcome (PLOs)

After successful completion of a Bachelor's degree in Biotechnology, the students will be able to;		
PLO 1	Critical thinking, Analysis and Problem Solving	Think critically, identify, analyze the problems and then attempt to design solutions that meet with specified goals. Apply appropriate tools efficiently in learners, and daily activities of academics and communication. Analyze with solutions to environmental issues and commit the problems to sustainable development in the environment. Understand the human in term of bioethics
PLO 2	Understanding the need for sustainable solutions	Function significantly at various problem and situations. Communicate proficiently (written or oral) as a responsible member of modern biotechnologist. Understand the research methods and able to analyze, interpret and derive a real conclusion.
PLO 3	Development of practical skills	Equipped with practical skills and the ability to apply their theoretical concepts to design, perform experiments, analyze and interpret data and thus develop proficiency in laboratory management.
PLO 4	Developing an inclination towards research	Develop an aptitude towards research through the internship in various fieldwhich promote and infuse professional ethics and code of practice among learners, empowering them to work within team with a multidisciplinary perspective.

7. Course Structure

B.Sc. (Hons.) Biotechnology

SEMESTER I		SEMESTER II	
C1	**Biochemistry & Metabolism**	**C3**	**Mammalian Physiology**
C2	**Cell Biology**	**C4**	**Plant Physiology**
AECC1	**EVS/English/MIL**	**AECC2**	**EVS/English/MIL**
GE	**GE1**	**GE**	**GE2**

SEMESTER III		SEMESTER IV	
C5	**Genetics**	**C8**	**Molecular Biology**
C6	**General Microbiology**	**C9**	**Immunology**
C7	**Chemistry - 1**	**C10**	**Chemistry -2**
SEC	**SEC1**	**SEC**	**SEC2**
GE	**GE3**	**GE**	**GE4**

SEMESTER V		SEMESTER VI	
C11	**Bioprocess Technology**	**C13**	**Bio Analytical Tools**
C12	**Recombinant DNA Technology**	**C14**	**Genomics and Proteomics**
DSE	**DSE1**	**DSE**	**DSE3**
DSE	**DSE2**	**DSE**	**DSE4**

GENERIC ELECTIVE SUBJECTS (GE) (any one per semester in semesters 1-4)

- Entrepreneurship Development
- Bioethics and Biosafety
- Biotechnology and Human Welfare
- Developmental Biology

SKILL ENHANCEMENT COURSES (SEC) (any one per semester in semesters 3-4)

- Molecular Diagnostics
- Enzymology
- Industrial Fermentations
- Drug Designing
- Basics of Forensic Science

DISCIPLINE CENTRIC SUBJECTS (DSE) (any two per semester in semesters 5-6)

- Bioinformatics
- Animal Biotechnology
- Biostatistics
- Ecology and Environment Management
- Plant Biotechnology
- Intellectual Property Rights
- Environmental Biotechnology
- Evolutionary Biology

8. Course Credit

Year	Semes--ter	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
							CA	ESE	TOTAL
1	**Semester-I**								
	I	Core-1		CT1: Biochemistry & Metabolism	6	4-0-0	15	60	75
				CP1: Biochemistry Metabolism-**Lab**		0-0-4			
		Core-2		CT2: Cell Biology	6	4-0-0	15	60	75
				CP2: Cell Biology-**Lab**					
		GE-1		TBD	6	4/5	15	60	75
				TBD		2/1			
		AECC-1		English/MIL	2	1-1-0	10	40	50
	Semester -I: total				**20**		**275**		
	Semester-II								
	II	Core-3		CT3: Mammalian Physiology	6	4-0-0	15	60	75
				CP3: Mammalian Physiology-**Lab**		0-0-4			
		Core-4		CT4: Plant Physiology	6	4-0-0	15	60	75
				CP4: Plant Physiology-**Lab**		0-0-4			
		GE-2		TBD	6	4/5	15	60	75
				TBD		2/1			
		AECC-2		ENVS	4		20	80	100
	Semester-II : total				**22**		**325**		

Year	Semes--ter	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
							CA	ESE	TOTAL
2	**Semester-III**								
	III	Core-5		CT5: Genetics	6	4-0-0	15	60	75
				CP5: Genetics-**Lab**		0-0-4			
		Core-6		CT6: General Microbiology	6	4-0-0	15	60	75
				CP6: General Microbiology-**Lab**		0-0-4			
		Core-7		CT7: Chemistry-1	6	4-0-0	15	60	75
				CP7: Chemistry-1-**Lab**		0-0-4			
		GE-3		TBD	6	4/5	15	60	75
						2/1			
		SEC-1		TBD	2	1-1-0/ 1-0-2	10	40	50
	Semester – III : total 26								**350**
	Semester-IV								
	IV	Core-8		CT8: Molecular Biology	6	4-0-0	15	60	75
				CP8: Molecular Biology-**Lab**		0-0-4			
		Core-9		CT9: Immunology	6	4-0-0	15	60	75
				CP9: Immunology-**Lab**		0-0-4			
		Core-10		CT10: Chemistry-2	6	4-0-0	15	60	75
				CP10: Chemistry-2-**Lab**		0-0-4			
		GE-4		TBD	6	4/5	15	60	75
						2/1			
		SEC-2		TBD	2	1-1-0/ 1-0-2	10	40	50
		Semester – IV : total 26							**350**

Year	Semes--ter	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
							CA	ESE	TOTAL
3	V	Semester-V							
		Core-11		CT11: Bioprocess Technology	6	4-0-0	15	60	75
				CP11: Bioprocess Technology-**Lab**		0-0-4			
		Core-12		CT12: Recombinant DNA Technology	6	4-0-0	15	60	75
				CP12: Recombinant DNA Technology-**Lab**		0-0-4			
		DSE-1		TBD	6	4-0-0	15	60	75
						0-0-4			
		DSE-2		TBD	6	4-0-0	15	60	75
						0-0-4			
		Semester –V : total 24							**300**
	VI	Semester-VI							
		Core-13		CT13: Bio Analytical Tools	6	4-0-0	15	60	75
				CP13: Bio Analytical Tools-**Lab**		0-0-4			
		Core-14		CT14: Genomics and Proteomics	6	4-0-0	15	60	75
				CP14: Genomics and Proteomics-**Lab**		0-0-4			
		DSE-3		TBD	6	4-0-0	15	60	75
						0-0-4			
		DSE-4		TBD	6	4-0-0	15	60	75
						0-0-4			
		Semester – VI : total 24							**300**
Total in all semester:					**142**				**1900**

CC = Core Course, **AECC** = Ability Enhancement Compulsory Course, **GE** = Generic Elective, **SEC** = Skill Enhancement Course, **DSE** = Discipline Specific Elective, **CA**= Continuous Assessment, **ESE**= End Semester Examination, **TBD**=To be decided, **CT** = Core Theory, **CP**=Core Practical, **L** = Lecture, **T** = Tutorial, P = Practical, **MI**L = Modern Indian Language, **ENV**S = Environmental Studies.

Each Paper Marks distribution:

- **Full marks of each paper except SEC & AECC: (Theory 40 + Practical 20 + Attendance 5 + Internal 10) = 75**
- **For SEC: (Theory 25 + Practical 15 + Attendance 5 + Internal 5) = 50**
- **For AECC1: (Theory 40 + Assessment 10) = 50**
- **For AECC2: (Theory 70 + Project 30) = 100**

9. PATTERN OF QUESTION

- The paper comprises five Units containing one question of 12marks from each unit.
- All five questions are compulsory with internal choice within each question.
- Each question will comprise

  [a] 2 objective type questions (1 mark each),

  [b] 2 short answer questions (2 marks each) and

  [c] 6 conceptual type questions (6 marks each). Of these questions 30% questionswould be analytical questions (problem solving type).
- Maximum up to 40% of the question paper's content may be repeated in next examination

10. Course Learning Objectives (CLOs)

C-1: BIOCHEMISTRY & METABOLISM

On the successful completion of this course the students will be able to:
CLO1: Discuss the structure of atoms, biomolecules and chemical bonds.
CLO2: Understand concepts of enzyme kinetics, bio-polymers, metabolic reactions in a living system.
CLO3: Understand and apply general laboratory safety measures as well as calculate for preparation of various chemicals for experiments.
CLO4: Prepare different solutions such as buffers, reagents and stock solutions for experiments independently.
CLO5: Operate various lab instruments such as weighing balance, water bath and spectrophotometer.

C-2: CELL BIOLOGY

On the successful completion of the course, students will be able to:
CLO1: Correlate the function of each cell organelle with proper coordination.
CLO2: Demonstrate an understanding of cell communication.
CLO3: Prepare various plant and animal specimens for observation of cell structures
CLO4: Identify and analyse different biological cells using a compound microscope.

GE: GENERIC ELECTIVES

On the successful completion of the course, students will be able to:
CLO1: Understanding the role of biotechnology in mankind and environment.
CLO2: Overview on basic biology and Identify and analyses different biological cells using a compound microscope.
CLO3: Idea on entrepreneurship development and marketing
CLO4: Understanding the ethical issue to the mankind to ecology.

AECC: ABILITY ENHANCEMENT COMPULSORY COURSES

On the successful completion of the course, students will be able to:

CLO1: Enhancement of communication skill with global language

CLO2: Enriching representation skill academic, research, industry section to society

CLO3: Understanding the global impact of environment.

CLO4: Overview on environmental factors, their role in organism to ecology.

C3 & C4: MAMMALIAN PHYSIOLOGY AND PLANT PHYSIOLOGY

On the successful completion of the course, students will be able to:

CLO1: Explain classification of plant and animal kingdom.

CLO2: Distinguish between various phyla of the plant and animal kingdoms based on their characteristics.

CLO3: Compare and contrast the differences in morphology and anatomy in Angiosperms.

CLO4: Explain features of the non-chordates and chordates.

CLO5: Sketch the morphology and anatomy of selected plant and animal specimens.

C-5: GENETICS

On the successful completion of the course, students will be able to:

CLO1: Outline the basic principles of Mendelian genetics and compare and analyze different inheritance patterns as well as solve problems based on genetic principles.

CLO2: Compare and contrast different mutations, their effects on cells and the application of the same to research.

CLO3: Differentiate between the structure and working of a compound and dissection microscope.

CLO4: Construct and interpret a karyotype prepared from a spread of metaphase chromosomes.

C6: MICROBIOLOGY

On the successful completion of the course, students will be able to:

CLO1: Understand the scope and importance of Microbiology, classification schemes, cultivation, preservation and maintenance of microbial cultures.

CLO2: Discriminate between various groups of microorganisms and also comprehend the beneficial and harmful effects of each group of microorganisms.

CLO3: Compare, analyses and apply the concepts of the principle and working of various types of microscopes.

CLO4: Adhere to strict laboratory safety measures to be followed in a microbiology laboratory.

CLO5: Master skills in aseptic techniques as well comprehend the importance of cleaning and decontamination.

C7: CHEMISTRY

On the successful completion of the course, students will be able to:

CLO1: Understand the structure, synthesis and application of inorganic molecules.

CLO2: Overview on role of chemistry in biology.

CLO3: Compare, analyses and apply the concepts of the pure chemistry in biotechnology and biochemistry.

CLO4: Idea on chemicals as therapeutic agent.

SEC: SKILL ENHANCEMENT COURSES

On the successful completion of the course, students will be able to:

CLO1: Understand the basis and detection of disease.

CLO2: Overview on modern techniques for disease detection qualitative and quantitative manner.

CLO3: Idea on advance molecular biology like forensic science.

CLO4: Understand regarding cyber-crime and role of IPR to the mankind.

C-8: MOLECULAR BIOLOGY

On the successful completion of the course, students will be able to:

CLO1: Explain the structure of DNA and RNA.

CLO2: Understand basic concepts in molecular biology.

CLO3: Compare differences between replication, transcription and translation processes in prokaryotes and eukaryotes.

CLO4: Describe the mechanism of gene transfer and regulation.

CLO5: Isolate and purify genomic DNA.

C-9: IMMUNOLOGY

On the successful completion of the course, students will be able to:

CLO1: Compare and contrast primary and secondary immune response.

CLO2: Gain knowledge of the structure and function of the cells and organs of immune systems.

CLO3: Describe the mechanisms of Ag-Ab reaction, hypersensitivity reactions and importance Complement system.

CLO4: Understand the importance of Monoclonal Ab and various immunodeficiency diseases.

CLO5: Familiarize with various techniques involved in Immunology.

C-10: CHEMISTRY-2

On the successful completion of the course, students will be able to:

CLO1: Understand the structure, synthesis and application of organic molecules.

CLO2: Overview on role of organic chemistry in biology.

CLO3: Compare, analyses and apply the concepts of the pure organic chemistry in biotechnology and biochemistry.

CLO4: Idea on organic chemicals as therapeutic agent.

C-11: BIOPROCESS TECHNOLOGY

On the successful completion of the course, students will be able to:

CLO1: Understand and explain various parts of a fermenter.

CLO2: Comprehend various concepts of Upstream and Downstream processes.

CLO3: Describe the production processes of fermentation products like wine or vinegar at the industrial level.

CLO4: Design small scale experiments to produce common enzymes like amylase.

CLO5: Prepare basic fermentation products like wine, vinegar, etc.

C-12: RECOMBINANT DNA TECHNOLOGY

On the successful completion of the course, students will be able to:

CLO1: Understand the functions of several enzymes and vectors used in genetic engineering.

CLO2: Acquaint to the versatile tools and techniques employed in recombinant DNA technology.

CLO3: Explain the construction of DNA & c DNA library.

CLO4: Acquire skills on techniques of plasmid isolation.

CLO5: Develop skills for transformation and selection of recombinants.

DSE: PLANT BIOTECHNOLOGY

On the successful completion of the course, students will be able to:

CLO1: Understand that various parts of the plant that can be cultured, with each type of culture having specific applications.

CLO2: Comprehend concepts of protoplast culture, somatic hybridization and production of secondary metabolites.

CLO3: Describe genetic engineering methods for production of transgenic plants.

CLO4: Understand aspects of plant biotechnology like set up of laboratory, culture of explants.

CLO5: Perform techniques of root/shoot callus production and cell suspension culture.

DSE: BIOINFORMATICS

On the successful completion of the course, students will be able to:

CLO1: Explain the scope of Bioinformatics.

CLO2: Understand the basic concept of biological databases, various types and applications of biological databases.

CLO3: Describe the various applications of BLAST and FASTA in understanding differences in evolutionary patterns.

CLO4: Assess mutations, genetic disorders and understand the importance of drug design in silico.

CLO5: Will be able to construct evolution tree, cladogram, retrieve the biological information accessed through various information resources.

C13: BIOANALYTICAL TOOLS

On the successful completion of the course, students will be able to:

CLO1: Explain the principle, types of centrifugation and their functions in biological sciences.

CLO2: Understand the basic differences between agarose electrophoresis, SDS and native PAGE.

CLO3: Explain the principle and applications of various spectroscopic and chromatographic techniques.

CLO4: Discuss radioactivity, radioactivity techniques used in biomedical research.

CLO5: Perform purification and separation of proteins.

C14: GENOMICS & PROTEOMICS

On the successful completion of the course, students will be able to:

CLO1: Explain the genome and proteome and their role on organism.

CLO2: Understand the basic concept of biological databases, various types and applications of biological databases.

CLO3: Describe the various computer tools for genetic disease and divergence.

CLO4: Assess mutations, genetic disorders and understand the importance of drug design in silico.

CLO5: Will be able to construct evolution tree, cladogram, retrieve the biological information accessed through various information resources.

DSE: ANIMAL BIOTECHNOLOGY

On the successful completion of the course, students will be able to:

CLO1: Understand the basic concepts of animal cell culture.

CLO2: Comprehend the various requirements and techniques for animal cell culture and importance of the same.

CLO3: Understand the importance of primary and established cell lines for biotechnological applications.

CLO4: Appreciate the various methods of characterization and growth assessment techniques in culturing animal cells.

CLO5: Understand the applications of animal cells in the development of disease diagnostics and therapeutics.

DSE: ENVIRONMENTAL BIOTECHNOLOGY

On the successful completion of the course, students will be able to:

CLO1: Explain the scope of Environmental Biotechnology.

CLO2: Understand basic ecological concepts, various pollution, its measurements & remediation.

CLO3: Describe the various eco-friendly bio-products.

CLO4: Assess quality of water sample through various parameters - MPN test, dissolved oxygen concentration, biological oxygen demand, chemical oxygen demand nitrates of water sample.

CLO5: Understand the working of sewage treatment plant.

DSE: BIOSTATISTICS

On the successful completion of the course, students will be able to:

CLO1: Explain the importance of Biostatistics in biology.

CLO2: Understand the concepts of Sampling.

CLO3: Represent and interpret the data using graphical method and MS Excel

CLO4: Solve problems on measures of central tendency, dispersion and hypothesis testing.

CLO5: Apply appropriate statistical tools in their project work.

DSE: EVOLUTIONARY BIOLOGY

On the successful completion of the course, students will be able to:

CLO1: Understand basic concepts of evolution and anthropology and importance in biotechnology.

CLO2: Explain the evolutionary history and describe the historical development of anthropology.

CLO3: Explain past and present cultures including ecological adaptations with scientific approach.

CLO4: Describe quantitative and qualitative methods in the analysis of anthropological data.

CLO5: Critically evaluate the logic of anthropological research and apply anthropological research to contemporary environmental, social, or health issues worldwide.

GE: BIOETHICS AND BIOSAFETY

On the successful completion of the course, students will be able to:
CLO1: Understand importance of general safety measures in laboratories and biosafety guidelines.
CLO2: Justify the design of confinement facilities at different Biosafety levels.
CLO3: Implement good laboratory practices.
CLO4: Discuss the relevance of intellectual property rights to biotechnological innovations. CLO5: Describe the standard operating procedures for disposal of various types of wastes from the Biotechnology laboratory.

11. Teaching-Learning-Evaluation Pedagogies

Teaching-Learning pedagogies

Learners should be encouraged to focus on key areas of the course and spend time on learning the course fundamentals and their application. In teaching and learning pedagogy, there should be a shift from domain-based approach to the experiential-based approach. The teaching of undergraduate Biotechnology for each course, shall include lectures followed by laboratory hoursfor that particular course. Lectures can have good proportion of visuals learning component and ICT enabled delivery. In order to achieve its objective of focused process based learning and holistic development the department uses various teaching methodologies such as, lecture method,group discussion, problem solving, and other innovative methods such as flipped classrooms, casestudies, laboratory work, project work, study/ field visits.

Lectures

Class room lectures and use of black/white boards are the usual ways of teaching. Also, use of various ICT tools involving power point presentations, videos, animations, models, improve the understanding and make the teaching sessions enjoyable.

Group Discussion, team work and problem solving

Discussions are critical components of learning, can be used as a platform for students to be creative and critical with old and new ideas, arriving at consensus on various scientific issues and discussions will lead to development of innovative problem-solving attitude that would contributeto success. In the process of team work, learners will acquire the skills of managing knowledge acquisition and other collaborative learners, thereby understanding how to incorporate and balancepersonalities.

Flipped classrooms

To make teaching-learning interactive and an enjoyable process, various cooperative learning strategies such as, One-stray method, think-pair-share, three step interviews, Padlet, PolleV, ED puzzle, etc. are being used.

Case Studies

To express acquired knowledge, skills and attitudes, case-based learning can be used where the

students are given case specific problems both for theory and practical courses to find creative solutions to complex problems in the concerned areas of life sciences.

Laboratory work

As biotechnology graduates in their career opt for research, industrial jobs, hence more emphasis is given in enhancing basic laboratory skills.

Project work

The students are encouraged to carry out mini projects of their choice to enable them have first- hand experience toward basic research.

Evaluation pedagogies

The department carries out assessment of the learners of B.Sc. biotechnology students through

Formative assessments (Continuous Assessments such as, Objectives, Subjective test, MCQs, Oral presentations, E-assignments writing, Open or Closed book tests)

Summative assessments (Semester End Examination as 2-hour test).

Practical Continuous Assessments (understanding and performing laboratory experiments, case study discussion within a peer group) and any other pedagogic approaches as may be relevant keeping in view the learners' level, credit load and class size.

12. Details of Course

SEMESTER I

PAPER – C1 CONTENT – BIOCHEMISTRY & METABOLISM

Total – 60 Hrs. CREDITS - 4

UNIT I: Introduction to Biochemistry: (10 Periods)

A historical prospective.

Amino acids & Proteins**:** Structure & Function. Structure and properties of Amino acids, Types of proteins and their classification, Forces stabilizing protein structure and shape. Different Level of structural organization of proteins, Protein Purification. Denaturation and renaturation of proteins. Fibrous and globular proteins.

Carbohydrates: Structure, Function and properties of Monosaccharides, Disaccharides and Polysaccharides. Homo & Hetero Polysaccharides, Mucopolysaccharides, Bacterial cell wall polysaccharides, Glycoprotein's and their biological functions

UNIT II (10 Periods)

Lipids: Structure and functions –Classification, nomenclature and properties of fatty acids, essential fatty acids. Phospholipids, sphingolipids, glycolipids, cerebrosides, gangliosides, Prostaglandins, Cholesterol.

Nucleic acids: Structure and functions: Physical & chemical properties of Nucleic acids, Nucleosides & Nucleotides, purines & pyrimidines, Biologically important nucleotides, Double helical model of DNA structure and forces responsible for A, B & Z – DNA, denaturation and renaturation of DNA.

UNIT III (20 Periods)

Enzymes: Nomenclature and classification of Enzymes, Holoenzyme, apoenzyme, Cofactors, coenzyme, prosthetic groups, metalloenzymes, monomeric & oligomeric enzymes, activation energy and transition state, enzyme activity, specific activity, common features of active sites, enzyme specificity: types & theories, Biocatalysts from extreme thermophilic and hyperthermophilic archaea and bacteria. Role of: NAD^+, $NADP^+$, FMN/FAD, coenzymes A, Thiamine pyrophosphate, Pyridoxal phosphate,lipoic-acid, Biotin vitamin B12, Tetrahydrofolateand metallic ions.

UNIT IV **(20 Periods)**

Carbohydrates Metabolism: Reactions, energetics and regulation. Glycolysis: Fate of pyruvate under aerobic and anaerobic conditions. Pentose phosphate pathway and its significance, Gluconeogenesis, Glycogenolysis and glycogen synthesis. TCA cycle, Electron Transport Chain, Oxidative phosphorylation. ß-oxidation of fatty acids.

PRACTICALS

Total – 60 Hrs. **CREDITS - 2**

1. To study activity of any enzyme under optimum conditions.
2. To study the effect of pH, temperature on the activity of salivary amylase enzyme.
3. Determination of - pH optima, temperature optima, Km value, Vmax value, Effect of inhibitor (Inorganic phosphate) on the enzyme activity.
4. Estimation of blood glucose by glucose oxidase method.
5. Principles of Colorimetry**: (i)** Verification of Beer's law, estimation of protein. (**ii)** To study relation between absorbance and % transmission.
6. Preparation of buffers.
7. Separation of Amino acids by paper chromatography.
8. Qualitative tests for Carbohydrates, lipids and proteins

SUGGESTED READING

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman and Co.
2. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants.American Society of Plant Biologists.
3. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.
4. Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.
5. Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology, Wadsworth Publishing Co. Ltd.

PAPER – C2 CONTENT – CELL BIOLOGY

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I **(10 Periods)**

Cell: **I**ntroduction and classification of organisms by cell structure, cytosol, compartmentalization of eukaryotic cells, cell fractionation.

Cell Membrane and Permeability: Chemical components of biological membranes, organization and Fluid Mosaic Model, membrane as a dynamic entity, cell recognition and membrane transport.

UNIT II **(15 Periods)**

Membrane Vacuolar system, cytoskeleton and cell motility: Structure and function of microtubules, Microfilaments, Intermediate filaments.

Endoplasmic reticulum: Structure, function including role in protein segregation. Golgicomplex: Structure, biogenesis and functions including role in protein secretion.

UNIT III **(20 Periods)**

Lysosomes: Vacuoles and micro bodies: Structure and functions Ribosomes:

Structures and function including role in protein synthesis.Mitochondria:

Structure and function, Genomes, biogenesis.

Chloroplasts: Structure and function, genomes, biogenesis Nucleus:

Structure and function, chromosomes and their structure.

UNIT IV **(15 Periods)**

Extracellular Matrix: Composition, molecules that mediate cell adhesion, membrane receptorsfor extra cellular matrix, macromolecules, regulation of receptor expression and function. Signal transduction.

Cancer: Carcinogenesis, agents promoting carcinogenesis, characteristics and molecular basis of cancer.

PRACTICALS

Total – 60 Hrs. **CREDITS - 2**

1. Study the effect of temperature and organic solvents on semi permeable membrane.
2. Demonstration of dialysis.
3. Study of plasmolysis and de-plasmolysis.
4. Cell fractionation and determination of enzyme activity in organelles using sprouted seed or any other suitable source.
5. Study of structure of any Prokaryotic and Eukaryotic cell.
6. Microtomy: Fixation, block making, section cutting, double staining of animal tissues like liver, oesophagus, stomach, pancreas, intestine, kidney, ovary, testes.
7. Cell division in onion root tip/ insect gonads.
8. Preparation of Nuclear, Mitochondrial & cytoplasmic fractions.

SUGGESTED READING

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition.Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASMPress & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

PAPER – GE1 CONTENT – BIOTECHNOLOGY AND HUMAN WELFARE

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I **(10 Periods)**

Industry: protein engineering; enzyme and polysaccharide synthesis, activity and secretion, alcohol and antibiotic formation.

UNIT II **(10 Periods)**

Agriculture: N2 fixation: transfer of pest resistance genes to plants; interaction between plants and microbes; qualitative improvement of livestock.

UNIT III **(15 Periods)**

Environments: e.g. chlorinated and non-chlorinated organ pollutant degradation; degradation of hydrocarbons and agricultural wastes, stress management, development of biodegradable polymers such as PHB.

UNIT IV **(12 Periods)**

Forensic science: e.g. solving violent crimes such as murder and rape; solving claims of paternityand theft etc. using various methods of DNA finger printing.

UNIT V **(13 Periods)**

Health: e.g. development of non- toxic therapeutic agents, recombinant live vaccines, gene therapy, diagnostics, monoclonal in *E. coli*, human genome project.

PRACTICALS

Total – 60 Hrs. **CREDITS - 2**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Perform of ethanolic fermentaion using Baker's yeast
2. Study of a plant part infected with a microbe
3. To perform quantitative estimation of residual chlorine in water samples
4. Isolation and analysis of DNA from minimal available biological samples
5. Case studies on Bioethics (any two)

SUGGESTED READING

1. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
2. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age internationalpublishers

SEMESTER III Paper- C3

CONTENT – MAMMALIAN PHYSIOLOGY TOTAL – 60 Hrs CREDITS - 4

UNIT I: Digestion and Respiration (15 Periods)

Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins, Lipids and nucleic acids. Composition of bile, Saliva, Pancreatic, gastric and intestinal juice

Respiration: Exchange of gases, Transport of O_2 and CO_2, Oxygen dissociation curve, Chloride shift.

UNIT II: Circulation (15 Periods)

Composition of blood, Plasma proteins & their role, blood cells, Haemopoisis, Mechanism of coagulation of blood.

Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heart beat.

UNIT III: Muscle physiology and osmoregulation (15 Periods)

Structure of cardiac, smooth & skeletal muscle, threshold stimulus, All or None rule, single muscle twitch, muscle tone, isotonic and isometric contraction, Physical, chemical & electrical events of mechanism of muscle contraction.

Excretion: modes of excretion, Ornithine cycle, Mechanism of urine formation.

UNIT IV: Nervous and endocrine coordination (15 Periods)

Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction, saltatory conduction, Neurotransmitters,

Mechanism of action of hormones (insulin and steroids)

Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid andadrenals, hypo & hyper-secretions.

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

1. Finding the coagulation time of blood
2. Determination of blood groups
3. Counting of mammalian RBCs
4. Determination of TLC and DLC
5. Demonstration of action of an enzyme
6. Determination of Haemoglobin

SUGGESTED READING

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition. John wiley & sons,Inc.

PAPER – C4 **CONTENT – PLANT ANATOMY AND PHYSIOLOGY**

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I: Anatomy **(10 Periods)**

The shoot and root apical meristem and its histological organization, simple & complex permanent tissues, primary structure of shoot & root, secondary growth, growth rings, leaf anatomy (dorsi-ventral and isobilateral leaf)

UNIT II: Plant water relations and micro & macro nutrients **(12 Periods)**

Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis, imbibition, guttation, transpiration, stomata & their mechanism of opening & closing.

Micro & macro nutrients: criteria for identification of essentiality of nutrients, roles and deficiency systems of nutrients, mechanism of uptake of nutrients, mechanism of food transport

UNIT III: Carbon and nitrogen metabolism **(20 Periods)**

Photosynthesis- Photosynthesis pigments, concept of two photo systems, photphosphorylation,calvin cycle, CAM plants, photorespiration, compensation point

Nitrogen metabolism- inorganic & molecular nitrogen fixation, nitrate reduction and ammonium assimilation in plants.

UNIT IV: Growth and development **(18 Periods)**

Growth and development: Definitions, phases of growth, growth curve, growth hormones (auxins, gibberlins, cytokinins, abscisic acid, ethylene)

Physiological role and mode of action, seed dormancy and seed germination, concept of photo-periodism and vernalization

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

1. Preparation of stained mounts of anatomy of monocot and dicot's root, stem & leaf.
2. Demonstration of plasmolysis by *Tradescantia* leaf peel.
3. Demonstration of opening & closing of stomata
4. Demonstration of guttation on leaf tips of grass and garden nasturtium.
5. Separation of photosynthetic pigments by paper chromatography.
6. Demonstration of aerobic respiration.
7. Preparation of root nodules from a leguminous plant.

SUGGESTED READING

1. Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
3. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
5. Mauseth, J.D. 1988 Plant Anatomy. The Benjammin/Cummings Publisher, USA.
6. Nelson, D.L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, 4thedition, W.H. Freeman and Company, New York, USA.
7. Salisbury, F.B. and Ross, C.W. 1991 Plant Physiology, Wadsworth Publishing Co. Ltd.
8. Taiz, L. and Zeiger, E. 2006 Plant Physiology, 4th edition, Sinauer Associates Inc .MA, USA

PAPER – GE2 CONTENT – DEVELOPMENT BIOLOGY

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I: Gametogenesis and Fertilization **(10 Periods)**

Definition, scope & historical perspective of development Biology, Gametogenesis – Spermatogenesis, Oogenesis Fertilization - Definition, mechanism, types of fertilization. Different types of eggs on the basis of yolk.

UNIT II: Early embryonic development **(20 Periods)**

Cleavage: Definition, types, patterns & mechanism Blastulation: Process, types & mechanism Gastrulation: Morphogenetic movements– epiboly, emboly, extension, invagination, convergence, de-lamination. Formation & differentiation of primary germ layers, Fate Maps inearly embryos.

UNIT III: Embryonic Differentiation **(20 Periods)**

Differentiation: Cell commitment and determination- the epigenetic landscape: a model of determination and differentiation, control of differentiation at the level of genome, transcription and post-translation level Concept of embryonic induction: Primary, secondary & tertiary embryonic induction, Neural induction and induction of vertebrate lens.

UNIT IV: Organogenesis **(10 Periods)**

Neurulation, notogenesis, development of vertebrate eye. Fate of different primary germlayers Development of behaviour: constancy & plasticity, Extra embryonic membranes, placenta in Mammals**.**

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

1. Identification of developmental stages of chick and frog embryo using permanent mounts
2. Preparation of a temporary stained mount of chick embryo
3. Study of developmental stages of *Anopheles*.
4. Study of the developmental stages of *Drosophila* from stock culture/ photographs..
5. Study of different types of placenta.

SUGGESTED READING

1. Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson ComputerPress.
3. Kalthoff, (2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional.

SEMESTER-III

CONTENT – GENETICS

PAPER – C5

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I **(12 Periods)**

Introduction: Historical developments in the field of genetics. Organisms suitable for genetic experimentation and their genetic significance.

Cell Cycle: Mitosis and Meiosis: Control points in cell-cycle progression in yeast. Role of meiosis in life cycles of organisms.

Mendelian genetics: Mendel's experimental design, monohybrid, di-hybrid and tri hybrid crosses, Law of segregation & Principle of independent assortment. Verification of segregates bytest and back crosses, Chromosomal theory of inheritance, Allelic interactions: Concept of dominance, recessiveness, incomplete dominance, co-dominance, semi-dominance, pleiotropy, multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity.

UNIT II **(18 Periods)**

Non allelic interactions: Interaction producing new phenotype complementary genes, epistasis (dominant & recessive), duplicate genes and inhibitory genes.

Chromosome and genomic organization: Eukaryotic nuclear genome nucleotide sequence composition –unique & repetitive DNA, satellite DNA. Centromere and telomere DNA sequences, middle repetitive sequences- VNTRs & dinucleotide repeats, repetitive transposed sequences- SINEs & LINEs, middle repetitive multiple copy genes, noncoding DNA.

Genetic organization of prokaryotic and viral genome.

Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, concept of euchromatin and heterochromatin. packaging of DNA molecule into chromosomes, chromosome banding pattern, karyotype, giant chromosomes, one gene one polypeptide hypothesis, concept of cistron, exons, introns, genetic code, gene function.

UNIT III **(15 Periods)**

Chromosome and gene mutations: Definition and types of mutations, causes of mutations, Ames test for mutagenic agents, screening procedures for isolation of mutants and uses of mutants, variations in chromosomes structure - deletion, duplication, inversion and translocation (reciprocal and Robertsonian), position effects of gene expression, chromosomal aberrations in human beings, abonormalities– Aneuploidy and Euploidy.

Sex determination and sex linkage: Mechanisms of sex determination, Environmental factors andsex determination, sex differentiation, Barr bodies, dosage compensation, genetic balance theory, Fragile-X- syndrome and chromosome, sex influenced dominance, sex limited gene expression, sex linked inheritance.

UNIT IV **(15 Periods)**

Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination of genes in a chromosome crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Crossing over at four strand stage, Multiple crossing overs Genetic mapping.

Extra chromosomal inheritance: Rules of extra nuclear inheritance, maternal effects, maternal inheritance, cytoplasmic inheritance, organelle heredity, genomic imprinting.

Evolution and population genetics: In breeding and out breeding, Hardy Weinberg law (prediction, derivation), allelic and genotype frequencies, changes in allelic frequencies, systemsof mating, evolutionary genetics, natural selection.

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

1. Permanent and temporary mount of mitosis.
2. Permanent and temporary mount of meiosis.
3. Mendelian deviations in dihybrid crosses
4. Demonstration of - Barr Body -*Rhoeo* translocation.
5. Karyotyping with the help of photographs
6. Pedigree charts of some common characters like blood group, color blindness and PTC tasting.
7. Study of polyploidy in onion root tip by colchicine treatment.

SUGGESTED READING

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings.

PAPER – C6 CONTENT – GENERAL MICROBIOLOGY

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I **(10 Periods)**

Fundamentals, History and Evolution of Microbiology.

Classification of microorganisms: Microbial taxonomy, criteria used to include molecularapproaches, Microbial phylogeny and current classification of bacteria.

Microbial Diversity: Distribution and characterization Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms eg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.

UNIT II **(10 Periods)**

Cultivation and Maintenance of microorganisms: Nutritional categories of micro-organisms,methods of isolation, Purification and preservation.

UNIT III **(20 Periods)**

Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria.

Microbial Metabolism: Metabolic pathways, amphi-catabolic and biosynthetic pathways Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria.

UNIT IV **(20 Periods)**

Control of Microorganisms: By physical, chemical and chemotherapeutic Agents

Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewagecomposition and its disposal.

Food Microbiology: Important microorganism in food Microbiology: Moulds, Yeasts, bacteria. Major food born infections and intoxications, Preservation of various types of foods. Fermented Foods

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

1. Isolation of bacteria & their biochemical characterization.
2. Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.
3. Preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources.
4. Determination of bacterial cell size by micrometry.
5. Enumeration of microorganism - total &viable count.

SUGGESTED READING

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4 th edition. John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA. (2005). *Modern Food Microbiology*. 7thedition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.
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. (1993). 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.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

CC- 7: CHEMISTRY-I (PHYSICAL CHEMISTRY) C7T: Chemistry-I (PhysicalChemistry) Credits 04

Theory

1. Thermodynamics- Concept of energy, heat and work; thermodynamics functions- internal energy, entropy, enthalpy and free energy; bioenergetics- spontaneity equation in terms of entropy and concept of equilibrium; transport across membranes- Donnan equilibrium

2. Radioactivity- Alpha, beta, gamma radiation, law of radioactive decay, unit of radioactivity, idea of artificial. Radioactivity, application-radiolabelling

3. Electrochemistry- Electrolytic dissociation and conduction, ionic equilibrium, pH, indicator, acid base neutralization curve, buffer action, Bronsted acid, HendersonHasselbalch equation, preparation of buffer, buffer capacity

4. Properties of molecules- Structure of atom, Electronic theory of valency, dipole moment, hydrogen bonds, Van der Waals' interactions, Electrostatic interactions, Hydrophobic interactions;

5. Chemical Kinetics- Transition State theory, Arrhenius equation. Preliminary ideas about 1st and 2nd order reactions with examples.

C7P: Chemistry-I (Physical Chemistry) Credits 02 Practical

i) Equilibrium constant of the reaction KI + I2 = KI3.

ii) Solubility/solubility product in presence/absence of common ions and/or neutral electrolytes (e.g. Na- oxalate, Mg-carbonate, K-hydrogen tartarate, etc).

iii) Conductometric and potentiometric titrations of an acid or a base (acid may be monobasic/ dibasic, and similarly for the base)

iv) Kinetics of decomposition of H2O2 and hydrolysis of an ester.

v) Verification of Beer's law and finding strengths of unknown solutions by colorimetry; (also, colour matching principle to find unknown concentrations)

PAPER – SEC1 CONTENT – MOLECULAR DIAGNOSTICS

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I

Enzyme Immunoassays:

Comparison of enzymes available for enzyme immunoassays, conjugation of enzymes. Solid phases used in enzyme immunoassays. Homogeneous and heterogeneous enzyme immunoassays. Enzyme immunoassays after immuno blotting. Enzyme immuno histochemical techniques. Use of polyclonal or monoclonal antibodies in enzymes immuno assays.

Applications of enzyme immunoassays in diagnostic microbiology

UNIT II

Molecular methods in clinical microbiology:

Applications of PCR, RFLP, Nuclear hybridization methods, Single nucleotideand plasmid finger printing in clinical microbiology

Laboratory tests in chemotherapy:

Susceptibility tests: Micro-dilution and macro-dilution broth procedures. Susceptibility tests:Diffusion test procedures. Susceptibility tests: Tests for bactericidal activity. Automated procedures for antimicrobial susceptibility tests.

UNIT III **(18 Periods)**

Automation in microbial diagnosis, rapid diagnostic approach including technical purificationand standardization of antigen and specific antibodies. Concepts and methods in idiotypes.Antiidiotypes and molecular mimicry and receptors. Epitope design and applications. Immunodiagnostic tests. Immuno florescence. Radioimmunoassay.

UNIT IV **(12 Periods)**

GLC, HPLC, Electron microscopy, flowcytometry and cell sorting.

Transgenic animals.

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated throughany other material or medium including videos/virtual labs etc.)

1. Perform/demonstrate RFLP and its analysis
2. Kirby-Bauyer method (disc-diffusion method) to study antibiotic sensitivity of a bacterial culture
3. A kit-basd detection of a microbial infection (Widal test)
4. Study of Electron micrographs (any four).
5. Perform any one immuno diagnostic test (Typhoid, Malaria, Dengue)

SUGGESTED READING

1. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker

2. Bioinstrumentation, Webster
3. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe,Kluwer Academic
4. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ). University Press Publication.
5. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication.
6. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier.
7. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition. Appleton-Centuary-Crofts publication.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

PAPER – GE3 CONTENT – BIOETHICS & BIOSAFETY

TOTAL – 60 Hrs **CREDITS - 4**

Unit I

Biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs private funding, biotechnology in international relations, globalization and development divide. Introduction to bioethics: Social and ethical issues in biotechnology. Principles of bioethics. Ethical conflicts in biotechnology- interference withnature, unequal distribution of risk and benefits of biotechnology, bioethics vs business ethics.

Unit II

Biosafety: Definition of bio-safety, Biotechnology and bio-safety concerns at the level of individuals, institutions, society, region, country and world with special emphasis on Indian concerns. Biosafety in laboratory institution: laboratory associated infection and other hazards, assessment of biological hazards and level of biosafety. Bio safety regulation: handling ofrecombinant DNA products and process in industry and in institutions (Indian context).

Unit III

Introduction to IPR: IPR, forms of IPR and Intellectual property protection. Concept of propertywith respect to intellectual creativity, Tangible and Intangible property. WTO: agency controlling trade among nations, WTO with reference to biotechnological affairs, TRIPs. WIPO, EPO.

Unit IV

Concept related to patents novelty, non-obviousness, utility, anticipation, prior art etc. Type of patents. Indian patent act and foreign patents. Patentability, Patent application, Revocation of patent, Infringement and Litigation with case studies on patent, Commercialization and Licensing.

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated throughany other material or medium including videos/virtual labs etc.)

1. Proxy filing of Indian Product patent
2. Proxy filing of Indian Process patent
3. Planning of establishing a hypothetical biotechnology industry in India
4. A case study on clinical trials of drugs in India with emphasis on ethical issues.
5. Case study on women health ethics.
6. Case study on medical errors and negligence.
7. Case study on handling and disposal of radioactive waste

SUGGESTED READING

1. Fleming, D.A., Hunt, D.L., (2000). Biotechnology and Safety Assessment (3rd Ed) Academic press.ISBN-1555811804,9781555811808.

2. Thomas, J.A., Fuch, R.L. (1999). Biotechnology and safety assessment (3rd Ed). CRC press, Washington. ISBN: 1560327219, 9781560327219

3. Law and Strategy of biotechnological patents by Sibley. Butterworth publication.(2007) ISBN: 075069440, 9780750694445.

4. Intellectual property rights- Ganguli-Tat McGrawhill. (2001) ISBN-10: 0074638602,

5. Intellectual Property Right- Wattal- Oxford Publicatiopn House.(1997) ISBN:0195905024.

6. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nd ed) ISBN-10 3527304320.

SEMESTER IV

PAPER – C8 CONTENT – MOLECULAR BIOLOGY

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I: DNA structure and replication **(15 Periods)**

DNA as genetic material, Structure of DNA, Types of DNA, Replication of DNA in prokaryotesand eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases, the replication complex: Pre-primming proteins, primosome, replisome, Rolling circle replication, Unique aspects of eukaryotic chromosome replication, Fidelity of replication.

UNIT II: DNA damage, repair and homologous recombination **(10 Periods)**

DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair: Photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, translesion synthesis, recombinational repair, nonhomologous end joining. Homologous recombination: models and mechanism.

UNIT III: Transcription and RNA processing **(17 Periods)**

RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase,role of sigma factor, promoter, Initiation, elongation and termination of RNA chains Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5’ cap formation, polyadenylation, splicing,rRNA and tRNA splicing.

UNIT IV: Regulation of gene expression and translation **(18 Periods)**

Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Genetic code and its characteristics, Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides, Fidelity of translation, Inhibitors of translation.,Posttranslational modifications of proteins.

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated throughany other material or medium including videos/virtual labs etc.)

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from bacterial cells.
3. Isolation of Plasmid DNA by alkaline lysis method
4. Agarose gel electrophoresis of genomic DNA & plasmid DNA
5. Preparation of restriction enzyme digests of DNA samples
6. Demonstration of AMES test or reverse mutation for carcinogenicity

SUGGESTED READING

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene (VI Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.

PAPER – C9 CONTENT – IMMUNOLOGY

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I (20 Periods)

Immune Response - An overview, components of mammalian immune system, molecular structure of Immuno-globulins or Antibodies, Humoral & Cellular immune responses, T- lymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells), T-cell receptors, genome rearrangements during B-lymphocyte differentiation, Antibody affinity maturation class switching, assembly of T-cell receptor genes by somatic recombination.

UNIT II (15 Periods)

Regulation of immunoglobulin gene expression – clonal selection theory, allotypes & idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis of antibody diversity, hypotheses (germ line & somatic mutation), antibody diversity.

UNIT III (13 Periods)

Major Histocompatibility complexes – class I & class II MHC antigens, antigen processing. Immunity to infection – immunity to different organisms, pathogen defense strategies, avoidanceof recognition. Autoimmune diseases, Immunodeficiency-AIDS.

UNIT IV (12 Periods)

Vaccines & Vaccination – adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization. Introduction to immunodiagnostics – RIA, ELISA.

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated throughany other material or medium including videos/virtual labs etc.)

1. Differential leucocytes count
2. Total leucocytes count
3. Total RBC count
4. Haemagglutination assay
5. Haemagglutination inhibition assay
6. Separation of serum from blood
7. Double immunodiffusion test using specific antibody and antigen.
8. ELISA.

SUGGESTED READING

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6 th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

CC-10: Chemistry-2(Organic Chemistry) Credits 06

C10T: Chemistry-2(Organic Chemistry) Credits 04

1. Alkane structural formulae, Nomenclature, Homologous series,Alkene, Conformational analysis, Alkenes and alkynes, orbital picture.

2. Monohydric alcohol, polyhydric alcohols, unsaturated alcohols, ether, carbonyl compounds and acids.

3. Stereochemistry : Different types of isomerism-Geometric and Optical isomerism, Diisomerism , Enantiomers, Chirality and asymmetricity in relation to biomolecules.Mesomerism,Racemic modifications. Steriochemical nomenclature. R-S, EZ, DL, Pro-R, Pro-S, Erythro and threo designations of enantiotropic atoms. Fischer, Newman, Sawhorse and Wedge structures and their interconversation.

4. Aliphatic compounds of sulphur, phosphorous, organometallic compounds.Grignard Reagent and use.

5. Nomenclature of aromatic compound. Reaction mechanism : SN1 and SN2 reaction, E1and E2 reaction of organic reactions. Saytzett and Hoffmann elimination. Neucleophilic and Electrophilic aromatic substitution. Aromaticity orbital picture, Electrometric effect, mesomeric effect. Resonance and delocalization of π electrons in different organic compounds.

6. Spectroscopy : idea of electromagnetic radiation orbital theory, Concept of orbital Beer's Law and its importance. Fluoroscence spectroscopy. Steady state fluorescence application in biology, UV-VIS spectroscopy.

C10P: Chemistry-2(organic Chemistry) Credits 02

Practical Detection of special elements (N,S,Cl) and any one of the following functional groupsin solid organic compounds : -NH2, -NO2, -CONH2, phenolic-OH, COOH, =CO, -CHO.

SEMESTER IV

PAPER – SEC 2 CONTENT – BASICS OF FORENSIC SCIENCE

TOTAL – 60 Hrs **CREDITS - 4**

Unit I **(15 Periods)**

Introduction and principles of forensic science, forensic science laboratory and its organization and service, tools and techniques in forensic science, branches of forensic science, causes of crime, role of modus operandi in criminal investigation. Classification of injuries and their medico-legal aspects, method of assessing various types of deaths.

Unit II **(15 Periods)**

. **Intellectual Property Right and Management of Biotechnology** – IPR, Forms of Protection, Patenting strategy, Copy right, Plant variety protection, WIPO, GATT, WTO, Patent status international scenario Role of patent in Pharmaceutical Industry, Role and regulation of Indian Patent.

Biosafety and Bioethics-Risk for Human health, Biosafety guideline and regulation, Marketing – Commercialization of Biotechnology, Research and Development of University-Industry agreement.

Unit III **(15 Periods)**

Role of the toxicologist, significance of toxicological findings, Fundamental principles of fingerprinting, classification of fingerprints, development of finger print as science for personal identification,

Unit IV **(15 Periods)**

Principle of DNA fingerprinting, application of DNA profiling in forensic medicine,Investigation Tools, eDiscovery, Evidence Preservation, Search and Seizure of Computers, Introduction to Cyber security.

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

1. Documentation of crime scene by photography, sketching and field notes.

2. a. Simulation of a crime scene for training.

b. To lift footprints from crime scene.

3. Case studies to depict different types of injuries and death.
4. Separation of nitro compounds (explosives)/ ink samples by thin layer chromatography.
5. Investigate method for developing fingerprints by Iodine crystals.
6. PCR amplification on target DNA and DNA profiling,
7. E-Mail Investigation, E-Mail Tracking, IP Tracking, E-Mail Recovery, Recovering deleted evidences, Password Cracking.

SUGGESTED READING

1. Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
2. B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001).
3. M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi (2002).
4. S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005).
5. W.G. Eckert and R.K. Wright in Introduction to Forensic Sciences, 2nd Edition, W.G. Eckert (ED.), CRC Press, Boca Raton (1997).
6. R. Saferstein, Criminalistics, 8th Edition, Prentice Hall, New Jersey (2004).

PAPER – GE4 CONTENT – ENTERPRENEURSHIP DEVELOPMENT

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I INTRODUCTION (10 Periods)

Meaning, Needs and Importance of Entrepreneurship, Promotion of entrepreneurship, Factors influencing entrepreneurship, Features of a successful Entrepreneurship.

UNIT II ESTABLISHING AN ENTERPRISE (12 Periods)

Forms of Business Organization, Project Identification, Selection of the product, Project formulation, Assessment of project feasibility.

UNIT III FINANCING THE ENTERPRISE (15 Periods)

Importance of finance / loans and repayments, Characteristics of Business finance, fixed capital management: Sources of fixed capital, working capital its sources and how to move for loans, Inventory direct and indirect raw materials and its management.

UNIT IV MARKETING MANAGEMENT (13 Periods)

Meaning and Importance, Marketing-mix, product management – Product line, Product mix, stages of product like cycle, marketing Research and Importance of survey, Physical Distributionand Stock Management.

UNIT V ENTREPRENEURSHIP AND INTERNATIONAL BUSINESS (10 Periods)

Meaning of International business, Selection of a product, Selection of a market for international business, Export financing, Institutional support for exports.

PRACTICAL

TOTAL – 60 Hrs **CREDITS - 2**

Project Report on a selected product should be prepared and submitted.

SUGGESTED READING

1. Holt DH. Entrepreneurship: New Venture Creation.
2. Kaplan JM Patterns of Entrepreneurship.
3. Gupta CB, Khanka SS. Entrepreneurship and Small Business Management, Sultan Chand & Sons.

SEMESTER V

PAPER – C11 CONTENT –BIOPROCESSING TECHNOLOGY

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I **(10 Periods)**

Introduction to bioprocess technology. Range of bioprocess technology and its chronological development. Basic principle components of fermentation technology. Types of microbial culture and its growth kinetics– Batch, Fedbatch and Continuous culture.

UNIT II **(20 Periods)**

Design of bioprocess vessels- Significance of Impeller, Baffles, Sparger; Types of culture/production vessels- Airlift; Cyclone Column; Packed Tower and their application in

production processes. Principles of upstream processing – Media preparation, Inoculadevelopment and sterilization.

UNIT III **(15 Periods)**

Introduction to oxygen requirement in bioprocess; mass transfer coefficient; factors affecting KLa. Bioprocess measurement and control system with special reference to computer aided process control.

UNIT IV **(15 Periods)**

Introduction to downstream processing, product recovery and purification. Effluent treatment. Microbial production of ethanol, amylase, lactic acid and Single Cell Proteins.

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated throughany other material or medium including videos/virtual labs etc.)

1. Bacterial growth curve.
2. Calculation of thermal death point (TDP) of a microbial sample.
3. Production and analysis of ethanol.
4. Production and analysis of amylase.
5. Production and analysis of lactic acid.
6. Isolation of industrially important microorganism from natural resource.

SUGGESTED READING

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
4. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

PAPER – C12 CONTENT – RECOMBINANT DNA TECHNOLOGY

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I **(15 Periods)**

Molecular tools and applications- restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors (Bacteriophage-derived vectors, artificial chromosomes), Microinjection, Electroporation, Ultrasonication, Principle and applications of Polymerase chain reaction (PCR), primer-design, and RT- (Reverse transcription) PCR.

UNIT II **(20 Periods)**

Restriction and modification system, restriction mapping. Southern and Northern hybridization. Preparation and comparison of Genomic and cDNA library, screening of recombinants, reverse transcription, Genome mapping, DNA fingerprinting, Applications of Genetic Engineering Genetic engineering in animals: Production and applications of transgenic mice, role of ES cells in gene targeting in mice, Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines (one example each).

UNIT III **(10 Periods)**

Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis, Gene shuffling, production of chimeric proteins, Protein engineering concepts and examples (any two).

UNIT IV **(15 Periods)**

Genetic engineering in plants: Use of *Agrobacterium tumefaciens* and A. rhizogenes, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors.

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated throughany other material or medium including videos/virtual labs etc.)

1. Isolation of chromosomal DNA from plant cells
2. Isolation of chromosomal DNA from *E.coli*
3. Qualitative and quantitative analysis of DNA using spectrophotometer
4. Plasmid DNA isolation
5. Restriction digestion of DNA
6. Making competent cells
7. Transformation of competent cells.
8. Demonstration of PCR

SUGGESTED READING

1. Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K.
2. Clark DP and Pazdernik NJ. (2009). Biotechnology-Applying the Genetic Revolution. Elsevier Academic Press, USA.
3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington
4. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
5. Sambrook J, Fritsch EF and Maniatis T. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.

PAPER – DSE1 CONTENT – PLANT BIOTECHNOLOGY

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I

Introduction, Cryo and organogenic differentiation, Types of culture: Seed, Embryo, Callus, Organs, Cell and Protoplast culture. Micropopagation Axillary bud proliferation, Meristem and shoot tip culture, cud culture, organogenesis, embryogenesis, advantages and disadvantages of micropropagation. **(15 Periods)**

UNIT- II

In vitro haploid production Androgenic methods: Anther culture, Microspore culture andogenesis Sgnificance and use of haploids, Ploidy level and chromosome doubling, diplodization, Gynogenic haploids, factors effecting gynogenesis, chromosome elimination techniques for production of haploids in cereals. **(20 Periods)**

UNIT - III

Protoplast Isolation and fusion Methods of protoplast isolation, Protoplast development, Somatic hybridization, identifiation and selection of hybrid cells, Cybrids, Potential of somatic hybridization limitations.

Somaclonal variation

Nomenclautre, methods, applications basis and disadvantages.

UNIT - IV

Plant Growth Promoting bacteria.

Nitrogen fixation, Nitrogenase, Hydrogenase, Nodulation,

Biocontrol of pathogens, Growth promotion by free-living bacteria. **(10 Periods)**

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated throughany other material or medium including videos/virtual labs etc.)

1. Preparation of simple growth nutrient (knop's medium), full strength, half strength, solid and liquid.
2. Preparation of complex nutrient medium (Murashige & Skoog's medium)
3. To selection, Prune, sterilize and prepare an explant for culture.
4. Significance of growth hormones in culture medium.
5. To demonstrate various steps of Micropropagation.

SUGGESTED READING

1. Bhojwani, S.S. and Razdan 2004 Plant Tissue Culture and Practice.
2. Brown, T. A. Gene cloning and DNA analysis: An Introduction. Blackwell Publication.
3. Gardner, E.J. Simmonns, M.J. Snustad, D.P. 2008 8th edition Principles of Genetics. Wiley India.
4. Raven, P.H., Johnson, GB., Losos, J.B. and Singer, S.R. 2005 Biology. Tata MC Graw Hill.
5. Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Narosa Publishing House.
6. Russell, P.J. 2009 Genetics – A Molecular Approach. 3rdedition. Benjamin Co.
7. Sambrook & Russel. Molecular Cloning: A laboratory manual. (3rd edition)
8. Slater, A., Scott, N.W. & Fowler, M.R. 2008 Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.

PAPER – DSE2 CONTENT – BIOINFORMATICS

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I

History of Bioinformatics. The notion of Homology. Sequence Information Sources, EMBL, GENBANK, Entrez, Unigene, Understanding the structure of each source and using it on the web. **(10 Periods)**

UNIT II

Protein Information Sources, PDB, SWISSPROT, TREMBL, Understanding the structure ofeach source and using it on the web. Introduction of Data Generating Techniques and Bioinformatics problem posed by them- Restriction Digestion, Chromatograms, Blots, PCR, Microarrays, Mass Spectrometry. **(20 Periods)**

UNIT III

Sequence and Phylogeny analysis, Detecting Open Reading Frames, Outline of sequence Assembly, Mutation/Substitution Matrices, Pairwise Alignments, Introduction to BLAST, usingit on the web, Interpreting results, Multiple Sequence Alignment, Phylogenetic Analysis.

(20 Periods)

UNIT IV

Searching Databases: SRS, Entrez, Sequence Similarity Searches-BLAST,

FASTA, Data Submission.

Genome Annotation: Pattern and repeat finding, Gene identification tools. **(10 Periods)**

1. Sequence information resource
2. Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR)
3. Understanding and using: PDB, Swissprot, TREMBL
4. Using various BLAST and interpretation of results.
5. Retrieval of information from nucleotide databases.
6. Sequence alignment using BLAST.
7. Multiple sequence alignment using Clustal W.

SUGGESTED READING

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

SEMESTER VI

PAPER – C13 CONTENT – BIO-ANALYTICAL TOOLS

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I **(10 Periods)**

Simple microscopy, phase contrast microscopy, florescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy

UNIT II **(15 Periods)**

Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infra- red), centrifugation, cell fractionation techniques, isolation of sub-cellular organelles and particles.

UNIT III **(15 Periods)**

Introduction to the principle of chromatography. Paper chromatography, thin layer chromatography, column chromatography: silica and gel filtration, affinity and ion exchange chromatography, gas chromatography, HPLC.

UNIT IV **(20 Periods)**

Introduction to electrophoresis. Starch-gel, polyacrylamide gel (native and SDS-PAGE), agarose-gel electrophoresis, pulse field gel electrophoresis, immuno- electrophoresis, isoelectric focusing, Western blotting. Introduction to Biosensors and Nanotechnology and their applications**.**

PRACTICAL

TOTAL – 60 Hrs **CREDITS - 2**

1. Native gel electrophoresis of proteins
2. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
3. Preparation of the sub-cellular fractions of rat liver cells.
4. Preparation of protoplasts from leaves.
5. Separation of amino acids by paper chromatography.
6. To identify lipids in a given sample by TLC.
7. To verify the validity of Beer's law and determine the molar extinction coefficient of NADH.

SUGGESTED READING

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley& Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World of the Cell.7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

PAPER – C14 CONTENT – GENOMICS & PROTEOMICS

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I **(15 Periods)**

Introduction to Genomics, DNA sequencing methods – manual & automated: Maxam & Gilbert and Sangers method. Pyrosequencing, Genome Sequencing: Shotgun & Hierarchical (clone contig) methods, Computer tools for sequencing projects: Genome sequence assembly software.

UNIT II **(10 Periods)**

Managing and Distributing Genome Data: Web based servers and softwares for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome. Selected Model Organisms' Genomes and Databases.

UNIT III **(20 Periods)**

Introduction to protein structure, Chemical properties of proteins. Physical interactions thatdetermine the property of proteins. Short-range interactions, electrostatic forces, van der waal interactions, hydrogen bonds, Hydrophobic interactions. Determination of sizes (Sedimentation analysis, gel filteration, SDS-PAGE); Native PAGE, Determination of covalent structures – Edman degradation.

UNIT IV **(15 Periods)**

Introduction to Proteomics, Analysis of proteomes. 2D-PAGE. Sample preparation,

solubilization, reduction, resolution.

Reproducibility of 2D-PAGE. Mass spectrometry based methods for protein identification. *Denovo* sequencing using mass spectrometric data.

PRACTICALS

TOTAL – 60 Hrs **CREDITS - 2**

1. Use of SNP databases at NCBI and other sites
2. Use of OMIM database
3. Detection of Open Reading Frames using ORF Finder
4. Proteomics 2D PAGE database
5. Softwares for Protein localization.
6. Hydropathy plots
7. Native PAGE
8. SDS-PAGE

SUGGESTED READING

1. Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2. Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
5. Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
6. Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
7. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). *i*Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.

Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition. John Wiley & Sons

PAPER – DSE3 CONTENT – ANIMAL BIOTECHNOLOGY

TOTAL – 60 Hrs **CREDITS - 4**

UNIT I

Gene transfer methods in Animals – Microinjection, Embryonic Stem cell, gene transfer, Retrovirus & Gene transfer. **(10 Periods)**

UNIT II

Introduction to transgenesis. Transgenic Animals – Mice, Cow, Pig, Sheep, Goat, Bird, Insect. Animal diseases need help of Biotechnology – Foot-and mouth disease, Coccidiosis, Trypanosomiasis, Theileriosis. **(10 Periods)**

UNIT III

Animal propagation – Artificial insemination, Animal Clones. Conservation Biology – Embryo transfer techniques. Introduction to Stem Cell Technology and its applications. **(20 Periods)**

UNIT IV

Genetic modification in Medicine - gene therapy, types of gene therapy, vectors in gene therapy, molecular engineering, human genetic engineering, problems & ethics. **(20 Periods)**

PRACTICAL

TOTAL – 60 Hrs **CREDITS - 2**

1. Sterilization techniques: Theory and Practical: Glass ware sterilization, Media sterilization, Laboratory sterilization
2. Sources of contamination and decontamination measures.
3. Preparation of Hanks Balanced salt solution
4. Preparation of Minimal Essential Growth medium
5. Isolation of lymphocytes for culturing
6. DNA isolation from animal tissue
7. Quantification of isolated DNA.
8. Resolving DNA on Agarose Gel.

SUGGESTED READING

1. Brown, T.A. (1998). Molecular biology Labfax II: Gene analysis. II Edition. Academic Press, California,USA.
2. Butler, M. (2004). Animal cell culture and technology: The basics. II Edition. Bios scientific publishers.
3. Glick, B.R. and Pasternak, J.J. (2009). Molecular biotechnology- Principles and applications of recombinant DNA. IV Edition. ASM press, Washington, USA.
4. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An introduction to genetic analysis. IX Edition. Freeman & Co., N.Y., USA.
5. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA-genes and genomes- A short course. III Edition. Freeman and Co., N.Y., USA.

PAPER – DSE4 CONTENT – ENVIRONMENT BIOTECHNOLOGY

TOTAL – 60 Hrs **CREDITS – 4**

UNIT I **(18 Periods)**

Conventional fuels and their environmental impact – Firewood, Plant, Animal, Water,

Coal and Gas. Modern fuels and their environmental impact – Methanogenic bacteria, Biogas, Microbial hydrogen Production, Conversion of sugar to alcohol Gasohol

UNIT II **(20 Periods)**

Bioremediation of soil & water contaminated with oil spills, heavy metals and detergents.Degradation of lignin and cellulose using microbes. Phyto-remediation. Degradation of pesticides and other toxic chemicals by micro-organisms- degradation aromatic and chlorinates

hydrocarbons and petroleum products.

UNIT III **(12 Periods)**

Treatment of municipal waste and Industrial effluents. Bio-fertilizers
Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil. Algal and fungal biofertilizers (VAM)

UNIT IV

Bioleaching, Enrichment of ores by microorganisms (Gold, Copper and Uranium). Environmental significance of genetically modified microbes, plants and animals.

PRACTICAL

TOTAL – 60 Hrs **CREDITS - 2**

1. Project Work related to environmental science.
2. Visit to CSIR Laboratory / Industrial Visit & Submission of notebook.

SUGGESTED READING

1. Environmental Science, S.C. Santra
2. Environmental Biotechnology, Pradipta Kumar Mohapatra
3. Environmental Biotechnology – Concepts and Applications, Hans-Joachim Jordening and Jesef Winter
4. Waste Water Engineering, Metcalf and Eddy, Tata McGraw hill
5. Agricultural Biotechnology, S.S. Purohit
6. Environmental Microbiology : Methods and Protocols, Alicia L. Ragout De Spencer, John F.T. Spencer
7. Introduction to Environmental Biotechnology, Milton Wainwright
8. Principles of Environmental Engineering, Gilbert Masters
9. Wastewater Engineering – Metcalf & Eddy

PAPER – DSE CONTENT – BIOSTATISTICS

TOTAL – 60 Hrs **CREDITS – 4**

UNIT I **(12 Periods)**

Types of Data, Collection of data; Primary & Secondary data, Classification and Graphical representation of Statistical data. Measures of central tendency and Dispersion. Measures of Skewness and Kurtosis.

UNIT II **(18 Periods)**

Probability classical & axiomatic definition of probability, Theorems on total and compound probability), Elementary ideas of Binomial, Poisson and Normal distributions.

UNIT III **(18 Periods)**

Methods of sampling, confidence level, critical region, testing of hypothesis and standard error, large sample test and small sample test. Problems on test of significance, t-test, chi-square test for goodness of fit and analysis of variance (ANOVA)

UNIT IV **(12 Periods)**

Correlation and Regression. Emphasis on examples from Biological Sciences.

PRACTICAL

TOTAL – 60 Hrs **CREDITS - 2**

PRACTICALS

1. Based on graphical Representation
2. Based on measures of Central Tendency & Dispersion
3. Based on Distributions Binomial Poisson Normal
4. Based on t, f, z and Chi-square

SUGGESTED READING

1. Le CT (2003) Introductory biostatistics. 1st edition, John Wiley, USA
2. Glaser AN (2001) High Yield^{TM} Biostatistics. Lippincott Williams and Wilkins, USA
3. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
4. Danial W (2004) Biostatistics : A foundation for Analysis in Health Sciences, John Wiley and Sons Inc.

PAPER – SEC **CONTENT – ENZYMOLOGY**

TOTAL – 40 Hrs **CREDITS – 2**

ENZYMOLOGY

UNIT - I **(20 Periods)**

Isolation, crystallization and purification of enzymes, test of homogeneity of enzyme preparation, methods of enzyme analysis.
Enzyme classification (rationale, overview and specific examples) Zymogens and their activation (Proteases and Prothrombin).
Enzyme substrate complex: concept of E-S complex, binding sites, active site, specificity, Kinetics of enzyme activity, Michaelis-Menten equation and its derivation,
Different plots for the determination of Km and Vmax and their physiological significance, factors affecting initial rate, E, S, temp. & pH. Collision and transition state theories, Significance of activation energy and free energy.

UNIT – II **(15 Periods)**

Two substrate reactions (Random, ordered and ping-pong mechanism) Enzyme inhibition types of inhibition, determination of Ki, suicide inhibitor.
Mechanism of enzyme action: General mechanistic principle, factors associated with catalytic efficiency: proximity, orientation, distortion of strain, acid-base, nucleophilic and covalent catalysis. Techniques for studying mechanisms of action, chemical modification of active site groups, specific examples-: chymotrypsin, Iysozyme, GPDH, aldolase, RNase, Carboxypeptidase and alcohol dehydrogenase.
Enzyme regulation: Product inhibition, feed backcontrol, covalent modification.

UNIT – III **(13 Periods)**

Allosteric enzymes with special reference to aspartate transcarbomylase and phosphofructokinase. Qualitative description of concerted and sequential models. Negative co- operativity and half site reactivity. Enzyme - Enzyme interaction, Protein ligand binding, measurements analysis of binding isotherm, cooperativity, Hill and scatchard plots, kinetics of allosteric enzymes. Isoenzymes– multiple forms of enzymes with special reference to lactate dehydrogenase. Multienzyme complexes. Ribozymes. Multifunctional enzyme-eg Fatty Acid synthase.

UNIT – IV **(12 Periods)**

Enzyme Technology: Methods for large scale production of enzymes. Structure of enzyme.
Immobilized enzyme and their comparison with soluble enzymes, Methods for immobilization of enzymes. Immobilized enzyme reactors. Application of Immobilized and soluble enzyme in health and industry. Application to fundamental studies of biochemistry. Enzyme electrodes.
Thermal stability and catalytic efficiency of enzyme, site directed mutagenesis and enzyme engineering– selected examples, Delivery system for protein pharmaceuticals, structure function relationship in enzymes, structural motifs and enzyme evolution. Concept of protein folding.

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PRACTICALS

1. Purification of an enzyme from any natural resource
2. Quantitative estimation of proteins by Bradford/Lowry's method.
3. Perform assay for the purified enzyme.
4. Calculation of kinetic parameters such as Km, Vmax, Kcat

SUGGESTED READING

1. Biochemistry, Lubert Stryer, 6th Edition, WH Freeman, 2006.
2. Harper's illustrated Biochemistry by Robert K. Murray, David A Bender, Kathleen M.Botham, Peter J. Kennelly, Victor W. Rodwell, P. Anthony Weil. 28th Edition, McGrawHill, 2009.
3. Biochemistry, Donald Voet and Judith Voet, 2nd Edition, Publisher: John Wiley andSons, 1995.
4. Biochemistry by Mary K.Campbell & Shawn O.Farrell, 5th Edition, Cenage Learning,2005.
5. Fundamentals of Enzymology Nicholas Price and Lewis Stevens Oxford University Press 1999
6. Fundamentals of Enzyme Kinetics Athel Cornish-Bowden Portland Press 2004
7. Practical Enzymology Hans Bisswanger Wiley–VCH 2004
8. The Organic Chemistry of Enzyme-catalyzed Reactions Richard B. Silverman Academic Press 2004

13. Learning Outcome Matrixs

MATRIX -1 *(Entire Programme)* MAPPING COURSES/ACTIVITIES TO PROGRAMME LEARNING OUTCOME PROGRAMME: B.Sc. in Biotechnology									
PLOS / Course/Activity		PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2 Environment 68olution68bility & Ethics	PLO -3: Individual and Team work, Communicationa & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable 68olutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
Courses Component A	C-1: BIOCHEMISTRY	☑	☒	☑	☑	☑	☒	☑	☑
	C-2: CELL BIOLOGY	☑	☒	☑	☑	☑	☒	☑	☑
	C-5:GENETICS	☑	☒	☑	☑	☑	☒	☑	☑
	C-6: MICROBIOLOGY	☑	☒	☑	☑	☑	☒	☑	☑
	C-8: MOLECULAR BIOLOGY	☑	☒	☑	☑	☑	☒	☑	☑
	C-3 & C-4: MAMALIAN & PLANT PHYSIOLOGY	☑	☒	☑	☑	☑	☒	☑	☑
	C-7: CHEMISTRY-1	☑	☒	☑	☑	☑	☒	☑	☑
	DES: BIOSTATISTICS	☑	☒	☑	☑	☑	☒	☑	☑
	DSE: ENZYMOLOGY	☑	☒	☑	☑	☑	☒	☑	☑
	C-9: IMMUNOLOGY	☑	☒	☑	☑	☑	☑	☑	☑
	C-10: CHEMISTRY-2	☑	☒	☑	☑	☑	☒	☑	☑
	C-13: BIOANALYTICAL TOOL	☑	☒	☑	☑	☑	☑	☑	☑
	DSE: EVOLUTIONARY BIOLOGY	☑	☒	☑	☑	☑	☑	☑	☑
	C12: R-DNA TECHNOLOGY (RDT)	☑	☒	☑	☑	☑	☒	☑	☑
	C14: GENOMICS & PROTEOMICS	☑	☑	☑	☑	☑	☑	☑	☑
	SEC: MOLECULAR DIAGNOSTIC	☑	☒	☑	☑	☑	☒	☑	☑
	DSE: ENVIRONMENTAL BIOTECHNOLOGY	☑	☑	☑	☑	☑	☑	☑	☑
	DSE: PLANT BIOTECHNOLOGY	☑	☑	☑	☑	☑	☑	☑	☑
	DSE: BIOINFORMATICS	☑	☑	☑	☑	☑	☑	☑	☑

Courses Component A										
		C11: BIOPROCESS TECHNOLOGY	☑	☒	☑	☑	☑	☒	☑	☑
		SEC: BASIS OF FORENSIC SCIENCE & IPR	☑	☑	☑	☑	☑	☑	☑	☑
		GE: BIOTECHNOLOGY & HUMAN WELFARE	☑	☒	☑	☑	☑	☒	☑	☑
		GE: DEVELOPMENT BIOLOGY	☑	☑	☑	☑	☑	☑	☑	☑
		GE: BIOETHICS & BIOSAFETY	☑	☒	☑	☑	☑	☒	☑	☑
		GE: ENTREPRENEURSHIP DEVELOPMENT	☑	☒	☑	☑	☑	☒	☑	☑
		SEC: ENZYMOLOGY	☑	☒	☑	☑	☑	☒	☑	☑
Courses Component B		**Language**	☑	☑	☑	☑	☑	☒	☑	☑
		Academic Writing	☑	☑	☑	☑	☑	☑	☑	☑
		Research Writing	☑	☑	☑	☑	☑	☑	☑	☑
		Statistical methods	☑	☒	☑	☑	☑	☒	☑	☑
		EVS	☑	☑	☑	☑	☑	☑	☑	☑
C		**Sports/NSS /NCC/SE/OP (By college)**	☑	☑	☑	☑	☑	☑	☑	☑
D		**Project Work**	☑	☑	☑	☑	☑	☑	☑	☑
Activities of the departme -nt		***Assignment & seminar on advance biology***	☑	☑	☑	☑	☑	☑	☑	☑
		Industrial/laboratory visit	☑	☑	☑	☑	☑	☑	☑	☑

MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(Core)*
Course Code: *.C-1*
Course Title: *Biochemistry & Metabolism*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(Core)*
Course Code: *C-2*
Course Title: *CELL BIOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(Core)*
Course Code: *C-5*
Course Title: *GENETICS*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(Core)*
Course Code: *C-6*
Course Title: *MICROBIOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(Core)*
Course Code: *C-8*
Course Title: *MOLECULAR BIOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(Core)*
Course Code: *C3 & C4*
Course Title: *MAMMALIAN & PLANT PHYSIOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(DSE)*
Course Code: *DSE*
Course Title: *BIOSTATISTICS*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(DSE)*
Course Code: *SEC*
Course Title: *ENZYMOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(Core)*
Course Code: *C9*
Course Title: *IMMUNOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(SEC)*
Course Code: *SEC*
Course Title: *MOLECULAR DIAGNOSTIC*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(Core)*
Course Code: C13
Course Title: *BIOANALYTICAL TOOL*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(DSE)*
Course Code: *DSE*
Course Title: *EVOLUTIONARY BIOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(SEC)*
Course Code: *SEC*
Course Title: *BASIC OF FORENSIC SCIENCE & IPR*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(Core)*
Course Code: C12
Course Title: *RECOMBINANT DNA TECHNOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(CORE)*
Course Code: C7 & C8
Course Title: *CHEMISTRY-1 & 2*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(DSE)*
Course Code: *DSE*
Course Title: *ENVIRONMENTAL BIOTECHNOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(DSE)*
Course Code: *DSE*
Course Title: *PLANT BIOTECHNOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(DSE)*
Course Code:DSE
Course Title: *BIOINFORMATICS*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(Core)*
Course Code: C11
Course Title: *BIOPROCESS TECHNOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(GE)*
Code: *GE*
Course Title: *BIOETHICS AND BIOSAFETY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology

Type of Course: *(GE)*

Code: *GE*

Course Title: *DEVELOPMENT BIOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
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MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(GE)* **Course**
Code: *GE*
Course Title: *BIOTECHNOLOGY & HUMAN WELFARE*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
1	☑	☑	☑	☑	☑	☑	☑	☑
2	☑	☑	☑	☑	☑	☑	☑	☑
3	☑	☑	☑	☑	☑	☑	☑	☑
4	☑	☑	☑	☑	☑	☑	☑	☑
5	☑	☑	☑	☑	☑	☑	☑	☑

MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(GE)* **Course**
Code: GE
Course Title: *ENTREPRENEURSHIP DEVELOPMENT*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
1	☑	☑	☒	☒	☑	☑	☑	☑
2	☑	☑	☒	☒	☑	☑	☑	☑
3	☑	☑	☑	☑	☑	☑	☑	☑
4	☑	☑	☑	☑	☑	☑	☑	☑
5	☑	☑	☑	☑	☑	☑	☑	☑

MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(DSE)*
Course Code: *DSE*
Course Title: *ANIMAL BIOTECHNOLOGY*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
1	☑	☒	☒	☒	☑	☒	☑	☑
2	☑	☒	☒	☒	☑	☒	☑	☑
3	☑	☒	☑	☑	☑	☒	☑	☑
4	☑	☒	☑	☑	☑	☒	☑	☑
5	☑	☑	☑	☑	☑	☒	☑	☑

MATRIX -2
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: Biotechnology
Type of Course: *(CORE)*
Course Code: C*14*
Course Title: *GENOMICS & PROTEOMICS*

PLOs / CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: *Critical thinking, Analysis and Problem Solving*	PLO-6 Understanding the need for sustainable solutions	PLO-7: Development of practical skills	PLO-8: Developing an inclination towards research)
1	☑	☒	☒	☑	☑	☒	☑	☑
2	☑	☒	☒	☑	☑	☒	☑	☑
3	☑	☒	☒	☑	☑	☒	☑	☑
4	☑	☒	☒	☑	☑	☒	☑	☑
5	☑	☒	☒	☑	☑	☒	☑	☑

MATRIX 3
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: BSc in Biotechnology
Course: CORE

Blooms Taxonomy Levels (1-6)	T-L-E modes	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	PLO 1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
1-5	Traditional Lecture Method	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
1-5	Interactive Lecture Method	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
1-6	Group Discussion	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
1-5	Debate	☑	☑	☒	☒	☒	☒	☒	☑	☒	☑	☒	☒	☒
1-4	Experiential Learning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Out-door Experiments	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
4-5	Laboratory Work	☑	☒	☑	☑	☑	☑	☒	☑	☑	☑	☒	☑	☑
	POGIL	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
	Flipped Classroom	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
	Field based studies	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
1-6	Problem Based Learning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Project based Learning	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: BSc in Biotechnology
Course: GENERIC ELECTIVE

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO -1	CLO 2	CLO 3	CLO 4	CLO 5	PLO 1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
1 - 5	Traditional Lecture Method	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
1 - 5	Interactive Lecture Method	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
2 & 4	Group Discussion	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
	Debate	☑	☑	☒	☒	☒	☒	☒	☑	☒	☑	☒	☒	☒
2 & 4	Experiential Learning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Out-door Experiments	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
2, 3, 4, 5	Laboratory Work	☑	☒	☑	☑	☑	☑	☒	☑	☑	☑	☒	☑	☑
1 - 5	POGIL	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
1 - 5	Flipped Classroom	⊟	⊟	⊟	⊟	⊟	☑	☒	☑	☑	☑	☑	☒	☒
2 & 4	Field based studies	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
1 - 5	Problem Based Learning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Project based Learning	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: BSc in Biotechnology
Course: SEC

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO -1	CLO 2	CLO 3	CLO 4	CLO 5	PLO 1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
1-5	Traditional Lecture Method	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
1-5	Interactive Lecture Method	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
1-6	Group Discussion	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
1-5	Debate	☑	☑	☒	☒	☒	☒	☒	☑	☒	☑	☒	☒	☒
1-4	Experiential Learning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Out-door Experiments	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
4-5	Laboratory Work	☑	☒	☑	☑	☑	☑	☒	☑	☑	☑	☒	☑	☑
	POGIL	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
	Flipped Classroom	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
	Field based studies	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
1-6	Problem Based Learning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Project based Learning	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3

MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs

PROGRAMME: BSc in Biotechnology

Course:DSE

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	PLO 1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
1 & 2	Traditional Lecture Method	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
2	Interactive Lecture Method	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
2 & 3	Group Discussion	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☑
3	Debate	☑	☑	☒	☒	☒	☒	☒	☑	☒	☑	☒	☒	☒
2 & 4	Experiential Learning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Out-door Experiments	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2, 3 & 4	Laboratory Work	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	POGIL	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2 & 3	Flipped Classroom	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
	Field based studies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4 & 5	Problem & Project Based Learning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 4

MAPPING ASSESSMENT MODES TO CLOs AND PLOs

PROGRAMME: BSc in Biotechnology Course:

Blooms Taxonomy	T-L-E modes	CLO-1	CLO 2	CLO 3	CLO 4	CL O5	PL O1	PL O2	PL O3	PL O4	PL O5	PL O6	PL O7	PL O8
4	Problem Based Learning	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☒	☑	☑
6	Project based Learning	☑	☑	☒	☒	☒	☑	☒	☑	☑	☑	☒	☑	☑
3	Student Seminars	☑	☑	☒	☒	☒	☑	☒	☑	☑	☑	☒	☑	☑
5	Case Studies	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☒	☑	☑
3	Student Presentations	☑	☑	☒	☒	☒	☑	☒	☑	☑	☑	☒	☑	☑
	Gobbet	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
5	Assignments	☑	☑	☒	☒	☒	☑	☒	☑	☑	☑	☒	☑	☑
5	Open Book Exam	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
4	SAQs	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☒	☑	☑
4	MCQs	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☒	☑	☑
	Portfolio	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
	Concept Maps	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
5	Research Based Analysis	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☒	☑	☑
	Enacting /Roleplay	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟
5	Summative term and exam	☑	☑	☑	☑	☒	☑	☑	☑	☑	☑	☒	☑	☑
4 & 6	Laboratory practical & Research work	☑	☑	☑	☑	☑	☑	☒	☑	☑	☑	☒	☑	☑