DWARAKA DOSS GOVERDHAN DOSS VAISHNAV COLLEGE

(Autonomous)

"College with Potential for Excellence"

(Linguistic Minority Institution),

"Gokulbagh" 833, Periyar E.V.R. Salai,
Arumbakkam, Chennai – 106

Syllabus

For

M.Sc., Biotechnology (2021-2022)

CHOICE BASED CREDIT SYSTEM

OUTCOME BASED EDUCATION (OBE)

PROGRAMME CODE: 025

POST GRADUATE – DEPARTMENT OF BIOTECHNOLOGY

(Applicable for students admitted for the academic year 2021-22)

Department of Biotechnology

ACADEMIC YEAR 2021–2022

I–IV Semesters
SCHEME AND SYLLABUS
CHOICE BASED CREDIT SYSTEM

OUTCOME BASED EDUCATION (OBE)

DWARAKA DOSS GOVERDHAN DOSS VAISHNAV COLLEGE

(Autonomous)
"College with Potential for Excellence"
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Arumbakkam, Chennai – 10611

VISION

To impart value based quality academia; to empower students with wisdom and to charge them with rich Indian traditions and culture; to invoke the self, to broaden the same towards nation building, harmony and Universal brotherhood.

MISSION

To ensure sustained progress and development in imparting quality education, to pioneer new avenues of teaching and research and to emerge as an institution with potential for excellence.

DEPARTMENT OF BIOTECHNOLOGY

VISION

Our vision is to produce competent Biotechnologists with profound expertise, providing a sustainable competitive edge to the present society with their entrepreneurial skills.

MISSION

M1	To impart highly innovative and technical knowledge in the field of biotechnology.
M2	To create opportunities for multi-disciplinary education, training and research in biotechnology.
M3	To expand the scope of Industry -Academia interaction towards commercialization of bio products.

PROGRAM EDUCATION OBJECTIVES (PEOs)

Master Graduates will be

PEO1	Will be able to demonstrate technical and theoretical knowledge in the field of biotechnology entailed for their professional career, upholding social and ethical responsibilities.
PEO2	Will exhibit ability to pursue higher studies and research careers in interdisciplinary areas of biotechnology.
PEO3	Will demonstrate excellent communication and innovative abilities equipped with entrepreneurship skills for the contribution of self and national development.
PEO4	Will possess the insights required for the continuous improvement of self-knowledge through constant learning and attributes of an effective team leader in the global environment.
PEO5	Will be able to address the increasing demand of skillful scientific manpower in the field of biotechnology and its associated fields.

PEO TO MISSION STATEMENT MAPPING

MISSION STATEMENTS	PEO1	PEO2	PEO3	PEO4	PEO5
M1	3	3	1	2	2
M2	3	3	2	2	3
M3	2	3	3	2	3

CORRELATION: 3- STRONG 2- MEDIUM 1- LOW

PROGRAM OUTCOMES (PO) IN RELATION TO GRADUATE ATTRIBUTES

PROGRAMME OUTCOMES

At the completion of the M.Sc. Biotechnology program, the students of our Department will be able to:

PO1	To attain suitable scientific knowledge and technical skills to realize, calibrate and develop innovative processes / skills for creation of inventive products which are beneficial to society.
PO2	To implement discipline, professionalism, team spirit, communication skills, social and ethical commitment in the post graduates in order to embellish leadership roles expediting perfection in different sector with a categorical professional distinctiveness, business savvy, international recognition and imperishable expansion
PO3	To be habituated with the emerging expanses of erudition and their applications in several domains of biological sciences and to enlighten the students of its relevance in forthcoming studies
PO4	To enhance the insight of research-oriented knowledge in conjunction with literature survey, design of experimental methodology, analysis and interpretation of results and draw valid conclusions.
PO5	To provoke entrepreneurship among the students along with strong ethics and communication skills
PO6	To engage in Lifelong learning and enduring proficient progress

Mapping of POs TO PEOs

PEO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
PEO 1	3	3	1	3	3	2
PEO 2	3	3	1	3	3	2
PEO 3	2	3	2	3	1	1
PEO 4	3	1	3	3	2	3
PEO 5	2	3	2	3	3	3

3-Strong Correlation 2- Medium Correlation 1- Low Correlation

PROGRAM SPECIFIC OUTCOMES

PSO1	Understand the core concepts, principles, applications, recent and emerging developments in biotechnology and its associated fields.
PSO2	Master various techniques and apply them at different areas of life science for the professional career, higher education and entrepreneurship development.
PSO3	Possess contemporary knowledge in the field of biotechnology and ability to ascertain different career options in biotechnology and its related domains.
PSO4	Acquire fundamental thinking to converse scientific ideas effectively in oral, visual and written, solve research problems, design and execute experiments, analyze and interpret data using statistical tools and draw suitable conclusion for the research objective.
PSO5	Familiarize with the essential knowledge on global environmental concern, ethical issues pertaining to the field of biotechnology and will uphold commitment and responsibilities of a biotechnologist.

DWARAKA DOSS GOVERDHAN DOSS VAISHNAV COLLEGE

(Autonomous)

DEPARTMENT OF BIOTECHNOLOGY

(CHOICE BASED CREDIT SYSTEM)

M. Sc., BIOTECHNOLOGY

ELIGIBILITY FOR ADMISSION

A Candidate with a Bachelor's Degree in Science in the disciplines of Biotechnology, Biology, Botany, Zoology, Microbiology, Genetics, Chemistry, Biochemistry, Physics, Agriculture as a main subject from this University or B.E/ B.TECH (Biotechnology), B.V.Sc, MBBS, BDS or an examination of some other University accepted by the Syndicate as equivalent thereto shall be for the M.Sc. Degree Examination of this University.

DURATION OF THE COURSE

The minimum duration for completion of a two-year Master Programme in any subject is four semesters. The maximum period for completion is Ten semesters. An academic year consists of two semesters. Odd Semester (I and III Semesters): July to November Even Semester (II and IV Semesters): December to April. A semester normally extends over a period of 15 weeks (90 days).

M.Sc. BIOTECHNOLOGY CURRICULUM

The postgraduate programmes are designed in such a manner that students are exposed to both different basic and applied concepts of the subject. The core main subject includes, Biochemistry, Microbiology, Immunology & Immunotechnology, Molecular Cell Biology, Animal Biotechnology, Plant Biotechnology, Environmental biotechnology, Genetic Engineering, Bioprocess Technology, Bioinformatics, Enzymes & Enzyme Technology, Extradisciplinary courses includes Pharmaceutical biotechnology and Research Methodology, Bioethics & Biostatistics, Elective course includes, Molecular Genetics, Ecology, Evolution and Behaviour, Developmental Biology, Forensic science, Marine Biotechnology, DNA Barcoding technology, Animal and Plant physiology, Clinical trials, Stem cell biology, Advanced Molecular techniques, Nanobiotechnology and Tissue Engineering.

INTERNSHIP & DISSERTATION

Internship is intended to gain practical knowledge related to the study. The duration is for 4-6 weeks for 2 credits and it should be carried out in an organization recommended by the Department during the summer vacation of the first year. A report must be prepared and submitted to the HOD concerned for evaluation and grading; based on the report the 2 credits will be awarded.

As part requirement for the award of postgraduate degree, a project culminating in the submission of a dissertation must normally be carried out by students in their final semester of study. At the end of the final semester, dissertation/project report must be prepared and submitted to the department for evaluation and grading. The dissertation/project will be evaluated for 100 marks, 50 for external evaluation and 50 marks for the continuous assessment.

ELIGIBILITY FOR THE AWARD OF DEGREE

A candidate shall be eligible for the award of the degree only if he/she has undergone the prescribed course of study in the college for a period of not less than two academic years, passed the examination of all the four semesters prescribed earning minimum of 91 credits and fulfilled such conditions as have been prescribed there for.

ATTENDANCE & EVALUATION

- A candidate who has less than 75% attendance shall not be permitted to write the end-semester examination in the course in which the shortfall exists.
- Evaluation will be done by continuous internal assessment throughout the course. Each semester will have minimum two CIA tests, followed by one generic skill. End-semester examination will be conducted at the end of each semester.
- A candidate has to secure a minimum of 50 percent of marks (inclusive Two CIA Tests marks, generic skills & End- Semester examination mark) in each paper.
- A candidate should have passed also in soft skills for successful completion of the course.

EXAMINATION

- There shall be one End-semester examination of 3 hours duration carrying 100% of marks in each course covering the entire syllabus prescribed for the course. The End semester examination is normally a written/laboratory-based examination.
- For theory examinations, each course carries 100 marks, 50 marks (ESE) for final examination and 50 marks as continuous internal assessment (CIA). Similarly, for practical examinations, each course carries 100 marks, 50 for external evaluation and 50 marks for the continuous assessment. And the soft skill examination carries 100 marks, 50 for external evaluation and 50 marks for the continuous assessment.

Credit distribution

S.No	Semester	No of credits
1	I	25
2	II	27
3	III	25
4	IV	14
Total no of credits		**91**

Subjects	**Papers**	**Credits**	**Total credits**
Core	11	4	44
Elective	4	3	12
Open Elective	1	3	03
Extra Disciplinary	2	3	06
Core Practical's	5	2	10
Soft skill	4	2	08
Project		4	06
Mini project/Summer internship		2	02
Total no of credits			**91**

Question paper Pattern-Theory Maximum marks (100)

Section - A	Answer all the 10 Questions (10 x 2= 20 marks)
Section – B	Answer the 5 Questions in either/or pattern choice (5 x 7 = 35 marks)
Section - C	Answer all the Questions [Q. NO: 16 is compulsory] (3 ×15 = 45 marks)

SCHEME ON EXAMINATIONS

As per the University Regulation the following split up of marks for Theory, practical and project are to be followed.

(i) SPLIT UP FOR INTERNAL AND EXTERNAL MARKS FOR THEORY AND PRATICAL PAPER:

Sl. No.	Paper	Internal	External	Total
1.	Theory	50	50	100
2.	Practical	50	50	100

(ii) SPLIT UP FOR INTERNAL ASSESSMENT MARKS (50) FOR THEORY:

CIE- Continuous Internal Evaluation (50 Marks)

Bloom's Category	Tests	Attendance	Generic skills
Marks (out of 50)	**30**	**5**	**15**
Remember	2		
Understand	2		
Apply	2		3
Analyze	6		3
Evaluate	9		3
Create	9		6

ESE- Semester End Examination (100 Marks; weightage 50%)

Bloom's Category	Weightage %
Remember	10
Understand	10
Apply	14
Analyse	22
Evaluate	29
Create	15

DEPARTMENT OF BIOTECHNOLOGY

SCHEME OF FIRST SEMESTER M.SC., PROGRAM

Sl. NO	Course Code	Course	BOS	Credit Distribution				Over all Credits	Marks		
				L	P	T	S		CIA	ESE	Total
1.		Core Paper-1 Biochemistry	BT	4	0	0	0	4	50	50	100
2.		Core Paper-2 Molecular Cell Biology	BT	4	0	0	0	4	50	50	100
3.		Core Paper-3 Microbiology	BT	4	0	0	0	4	50	50	100
4.		Core Paper-4 Immunology	BT	4	0	0	0	4	50	50	100
5.		Elective Paper – 1A* Molecular Genetics	BT	4	0	0	0	3	50	50	100
		Elective Paper – 1B* Ecology, Evolution and Behavior	BT	4	0	0	0	3	50	50	100
		Elective Paper – 1C* Developmental Biology	BT	4	0	0	0	3	50	50	100
6.		Core Practical - I Biochemistry and Molecular Cell Biology	BT	0	5	0	0	2	50	50	100
7.		Core Practical - II* Microbiology, Immunology and Immunotechnology	BT	0	5	0	0	2	50	50	100
8.		Soft Skill – I						2	50	50	100
	Total							25	400	400	800

* Any one elective paper should be chosen by the candidate.

DEPARTMENT OF BIOTECHNOLOGY

SCHEME OF SECOND SEMESTER M.SC., PROGRAM

Sl. NO	Course Code	Course	BOS	Hour Distribution				Over all Credits	Marks		
				L	P	T	S		CIA	ESE	Total
1.		Core Paper-5 Animal Biotechnology	BT	4	0	0	0	4	50	50	100
2.		Core Paper-6 Plant Biotechnology	BT	4	0	0	0	4	50	50	100
3.		Core Paper-7 Environmental Biotechnology	BT	4	0	1	0	4	50	50	100
4.		Extra Disciplinary – 1 Pharmaceutical Biotechnology	BT	3	0	1	0	3	50	50	100
5.		Elective Paper – 2A* Forensic Science	BT	3	0	1	0	3	50	50	100
		Elective Paper – 2B* Marine Biotechnology	BT	3	0	1	0	3	50	50	100
		Elective Paper – 2C* DNA Barcoding Technology	BT	3	0	1	0	3	50	50	100
6.		Elective Paper – 3A* Animal and Plant Physiology	BT	3	0	1	0	3	50	50	100
		Elective Paper – 3B* Clinical Trials	BT	3	0	1	0	3	50	50	100
		Elective Paper – 3C* Stem cell Biology	BT	3	0	1	0	3	50	50	100
7.		Core Practical - III Animal Biotechnology, Plant Biotechnology and Environmental Biotechnology	BT	0	6	0	0	2	50	50	100
8.		Soft Skill – II						2	50	50	100
		Mini project/Internship*	BT					2			
	Total							27	400	400	800

Mini project/ Internship*

* Summer Internship/ Mini project will be carried out during end of the first year for at least 4-6 weeks duration in any industry and institutes. Credits will be included in third Semester mark statement.

* Any one elective paper should be chosen by the candidate

DEPARTMENT OF BIOTECHNOLOGY

SCHEME OF THIRD SEMESTER M.SC., PROGRAM

Sl. NO	Course Code	Course	BOS	Hour Distribution				Over all Credits	Marks		
				L	P	T	S		CIA	ESE	Total
1.		Core Paper-8 Genetic Engineering	BT	4	0	0	0	4	50	50	100
2.		Core Paper-9 Bioprocess Technology	BT	4	0	0	0	4	50	50	100
3.		Core Paper-10 Bioinformatics	BT	4	0	0	0	4	50	50	100
4.		Core Paper-11 Enzymes & enzyme Technology	BT	4	0	0	0	4	50	50	100
5.		Elective Paper – 4A* Advanced Molecular techniques	BT	4	0	0	0	3	50	50	100
		Elective Paper – 4B* Nano Biotechnology	BT	4	0	0	0	3	50	50	100
		Elective Paper – 4C* Tissue Engineering	BT	4	0	0	0	3	50	50	100
6.		Core Practical - IV Genetic Engineering and Bioprocess Technology	BT	0	5	0	0	2	50	50	100
7.		Core Practical - V Bioinformatics and Enzymes & enzyme Technology	BT	0	5	0	0	2	50	50	100
8.		Soft Skill – I						2	50	50	100
	Total							25	400	400	800

Core Practical - IV & V* - Examination will be conducted during the end of the even semester.

DEPARTMENT OF BIOTECHNOLOGY

SCHEME OF FOURTH SEMESTER M.SC., PROGRAM

Sl. NO	Course Code	Course	BOS	Hour Distribution				Over all Credits	Marks		
				L	P	T	S		CIA	ESE	Total
1.		Extra Disciplinary – 2 Research Methodology, Bioethics & Biostatistics	BT	5	0	0	0	3	50	50	100
2.		Open Elective – 1 Herbal Technology	BT	5	0	0	0	3	50	50	100
3.		Project dissertation & Viva voce	BT	0	15	0	0	6	50	50	100
4.		Soft Skill – IV						2	50	50	100
	Total							14	200	200	400

Course of Study and Scheme of Examination – First Semester

S. No.	Course Components	Name of Course	Semester	Inst. Hrs	Credits	Exam Hrs	Max. Marks	
							CIA	External
1.	Core Paper – 1	Biochemistry	I	4	4	3	50	50
2.	Core Paper – 2	Molecular Cell Biology	I	4	4	3	50	50
3.	Core Paper – 3	Microbiology	I	4	4	3	50	50
4.	Core Paper – 4	Immunology & Immunotechnology	I	4	4	3	50	50
5.	Elective Paper – 1A*	Molecular Genetics	I	4	3	3	50	50
	Elective Paper –1B*	Ecology, Evolution and Behavior	I	4	3	3	50	50
	Elective Paper – 1C*	Developmental Biology	I	4	3	3	50	50
6.	Core Practical – I	Biochemistry and Molecular Cell Biology	I	5	2	6	50	50
7.	Core Practical – II	Microbiology, Immunology and Immunotechnology	I	5	2	6	50	50
8.		Soft Skill – I	I		2	3	50	50
	Total Credits: 25							

Second Semester

S. No.	Course Components	Name of Course	Semester	Inst. Hrs	Credits	Exam Hrs	Max. Marks	
							CIA	External
1.	Core Paper – 5	Animal Biotechnology	II	4	4	3	50	50
2.	Core Paper – 6	Plant Biotechnology	II	4	4	3	50	50
3.	Core Paper – 7	Environmental Biotechnology	II	4	4	3	50	50
4.	Extra Disciplinary – 1	Pharmaceutical Biotechnology	II	4	3	3	50	50
5.	Elective Paper – 2A*	Forensic Science	II	4	3	3	50	50
	Elective Paper – 2B*	Marine Biotechnology	II	4	3	3	50	50
	Elective Paper – 2C*	DNA Bar Coding Technology	II	4	3	3	50	50
6.	Elective Paper – 3A*	Animal and Plant Physiology	II	4	3	3	50	50
	Elective Paper – 3B*	Clinical Trials	II	4	3	3	50	50
	Elective Paper – 3C*	Basics in stem cell Biology	II	4	3	3	50	50
7.	Core Practical – III	Animal Biotechnology, Plant Biotechnology and Environmental biotechnology	II	6	2	6	50	50
8.		Soft skill – II	II		2	3	50	50
9.		Mini project/Internship*	II		2			
		* Summer Internship/ Mini project will be carried out during end of the first year for at least 4 – 6 weeks duration in any industry and institution. The credits will be included in the third semester mark statement						
Total credits: 27								

Third Semester

S. No.	Course Components	Name of Course	Semester	Inst. Hrs	Credits	Exam Hrs	Max. Marks	
							CIA	External
1.	Core Paper – 8	Genetic Engineering	III	4	4	3	50	50
2.	Core Paper – 9	Bioprocess Technology	III	4	4	3	50	50
3.	Core Paper – 10	Bioinformatics	III	4	4	3	50	50
4.	Core Paper – 11	Enzymes & enzyme Technology	III	4	4	3	50	50
5.	Elective Paper – 4A*	Advanced Molecular techniques	III	4	3	3	50	50
	Elective Paper – 4B*	Nano Biotechnology	III	4	3	3	50	50
	Elective Paper – 4C*	Tissue Engineering	III	4	3	3	50	50
6.	Core Practical – IV	Genetic Engineering and Bioprocess Technology	III	5	2	6	50	50
7.	Core Practical – V	Bioinformatics and Enzymes & enzyme Technology	III	5	2	6	50	50
		Soft Skill – III	III		2	3	50	50
Total Credits : 25								

Fourth Semester

S. No	Course Component	Name of Course	Semester	Inst. Hrs	Credits	Exam Hrs	Max. Marks	
							CIA	External
1.	Extra Disciplinary – 2	Research Methodology, Bioethics & Biostatistics	IV	5	3	3	50	50
2.	Open Elective – 1	Herbal Technology	IV	5	3	3	50	50
3.	Core Paper	Project dissertation & Viva voce	IV	15	6		50	50
4.		Soft Skill – IV	IV		2	3	50	50
Total Credits : 14								

Subjects	Papers	Credits	Total credits
Core	11	4	44
Elective	5	3	15
Extra Disciplinary	2	3	6
Core Practicals	5	2	10
Soft skill	4	2	08
Project		4	06
Mini project/Summer internship		2	02
Total no of credits			**91**

First Semester

Course Title: Biochemistry: Core Paper: 1

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

This course would enable students to learn about composition, structure and functions of biomolecules, to understand about various metabolic pathways, to analyze and understand the chemical and biochemical properties of bio molecules and the significance of chemistry of Biomolecules and their vital role in Biological systems.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Classify and analyze the structure, composition and function of biomolecules and gain knowledge on the acidity and alkalinity of the biological buffer systems; able to apply the principles of thermodynamics in the reactions involving high energy compounds
CO2	Illustrate the metabolic pathways of macromolecules such as carbohydrates.
CO3	Sketch the metabolic pathway of fatty acids and the structure of biological membrane and summarize the transport of ions across the membrane
CO4	Integrate the synthesis and degradation of protein metabolism and gain insights on the cell signaling pathways and hormonal regulation of mammalian metabolism
CO5	Discuss the metabolism of nucleic acids and recommend the type of analytical technique for the separation and purification of biomolecules

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	1	1	3	2	1	2	3	2	3	1	2
CO 2	1	1	3	2	1	2	2	2	3	1	1
CO 3	1	1	3	2	1	2	2	2	3	2	1
CO 4	1	1	3	2	1	2	2	2	3	1	2
CO 5	1	1	3	2	1	2	2	2	3	1	1

Course Title: Biochemistry; Core Paper: 1

Sl. No	CONTENTS OF MODULE	Hrs	Cos
1.	pH, pKa, acids, bases, weak bonds, Biological buffer system, Principles of Thermodynamics, High Energy compounds. Overview of biomolecules: Structure, Properties, Classification and functions of Carbohydrates, Lipids, Amino acids, Proteins, Purines and Pyrimidines.	**12**	**CO1**
2.	Carbohydrate Metabolism - Glycolysis, citric acid cycle, Electron Transport Chain, Oxidative phosphorylation. Photophosphorylation. Pentose phosphate pathway, Gluconeogenesis, Glycogenesis and Glycogenolysis.	12	**CO2**
3.	Oxidation of Fatty acid- α, β and ω Oxidation of fatty acids. Lipid peroxidation. Cholesterol - Biosynthesis, regulation, transport and excretion. Ketone bodies. Biological membrane and transport.	12	**CO3**
4.	Structure of protein – Primary, Secondary, Tertiary and Quaternary. Characterization of protein, Ramachandran plot, Chemical synthesis of peptide. Transamination, Deamination and Urea cycle. Study of specific proteins like Hemoglobin and Myoglobin.	12	**CO4**
5.	Nucleic acid Metabolism- Biosynthesis and degradation of purine and pyrimidine nucleotides and its regulation-De Novo and salvage pathway Disorders of nucleotide metabolism- Gout. Separation Methods: Chromatography: Principle, Instrumentation, Procedure and Applications of Paper chromatography and Thin layer chromatography.	12	**CO5**

Text Books:	
1.	Nelson David L, Cox Michael M, L. Lehninger Albert L. (2017). *Lehninger Principles of Biochemistry,* (7th ed.), W.H. Freeman publishers, New York, ISBN: 9781319150877.
2.	Satyanarayana. U, Chakrapani. U (2019). *Essentials of Biochemistry,* (3rd ed.), Books & Allied Pvt Ltd., ISBN: 9788193897492.
3.	Victor Rodwell .W., David Bender A., Kathleen Botham M, Peter Kennelly J, Anthony Weil P. (2018). *Harper's Illustrated Biochemistry,* (31st ed.), Overruns Publisher, ISBN: 9781259837937.

Reference Books:	
1.	Donald Voet, Judith Voet G. (2010). *Biochemistry,* (4th ed.), New Jersey, John Wiley & Sons, Inc., ISBN: 978-0-470-57095-1.
2.	Jeremy Berg M, John Tymoczko L, Lubert Stryer (2011). *Biochemistry,* (7th ed.), Palgrave MacMillan, ISBN: 9781429276351.

Course Title: Molecular Cell Biology- Core Paper: 2

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

The course emphasizes conceptual appreciation of the molecular interplays which are the basis of "chemical processes" in living systems. The objective of the course is to provide students with a comprehensive and concise overview of biological science with emphases on its relationship with biotechnology and to understand the functions of macromolecules in molecular level. Molecular cell biology from molecular structure, gene regulation to protein function will be presented from biotechnology perspectives.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Determine the structure of cell organelles and biomolecules and discuss the dynamics of cell components
CO2	Demonstrate the different kinds of microscopy, hybridization techniques and DNA microarray.
CO3	Revise the structure and functions of Nucleic acids & genome organization.
CO4	Explain the replication, regulation, signaling and pathways of eukaryotic cell.
CO5	Discuss the regulation of cell cycle check points and compare the genes involved in cancer.

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	1	1	1	1	2	1	3	3
CO 2	2	1	1	1	1	1	1	2	3	2	1
CO 3	2	1	1	1	1	1	1	3	2	1	2
CO 4	2	1	2	2	1	1	1	2	2	2	2
CO 5	2	1	2	3	1	1	1	3	3	2	2

Course Title: Molecular Cell Biology- Core Paper: 2

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	The cell dynamics; structure and function of eukaryotic organelles (mitochondria, chloroplast, nucleus, golgi apparatus, lysosome, ribosome and cytoskeleton); biomembranes structure; extracellular matrix. Microfilaments – actin structure and assembly, myosin and molecular motors; intermediate filaments; microtubulins -structure and dynamics.	**12**	**CO1**
2	Principles of microscopy-bright field, phase contrast, Fluorescence, electron (TEM, SEM &tunneling SEM); hybridization-FISH, flowcytometry; DNA Microarray, Microtome and its types and Histochemical methods – Histochemistry of proteins, carbohydrates and lipids, cell fractionation.	**12**	**CO2**
3	Structure of nucleic acids and its types, the genetic code, co-linearity of gene and polypeptides; genome organization in eukaryotes, chromosome and chromatin structure.	**12**	**CO3**
4	DNA replication, transcription in prokaryotes and eukaryotes; post and co-transcriptional modification; translation in prokaryotes and eukaryotes, post translational modification; transcriptional and translational controls; protein sorting and secretion; protein folding and degradation; regulation of gene expression in prokaryotes and eukaryotes.	**12**	**CO4**
5	Molecular basis of eukaryotic cell cycle; regulation of cell cycle check points; cell-cell signaling; signal transduction pathways; mitogens and oncogenes; proto oncogenes and tumor suppressor genes-Rb, p53; apoptosis.	**12**	**CO5**

Text Books:	
1.	T. Fleming (2002). *Cell-Cell interactions: A practical approach*, (2nd Edition), Oxford University Press, ISBN: 978-0199638635.
2.	Karp, Gerald (2013). *Cell and molecular biology: concepts and experiments*, (7th edition), John Wiley & Sons, ISBN: 978-1-118-88614-4.
3.	Lodish, H., Berk, S., Zipursky, S.L., Matsudaria, P., Baltimore, D. and Darwell, J. (2016). *Molecular Cell Biology*, (8th edition), W.H. Freeman and company, ISBN: 0-7167-3136-3.

Reference Books:	
1.	Bruce Alberts, Alexander Johnson Julian Lewis, Martin Raff, Keith Roberts (2014). *Molecular Biology of The Cell*, (6th Edition), UK, Garland Science, ISBN: 0-8153-4072-9.
2.	Geoffrey. M. Cooper, Robert, E. Hausman (2007). *The cell –A molecular approach*, (4th Edition), United States, Sinauer Associates, ISBN: 978-0878930500.

Course Title: Microbiology- Core Paper: 3

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

To indulge students with basic knowledge about the history and the importance of microbiology, to learn about the microorganisms to evolve, survive and to control infections. Elaborate study about the common most pathogenic microbes and its virulence factors would equip the students about the general cause of most of the diseases.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Understand the historical perspective of modern microbiology and describe the morphological features of prokaryotic and eukaryotic cells.
CO2	Identify and compare the applications of various microscopic techniques.
CO3	Compare the effectiveness of moist heat, dry heat, filtration on controlling the microbial growth.
CO4	Describe the mechanism of action of various antimicrobial agents against different microorganisms.
CO5	Able to identify the virulence factor that contributes to the pathogenicity of various microorganisms
CO6	Correlate the beneficial and harmful effects of different types of microbes for the human mankind

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	1	1	1	2	2	2	3	2
CO 2	1	1	2	3	1	1	2	2	3	3	1
CO 3	3	1	2	1	2	1	2	2	3	3	1
CO 4	2	1	1	3	1	1	2	2	2	3	1
CO 5	1	1	1	3	2	1	2	2	2	3	1
CO 6	1	1	1	3	2	1	2	2	2	3	1

Course Title: Microbiology-Core Paper: 3

Sl. No	CONTENTS OF MODULE	Hrs	Cos
1.	Introduction and History of Microbiology - Spontaneous generation, Biogenesis, Golden era of microbiology, Germ Theory of Disease, Koch's Postulates; Classification of microorganisms: Whittaker's five kingdom concept; Structure and function of prokaryotic and eukaryotic cells	**12**	**CO1**
2.	Microscopy and its applications: Bright filed microscopy; Dark Field microscopy and Phase contrast Microscopy: Growth media and pure culture techniques; Bacterial growth - Bacterial Division, Generation Time, Growth curve and its phases; Direct and Indirect measurement of Microbial Growth; Factors affecting the growth of bacteria - nutrition, temperature and pH.	**12**	**CO2**
3.	Microbial growth control: Physical Methods – Heat, Filtration, Low Temperatures, High Pressure, Desiccation, Osmotic Pressure, Radiation; Chemical Methods - Types of Disinfectants; Anti-microbial agents: Mechanism of action - Inhibiting Cell Wall Synthesis, Protein Synthesis, Nucleic Acid synthesis, Essential Metabolites, injuring the Plasma Membrane; Common antibacterial, antifungal, antiviral, Antiprotozoan and Antihelminthic Drugs; Resistance to antibiotics.	**12**	**CO3**
4.	General characteristics of Algae, fungi, and virus. Microbial pathogenic mechanism: Pathogenic Properties of bacteria - Capsules - Cell Wall Components - Enzymes – Antigenic Variation - Penetration into the Host – Biofilms – toxin; Pathogenic Properties of Viruses - Viral Mechanisms for Evading Host Defenses - Cytopathic Effects - Pathogenic Properties of Fungi, Protozoa, Helminths, and Algae	**12**	**CO4**
5.	Normal microbial flora of human; Microbial diseases - General characteristics, pathogenesis, laboratory diagnosis and control measures of bacterial disease - tuberculosis, cholera; viral diseases - Hepatitis, HIV; Parasitic disease - Entamoebiasis: Fungal disease: candidiasis; Important role of Endotoxin and Bioburden analysis in pharma industry	**12**	**CO5**

Text Books:	
1.	Ananthanarayan and Paniker's (2017) *Textbook of Microbiology*, (10th edition), The Orient Blackswan, ISBN: 978-9386235251.
2.	Gary W. Procop, Elmer W. Koneman, (2016). *Color Atlas and Textbook of Diagnostic Microbiology*, (7th edition), Lippincott Williams and Wilkins, ISBN:978-1451189353.
3.	D K Maheshwari, R C Dubey, (2013). *A Textbook of Microbiology*, (4th edition), S Chand Publishing, ISBN:978-8121926201.

Reference Books:	
1.	Gerard J Tortora and Berdell R Funke and Christine L Case, (2016). *Microbiology - An Introduction*, (11th Edition), Pearson Publishers, ISBN: 978-0321796677.
2.	Joanne Willey, Linda Sherwood, Christopher J. Woolverton, (2017). *Prescott's Microbiology*, (10^{th} edition), McGraw-Hill Education, ISBN: 978-1259281594.

Course Title: Immunology & Immunotechnology- Core Paper: 4

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

The course content imparts knowledge on the immune system and its biological functions about each cell type which in turn indulges the students in acquiring knowledge about the foreign and native substances, innate and acquired immunity and the immunotechniques.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Classify different types of immunity, cells and lymphoid organs and their protective role in immune system.
CO2	Outline the properties of antigens and antibody, and theories of antibody formation. Explains the pathways of complement system. Apply concepts of Hybridoma technology for the production of monoclonal antibody
CO3	Gain insights on cell mediated and antibody mediated immune response, different methods of extraction and purification of antigens and antibodies.
CO4	Exhibit knowledge in immune specific diseases- Hypersensitivity and auto immunity. Understand the immune response produced in tumors and transplantation.
CO5	Enumerate the various immunological techniques and its applications. Debate the importance of vaccines technology over the current trend of vaccine production

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	2	1	1	2	2	3	2	1
CO 2	1	1	2	1	2	1	2	2	3	2	1
CO 3	2	1	1	1	1	1	2	2	3	2	1
CO 4	2	1	1	2	1	1	2	2	3	2	1
CO 5	1	1	2	2	1	1	2	2	3	2	1

Course Title: Immunology & Immunotechnology - Core Paper: 4

Sl. No	CONTENTS OF MODULE	Hrs	Cos
1.	Introduction to Immunology- Overview and historic perspectives, Components of immunity- Innate and Adaptive immunity, Cells of the immune system- Neutrophils, Eosinophils, Mastcells, Macrophages, T& B lymphocytes, Dendritic cells, Natural killercells and Lymphokine activated killer cells – structure and functions. Primary Lymphoid organs: Bone marrow & thymus, Secondary lymphoid organs-Spleen, lymph nodes and MALT.	**12**	**CO1**
2.	Antigens and immunogenicity, epitope, haptens, adjuvants, properties and types of antigens, Histocompatible antigens and antigens receptors. Immunoglobulins- Structure, classes, properties and functions, Theories of antibody formation –Clonal selection theory, Structural basis of antibody diversity, Hybridoma and monoclonal antibody production and its applications. Complement- components, nomenclature, classical, lectin and alternate pathways and its biological effects.	12	**CO2**
3.	Immune response-Antigen processing and presentation through MHC I and II,T cell receptors, activation and differentiation of T cells – Cell mediated response. B cell receptor, activation and differentiation of B cells- Antibody mediated immune response. Antigen- Isolation, purification and characterization of various antigens and haptens from pathogens. Production, purification and characterization of antibodies.	12	**CO3**
4.	Hyper sensitivity- Types of immediate and delayed hypersensitive reactions – mechanism. Auto immunity- mechanism, organ specific and nonorgan specific auto immune diseases, Transplantation immunology- Graft versus host reactions, HLA typing, Immune tolerance and immune suppression. Tumor Immunology- Immune response to tumors.	12	**CO4**
5.	Antigen and antibodies interactions- affinity- avidity--cross reactivity Precipitations (SID & DID) and agglutination reactions, complement fixation tests, Radio immunoassay, ELISA, Immunofluorescence, western blot, FACS, Immuno electrophoresis, and Immuno blotting. Vaccine technology including DNA vaccines, recombinant, multi subunit vaccines – production and applications.	12	**CO5**

Text Books:	
1.	Weir DM., Herzenberg LA, Blackwell C (1989). *Handbook of Experimental Immunology,* Black well Scientific Publication, Oxford, ISBN: 9780632009756.
2.	Abdul K, Abbas, Andrew Lichtman, Shiv Pillai (2014), *Cellular and Molecular Immunology,* (8^{th} edition), Elsevier, ISBN: 9780323479783.
3.	Janeway Travers, (2009). *Immunobiology, (7th edition),* IUBM Inc., ISBN: 978-0815345053.

Reference Books:	
1.	Jenni Punit, Sharon Stranford, Patricia Jones, Judith A Owen (2018). *Kuby Immunology,* (8th edition), ISBN: 978-1464189784.
2.	David Male, Jonathan Brostoff, David Roth, Ivan Roitt (2006). *Immunology,* (7^{th} edition), Black well Scientific Publications, ISBN: 978-0323080583.

Course Title: Molecular Genetics Elective Paper: 1A

Course Code :	**Credits : 03**
L:T:P:S : 3:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

The syllabus focuses the study of genetic material, the gene as a unit of recombination, mutation. It concentrates on branches like Mendelian (classical or transmission) genetics which helps to understand how traits are inherited and to use this understanding in analyses (to solve problems and complete pedigrees) Linkage, Crossing over and population genetics. The subject helps them to understand the inheritance pattern by the way of studying in-depth about the role of genes, its linkage process, and the way of transmission for several generations.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Analyze the structure and functional aspects of genes and their contribution in evolution of genomes and to identify the DNA as the genetic material.
CO2	To acquire a strong foundation of Mendelian genetics and the laws of Mendelian inheritance and solve basic Mendelian and non - Mendelian genetics problems.
CO3	Assess the strength of mutations in genetic evolution and to identify the correlation between mutagenesis and carginogenesis.
CO4	Explain the significance of transposons in evolution and the fundamental aspects of plasmids that enable their exploitation in genetic engineering strategies.
CO5	Comprehensive and in-depth vision of inbreeding, Genome evolution, population variation, speciation and natural selection.

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	1	1	1	1	3	1	1	1	1
CO 2	2	1	1	1	1	1	3	1	1	1	1
CO 3	1	1	1	3	1	2	3	1	2	1	1
CO 4	3	1	1	2	1	1	3	1	2	1	1
CO 5	2	1	1	1	1	1	3	1	2	1	1

Course Title: Molecular Genetics Elective Paper: 1A

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Genetic Basis-** Structure and types of DNA and RNA, Fine structure of the gene: cistron, muton and recon; Complexity of eukaryotic genome - introns, exons repetitive DNA, gene duplication and pseudogenes, organellar DNA. Identification of DNA as the genetic material –Experiments of Griffith; Avery, Macleod and Mc Carthy; Hershey and Chase; RNA as the genetic material –Experiments of Fraenkel and Singer.	**9**	**CO1**
2	**Mendelian genetics** – monohybrid and dihybrid cross, test and back cross, laws of Mendel, interaction of genes during inheritance. Gene mapping: Linkage and crossing over, two-point and three-point test cross, calculation of map distances, Tetrad analysis; Mapping genes in human chromosome.	**9**	**CO2**
3	**Mutations and Polymorphism**s- Definition and types of mutations-point, reverse and suppressor mutations, spontaneous and induced, physical and chemical Mutagens. Correlation between mutagenicity and carcinogenicity. Polymorphism and Chromosomal abnormalities.	**9**	**CO3**
4	**Transposons-** Transposable elements in bacteria- IS elements and Tn3 family. Transposons in maize and Drosophila, retro transposons. Plasmids- Definition, types, replication, copy number and maintenance of plasmids and its significance.	**9**	**CO4**
5	**Developmental and population genetics-** Allele frequencies and genotype frequencies, the Hardy-Weinberg law, genetic variations, systems of mating, inbreeding, genetics and evolution, mutation and migration, random genetic drift and natural selection.	**9**	**CO5**

Text Books:

1. Peter J. Russel (2010). *igenetics-A molecular approach*, (3rd edition), Pearson education, ISBN: 978-0321772886.

2. Garden, Simmons and Snustad (2005). *Principles of Genetics*, (8th edition), John Wiley & Sons, ISBN: 978-9971513467.

Reference Books:

1. Benjamin A. Pierce Freeman (2005). *Genetics- A conceptual approach*, (2nd edition), W.H. Freeman, ISBN: 978-1319216801.

2. Robert J. Brooker (2017). *Genetics –Analysis and Principles*, (6 edition), McGraw-Hill Education, ISBN: 9781259616020.

3. Anthony J.F. Griffiths, William M. Gilbart, Jeffery H. Miller and Richard C. Lewontin (2008). *Modern genetic analysis*, W.H. Freeman and company, ISBN: 9780716749394.

Course Title: Ecology, Evolution and Behavior - Elective: 1B

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

The objective of the course is to enlighten students about the basic concepts of ecology, to know the environment in which we live and to improve knowledge in evolution and behavioural science and to help students prepare for the competitive exams like CSIR, GATE etc.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Discuss the concepts of ecology and its resource partitions.
CO2	Explicate the various species interaction in all levels of species diversity.
CO3	Compare the types of ecological succession, food web and food pyramids and analyze the case studies on conservation of ecosystem.
CO4	Elaborate the concepts in theories of evolution and evolutionary timeline by constructing timeline maps of eras and justify the importance of various theories of evolutionary processes.
CO5	Adapt to the social community by developing communication & social skills that are essential to be a part of society.

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	3	1	1	2	3	1	2	3	3
CO 2	2	1	3	1	1	2	3	1	1	3	3
CO 3	2	1	3	1	1	1	3	1	1	3	3
CO 4	3	1	3	1	1	1	3	1	1	3	3
CO 5	2	1	3	1	1	2	3	3	3	3	3

Course Title: Ecology, Evolution and Behavior- Elective: 1B

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Ecological principles: Abiotic and biotic environment, Biotic and abiotic interactions, limiting factors, adaptation, Habitat and Niche – concepts, niche width and overlap, Fundamental and realized niche, Resource partitioning, character displacement.	**9**	**CO1**
2	Species interactions: types of interactions, interspecific competition - herbivory, carnivory. Pollination, Symbiosis, Community ecology: nature of communities, community structure and attributes, levels of species diversity and its measurement, edges and ecotones.	9	**CO2**
3	Ecological succession: types and mechanisms, changes involved in succession, concept of climax, different types of ecosystem ecosystem – structure and function, food web, food pyramids and energy flow, production and decomposition in a system, ecological efficiencies. Indian case studies on conservation/ management strategy, project tiger, biosphere reserves.	9	**CO3**
4	Evolution: Lamarck, Darwin concepts of variation, adaptation, struggle, fitness and natural selection, unicellular and multicellular evolution, origin of basic biological molecules, concept of Oparin and Haldane, Experiments of miller, evolutionary time scale: eras, periods and epochs.	9	**CO4**
5	Development of behavior: biological clocks, development of behavior, social communication, social dominance, use of space and territoriality, parental care, aggressive behavior, habitat selection and optimality in foraging, migration, domestication and behavioral change.	9	**CO5**

Text Books:	
1.	Thomas M Smith (2015). *Elements of Ecology*, (9th edition), Pearson publications, ISBN: 9780321934185.
2.	Charles J Krebs (2007). *Ecology*, (Sixth edition), Pearson publications, ISBN: 9780321507433.
3.	Kanwaljit Kaur (2013). *Text book of Behavioural Science*, (First edition), Lotus publishers, Private circulation.

Reference Books:	
1.	Eugene Odum and Garry W Barret (2004). *Fundamentals of Ecology*, (5^{th} edition), Brooks publisher, ISBN: 978-0534420666.
2.	Brian K Hall and Benedict Hallgrimsson (2013). *Strickberger's Evolution*, (5th edition), Jones and Bartlett Learning, ISBN: 978-1449614843.

Course Title: Developmental Biology -Core Elective: 1C

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

This subject instills an introduction to animal development and places special emphasis on vertebrate development. The course content also imparts basic knowledge on cellular mechanisms in embryology, essential for doing research in developmental biology field. The basic understandings of developmental biology provide invaluable foundation for other aspects of Biology.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	To read the early embryonic development and molecular recognition.
CO2	To illustrate cell to cell communications, interactions and signal transduction pathway for the development of embryonic cells.
CO3	To explore the steps in cell division, cleavage and gastrulation in zebra fish, mammals and chick.
CO4	To analyze the structure of embryonic development and the molecules involved.
CO5	To compare the development and developmental disorders of vertebrates.
CO6	To identify the maternal effect of gene in drosophila and hormonal control in amphibians.

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	1	2	1	1	2	2	2	3	2
CO 2	2	1	2	1	1	1	2	2	1	3	1
CO 3	2	1	1	2	1	1	1	3	3	3	2
CO 4	3	1	1	1	1	1	2	1	2	2	1
CO 5	2	1	1	1	1	1	2	2	2	3	1
CO 6	2	1	1	1	1	1	2	2	2	3	1

Course Title: Developmental Biology Core Elective: 1C

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Early embryonic development - Structure of gametes, spermatogenesis, oogenesis. Fertilization- types, Process- Molecular recognition of egg and sperm, Acrosomal reaction, egg activation, prevention of polyspermy	**9**	**CO1**
2	Cell- Cell Communication in Development- Induction and competence, Instructive and permissive interaction, epithelial-mesenchymal interactions, Signal Transduction Pathways in vertebrate development- RTK & JAK STAT	**9**	**CO2**
3	Introduction to Cleavage – Cleavage in zebra fish, chick and mammals. Gastrulation- Morphogenetic movements, germ layers, Gastrulation in zebra fish, Chick and mammals	**9**	**CO3**
4	Vertebrate development- Formation of neural tube, Myogenesis, Osteogenesis and Angiogenesis. Developmental disorders – Spina bifida, Anencephaly & Craniorachischisis, Cyclopia, Thantophoric dysplasia.	**9**	**CO4 CO5**
5	Drosophila maternal effect genes, Metamorphosis and hormone control in Amphibia, Heterochrony, Regeneration – Epimorphic regeneration of salamander limbs, Senescence	**9**	**CO6**

Text Books:	
1.	Scott F. Gilbert (2006). *Developmental Biology,* Sinauer Associates, ISBN: 0-87893-243-7
2.	Jonathan Slack (2001), *Essential Developmental Biology,* Blackwell, ISBN: 978-0632052332
3.	Arumugam N, (2013). *Developmental Zoology,* Saras publications, Private circulation.

Reference Books:	
1.	Richard M. Twynman (2001), *Developmental Biology*, (2nd edition), Viva Publications, New Delhi, ISBN: 8176490024.
2.	Subramaniam T. (2002). *Developmental Biology,* (1st edition), Narosa publication, ISBN: 9781842650707.

Course Title: Biochemistry and Molecular Cell Biology Practical-Core Practical: I

Course Code	**:**	**Credits**	**: 02**
L:T:P:S	**:0:0:3:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

On taking this practical course, the student will be able to prepare chemical solutions of appropriate pH, to estimate the biomolecules present in chemical solutions and to separate and identify the biomolecules by analytical techniques. The student will be able to analyze the stages of cell divisions and to use the microtome for various histochemical techniques, to isolate and identify cellular components from various tissues.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Prepare the buffer solutions by calibrating the pH
CO2	Estimate the bio molecules such as carbohydrates, protein, lipids and nucleic acids in unknown chemical solutions
CO3	Quantify the concentration of unknown DNA and RNA from different samples
CO4	Separate and identify the amino acids, sugars and lipids by employing paper chromatography
CO5	Sketch the gel permeation chromatography
CO6	Analyze the stages of mitosis, meiosis and effect of mutation.
CO7	Isolate nucleic acid from various samples observe the chromosome structure.
CO8	Demonstrate and equip the microtome sectioning for different tissues and to visualize the internal structures of tissues using histochemical technique.
CO9	Isolate and identify cell organelles from plant tissues
CO10	Identify the cellular and sub cellular components and detection of marker enzymes

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	PO						PSO				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	1	2	1	2	3	2	1	3	1
CO 2	3	1	1	2	1	2	3	2	1	3	1
CO 3	3	1	1	2	1	2	3	2	1	3	1
CO 4	3	1	1	2	1	2	3	2	1	3	1
CO 5	3	1	1	2	1	2	3	2	1	3	1
CO 6	3	1	1	2	1	1	1	2	1	3	1
CO 7	3	1	1	3	1	1	1	2	3	2	1
CO 8	2	1	1	3	1	1	1	3	2	1	1
CO9	2	1	1	2	1	1	1	2	2	2	1
CO10	3	1	1	3	1	1	1	3	3	2	1

Course Title: Biochemistry and Molecular Cell Biology Practical; Core Practical: I

Sl. No	Contents of Module	Hrs	Cos
1.	**BIOCHEMISTRY** 1. Preparation of Normality, Molality, Molarity solutions; 2. Preparation of Buffers; Calibration of pH 3. Estimation of carbohydrate by Anthrone method 4. Estimation of Cholesterol by Zak's method 5. Estimation of Protein by Lowry's method 6. Estimation of DNA by Diphenyl amine method 7. Estimation of RNA by Orcinol method 8. Separation of Amino acids by paper chromatography 9. Separation of Sugars by Paper chromatography. 10. Separation of Lipids by Thin layer chromatography 11. Absorption studies with protein 12. Absorption studies with DNA 13. Gel permeation chromatography (demo)	**30**	**CO1** **CO2** **CO3** **CO4** **CO5**
2.	**MOLECULAR CELL BIOLOGY** 1. Mitosis stages in onion root tip- mutagenic effect. 2. Stages of meiosis from flower buds. 3. Squash preparation of giant chromosome of salivary gland of 4. Chironomus larva Isolation and Quantification of DNA from plants/animals 5. Microtomy 6. Fixation and embedding of tissues 7. Sectioning and staining (H&E) of tissues 8. Histochemical staining for proteins, carbohydrates, lipids 9. Isolation of mitochondria from plant tissues 10. Subcellular fractionation and marker enzyme detection of 11. succinate dehydrogenase (Mitochondria)	**30**	**CO6** **CO7** **CO8** **CO9** **CO10**

Reference Books/Manuals:	
1.	Soundravally Rajendiran, Pooja Dhiman (2019). *Biochemistry Practical Manual*, (1st ed.). Elsevier India, ISBN: 9788131253519.
2.	Vasudevan D.M., Das S.K. (2013). *Practical Textbook of Biochemistry for Medical Students*, (2nd ed.), Jaypee Brothers Medical Publishers, ISBN: 978-93-5090-668-2.
3.	K.V. Chaitanya, (2013). *Cell and Molecular Biology*: *Lab Manual*, PHI publishers, ISBN: 9788120348004.

Course Title: Microbiology, Immunology and Immunotechnology Practical; Core Practical: II

Course Code	**:**	**Credits**	**: 02**
L:T:P:S	**:0:0:3:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

On taking this practical course, the student will be able to understand the fundamentals of microbiology and perform the microbiological techniques of isolation, detection, and characterization of microorganisms. The student will be able to evaluate blood samples using different laboratory testing procedures and relate them to clinical diseases.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Isolate microorganisms from different sources and to differentiate the applications of various microbiology media for the growth of microorganisms.
CO2	Elucidate the growth of microorganisms using bacterial growth curve technique
CO3	Understand the fundamental of stains, basic staining techniques, and related bacterial and fungal morphology.
CO4	Characterize different group of microorganisms using biochemical tests
CO5	Evaluate the antibiotic property against bacterial pathogens using Kirby Bauer Method
CO6	To isolate, identify and culturing of lymphocytes. To purify IgG fraction by affinity chromatography
CO7	Understand the Antigen antibody reactions by performing widal, VDRL,slide & tube agglutination reactions
CO8	Perform single and double Immunodiffusion techniques
CO9	To perform various types of electrophoersis to quantify the antigens/ antibodies
CO10	To detect antigens or antibodies by ELISA

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	PO						PSO				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	2	1	1	1	1	3	2	3	1
CO 2	2	1	2	1	1	1	1	3	2	3	1
CO 3	2	1	2	1	1	2	1	3	2	3	1
CO 4	2	1	2	1	1	1	1	3	2	3	1
CO 5	2	1	2	1	1	1	1	3	2	3	1
CO 6	2	1	2	1	1	2	1	3	2	3	1
CO 7	1	1	2	1	2	2	1	3	2	3	1
CO 8	1	1	3	2	2	2	1	3	2	3	1
CO9	2	1	2	1	3	3	1	3	2	3	1
CO10	2	1	2	1	3	3	1	3	2	3	1

Course Title: Microbiology, Immunology and Immunotechnology Practical; Core Practical: II

Sl. No	Contents of Module	Hrs	Cos
1.	**MICROBIOLOGY** 1. Isolation of microbes from soil, water, air and plant surface. 2. Preparation of different microbiological Media. 3. Isolation of pure culture of *E.coli*, *Aspergillus* sp and 4. *Streptomyces* sp. Bacterial growth curve. 5. Morphological characterization of microbes – Gram staining, Hanging drop technique, Endospore staining, Capsular staining, Lactophenol cotton blue test. 6. Biochemical tests for identification of bacteria – Catalase test, Oxidase test, Indole test, Methyl red and Voges Proskauer test, Citrate utilization test. 7. Antimicrobial Sensitivity test: Kirby Bauer Method.	**30**	**CO1** **CO2** **CO3** **CO4** **CO5**
2.	**IMMUNOLOGY AND IMMUNOTECHNOLOGY** 1. Isolation and identification of of Lymphocytes. 2. Separation of Immunoglobulin G fractions using affinity chromatography 3. Culturing of Leucocytes 4. Separation of different components from blood 5. Antigen Antibody reactions 6. Widal, VDRL, Slide and tube agglution reactions 7. Quantification of antigen using Single radial Immunodiffusion 8. OuchterlonyI double Immunodiffusion, 9. Immuno electrophoresis 10. Counter current Immuno electrophoresis 11. Rocket immune electrophoresis 12. ELISA –Detection of antigens /antibodies (Demo)	**30**	**CO6** **CO7** **CO8** **CO9** **CO10**

Reference Books/Manuals:	
1.	James G. Cappuccino, Natalie Sherman (2013). *Microbiology: A Laboratory Manual*, (10th edition), Pearson Benjamin Cummings, ISBN: 9789332535190.
2.	Shukla Das and Rumpa Saha (2019). *Microbiology Practical Manual*, (1st Edition), CBS Publishers and Distributors, ISBN: 9788194125457.
3.	Rabindra Narain (2012). *Practical Immunology*, Dom & Wisdom publications, ISBN: 9789381052815.
4.	Franck C.Hay, Olwyn MR, Westwood (2010). *Practical Immunology*, Wiley- Blackwell Publications, ISBN: 9780865429611.
5.	James P. Gosling (2010). *Immunoassays: A Practical Approach*, Oxford University Press, USA, ISBN: 9780199637102.

Second Semester

Course Title: Animal Biotechnology - Core Paper - 5

Course Code :	**Credits : 04**
L:T:P:S : 4:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

The course content provides an introduction to animal cell culture technique makes the student expose to the application of culture techniques to improve the quality and quantity of the animal derived product and it helps the students to understand the handling of animal cell lines in tissue culture lab.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Acquire theoretical knowledge required to handle and work with animal cells in culture, media preparation and methodology used to obtain primary and established cell lines.
CO2	Predict the methods used for the characterization of cell lines such as karyotyping, cell counting and viability assays.
CO3	Differentiate the various methods used for cell separation and to understand the technology of cryopreservation.
CO4	Describe the methodology involved in the transgenesis and the applications of transgenic animals.
CO5	Acquire a deeper understanding of the applications of animal cell culture to human health and improvement and the strategies related to the ethics of animal cell lines.

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	2	2	1	1	3	2	1	1	1
CO 2	1	1	2	3	1	1	1	3	1	1	1
CO 3	1	1	1	3	1	1	2	3	1	1	1
CO 4	1	1	3	1	1	1	2	3	1	1	1
CO 5	1	1	1	3	2	1	1	2	3	1	1

Course Title: Animal Biotechnology; Core Paper – 5

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Animal Tissue Culture Technique: Cell culture Technologies- Setting up a new cell culture laboratory, cell lines- primary and established cell line cultures, Immortalization of cell lines. Culture media-physicochemical properties, balanced salt solutions, complete media, serum, serum-free media- Adaptation of mammalian cells to growth in serum free media.	15	CO1
2	Characterization of cell lines –need for characterization, morphology, chromosome analysis, DNA content, RNA and protein, enzyme activity, antigenic markers. Cell evaluation protocols- Cell counting and viability measurements. Molecular methods- vectors for gene cloning in mammalian cells – SV 40, adenoviral vectors, retroviral vectors.	15	CO2
3	Organ culture and histotypic culture, Cell separation methods- centrifugation, antibody based techniques, magnetic sorting, fluorescence-activated cell sorting, Cryopreservation.	10	CO3
4	Transgenic Animals: Gene transfer methods- calcium phosphate co-precipitation, electroporation, lipofection, retroviral vector method, DNA microinjection, engineered embryonic stem cell method, nuclear transfer. Transgenic Mice, Goat, Cattle and their applications.	10	CO4
5	Applications of animal cell culture and Ethics - Gene Pharming, recombinant vaccines and immunotoxins, Hybridoma technology for monoclonal antibody production, gene therapy, *in vitro* fertilization and embryo transfer, stem cell applications. Ethical issues in animal biotechnology.	10	CO5

Text Books:	
1.	Ian Freshney R. (2006). *Culture of Animal Cells- A Manual of Basic Techniques*, (5th edition), John Wiley & Sons (Asia) Pvt. Ltd., ISBN: 978-0-471-74759-8.
2.	Ramadoss. P, Meerarani S (2002). *Textbook of Animal Biotechnology*, (2nd edition), Madras Veterinary College, Chennai, Private circulation.
3.	N. Arumugam, L. M. Narayanan et al., (2014). *Molecular Biology and Genetic Engineering*, Saras Publications, Private circulation.

Reference Books:	
1.	Nigel Jenkins (1999). *Animal Cell Biotechnology –Methods and Protocols*, Humana Press, ISBN: 978-1-59259-486-3.
2.	A. Phular (1996). *Genetic Engineering of Animals,* VCH publishers, Weinheim, FRG, ISBN: 978-1560818281.

Course Title: Plant Biotechnology - Core Paper: 6

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

Plant biotechnology provides knowledge in advanced techniques includes micropropagation and genetic transformation methods. Plant tissue culture technique also provides practical knowledge about the production and propagation of disease -free plants, molecular markers for identification of traits in genome and also useful tool for soma clonal variation. The students will gain the knowledge of an overview of plant tissue culture and genetic manipulation of plants.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Outline the history of plant biotechnology and state its importance during the different stages of plant development and Recollect the role of phyto hormones in plants
CO2	Learn in-depth the basic techniques of plant tissue culture and its application
CO3	Illustrate the organization of chloroplast mitochondrial genome and regulation of gene expression in nitrogen fixing bacteria
CO4	Develop molecular technique skills in plant tissue culture using Ti plasmid vectors in agrobacterium and able to gain insights on various polymorphism techniques
CO5	Elaborate the development of transgenic plants and its application in production of vaccine, drugs and protein

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	1	1	1	1	2	2	2	3	2
CO 2	3	1	1	2	1	1	2	2	3	1	1
CO 3	2	1	1	1	1	1	1	2	1	1	1
CO 4	2	1	1	2	2	1	2	1	2	3	1
CO 5	2	1	2	2	1	1	1	2	2	3	1

Course Title: Plant Biotechnology - Core Paper: 6

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	History of plant Biotechnology, Global impact of Biotechnology in Agriculture. Conservation of Plant using Biotechnology. Phytohormones- Auxins, Gibberellins, Cytokinins, Ethylene and Abscisic acid. Gene Expression during plant development: Differential regulation of gene expression, Genetic determinants of nodule formation, functions of Rhizobium genes, Plant nodule gene expression.	**12**	**CO1**
2	Basic techniques in plant tissue culture, Methods of plant cell, tissue and organ culture. Micropropagation, cell suspension culture, Somatic embryogenesis, protoplast culture, Somatic hybridization, Production of haploid and triploid plants, Application of plant tissue culture in agriculture, Horticulture and forestry, production of secondary metabolites.	**12**	**CO2**
3	Genome organization: Plant genome, Nitrogen fixation - Introduction, types of nitrogen fixing microorganisms, organization of chloroplast and mitochondrial genome, Regulation & control of gene expression, mt DNA and cytoplasmic male sterility, Import of proteins into mitochondria, Nuclear encoded chloroplast and mitochondria encoded genes for proteins, Seed storage proteins	**12**	**CO3**
4	Gene Transfer: Genetic transformation of plants by *Agrobacterium*, Basis of tumour formation, Hairy root; Features of Ti and Ri plasmids, Mechanisms of DNA transfer, Role of virulence genes, Transformation process, Regeneration of transformed plants, Direct transformation, Molecular marker aided breeding - RFLP maps, linkage analysis, RAPD markers, micro satellites, SCAR (Sequence Characterized Amplified Regions), SSCP (Single-strand Conformational Polymorphism), AFLP.	**12**	**CO4**
5	Plant Vectors- Use of Ti and Ri as vectors; Binary vectors; Use of 35S and other promoters; Genetic markers; Use of reporter genes, Reporter gene with introns. Transgenic plants and applications, Genetically engineered plants for virus, fungi, insect and herbicide resistance (one example each). GM plants for vaccine, drug and protein development, Plant transformation technology, Inducible gene expression: use of tissue specific, copper-controllable gene expression in plants	**12**	**CO5**

Text Books:	
1.	H.K. Dass (2005), *Text book of Biotechnology*, (Second Edition), Wiley Dreamtech, India (P) Ltd., ISBN: 9788126564040.
2.	Reynolds P.H.S. (1999). *Inducible gene expression in Plants*, CABI publishing, ISBN: 978-0851992594.
3.	H. Kreuzer and A. Massey (2001). *Recombinant DNA and Biotechnology: A guide for Teachers*, (Second Edition), ASM press, Washington, ISBN: 978-1555811761.

Reference Books:	
1.	Trevan (2001). *Biotechnology*, Tata McGraw Hill, ISBN:978-0070993914.
2.	M. Sudhir (2000). *Applied Biotechnology & Plant Genetics*, Dominant publishers & Distributors, ISBN: 978-8187336600.

Course Title: Environmental Biotechnology -Core Paper: 7

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

To adopt production processes that make optimal use of natural resources, by recycling biomass, recovering energy and minimizing waste generation. To promote the use of biotechnological techniques with emphasis on bioremediation of land and water, waste treatment, soil conservation, reforestation, afforestation and land rehabilitation. Social responsibility for environmental issues and application of remedial measures.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Perceive the role of biotechnology in environment protection and relate natural biogeochemical cycles with current environmental changes
CO2	Categorize various air pollutants and explain their effects on environment, human and other biotic communities
CO3	Illustrate reactor types and can explain its functioning along with its applications in industries
CO4	Elaborate the role of denitrifying bacteria in maintaining environmental balance and justify their role in waste water treatment process
CO5	Develop skills to utilize kinetics in successful industrial processes such as biofilm formation and special case biofilms
CO6	Explain various biomass generated and its role in energy production

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	3	2	1	3	3	1	1	3	3
CO 2	3	2	3	3	2	3	3	1	2	3	3
CO 3	3	3	2	2	3	2	3	3	3	3	3
CO 4	3	3	2	3	2	3	3	1	3	3	1
CO 5	3	3	2	3	3	2	3	3	3	3	3
CO 6	3	1	2	2	2	3	3	2	2	3	3

Course Title: Environmental Biotechnology - Core Paper: 7

Sl. No.	CONTENTS OF MODULE	Hrs	Cos
1.	Concept and scope of Environmental Biotechnology, the natural Biogeo cycles. Toxic chemicals in the environment (Arsenic, Cadmium, Mercury and Lead), Carcinogens, Air pollutants (Carbon monoxide, Nitrogen Oxide, Sulphur dioxide, acid rain), Air quality standards, air samplings and air monitoring.	12	**CO1** **CO2**
2.	Water pollutants, physical, chemical, Biological characterization of waste water, BOD, COD, TOC, use of indicator organism for biological characterization of waste water. Biodegradation, Bioremediation, Engineering strategies for Bioremediation-Evaluating bioremediation. Detoxification of hazardous chemicals and factors causing molecular recalcitrance.	12	**CO3**
3.	Reactors-Reactor types- Batch reactor- continuous flow stirred tank reactor with effluent recycle -A plug flow reactor with effluent recycles-Reactors with recycle of settled cell –Engineering design of reactors-Reactors in series. Reactor configuration – special factors for the design of anaerobic sludge digesters.	12	**CO4**
4.	Role of Microbes and Enzymes in waste water treatment; Drinking water treatment. Denitrification; physiology of denitrifying bacteria – Tertiary denitrification- one sludge denitrification, anaerobic treatment by methanogenesis – uses of methanogenic treatment.	12	**CO5**
5.	Biofilm kinetics, completely mixed biofilm reactor-Soluble microbial products and inert biomass. Biomass from the waste-Special case biofilm solutions. Linking stoichiometric equations to mass balance equations.	12	**CO6**

Text Books:	
1.	Smith, J.E. (1996). *Biotechnology*, (3rd edition), Cambridge Low price edition. Cambridge University press. ISBN: 9780521586948.
2.	Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. (2001). *Environmental Encyclopedia*, Jaico Publ. House, Mumbai. ISBN: 9788172247867.
3.	Sohal, H.S. and Srivastava, A.K. (1994). *Environmental and biotechnology*, (1st edition). Ashish Publishing House, New Delhi. ISBN: 9788131310076.

Reference Books:	
1.	Bruce E. Rittmann and Perry L. McCarty (2001). *Environmental biotechnology- Principles and Applications*, McGraw-Hill, New York, ISBN: 9780071181846.
2.	Bali Geetha (2002). *Environmental Biotechnology*, APH Pub. Corp., New Delhi, ISBN: 9788176483780.

Course Title: Pharmaceutical Biotechnology - Extra Disciplinary: 1

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

The course content helps student to understand the basic concepts, scope and applications of pharmacology. The course imparts the basic knowledge of Industrial production of pharmaceutical products, Drug designing and gene therapy. The content provides an importance and role of biotechnology in pharmaceutical industry.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Analyze the various types of drugs and its applications.
CO2	Demonstrate with pharmacokinetics and pharmacodynamics parameters of biopharmaceutical.
CO3	Exhibit knowledge in formulation and delivery of drugs.
CO4	Enumerate the various sources of biopharmaceuticals and its application
CO5	Comprehend the therapeutic value of biosimilar drugs
CO6	Illustrate the drug discovery process and pre-clinical studies of various therapeutic products.

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	2	1	2	1	2	3	2	2
CO 2	1	1	3	3	1	1	1	2	3	2	1
CO 3	1	1	2	2	2	2	1	2	2	2	1
CO 4	1	1	2	3	1	1	1	3	2	3	2
CO 5	1	1	2	3	1	1	1	2	2	2	1
CO 6	1	1	2	3	2	2	1	2	3	2	2

Course Title: Pharmaceutical Biotechnology, Extra Disciplinary: 1

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Pharmacology & Pharmacogenomics:** Introduction to Pharmacology; Pharmacological Classification of Drugs - Analgesics, Antipyretics, Anti-inflammatory, Antidepressants and CNS Stimulants, Anti-hypertensive Drugs and Anti-hyper lipidemic Drugs; Pharmacogenomics - Types of Genetic Variations, Drug Metabolizing enzymes, Pharmacodynamics – Drug efficacy, pharmacokinetics –ADME and Therapeutic drug monitoring.	9	**CO1 CO2**
2	**Drug Formulation and Delivery:** Capsules – Requirements, Method of Capsule Filling, Importance of Base Absorption; Tablets – Types, Granulation, Technology on large-scale; Controlled and sustained release dosage forms-enteric-coated tablets and capsules; Parental injections, Ointments and Creams, Emulsion and Suspensions; Stabilizing excipients; Delivery of biopharmaceuticals – oral delivery systems, pulmonary delivery, nasal, transmucosal, Parenteral Products, transdermal delivery system, Liposomes and Nanoparticles.	9	**CO3**
3	**Biopharmaceuticals and its sources** Biopharmaceuticals – Introduction, History of the pharmaceutical industry, age of biopharmaceuticals, Applications of biopharmaceuticals; Pharmaceuticals of animal origin- the androgens, the oestrogens, progesterone, Prostaglandins; Pharmaceutical substances of plant origin- Alkaloids, Flavonoids, xanthines and terpenoids; Pharmaceutical substances of microbial origin-Penicillin derivatives.	9	**CO4**
4	**Biosimilar drugs as therapeutics** Growth Hormones- Interferon, Interleukins, Erythropoietin, Insulin Hormone, Somatotropin, Human Growth Hormone, Somatostatin, Vaccines, Monoclonal Antibody Based Pharmaceuticals; Recombinant Blood products- Anticoagulants- Hirudin, Antithrombin, Thrombolytic agents- Tissue plasminogen activator, Streptokinase, Urokinase; Therapeutic enzymes- Superoxide dismutase, Dnase, α-Galactosidase, Debriding agents, Digestive aids.	9	**CO5**
5	**Drug Development Processes** Drug discovery and delivery process- Types of Clinical Research, Phases of Clinical Research; Pre-clinical studies-Toxicity (Reproductive toxicity and Teratogenicity, Mutagenicity, Carcinogenicity and Other tests); Clinical trials - Clinical trial design, Trial size design and study population.	9	**CO6**

Text Books:	
1.	Hiten J. Gutka, Harry Yang, Shefali Kakar (2018*). Biosimilars: Regulatory, Clinical, and Biopharmaceutical Development*, (1st ed), USA: Springer, ISBN: 978-3-319-99679-0.
2.	Oliver Kayser (Editor), Heribert Warzecha (Editor) (2012). *Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications*, (2nd Edition), Germany: Wiley VCH, ISBN: 978-3-527-32994-6.
3.	John F. Corpenter, Mark C. Manning (2012). *Rational Design of stable formulation Theory and Practice,* (1st edition), US: Springer Science, ISBN: 9781461351313.

Reference Books:	
1	Crommelin, Daan J. A., Sindelar, Robert, Meibohm, Bernd (Eds.) (2019). *Pharmaceutical Biotechnology Fundamentals and Applications,* (5th Ed), Springer International Publishing, ISBN: 978-1-4614-6485-3.
2	Yui-Wing F. L. and Stuart S. (2019). *Pharmacogenomics: Challenges and Opportunities in Therapeutic Implementation,* (2nd Ed), TX, USA: Academic Press, ISBN: 9780128126264.

Course Title: Forensic Science - Elective Paper: 2A

Course Code :	**Credits : 03**
L:T:P:S : 6:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

A forensic scientist must be capable of integrating knowledge and skills in the examination, analysis, interpretation, reporting, and testimonial support of evidence. Analysis of DNA samples allows precise identifications to be made from very tiny bits of evidence collected at the crime scene. The subject helps to understand the investigation of crime scene and document forgeries.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Outline the background of the development of Forensic science and elaborate on the advancements in the development of this technology in India.
CO2	Describe the biological basis and fundamental principles of fingerprinting and the consecutive steps used for detection, preservation and enhancement of fingerprints.
CO3	Predict the chromatographic and spectroscopic methods used for sample preparation in forensics.
CO4	Compare the role of narcotics and other drugs in forensic applications and the methods used for identifying and maintaining individual identity.
CO5	Analyze the significance of collecting biological evidences and social, legal and ethical concerns that can be solved using forensic science

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	1	3	1	1	3	3	3	3	1
CO 2	3	1	1	1	1	2	3	2	3	3	2
CO 3	2	1	2	2	1	1	3	3	3	2	1
CO 4	1	1	1	1	2	1	3	3	2	3	3
CO 5	2	1	1	1	1	1	3	3	3	3	3

Course Title: Forensic Science- Elective Paper: 2A

S. NO.	CONTENTS OF MODULE	Hrs	Cos
1	History and Development of Forensic Science in India; Definitions, Concepts and Functions of forensic science. Organizational set up of Forensic Science Laboratories in India and worldwide. Scope of forensic science. Basic principles of forensic science. Fingerprint Bureaus, National Crime Records Bureau	**9**	**CO1**
2	Forensic science in international perspectives, including set up of INTERPOL and FBI. Fingerprinting- Biological basis of fingerprints, Formation of ridges and types of fingerprints. Mechanism of detection of fingerprints by different developing reagents. Preservation of developed fingerprints. Data depiction and report writing.	**9**	**CO2**
3	Instrumentation - Sample preparation for chromatographic and spectroscopic evidence. Chromatographic methods. Fundamental principles and forensic applications of chromatography (thin layer, gas and liquid chromatography). Spectroscopic methods - Fundamental principles and forensic applications of UV-Visible spectroscopy.	**9**	**CO3**
4	Definition and Classification – Narcotics, stimulants, depressants and hallucinogens. Questioned Documents- Nature, scope and types. Comparison of Documents- Comparison of handwriting, Development of individuality in handwriting. Forgeries- Alterations in documents, including erasures, additions, over-writings and obliterations. Indented and invisible writings. Charred documents.	**9**	**CO4**
5	Biological Evidence- Nature and importance of biological evidence (skin, hair, nails, blood and semen). Types and identification of microorganisms of forensic significance. Significance of wildlife forensic. Illegal trading in wildlife items, such as skin, fur, bone, horn, teeth, flowers and plants.	**9**	**CO5**

Text Books:	
1.	Nanda, B.B. and Tiwari R. K. (2014). F*orensic Science in India: A Vision for the Twenty First Century*, (2nd edition), Select Publishers, New Delhi, ISBN: 9788190113526.
2.	Barbara H. Stuart (2013). *Forensic Analytical Techniques (Analytical Techniques in the Sciences (AnTs),* (1st edition), UK, Wiley, ISBN: 978-0-470-68727-7.
3.	C. Champod, C. Lennard, C. Margot, P. and Stoilovic (2015). *Fingerprints and other Ridge Skin Impressions*, (7th edition), Boca Raton, CRC Press, ISBN: 9781498728959.

Reference Books:	
1.	Harralson H. and Miller S. (2017). *Huber and Headrick's Handwriting Identification: Facts and Fundamentals,* (2nd Edition), Boca Raton, CRC Press, ISBN: 9781498751308.
2.	Ghosal S. and Avasthi A.S. (2018). *Fundamentals of Bioanalytical Techniques and Instrumentation,* (2nd Edition), Delhi, PHI, ISBN: 9789387472396.

Course Title: Marine Biotechnology - Elective Paper: 2B

Course Code : 1925213	**Credits : 03**
L:T:P:S : 3:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

The subject imparts knowledge on marine biodiversity and it's economical in context to global change. The course content also provides better understanding about marine bioresources and its biotechnological application. To enable the students to gain knowledge on improved aspects of marine environment, biodiversity of marine ecosystem and genetic uniqueness of marine organism to develop useful product and application.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Identify and to correlate the significance of marine biota to humans in biotechnological perspective and to describe optimal methods available for their *invitro* culture and maintenance.
CO2	Effectively explain the strategies adopted for enhancing the culture of specific marine organisms and the genetic approaches used for manipulating growth, reproduction and disease resistance in aquaculture.
CO3	Define the major pollutants and to critically think to evaluate the human impact on marine ecosystems and the influence of marine organisms in cycling of bioelements.
CO4	Develop competency for careers associated with research and development in marine related bioproducts, of advanced scope in pharmaceutical industry and in medical research.
CO5	Elaborate on biofouling, problems posed by marine biofouling and the biotechnological approaches used for their control.

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	1	1	1	1	3	1	3	1	1	1	2
CO 2	1	1	1	1	3	1	1	3	1	1	2
CO 3	2	1	1	1	1	1	1	1	1	2	3
CO 4	2	1	1	3	1	1	1	2	3	1	1
CO 5	2	1	2	1	2	1	1	2	1	1	3

Course Title: Marine Biotechnology - Elective Paper: 2B

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Introduction to marine biotechnology-** Aquafarming system – Traditional, Extensive, Semi-intensive and intensive. Culture techniques - monoculture, polyculture - pond, raceway, cages, pens, raft and rope culture, Criteria for selecting cultivable species.	**9**	**CO1**
2	**Design and construction of culture systems-** Induced breeding – mass production of seeds, invitro fertilization, and cryopreservation. Genetic engineering and ploidy manipulation to enhance growth and reproduction, disease resistance in aquaculture species. Live feed culture technique-artificial feed formulation.	**9**	**CO2**
3	**Marine pollution-** Types of marine pollution-major pollutants in marine environment – pollution control- recycling and waste management, Seaweeds for removal of metal pollutants, Biological indicators (Microbes, plankton, plants), Coral reefs in ecosystem management-Biomonitoring – Mussel watch concept, Bioremediation.	**9**	**CO3**
4	**Commercial marine natural products-** Microalgae- growth characterisitics, cultivation of microalgae; Structure, properties, source and applications of chitosan, chitin, hydrocolloids, agarose, carrageenan, alginates, polysaccharides. Marine derived pharmaceuticals - applications in biomedical and biotechnology.	**9**	**CO4**
5	**Biofouling and Control technology –** Biofouling organisms - Problems due to biofouling– Antifouling technology-methods adapted for antifouling, antifouling paints and its environmental pollution - Biotechnological approach to biofouling control.	**9**	**CO5**

Text Books:	
1.	Olguin E.J. *et al.* (2000). *Environmental Biotechnology and cleaner Bioprocess*, ISBN: 9780748407293.
2.	William (1996). *Introduction to Marine Pollution Control*, John Wiley, ISBN: 9780471019046.
3.	Rheinhemer G. (1980). *Aquatic Microbiology*, John Wiley& Sons, pp. 235, ISBN: 0-471966573.

Reference Books:	
1.	Ford, T.E. (1993), *Aquatic microbiology -An Ecological Approach*, Blackwell Scientific Publications, London, ISBN: 0865422257.
2.	Bruce, E. Rittmann and Perry L. McCarthy (2001). *Environmental Biotechnology, Principles and Applications*. McGraw Hill, ISBN: 9780072345537.

Course Title: DNA Barcoding Technology - Elective Paper: 2C

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

The course content provides knowledge on the significance of DNA Barcoding and its methods. To enable the students to construct a workflow using a series of molecular techniques and to utilize Bioinformatics tools in identification of an organism. To apply the DNA barcoding methods in various fields of Human Welfare.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Explain the history of DNA barcoding and criticize the significance of the field with respect to conventional and older identification methods.
CO2	Outline the characters of DNA responsible for identifying organisms and distinguish the role of mitochondrial, chloroplast and nuclear DNA in identification.
CO3	Elaborate the DNA barcodes used in identifying different types of organisms such as bacteria, fungi, plants and animals.
CO4	Choose and construct a work flow for DNA barcoding by using series of molecular biological techniques.
CO5	Utilize the bioinformatics tool to compare and assess the results of DNA barcode sequencing in order to identify an organism.
CO6	Discover the importance of DNA barcoding in various fields of human welfare and judge their limitations.

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	3	3	1	2	3	3	3	3	3
CO 2	3	1	3	3	1	1	3	2	3	3	1
CO 3	3	1	3	2	1	1	3	3	3	3	1
CO 4	3	1	3	3	1	2	3	3	3	3	1
CO 5	3	3	2	3	3	2	3	3	3	3	1
CO 6	3	3	2	2	3	3	3	3	3	3	3

Course Title: DNA Barcoding Technology - Elective Paper: 2C

Sl. No.	CONTENTS OF MODULE	Hrs	Cos
1.	The concept of DNA barcoding – History, conventional identification (morphological, physiological, genetic – sequencing and metagenomics) against molecular identification using DNA barcodeand Metabarcoding.	**9**	**CO1**
2.	Structure of DNA, Genome organization & conserved sequeces, chloroplast DNA, Mitochondrial DNA, significance of chloroplast and mitochondrial DNA in DNA barcoding, DNA barcodes in plants – Nuclear genome sequence, chloroplast genome sequence, rbcl, matK, ITS, trnh – psb, DNA barcodes in animals – CO1, DNA barcodes in fungi - ITS.	9	**CO2 CO3**
3.	Procedure for DNA barcoding – Isolation of DNA – Method of DNA extraction, PCR – Basic principle, Reaction conditions and detection of PCR product, Sequencing – Maxam – Gilbert and Chain termination sequencing, Analysis of sequencing product.	9	**CO4**
4.	Primer design for sequencing, BLAST – Types of BLAST, FASTA sequence and its format, Sequence alignment, Phylogenetic analysis, phylogenetic tree development – methods of phylogenetic tree development. Softwares for Phylogenetic analysis – MEGA, Sequence annotation and submission – Barcode in Genbank, Libraries – CBOL, IBOL, QBOL.	9	**CO5**
5.	Application of barcode in taxonomy, identification of cryptic species, biodiversity conservation, food safety, adulterations in plant-based products (herbal cosmetics and medicine), Pest and disease control. Limitations of DNA barcode.	9	**CO6**

Text Books:	
1.	Baum D. A., & Smith S. D. (2013). *Tree thinking: an introduction to phylogenetic biology.* Greenwood Village, CO: Roberts, ISBN: 978-1936221165
2.	Judd W. S., Campbell C. S., Kellogg E. A., Stevens P. F., & Donoghue M. J. (2002). *Plant systematics.* Sunderland, Massachusetts, USA: Sinauer. ISBN: 0–87893–403–0
3.	Moritz, C., & Cicero, C. (2004). *DNA barcoding: promise and pitfalls*, PLoS biology, 2(10), pg. 354.

Reference Books:	
1.	Wheeler Q.D. (2008). *The New Taxonomy,* CRC Press, ISBN: 9780849390883.
2.	John Kres W. and David L. Erickson (2012). *"DNA Barcodes: Methods and Protocols"*. Humana Press, ISBN: 978-1-61779-591-6.

Course Title: Animal and Plant physiology - Elective Paper: 3A

Course Code :	**Credits : 03**
L:T:P:S : 3:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

The objective of the course is to ensure that a student learns various aspects of animal and plant physiology. To impart knowledge about structure and functions of organ system. It explains the physiological process of all body system and the interrelationship among cellular, tissue and organ function in each system.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Gain insights on components of cardio vascular system such as blood and blood groups. Explain the structure and conduction of heart and also the importance of hormones in humans.
CO2	Describe the structure and understand the mechanism of digestive, respiratory and excretory system.
CO3	Acquire knowledge on the structure and functions of skeletal, muscular Describe the structure of nervous system and understand the mechanism of nerve impulse transmission
CO4	Enumerate the process of photosynthesis, electron transport chain and CO_2 fixation in plants and illustrate the synthesis, storage, transport and action of plant hormones.
CO5	Demonstrate the importance of phytochrome, cryptochrome, phototropin in solute uptake, transport and translocation and stress physiology of plants

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	1	1	1	2	3	1	1	3	2
CO 2	3	1	2	1	1	2	3	1	1	1	1
CO 3	3	1	2	1	1	2	3	1	1	3	1
CO 4	2	1	2	1	1	2	3	1	1	1	1
CO 5	2	1	3	1	1	2	3	1	1	3	3

Course Title: Animal and Plant Physiology; Elective Paper: 3A

Sl. No	CONTENTS OF MODULE	Hrs	Cos
1.	Cardiovascular system - Components of Blood and functions - Blood Groups and importance – Structure of Heart – conduction system of heart-Cardiac Cycle – Regulation of Heart rate and Blood pressure. Endocrinology - Pituitary and thyroid gland- hormones & their actions.	**9**	**CO1**
2.	Digestive system - Organs of Digestive system – Digestion and Absorption. Excretory system - Structure of Kidney and Nephron – Mechanisms of Urine formation. Parts of Respiratory Systems – Mechanisms of Breathing – Regulation of Respiration.	**9**	**CO2**
3.	Nervous system: Types of Neuron and Synapses, mechanisms of Nerve impulse, Brain - Parts of Brain – Spinal Cord –Reflex Mechanism. Skeletal system: Types of Bone and function, Division of Skeleton. Muscular system: Parts of Muscle and mechanism of muscle contraction.	**9**	**CO3**
4.	Plant Physiology: Photosynthesis- Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C_3, $C_4$and CAM pathways. Plant hormones: Auxins and Gibberellins- Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action.	**9**	**CO4**
5.	Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins Solute transport and photoassimilate, translocation. Stress physiology- Responses of plants to biotic and abiotic stresses	**9**	**CO5**

Text Books:	
1.	Sembulingam K, Prema Sembulingam (2019). *Essentials of Medical Physiology*, (8^{th} edition), Jaypee brothers, India, ISBN: 9789352706921.
2.	Indu Khurana and Arushi khurana (2018). *Concise textbook of Human Physiology*, (3^{rd} edition), Elsevier, India, ISBN: 9788131252994.
3.	Jain VK (2017). *Fundamentals of Plant Physiology*, (19th edition), Chand S Publishers, India, ISBN: 9789352533343.

Reference Books:	
1.	Gerard J. Tortora, Bryan Derrickson (2014). *Principles of Anatomy and Physiology*, (14^{th} edition), Wiley & sons Inc., USA, ISBN: 9781118345009.
2.	Lincoln Taiz, Eduardo Zeiger, Ian Max Ma ller, Angus Murphy (2018). *Fundamentals of Plant Physiology*, Sinauer Associates Inc., ISBN: 9781605357454.

Course Title: Clinical Trials; Elective Paper: 3B

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 5:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

The branch of healthcare science that determines the safety and effectiveness of medications, devices, diagnostic products and treatment regimens intended for human use. Clinical research deals with researching medical equipment and medicines based on the parameters of safety and performance.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Discuss Clinical trials: Study of various clinical trials
CO2	Enumerate New drug discovery process in clinical trials
CO3	Exhibit knowledge in Various regulatory requirements in clinical trials
CO4	Explain Pre-clinical toxicology
CO 5	Explore Basic terminology used in clinical research

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	1	1	1	1	2	2	3	3
CO 2	1	1	2	3	1	1	1	2	2	2	2
CO 3	1	1	1	1	1	1	1	3	3	2	2
CO 4	2	1	1	3	1	1	1	2	2	3	2
CO 5	2	1	1	1	1	1	1	2	2	2	1

Course Title: Clinical Trials; Elective Paper: 3B

S.l NO	CONTENTS OF MODULE	Hrs	Cos
1	Introduction to Clinical trials: Study of various clinical trials. Clinical Trial Application in India. Import & Export of Drug in India. Investigational New Drug application (IND). Abbreviated New Drug Application (ANDA). New Drug Application (NDA). Design and organization of phase-I, phase-II, phase-III, phase-IV trials.	**9**	**CO1**
2	New drug discovery process- purpose, main steps involved in new drug discovery process, timelines of each steps, advantages and purposes of each steps, ethics in clinical research, unethical trials, thalidomide tragedy. Introduction and designing. Post Marketing surveillance – methods. Principles of sampling-Inclusion and exclusion criteria.	**9**	**CO2**
3	Various regulatory requirements in clinical trials, ICMR guidelines etc. Documents in clinical study. Investigator Brochure (IB), Protocol & Amendment in Protocol. Case Report Form (CRF), Informed Consent Form (ICF), Clinical Trial Report Essential Documents in Clinical Trial Good Clinical Practice: ICH guidelines, Indian GCP guidelines (CDCSO guidelines).	**9**	**CO3**
4	Pre-clinical toxicology: General principles, Systemic toxicology (Single dose and repeat dose toxicity studies), Carcinogenicity, Mutagenicity, Teratogenicity, Reproductive toxicity, Local toxicity, Genotoxicity, animal toxicity requirements.	**9**	**CO4**
5	Basic terminology used in clinical research: Types of clinical trials, single blinding, double blinding, open access, randomized trials and their examples, interventional study, ethics committee and its members, cross over design, etc. and Institution Ethics Committee/ Independent Ethics Committee Data Management in clinical Research.	**9**	**CO5**

TEXT BOOKS:

1	Delva Shamley Brenda Wright (2017). *A Comprehensive and Practical Guide to Clinical Trials*, (1st Ed.), USA: Academic Press, ISBN: 9780128047293.
2	ICRIER Health Policy Initiative (2018). *Challenges and Prospects for Clinical Trials in India: A Regulatory Perspective*. Academic Foundation, ISBN: 9789332704268.

REFERENCES BOOKS:

1	Ali S. Faqi. (2013). *A Comprehensive Guide to Toxicology in Preclinical Drug Development.* (1st Ed.), MA, USA: Academic Press, ISBN: 9780123878151.
2	Benjamin Blass (2015). *Basic Principles of Drug Discovery and Development,* (1st Ed.) USA: Academic Press, ISBN: 9780124115088.
3	Michael J. Mc Graw. (2015). *Principles of Good Clinical Practice,* (1st Ed.), UK: Pharmaceutical Press, ISBN: 978-0-12-411508-8.

Course Title: Stem Cell Biology; Elective Paper: 3C

Course Code :	**Credits : 04**
L:T:P:S : 6:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

The course content provides better understanding of the basic biology of Stem Cells and Cancer and its impact on the human body has led to more effective treatments, enhanced detection methods and the development of prevention strategies.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Predict the formation of stem cells, their isolation and *invitro* maintenance and to differentiate the potential of embryonic stem cells with adult stem cells.
CO2	Demonstrate the properties and differentiation of stem cells. Helps to understand the epigenetic regulation of stem cells,
CO3	Gain insights into the techniques involved in isolation, expansion and characterization of stem cells
CO4	Evaluate the role of stem cells in clinical application and to design research strategies for disease control and prevention.
CO5	Acquire a deeper understanding of the ethical, legal and social concerns of Stem cell research and its applications to human health and improvement.

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	1	1	1	3	1	3	2	2
CO 2	3	1	2	2	1	2	3	3	3	2	2
CO 3	1	1	3	2	3	2	3	1	3	2	3
CO 4	1	1	3	2	1	2	3	2	3	2	1
CO 5	2	1	3	2	1	3	3	2	3	2	3

Course Title: Stem Cell Biology; Elective Paper: 3C

Sl. No	CONTENTS OF MODULE	Hrs	Cos
1.	**Introduction to stem cells**- definition, history, types and sources of stem cells. Capacity of stem cells- unipotent, multipotent, pluripotent, totipotent. Embryonic stem cells, Adult stem cells- Neuronal, gut epithelial, mesenchymal stem cells. Haematapoietic stem cells: cordblood, peripheral blood, bone marrow stem cells, induced pluripotent stem cells, stem cell micro environment/niche and cryopreservation.	9	**CO1**
2.	Properties-self renewal and differentiation. Regulation of stem cell –cell cycle regulation, gene expression, chromatin modification and epigenetic regulation (DNA histone methylation and acetylation) and miRNA roles. Epigenetic regulators in stem cell differentiation.	9	**CO2**
3.	Isolation of stem cells- Fluorescence activated cell sorter, culture and genetic manipulation of stem cells. Expansion of stem cells- Chemical and molecular approaches. Genetic reprogramming and iPSCells, Ex-vivo expansion used for stem cell characterization. Invitro functional assays- CAFC (Cobblestone area forming cell) and CFC (colony forming cells), In vivo serial transplantation assay.	9	**CO3**
4.	Therapeutic applications of stem cell- stem cell therapy and fundamentals of regenerative medicine. Autologous and allogenic stem cell transplantation, repair of damaged tissues and organs, uses of stem cells in heart and retinal diseases. Stem cells and ageing. Future prospects of stem cells.	9	**CO4**
5.	Ethical issues associated with stem cell research. Implications of human embryonic stem cell research: societal implications, pre-clinical regulatory considerations and Patient advocacy. Ethical guidelines of stem cell research-National (ICMR) and International society for stem cell research.	9	**CO5**

Text Books:	
1.	Jonathan Slack (2012). *Stem Cells: A Very Short Introduction*, Oxford University Press, ISBN: 9780199603381.
2.	Indumathi Somasundaram, Dhanasekaran Marrappagounder, Pankaj Kaigade (2019), *Stem Cell Biology*, Evincepub Publishing, ISBN: 9389774357.
3.	Kursad Turksen (2014). *Adult and Embryonic Stem Cells - Stem Cell Biology and Regenerative Medicine, (*2nd edition*)*, Humana Press, ISBN: 978-1627039529.

Reference Books:	
1.	Ann A Kiessling (2003). *Human Embryonic Stem Cells: An introduction to the Science and Therapeutic Potential*, Jones and Bartlett Publishers, ISBN: 9780763723415.
2.	A.D. Ho, R. Hoffman (2006). *Stem Cell Transplantation- Biology, Processes, Therapy*, Wiley-VCH, ISBN: 978-3527310180.

Course Title: Animal Biotechnology, Plant Biotechnology and Environmental Biotechnology - Core Practical: III

Course Code	**:**	**Credits**	**: 02**
L:T:P:S	**: 0:0:3:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

This course intends to emphasize students on the skills and the technical adequacy, required to handle animal cells for in vitro culture and their maintenance and establishment of primary cell lines. The establishment of callus cultures, direct organogenesis and suspension cultures by preparation and sterilization of suitable plant tissue culture media and incorporation of PGRs in Plant Tissue culture is also under the main focus stream. Further improving the quality of potable water by determination of acidity, alkalinity, Dissolved oxygen and BOD etc. are also skillfully exposed to students.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Demonstrate the media preparation for culturing of animal cells
CO2	Acquire skills in preparation of primary cell culture, trypsinization and counting of cells.
CO3	Enumerate and identify the viability of cell using typan blue method.
CO4	Analyze the cytotoxicity of the animal cells culture using MTT assay
CO5	Apply skills to isolate DNA from mammalian cell lines & fibroblast cells from chick.
CO6	Revise the training skills required to handle and perform experiments with plant cells in tissue culture media on a large scale, under sterile environment to generate *in vitro* plants.
CO7	Generate callus from explants of various plant sources and their subsequent maintenance through subcultures and also to effectively achieve micropropagation by regulating the concentration and combination of specific plant growth regulators in culture media.
CO8	Acquire skills for identifying, isolating and culturing anther under in vitro and embryos to obtain and analyse organogenesis.
CO9	Expertise in handling protoplast by isolating, culturing, testing viability and to carry out protoplast fusion by polyethene glycol.
CO10	To acknowledge the biological significance of Ti plasmids in genetic engineering practically by isolating plasmid DNA from cultured *Agrobacterium* cells.
CO11	Analyze, examine and estimate the quality of water by means of determining the acidity and alkalinity, estimating the nitrate concentration, finding dissolved oxygen concentration and estimating coliforms and to conclusively predict whether the water is potable.
CO12	Develop skills for isolating pesticide degrading bacteria from agricultural soil by repeated *in vitro* culture to isolate pure colonies.
CO13	Recognize the importance of reduce, reuse and recycle by diverting animal waste for biogas production and kitchen waste for vermicomposting using earthworms.
CO14	Create an awareness of constructing ecofriendly environment by reducing the amount of air pollutants with the demonstration of effect of SO_2 on crop plants.

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	PO						PSO				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	1	1	1	3	1	1	2	3	1	2	1
CO 2	2	1	1	3	1	1	1	3	1	2	1
CO 3	2	1	1	2	1	1	1	3	1	2	1
CO 4	2	1	1	2	1	1	1	3	1	1	1
CO 5	2	1	1	2	1	1	1	3	1	1	1
CO 6	2	1	1	3	1	1	2	3	1	2	1
CO 7	2	1	1	3	2	1	1	3	1	2	1
CO 8	2	1	1	3	2	1	1	3	1	2	1
CO9	3	1	1	2	1	1	1	3	1	1	1
CO10	2	1	1	3	1	1	1	3	1	1	1
CO 11	3	1	3	3	2	3	3	3	3	3	3
CO 12	3	1	3	2	3	3	3	2	3	3	3
CO 13	3	1	3	3	3	3	3	3	3	3	3
CO 14	3	1	1	2	1	3	3	3	3	3	3

Course Title: Animal Biotechnology, Plant biotechnology and Environmental biotechnology - Core Practical: III

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**ANIMAL BIOTECHNOLOGY** 1. Introduction to Animal Cell Culture: Procedure for handling cells and media. 2. Cleaning and sterilization of glassware and plastic wares. 3. Preparation of tissue culture media. 4. Preparation of single cell suspension from chick liver (primary cell culture). 5. Isolation of fibroblast cells from chick. 6. Trypsinization of established cell culture. 7. Total cell count by hemocytometer. 8. Cell viability using Trypan Blue. 9. Cytotoxicity assay using MTT. 10. Isolation of DNA from treated mammalian cell lines (Apoptosis-DNA fragmentation assay)	**30**	**CO1** **CO2** **CO3** **CO4** **CO5**
2.	**PLANT BIOTECHNOLOGY** 1. Preparation of plant tissue culture media and sterilization techniques. 2. Surface sterilization of explants. 3. Generation of *In vitro* plants. 4. Generation of Callus and maintenance of callus culture. 5. Micropropagation. 6. Anther culture 7. Organogenesis in peanuts (Embryo culture). 8. Isolation and culture of protoplast 9. Protoplast fusion by PEG 10. Protoplast viability test using Evan's blue dye. 11. Agrobacterium culture maintenance and isolation of plasmid DNA.	**30**	**CO6** **CO7** **CO8** **CO9** **CO10**
3.	**ENVIRONMENTAL BIOTECHNOLOGY** 1. Detection of coliforms for determination of purity of potable water 2. Determination of Acidity of given water sample 3. Determination of alkalinity of given water sample 4. Determination of dissolved oxygen content by Winkler's method 5. Determination of biological oxygen demand 6. Nitrate estimation in drinking water. 7. Isolation and Screening of pesticide/insecticide degrading bacteria 8. Biogas production 9. Vermicompost 10. Effect of Sulphur dioxide in crop plants	**30**	**CO11** **CO12** **CO13** **CO14**

Reference Books:	
1.	Thatoi et al. (2017). *Practical biotechnology: Principles and Protocols*, Orissa University, Private circulation.
2.	R. S. Chawla (2004). *Plant Biotechnology: Laboratory Manual for Plant Biotechnology*, Oxford and IBH Publishing, ISBN: 9788120416130.
3.	Purohit S.S. (2004). *A Laboratory Manual of Plant Biotechnology*, (2nd edition), Agrobios Publications,. ISBN: 9788177542226.
4.	Frederick W Pontinus (1990). *Water Quality and Treatment, American water works Association*, MC Graw Hill Inc., ISBN: 9780070015401.
5.	Agarwal S.K. (2009), *Environmental Microbiology*, APH Publishing corporation, New Delhi, ISBN: 9788170249603.

Third Semester

Course Title: Genetic Engineering - Core Paper: 8

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

The course content will help the student to understand the concepts and knowledge about genetic engineering and rDNA technology. The course also imparts the knowledge about different molecular techniques involved in the genetic engineering. Course content familiarize the concepts behind the recombinant technology and their applications.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Acquire knowledge on core concepts and applications of genetic engineering and rDNA technology.
CO2	Achieve broad thinking on different types of vectors and share insights of its applications in the field of biotechnology.
CO3	Differentiate the various steps involved in the construction of cDNA and genomic libraries and their role in recombinant DNA technology.
CO4	Gain insights on principle and applications of various techniques such as, nucleic acid hybridization, DNA sequencing, Microarray and blotting in the field life science.
CO5	Understand the different strategies of gene therapy, its role in various inherited diseases and also recent developments in recombinant vaccines.
CO6	Summarize various applications of genetic engineering in different fields

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	1	1	1	1	3	1	3	3	1
CO 2	2	1	1	1	1	1	3	1	3	3	1
CO 3	1	1	1	1	1	1	3	1	3	3	1
CO 4	1	1	1	3	1	1	3	2	3	3	1
CO 5	1	1	1	1	1	1	3	1	3	3	3
CO 6	3	1	3	1	1	1	3	1	3	3	3

Course Title: Genetic Engineering - Core Paper: 8

Sl. No	CONTENTS OF MODULE	Hrs	Cos
1.	History and scope of genetic engineering, Molecular tools used in engineering tools - Restriction enzymes: Endo & Exonucleases; ligases, alkaline phosphatase, polynucleotide kinase, terminal nucleotidyl transferase, DNA polymerases, Taq DNA polymerase, RNAse, reverse transcriptase, linkers, adapters, oligonucleotide primers and homopolymer tailing.	**12**	**CO1**
2.	Cloning vectors: Plasmids - properties and types; pUC19 & pBR322, phage vectors (λ & M13), Cosmid vectors, Shuttle and expression vectors, YAC (*S. cerevisiae* as a model) & BAC (*E.coli*). Eukaryotic vectors – SV40, Gemini Virus; Selection and screening of recombinants - Direct selection, Insertional inactivation, blue-white screening, colony hybridization technique, immunological tests.	**12**	**CO2**
3.	Construction of genomic & cDNA libraries; Molecular probes - Types of probes and its construction - probe labeling, Nick translation, End labeling and Random primer labeling, The labeling of DNA with radionucleotides. Molecular markers - Variable Nucleotide Tandem Repeats (VNTR's), Short Tandem Repeats (STR), Mini and Microsatellite sequences.	**12**	**CO3**
4.	Polymerase chain reaction and its variants; DNA fingerprinting; DNA sequencing - Maxam and Gilbert sequencing, Sanger's Dideoxy sequencing, Next-generation sequencing, Site directed mutagenesis; DNA microarray; Blotting techniques - Southern, Northern, Western; CRISPR technology.	**12**	**CO4**
5.	Gene Transfer methods - Vector based method - Direct methods; Gene therapy Different - Strategies for gene therapy, Gene therapy for inherited diseases, ADA, Cystic Fibrosis; Applications of genetic engineering in Industry, Medicine and Agriculture. Recombinant vaccines, Edible vaccines.	**12**	**CO5 & CO6**

Text Books:	
1.	T.A. Brown (2016). *Gene Cloning and DNA Analysis: An Introduction*, (7th edition), Wiley-Blackwell, ISBN: 9781119072560.
2.	Sandhya Mitra (2017). *Genetic Engineering*, (2nd edition), McGraw Hill Education, ISBN: 9789339203535.
3.	R C Dubey (2014). *Advanced Biotechnology*, (1st Edition), S. Chand Publishing, ISBN: 9788121942904.

Reference Books:	
1.	Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick (2017). *Lewin's GENES XII*, (12th edition), Jones and Bartlett Publishers, ISBN: 978-1-284-10449-3.
2.	Primrose S.B. (2014). *Principles of Gene Manipulation and Genomics*, (7th edition), John Wiley Blackwell, ISBN: 978-8126548392.

Course Title: Bioprocess Technology -Core Paper: 9

Course Code :	**Credits : 04**
L:T:P:S: 4:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

The subject will introduce the students with an up-to-date knowledge of upstream and downstream processing technology. The subject provides in-depth understanding of the key process design concepts relating to the production of biomolecules of industrial importance. The students will be equipped with knowledge of historical development of bioprocess technology, design of fermenter and types of fermentation process.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Acquainted with different methods of measuring microbial growth; and understanding the growth and death kinetic parameters of batch and continuous growth process.
CO2	Attains insightful on design, different critical components and various types of fermenter and able to formulate medium components for the industrial production of microbial metabolites.
CO3	Aware of various industrially important microbial products; their production process and assessment in modern industrial sector.
CO4	Demonstrate knowledge of intracellular product recovery from microbial biomass in industrial operation
CO5	Gain insights on multistage operation of downstream processing for product extraction involving, Liquid phase extraction, filtration, crystallization and drying.

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	1	1	1	2	2	1	2	1
CO 2	2	1	3	1	1	1	1	1	2	2	1
CO 3	3	1	3	1	1	1	2	3	1	1	2
CO 4	2	1	2	1	2	1	1	2	1	2	2
CO 5	2	1	3	1	1	1	2	2	3	2	3

Course Title: Bioprocess Technology -Core Paper: 9

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Historical Development of Bioprocess Technology, an overview of traditional and modern applications of biotechnology industry. Measurement of growth (Direct and indirect methods). Microbial growth kinetics (Batch, Continuous, Fed batch). Thermal death kinetics of microorganisms. Effect of environment (temperature, pH, substrate concentration) on product formation	**12**	**CO1**
2	General requirements of fermentation processes, Basic design and construction of fermenter and ancillaries. Types of bioreactors: submerged reactors, surface reactors, mechanically agitated reactors, non-mechanically agitated reactors. Medium requirements for fermentation processes. Simple and complex media, design and usage of various commercial media for industrial fermentations. Sterilization of liquid media, filter sterilization of liquid media and Air.	**12**	**CO2**
3	An overview of aerobic and anaerobic fermentation processes (Production of citric acid, penicillin, insulin and ethanol). and their application in the biotechnology industry. Solid substrate, slurry fermentation and its application. Behavior of microbes in different reactors (air lift, fluidized, batch, continuous fed batch condition). Cell immobilization, production of biomass and applications.	**12**	**CO3**
4	Downstream processing: Multi stage operation. Solid liquid separation: filtration, centrifugation, filter aids, flocculation. Recovery of intracellular components: Mechanical and non-mechanical (chemical and enzymatic methods).	**12**	**CO4**
5	Concentration of biological products: Evaporation, liquid-liquid extraction. Aqueous two-phase system (ATPS), supercritical fluid extraction, membrane filtration, precipitation, and adsorption. Product formulation: Principles and equipments, crystallization, drying, use of different types of dryers and lyophilization.	**12**	**CO5**

Text Books:	
1.	Michael L. Shuler and Fiket Kargi (2003). *Bioprocess Engineering*, PHI Publishers, ISBN: 978-8187336600.
2.	A.H. Patel (2011). *Industrial Microbiology,* (2nd edition), Laxmi publications, ISBN: 978-9350590089.
3.	Stanbury P. F., Whitaker A., Hall S.J. (2003). *Principles of Fermentation Technology*, (2nd ed.), Elsevier Science Publishers, BV, Amsterdam, ISBN: 07506-4501-6.

Reference Books:	
1.	R.G. Harrison, P. Todd, S. R. Rudge and D.P. Petrides (2003). *Bioseparation Science and Engineering*, Oxford Press, ISBN: 9780195391817.
2.	Harley and Klein (2002). *Microbiology: Presscott*, (Fifth edition), McGraw Hill, New York, ISBN: 978-0072320411.

Course Title: Bioinformatics - Core Paper: 10

Course Code :	**Credits : 04**
L:T:P:S : 4:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

The course is designed to provide basic knowledge about Bioinformatics and biological information on the web. Major research efforts in the field include sequence alignment, gene finding, genome assembly, drug design, drug discovery, protein structure alignment, protein structure prediction, prediction of gene expression. Common activities in bioinformatics include mapping and analyzing DNA and protein sequences, aligning DNA and protein sequences to compare them, and creating and viewing 3-D models of protein structures. Students will understand the algorithms and programs that are used for designing tools to analyze macromolecules to unravel their significant importance. It also gives them ideas on designing drugs by in silico studies.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Discuss about various types of biological databases and its importance
CO2	Explain various sequence alignment programs
CO3	Exhibit knowledge in evolutionary analysis and interpret in meaning manner
CO4	Enumerate genome structure and functions using gene sequencing technologies
CO5	Predict protein structure and to validate novel lead compounds using drug design approach

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	2	2	1	1	1	2	3	2	1
CO 2	2	1	2	3	1	1	1	2	2	2	1
CO 3	3	1	2	2	2	1	1	3	2	3	2
CO 4	2	1	3	2	2	2	1	2	2	2	2
CO 5	2	1	2	3	2	1	1	3	3	2	2

Course Title: Bioinformatics -Core Paper: 10

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Introduction to Bioinformatics** Introduction to Bioinformatics, Classification of biological databases –Protein and Nucleotide Sequence Database; Sequence motifs Databases: - Prosite, ProDom, Pfam, InterPro. Application of Bioinformatics in Various Fields; Introduction to Single Letter Code of Amino acids, Symbols Used in Nucleotides; Data Retrieval Systems- Entrez and SRS; Literature database – Pubmed, PMC, OMIM	**10**	**CO1**
2	**Sequence Alignment and Homology search** Introduction to Sequence Alignment: Substitution Matrices, Scoring Matrices – PAM and BLOSUM; Local and Global Alignment Concepts, Dot Plot. Dynamic Programming Methodology: Needleman and Wunsch Algorithm. Smith–Waterman Algorithm; Multiple sequence Alignment- Progressive Alignment. Homology search Using FASTA and BLAST Programs, Specialized BLAST programs	**13**	**CO2**
3	**Phylogenetic analysis** Evolutionary Analysis– Introduction, Phylogenetics - Tree construction methods – Distance based methods and character-based Methods; Cladistic and Phenetic Methods; Special tree types; Rooted and Unrooted Tree Representation; Bootstrapping Strategies, Use of Clustal, T-Coffee and PHYLIP	**12**	**CO3**
4	**Genome analysis tools and Next Generation Sequencing** Gene Finding Methods: Gene Prediction: Analysis and Prediction of Regulatory Regions, Promoter Prediction, Restriction Mapping, Repeat Sequence finder, ORF prediction; Fragment Assembly, Genome Sequence Assembly; Next Generation Sequencing: Sanger DNA Sequencing, Pyrosequencing, Illumina Genome Analyzer, Applied Biosystems SOLiD™; Concept of Gene Expression, Microarrays; GEO Database. Application of Microarrays	**13**	**CO4**
5	**Protein structure prediction and Drug designing** Protein structure prediction methods-secondary and tertiary structure prediction; Protein domains and motifs; Drug discovery and Identification, Steps in Ligand based and structure based Drug Design.	**12**	**CO5**

Text Books:	
1.	Baxevanis, Andreas D. and Francis B.F. Ouellette. (2005). *Bioinformatics- A Practical Guide to the Analysis of Genes and Proteins,* (3rd ed.), USA: John Wiley., ISBN: 978-0-471-46101-2.
2.	S. C. Rastogi, Namita Mendiratta, Parag Rastogi. (2013). *Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery,* PHI Learning Pvt. Ltd., ISBN: 9788120347854.
3.	R C Dubey (2014). *Advanced Biotechnology*, (1st Edition), S. Chand Publishing, ISBN: 9788121942904.

REFERENCE BOOKS:	
1.	S. C. Rastogi, M. Namita, P. Rastogi (2013). *Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery,* PHI Learning Pvt. Ltd., ISBN: 9788120347854.
2.	Lesk Arthur (2019). *Introduction to Bioinformatics,* (5th Ed.), UK: Oxford University Press, ISBN: 9780198794141.

Course Title: Enzymes & Enzyme Technology -Core Paper: 11

Course Code :	**Credits : 04**
L:T:P:S : 6:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

The course is specially designed to introduce a deeper insight in to the fundamentals of enzyme structure and its kinetics. The subject also provides the students, the basic understanding of enzyme function as biocatalysts and fermentation in various aspects of biotechnology. The course will help the students understand the kinetics and mechanism of enzyme action.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Identify the class, properties and functions of the enzymes and gain knowledge on various techniques involved in extraction, isolation and purification of enzymes.
CO2	Discuss the kinetics of enzyme catalyzed reactions and interpret the various equations involved in enzyme inhibition.
CO3	Determine the active site of an enzyme and discuss the general acid base catalysis of enzyme activity.
CO4	Illustrate the action and regulation of various enzymes and describe the production of industrial enzymes.
CO5	Appraise and practice the clinical and industrial application of enzymes for developing entrepreneurship skill.

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	1	1	1	3	1	1	2	1	3	1	3
CO 2	1	2	1	3	2	1	2	2	3	2	3
CO 3	1	2	1	3	1	1	2	1	3	1	3
CO 4	1	2	1	3	2	1	2	2	3	2	3
CO 5	1	1	1	3	1	1	2	1	3	1	3

Course Title: Enzymes & Enzyme Technology - Core Paper: 11

Sl. No	CONTENTS OF MODULE	Hrs	Cos
1.	Introduction to enzymes: Nomenclature and Classification of enzymes. Enzyme units- Katal and IU. Specific activity of enzymes. General properties like effect of pH, substrate and temperature on enzyme catalyzed reactions. Non protein enzymes – Ribozymes and DNAzymes. Metalloenzymes and metal activated enzymes. Coenzymes and Cofactors- Prosthetic group. Extraction, Isolation and purification of enzymes. Isoenzymes. Multienzymes.	12	**CO1**
2.	Enzyme Kinetics: Single substrate reactions, bisubstrate reactions, concept of Michaelis - Menten, Briggs Haldane relationship, Determination and significance of kinetic constants, Limitations of Michaelis-Menten Kinetics, line weaver burk plot, Hanes Woolf equation, Eadie Hofstee equation, Inhibition of enzyme activity – Competitive, Non-competitive and Uncompetitive (Only concepts)	12	**CO2**
3.	Enzyme catalysis: Enzyme specificity – Types: Absolute, Group, Linkage and Stereochemical. Active site- Salient features and Determination of active site. General acid-base catalysis, Nucleophilic and electrophilic attacks, metal ion catalysis. Mechanism of enzyme action – Lock and Key, Induced fit. Action of lysozyme, chymotrypsin, carboxypeptidase and DNA polymerase. Mechanism of action and regulation of pyruvate dehydrogenase and fatty acid synthase complex.	12	**CO3**
4.	Enzyme regulation: Allosteric regulation, sigmoidal kinetics and their physiological significance, Symmetric, MWC and sequential models of allosterism. Reversible and irreversible covalent modification of enzymes. Availability of the substrates.	12	**CO4**
5.	Production of industrial enzymes: Proteases, Amylases, Lipases and Cellulases. Immobilized enzymes and their industrial applications. Use of enzymes in Biosensors. Clinical and industrial applications of enzymes. Role of enzymes in Pharma industry, Food& Beverages industry, Textile processing, Clinical and Agricultural applications.	12	**CO4& CO5**

Text Books:	
1.	Nelson David L, Cox Michael M, L. Lehninger Albert L. (2017). *Lehninger Principles of Biochemistry,* (7th ed.), New York, W. H. Freeman publishers, ISBN: 9781319108243.
2.	Satyanarayana .U (2013). *Biotechnology,* Books & Allied Ltd., ISBN: 9788187134909.
3.	Nicholas C Price, Lewis Stevens (1989). *Fundamentals of Enzymology,* Oxford University Press, New York, ISBN: 978-0198502296.

Reference Books:	
1.	Reginald Garrett, David Jemiolo K., Steven Theg .M (2008). *Principles of Biochemistry: With a Human Focus*. Harcourt College Publishers, ISBN: 978-0-03-097369-7.
2.	Geoffrey Zubay .L *Biochemistry* (3rd ed.), William C Brown Pub., ISBN: 9780697142672.

Course Title: Advanced molecular Techniques -Elective Paper: 4A

Course Code :	**Credits : 03**
L:T:P:S : 3:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

This course helps the students to understand the principles of various molecular techniques. The course improves basic knowledge on imaging and diagnostic techniques and their clinical application. The content implies the importance and applications of various molecular techniques in field of science and technology.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Apply the principles of molecular techniques for the isolation and purification of biomolecules and to acquire a vast knowledge on the interaction of DNA, RNA and Protein in a cell.
CO2	Discuss the advancements in DNA and protein sequencing techniques and the applications of DNA, protein microarray in research perspective.
CO3	Develop skill in the protein separation techniques by understanding the principle of chromatography, electrophoresis and filtration and their applications in various research sectors.
CO4	Gain insight on the advances in Nucleic acid-based detection methods such as PCR based and hybridization methods.
CO5	Foster intellectual curiosity in molecular related- bioinstrumentation techniques that extends well beyond the course with a major focus on molecular based diagnostic approaches.

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	1	3	1	1	3	2	2	1	1
CO 2	2	1	1	3	1	1	1	2	1	3	1
CO 3	3	1	1	1	1	1	1	1	1	3	1
CO 4	1	1	3	2	1	1	1	1	1	3	1
CO 5	1	1	1	1	2	2	1	2	3	1	1

Course Title: Advanced molecular Techniques- Elective Paper: 4A

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Protein techniques -Purification of recombinant proteins, Protein sequencing - Edman degradation,peptide sequencing, enzyme assays,protein interaction and protein – nucleic acid interaction; Mass spectrometry- instrumentation and applications, MALDI-TOF, Spectrophotometry- UV and visible, Infrared, NMR; X-ray Crystallography.	9	CO1
2	Nucleic acid techniques -isolation, purification & quantification of Nucleic acids. DNA – Modification and methylation analysis. RNA - *In Vitro* Transcription, mRNA Stability Assay, RACE, RNA Electrophoresis, RNase Protection Assay, Sequencing – Next generation sequencing, DNA and Protein Microarray.	9	CO2
3	Separation techniques - Principles of biomolecule separation, Chromatography techniques- Ion- exchange chromatography, Affinity chromatography, HPLC, Gas Chromatography, Electrophoresis –Isoelectric focusing, PFGE, Ultra filtration.	9	CO3
4	Centrifugation –Basic principle-types-differential and density gradient centrifugation. Radioactivity- introduction and properties of alpha, beta and gamma radiations- radioisotopes-radioactive decay- radioisotopes in medical applications.	9	CO4
5	Molecular based diagnostic techniques - ELISA, PCR in molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage), ASA (Allele-Specific Amplification).	9	CO5

Text Books:	
1.	Keith Wilson and John Walker (2000). *Principles and Techniques of Practical Biochemistry,* (5th Edition), Cambridge University Press, ISBN: 978-0-521-51635-8.
2.	T. A. Brown (2010). *Gene cloning and DNA analysis- An introduction*, (sixth Edition), Wiley- Blackwell, ISBN: 978-1405181730.
3.	Primrose S B. Twyman R M and Old R W. (2001). *Principles of Gene Manipulation,* (6th Edition), S.B University Press, ISBN: 9780632059546.

Reference Books:	
1.	Freifelder D. (1982). *Physical Biochemistry- Application to Biochemistry and Molecular Biology*, (2nd Edition), W.H. Freeman & Company, San Francisco, ISBN: 978-0716714446.
2.	Susan Carson, Heather B. Meler et al., (2019). *Molecular Biology Techniques – A Classroom Laboratory Manual,* (4th edition), Academic Press, ISBN: 978-0128180242.

Course Title: Nano Biotechnology- Elective Paper: 4B

Course Code :	**Credits : 03**
L:T:P:S : 3:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

The course covers the basic knowledge about different nano scale structures and its properties on various levels. The course also helps the students to understand the importance of biological synthesis and applications of nanostructures in the field of biotechnology. To gain knowledge about the various process of nanoparticles synthesis and its applications in biological field.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Discuss the historical perspectives of nanotechnology and understand the physiochemical properties of different types of nanostructures.
CO2	Compare and gain knowledge on various types of nanoparticles synthesis such as, physical, chemical and biological and their advantages.
CO3	Summarize different techniques involved in the characterization of the nanostructures and its properties.
CO4	Criticize the toxic effect of nanoparticles in plants and foods and also to express ethical issues of nanotechnology and their need for regulation.
CO5	Debate the applications and emerging trends of nanotechnology in different areas of science and also able to list out the safety measures in handling of nanostructures.

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	3	1	2	3	1	1	3	3
CO 2	3	1	3	3	1	2	3	2	2	3	3
CO 3	2	1	1	3	1	1	3	3	3	3	1
CO 4	2	1	3	3	2	3	3	2	2	3	3
CO 5	3	2	3	2	1	2	3	3	3	3	3

Course Title: Nano Biotechnology- Elective Paper: 4B

Sl. No.	CONTENTS OF MODULE	Hrs	Cos
1	Nanotechnology introduction: History, Nanomaterials - Time and length scale in structures; Classification and types of nanoparticles; Properties at nanoscale – optical, mechanical, electronic and magnetic; Quantum dot, Carbon based nanostructures – buckyballs, nanotubes, graphene; metal based nanostructures – Gold, Silver, Copper and Zinc; Biological nanomaterials, nanopolymers, nanocomposites.	**9**	**CO1**
2	Synthesis of nanoparticles: Physical synthesis – Mechanical milling, Spinning, Nanolithography, Laser ablation, Pyrolysis, Sputtering, Thermal decomposition. Chemical synthesis- Sol-gel, Sonochemical routes, micro emulsion, Chemical Vapour Deposition. Biological synthesis- Synthesis of nanomaterials using Plants, bacteria, fungi and actinomycetes.	**9**	**CO2**
3	Characterization of nanobiomaterials: Basic principles, operations and applications of UV–Vis spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), Thermogravimetry analysis, Zeta potential measurement, Dynamic Light Scattering (DLS), X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Field Emission Scanning Electron Microscopy (FESEM)- Energy Dispersive X-ray Analysis (EDX), Transmission Electron Microscope (TEM), High Resolution Transmission Electron Microscope (HRTEM).	**9**	**CO3**
4	Nanotoxicity: Definition, Mechanism of nanotoxicity, nanotoxicity of metal oxide, nanotoxicity in plants and food, Assessment of nanotoxicity, Ethical issues and Intellectual property issues of nanotechnology- health issues, environmental issues and need for regulation. Benefits and risk of nanotechnology in developing nations.	**9**	**CO4**
5	Applications of Nanotechnology: In Agriculture, Food Technology, Environment, Biomedical, Textiles, Cosmetics, Military and Pharmaceutical Industry and other commodities. Future perspective and studies on implications of nanotechnology.	**9**	**CO5**

Text Books:	
1.	Debasis Bagchi, Manashi Bagchi, Hiroyoshi Moriyama, Fereidoon Shahidi (2013). *Bio-Nanotechnology: A Revolution in Food, Biomedical and Health Sciences*, Wiley-Blackwell, ISBN: 9780470670378.
2.	Rai, Mahendra, and Clemens Posten (2013). *Green biosynthesis of nanoparticles: Mechanisms and applications*, CABI, ISBN: 9781780642246.
3.	Pradeep T (2012). *Textbook of Nanoscience and Nanotechnology*, McGraw Hill publications, ISBN: 9781259007323.

Reference Books:	
1.	C.M.Niemeyer, C.A. Mirkin (2007). *Nanobiotechnology*, WILEY-VCH Verlag GmbH & Co. KG, Weinheim, ISBN: 9783527306589.
2.	Guozhong Cao (2004). Nanostructures and Nanomaterials, synthesis, properties and applications, Imperial College Press, ISBN: 978-1860944802.

Course Title: Tissue Engineering- Elective Paper: 4C

Course Code :	**Credits : 03**
L:T:P:S: 5:0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

This course aims that the students obtain deeper knowledge and understanding about the subject tissue engineering. The objectives are given that students will learn about key technologies used in tissue engineering and regenerative medicine, will deal with the basic and clinical aspects of stem cell research, the conversion of stem cell types into a variety of suitable tissues and gain state-of-the-art knowledge on the potential of stem cells for the regeneration of a wide range of tissues and organs. The subject will help the students understand the making of invitro tissues/organs.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Describe the basics and scope of tissue engineering, cell differentiation and apoptosis.
CO2	Configure the models of tissue engineering bioreactors and tissue engineering assembly.
CO3	Acquire knowledge on transplantation and immunomodulation
CO4	Explain the organ replacement devices.
CO5	Emphasize the role of tissue engineering in implants.

Mapping of Course Outcomes to Program Outcomes:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	3	1	2	1	1	1	1	3	3	3	3
CO 2	2	3	1	1	2	1	1	2	3	3	2
CO 3	2	1	2	1	1	1	2	3	2	3	1
CO 4	3	1	1	2	1	3	2	2	2	3	2
CO 5	2	1	1	3	1	2	1	3	3	2	1

Course Title: Tissue Engineering- Elective Paper: 4C

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Basic Biology of tissue engineering; Current scope and development in tissue engineering; Basis of growth and differentiation- Hormones and growth factors; Morphogenesis and tissue engineering. Biological description of apoptosis	**9**	**CO1**
2	Tissue engineering bioreactors-Introduction-types of bioreactors-tissue formation in bioreactor; Tissue engineering assembly in microgravity-cartilage, bone and liver tissue engineering –applications in diabetes; Organotypic and histotypic cultures- approaches-types of techniques.	**9**	**CO2**
3	Biomaterials in tissue engineering- cell sources-biomaterial scaffolds-scaffold requirements. Transplantation of engineered cells and tissues-immunomodulations- Immunoisolators. Cardiac prosthesis- Concepts and approaches.	**9**	**CO3**
4	RBC substitutes-cellular and acellular oxygen carriers. Bioartificial pancreas-modelling the cell; HepatAssist liver support system; Renal replacement device- dialysis, timing and complications; Musculoskeletal system.	**9**	**CO4**
5	Brain implants-history, modelling and complications; Neural stem cells-development and functions; Skin-basic biology of wound repair-classification-stages and phase of wound healing; Artificial womb-innate features-biobag-partial ectogenesis.	**9**	**CO5**

Text Books:	
1.	Robert, L. Robert, L., and Joseph, V. (2013). *Principles of Tissue Engineering (4th edition),* Cambridge. Academic Press, ISBN: 9780123983589.
2.	*B*ernhard, P. Jeffrey A.H. Robert, P., and Joseph D. B. (2019). *Tissue Engineering (1st edition*, Boca Raton. CRC Press, ISBN: 9780429214882.
3.	Anthony, A. Robert, L. Robert, N., and James, A.T. (2010). *Principles of Regenerative Medicine, (3rd edition),* Cambridge. Academic press, ISBN: 9780128098806.

Reference Books:	
1.	Paolo N. (2014). *Biomedical Foams for Tissue Engineering Applications* (1st edition), Cambridge. Academic press, ISBN: 9780857096968.
2.	Martin, J. Stoddart April, M. Craft Girish, P., and Oliver, F.W. G. (2018). *Developmental Biology and Musculoskeletal Tissue Engineering Principles and Applications,* (1st edition), Cambridge. Academic press, ISBN: 9780128115381.

Course Title: Genetic Engineering and Bioprocess technology - Core Practical: IV

Course Code	**:**	**Credits**	**: 02**
L:T:P:S	**:0:0:3:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

This course is designed to expertise students in working skills required to handle nucleic acids with regard to their isolation from microbial and animal sources and with techniques required for their application to Genetic manipulation strategies such as separation, amplification, ligation and hybridization. This course also emphasizes the utility of microorganisms in Industrial applications for the large-scale production, extraction and purification of secondary metabolites, organic acids and for scaling up of Biomass.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Gain hands on experience on various instruments associated with genetic engineering and molecular biology.
CO2	Estimate, Extract and separate DNA using molecular techniques.
CO3	Prepare competent cells for the transformation of interest DNA into to host cells.
CO4	Master the skills required for the amplification of DNA fragments using PCR technique.
CO5	Perform DNA fingerprinting analysis using Restriction Fragment Length Polymorphism (RFLP) technique
CO6	Understand the concepts of blotting techniques using southern hybridization
CO7	Comprehend the basics of isolation, preservation and maintenance of various industrially important microorganisms.
CO8	Screen and identify industrially important microbes for their various metabolite production.
CO9	Separate proteins using precipitation methods and analyze the purity of the proteins using electrophoretic techniques
CO10	Perform cell immobilization using a entrapment method and Execute column chromatography for the purification of secondary metabolites.
CO11	Demonstrate the production of organic acids and wine.

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	PO						PSO				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	1	1	1	2	3	2	3	1
CO 2	1	1	1	1	1	1	2	3	2	3	1
CO 3	2	1	1	2	1	1	3	3	2	3	1
CO 4	2	1	1	2	1	1	3	3	2	3	1
CO 5	1	1	1	3	1	1	3	3	2	3	1
CO 6	3	1	1	2	1	1	3	3	2	3	1
CO 7	2	1	2	1	1	1	2	1	3	1	3
CO 8	2	1	2	1	1	1	2	2	3	2	3
CO9	2	1	3	1	1	1	2	1	3	1	3
CO10	1	1	2	3	1	1	2	2	3	2	3
CO 11	1	1	1	1	2	1	2	1	3	1	3

Course Title: Genetic Engineering and Bioprocess technology - Core Practical: IV

Sl. No	Contents of Module	Hrs	Cos
1.	**GENETIC ENGINEERING** 1. Extraction of genomic DNA from microbes 2. Preparation of plasmid DNA by alkaline lysis method. 3. Agarose Gel electrophoresis 4. Estimation of DNA in animal tissue such as Blood, Liver (animal). 5. Elution of DNA from agarose gel. 6. Competent cell preparation, transformation and selection of recombinants. 7. DNA amplification by PCR **8.** Ligation of DNA fragments 9. Restriction digestion of λ DNA **10.** DNA fingerprinting using Restriction Fragment Length Polymorphism (RFLP) 11. **Demonstration Experiments:** • Identification of specific sequences of DNA by Southern Hybridization • Random Amplification of Polymorphic DNA	**30**	**CO1** **CO2** **CO3** **CO4** **CO5** **CO6**
2.	**BIOPROCESS TECHNOLOGY** 1. Isolation, Preservation and Maintenance of Industrial Microorganisms. 2. Estimation of Biomass. 3. Screening for Protease producing organisms. 4. Production and assay of protease activity. 5. Use of alginate for yeast cell immobilization. 6. Industrial production of ethanol and its estimation 7. Purification of secondary metabolite (antibiotic from *Bacillus sp*. by column chromatography) **8.** Aqueous phase extraction of protease from microorganism 9. Production of organic acids 10. Production of wine	**30**	**CO7** **CO8** **CO9** **CO10** **CO11**

Reference Books/Manuals:	
1.	Michael R. Green and Joseph Sambrook (2012). *Molecular Cloning - A Laboratory Manual*, (4th edition), Cold Spring Harbor Laboratory Press, ISBN: 978-1-936113-42-2.
2.	Vennison S. John, (2009). *Laboratory Manual for Genetic Engineering*, Prentice Hall India Learning Private Limited, ISBN: 978-8120338142.
3.	Linnea Fletcher (2011). *Introduction in Bioprocess Technology- Laboratory Manual*, (1st Edition), Austin Community College, ISBN: BIOL1414F2011
4.	Harisha .S (2012). *Biotechnology Procedure Experiments*, (3rd Edition), Infinity Science Press, ISBN: 978-1-934015-11-7.

Course Title: Bioinformatics, Enzymes and Enzyme technology - Practical: V

Course Code :	**Credits : 02**
L:T:P:S : 0:0:3:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

On taking this course the student is able to analyse the intermediate in enzyme- catalysed reactions and their investigation. To assess the molecular weight of proteins from the various samples. To impart practical exposure upon Bioinformatics tools and databases upon the analysis of genes and Proteins.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Predict functions of gene and genomes using online tools
CO2	Perform patterns, domains and motifs search in proteins using various programs
CO3	Predict and evaluate the sequence and structure of proteins and peptides
CO4	Align protein and nucleotide sequence using various algorithms
CO5	Retrieve chemical compound and to predict its properties
CO6	Perform molecular interaction analysis of protein and lead compound
CO7	Determine the various parameters such as optimum pH, temperature, substrate concentration and specific activity of amylase/protease enzymes.
CO8	Design and sketch the purification of proteins.
CO9	Determine the molecular weight of amylase by SDS-PAGE.
CO10	Demonstrate immobilization of enzymes by entrapment methods

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	PO						PSO				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	2	2	2	2	1	2	3	2	2
CO 2	2	1	2	3	1	2	1	2	2	2	1
CO 3	3	1	2	3	1	3	1	2	2	3	1
CO 4	1	1	2	2	2	2	1	1	3	2	1
CO 5	1	1	2	2	1	3	1	2	2	2	2
CO 6	1	1	3	3	3	2	1	2	3	2	1
CO 7	2	1	1	3	1	2	2	3	1	2	1
CO 8	2	1	1	3	1	2	2	3	1	2	1
CO9	2	1	1	3	1	2	2	3	1	2	1
CO10	2	1	1	3	1	2	2	3	1	2	1

Course Title: Bioinformatics, Enzyme and Enzyme technology - Core Practical: V

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**BIOINFORMATICS** **Gene and Genome sequence analysis** 1. Sequence Retrieval - NCBI 2. Genomic sequence analysis- Genscan, ORF Finder, Translate tool 3. Gene sequence analysis - PRIMER 3, NEBcutter **Protein sequence analysis and structure prediciton** 4. Retrieval -Uniprot, Profile and Domain analysis: Prosite, Pfam 5. Specialized Tools: Signal P, PSORT, TMHMM, 6. Protein primary and secondary sequence analysis: Protparam, GOR IV, 7. Protein tertiary structure prediction & evaluation -Swissmodel, SAVES 8. Protein Structure Database: PDB 9. Peptide sequence analysis- IEDB-MHC-I & MHC-II, BepiPred, 10. AlgPred, VaxiJen, GalaxyPepDock **Sequence alignment and Homology search** 11. Pairwise sequence alignment – Dotmatcher, Emboss- Needle and Emboss- Water 12. Multiple sequence alignment –Clustal omega 13. Homology Search – BLASTn, BLASTp **Bioactive compound Retrieval and property prediction** 14. Compound structure database: PUBCHEM 15. File format conversion: Open Babel 16. Properties and Drug likeliness prediction- Molinspiration **Structure visualization and Docking** 17. Protein structure visualization –RasMol 18. Molecular Docking: Argus Lab & 19. Interactions viewer –PyMol	**30**	**CO1** **CO2** **CO3** **CO4** **CO5** **CO6**
	ENZYME AND ENZYME TECHNOLOGY 1. Determination of optimum pH for amylase/protease enzyme activity. 2. Determination of optimum temperature for amylase/protease enzyme activity. 3. Determination of optimum substrate concentration for amylase/protease enzyme activity. 4. Determination of activity for amylase/protease enzyme activity. 5. Determination of specific activity for amylase/protease enzyme activity. 6. Precipitation of protein using ammonium sulphate technique 7. Purification of proteins by Dialysis 8. Purification of enzyme- lysozyme using Ion exchange chromatography 9. Determination of molecular weight of protein by SDS – PAGE 10. Immobilization of Enzyme Enzyme (amylase) immobilization by Entrapment method	**30**	**CO7** **CO8** **CO9** **CO10**

REFERENCE BOOKS	
1.	Peter M. Rice, Alan J. Bleasby, Jon C. Ison Lisa Mullan, Guy Bottu. (2020). *EMBOSS User's Guide: Practical Bioinformatics*, Cambridge University press, ISBN: 978-0521607254.
2.	Gokhale B.S, Gaud R.S, Gupta G.D (2018). *Practical Biotechnology*, (9th ed.), Nirali Prakashan publisher, ISBN: 9788185790657.
3.	Thomas Crowley .E (2014). *Experiments in the purification and characterization of enzymes – A laboratory manual*, (1st ed), Academic press, ISBN: 9780124095441.

Fourth Semester

Course Title: Research Methodology, Bioethics & Biostatistics - Extra Disciplinary: 2

Course Code :	**Credits : 03**
L:T:P:S :6 :0:0:0	**CIA Marks : 50**
Exam Hours : 03	**ESE Marks : 50**

LEARNING OBJECTIVES:

Implying research methodology for final year Post-graduate student plays a significant role in helping them to draft their projects effectively. It provides the knowledge to identify the overall process of designing a research study and able to identify research problem stated in a study. Bioethical issues concerning the reproduction is to be inculcated broadly without any gender bias. Graphical representation and statistical analysis will pave the way for the significant researcher. The need for research and train them the bioethical research. It even develops to use contemporary applications of epidemiological and statistical methods.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Share insights on various types of research, research problems, conceptualization of a research design and different sampling methods.
	Debate the bioethical and moral issues revolving around artificial reproduction methods, prenatal diagnosis, organ transplants, Gene therapy and Cloning.
CO3	Understand the different sampling designs, Analyze and represent the different sample variables using various statistical tools.
CO4	Tabulate the different types of data and quantify the extent of their variation using different measures such as mean, median, standard deviation and error.
CO5	Gain knowledge on fundamental concepts of probability theory, test of significance and aware of basic and modern statistical software tools for the analysis of biological data.

Mapping of Course Outcomes to POs/PSOs:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	3	1	1	1	2	2	3	3
CO 2	2	2	2	2	1	1	1	3	1	2	3
CO 3	1	1	1	3	1	1	1	2	1	2	2
CO 4	1	1	1	3	1	1	1	1	1	2	2
CO 5	1	1	1	3	1	1	1	1	2	2	1

Course Title: Research Methodology, Bioethics & Biostatistics - Extra Disciplinary: 2

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Research – definition, application, characteristics and types. Research process. Formulation of research problems, literature survey. Conceptualization (definition and function) of a research design. Data collection – Methods; Sampling – concept, principles and types; Writing a research proposal.	**12**	**CO1**
2	BioEthics-Issues concerning reproduction, Birth, life and Death (Artificial insemination, egg donation, IVF, embryo transplants, Prenatal diagnosis and sex selection & Abortion) – Ethical implication on issues concerning organ transplants, Stem Cells, Human genome project, Gene therapy and Cloning.	**12**	**CO2**
3	Sampling and sample designs, diagrammatic and graphic presentation-types of diagrams. Graphs - technique for constructing graphs. Graphs of frequency distributions-Histograms, frequency polygon, frequency curve, limitations of diagrams and graphs.	**12**	**CO3**
4	Biometry, collection, classification and tabulation of data, measures of central tendency-(Arithmetic harmonic and geometric mean), median and mode, measures of dispersions-standard deviation, quartile deviation and mean deviation, skewness, moments and kurtosis, standard error and standard curve.	**12**	**CO4**
5	Probability theory – probability distribution, Binomial, Poisson and Normal distribution. Correlation coefficient and regression analysis. Test of significance, t-test, chi square test, one way and two ways ANOVA. Introduction to software packages SPSS, MINITAB, MATLAB.	**12**	**CO5**

Text Books:	
1.	Ranjith Kumar (2011). *Research Methodology - A step by step guide to beginners*, (3rd edition), Delhi, Sage Publisher, ISBN: 978-1-84920-300-5.
2.	Kothari C.R. and Gaurav G. (2019). *Research Methodology: Methods and Techniques*, (4th edition), New age international publishers, Kolkata, ISBN: 978-81-224-2488-1.
3.	Ignacimuthu S (2014). *Bioethics* (2nd edition), Narosa Publishing House Pvt. Ltd., New Delhi, ISBN: 9788184872477.

Reference Books:	
1.	Booth C.W. *et al*., (2016). *The Craft of Research*, (4th edition), University of Chicago Press, ISBN: 978-0226239736.
2.	Myneni R.S. (2012). *Human Rights*, Asia law house, Hyderabad, ISBN: 9789382705017.

Course Title: Herbal Technology-Open Elective Paper: 1

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 50**
Exam Hours	**: 03**	**ESE Marks**	**: 50**

LEARNING OBJECTIVES:

The course content imparts the knowledge about herbal drugs and its recent developments. The course content also familiarizes the students about the extraction and evaluation of herbal drugs. It provides understanding about the medicinal properties, applications and development of herbal drugs.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Enable to identify the herbal materials and their therapeutic applications.
CO2	Analyse the different types of extraction of phytochemical constituents for promoted research.
CO3	Exhibit the industrial importance of herbal constituents and purification of their products.
CO4	Determine the quality of herbal drugs using molecular techniques and formulation of herbal drugs.
CO5	Discuss the guidelines for research in related fields and utilize the therapeutic properties of herbal drugs to meet the necessities of public health.

Mapping of Course Outcomes to Program Outcomes& Program Specific Outcomes:

CO/PO/PSO	**PO**						**PSO**				
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**
CO 1	2	1	1	1	1	1	2	2	3	2	2
CO 2	1	1	2	3	1	1	2	2	3	2	1
CO 3	3	1	2	1	2	1	2	2	3	2	1
CO 4	2	1	1	3	1	1	2	3	2	2	1
CO 5	1	1	1	3	2	1	2	2	2	2	3
CO 6	1	1	1	1	1	1	2	2	2	2	3

Course Title: Herbal Technology; Open Elective Paper: 1

Sl. No	CONTENTS OF MODULE	Hrs	Cos
1.	Introduction to Herbal technology: Herbal drug – Definition; Concepts of Herbal technology; Source of Herbs; Advantage over conventional drugs; Herbal medicinal product; Herbal medicine; Importance of Herbal therapies; Selection, identification and authentication of herbal materials; Classification of Crude drugs; Recent development in herbal technology.	**9**	**CO1**
2.	Processing of herbal materials: Collection and Processing of herbal materials; General methods of extraction of phyto-constituents from plant materials: Decoction, Maceration, infusion, Percolation, Distillation, Soxhlet extraction, Supercritical fluid extraction, Microwave assisted extraction.	**9**	**CO2**
3.	Phytoconstituents: Phytochemical Evaluation of herbal Drug: Methods of Phytochemical Screening; Isolation, assay methods and purification of with a special reference to their importance in herbal industries of following constituents - Alkaloids, Steroids, Terpenoids, Flavonoids, Glycosides, Tannins and Coumarins	**9**	**CO3**
4.	Quality control: Evaluation of crude drugs; Adulteration and Deterioration of herbal materials: Different of causes and measures of Adulteration; Sampling procedures, Determination of Foreign Matter, DNA Finger printing techniques for identification of drugs of natural origin, detection of pesticide residues, heavy metals, phytotoxin, microbial contamination in herbs and their formulations.	**9**	**CO4**
5.	Guidelines and Applications: Indian Council of Agricultural Research; WHO and AYUSH guidelines for safety monitoring of natural medicine; Medicinal Properties and Applications of herbal drug - Antimicrobial, anti-inflammatory, antibiotic drugs, antihypertensive, antioxidant, anti-inflammatory, antidiabetic and anticancer; Microbial analysis method and limitation for herbal drugs based on AYUSH regulation	**9**	**CO5**

Text Books:	
1.	Neelesh Malviya and Sapna Malviya (2019). *Herbal Drug Technology*, (1st Edition), CBS Publishers and Distributors, ISBN: 9789387964334.
2.	Rageeb Md. Usman, Vaibhav M. Darvhekar, Vijay Kumar D, and Akhila S.A, (2019). *Practical Book of Herbal Drug Technology*, (1st Edition), Nirali Prakashan Publishers, ISBN: 9789388108002.
3.	Pragi and Varun Arora (2019). *Herbal Drug Technology*, (1st Edition), S.Vikas and Company Publisher, ISBN: 9781543343687

Reference Books:	
1.	Agarwal and Paridhavi (2012). *Herbal Drug Technology*, (2nd Edition), Orient Blackswan Private Limited, ISBN: 9788173717871.
2.	Shanti Bhushan Mishra (2019). *Essentials of Herbal Drug Technology*, (1st Edition), Educreation Publishing, ISBN: 9789388719087.

VALUE ADDITION COURSE - 1

Duration : 30 Hours

Course Title : **Food Safety and Hygiene Standards**

Course Provider : Kirke Cheese Pvt Ltd, Chennai

SYLLABUS:

Module	CONTENTS OF MODULE
1	**BASICS OF FOOD SAFETY AND HYGIENE- PART 1**
	1.1. What is Food Safety?
	1.2. Basics of Food Safety and Hygiene:
	1.2.1. Personal hygiene and Grooming
	1.2.2. Cleaning, Disinfecting, Sanitization
	1.2.3. Time and temperature control, Danger zone temperature.
	1.2.4. FATTOM- (Fat, Acid, Time, Temperature, Oxygen and moisture)
	1.2.5. Cross-contamination
	1.2.6. Types of hazards
	1.2.7. Allergies- allergens and intolerance
	1.2.8. Right storage and handling practices.
	1.2.9. Pest control
2	**BASICS OF FOOD SAFETY AND HYGIENE- PART 2**
	1. What are the different food verticals?
	2. 5 Hygiene Stations.
	3. 21 reasons of food spoilage.
	4. Checklist and documents for each of the hygiene stations.
	5. Identification of spoilage bacteria
	6. Prevention of product spoilage by right storage and handling practices.
	7. Scope and Job Opportunities
3	**Food Microbiology and Food Chemistry**
	1. What is a food borne illness?

	2. What are germs?
	3. What are food pathogens?
	4. What are the food poisoning bacteria?
	5. Good and Bad bacteria.
	6. Types and Identification of food poisoning bacteria.
	7. Identification of bacteria via testing and microscope.
4	**HACCP and Practices**
	1. HACCP
	2. Plan
	3. Principles
	4. Risk Analysis
	5. What are the CCP- Critical Control Points for the 5 hygiene stations?
	6. Records and documentation
	7. HACCP Checklist
	8. Quality Assurance and total Quality Management
5	**FSSAI**
	1. What is FSSAI?
	2. Role of FSSAI
	3. FSS Act 2006
	4. Food Categorization
	5. Food Product Standards and Food Additives Regulations, 2011
	6. Licensing and Regulations Schedules (I, II, III, IV, V)
	7. Schedule 4 Part 5
	8. Guidelines on Packing and Labeling
	9. Recall and Traceability
	10. Mandatory Testing requirements of FSSAI

Course Outcomes: At the end of the Course, the Student will be able to:

1	To gain knowledge on food-manufacturing processes and the significance of food safety, Indian Food Regulations, hygiene standards.
2	To be aware of the diverse job opportunities in this stream related to testing of microbiological and chemical parameters.
3	To describe the causes of contamination of food that can occur in a food service establishment.
4	To predict and explain the food borne illness and allergens and the preventive and control measures.
5	To effectively identify the scopes related to food testing industry and to emphasize on Food Safety Regulations.

VALUE ADDITION COURSE - 2

Duration : 30 Hours

Course Title : **Clinical Research & Clinical Data Management**

Course Provider : Indian Health Care BPO, Chennai

SYLLABUS:

Module	CONTENTS OF MODULE
	CLINICAL RESEARCH
1	Clinical Research Introduction
2	Clinical Research Key Definitions
3	Different Types of Designs in Clinical Trial
4	Clinical Trial Players, Their Roles & Responsibilities
5	Different Types of Clinical Trials
6	Phases Of Clinical Trial
7	Drug Discovery
8	INDA, NDA
9	ANDA
10	Ethical Principles in CR
11	Ethic Committee
12	Sponsor & PI Responsibilities
13	ICH- GCP Principles
14	ICF & IB
15	Protocol & Essential Documents
16	Schedule Y
17	Declaration of HELSINKI
18	Clinical Trial other than Drugs
	CLINICAL DATA MANAGEMENT
19	Introduction
20	Objectives, Phases of CDM
21	Case Report Form
22	Data Capture
23	EDC

24	Data Validation
25	Quality Assurance & Quality Control
26	MEDRA Coding
27	Database Design
28	Computer System & Development of Clinical System
29	Software Validation
30	21 CFR PART 11 / Interview Preparation

Course Outcomes: At the end of the Course, the Student will be able to:

1	To gain knowledge on clinical research and clinical data management.
2	To understand the various phases of drug discovery and the systematic protocols adapted for clinical trials.
3	To know the ICH Good clinical practices and validation protocol.
4	To gain insights on medical coding and ethical principles in clinical research.
5	To acquire information related to Databases, their design, usage, validation and to use software for clinical data management.

APPENDIX A

OUTCOME BASED EDUCATION

Outcome-based education (OBE) is an educational theory that bases each part of an educational system around goals (outcomes). By the end of the educational experience each student should have achieved the goal. There is no specified style of teaching or assessment in OBE; instead classes, opportunities, and assessments should all help students achieve the specified outcomes.

There are three educational Outcomes as defined by the National Board of Accreditation:

Program Educational Objectives: The Educational objectives of an engineering degree program are the statements that describe the expected achievements of graduate in their career and also in particular what the graduates are expected to perform and achieve during the first few years after graduation. [nbaindia.org]

Program Outcomes: What the student would demonstrate upon graduation. Graduate attributes are separately listed in Appendix B.

Course Outcome: The specific outcome/s of each course/subject that is a part of the program curriculum. Each subject/course is expected to have a set of Course Outcomes.

MAPPING OF OUTCOMES

APPENDIX B

GRADUATE ATTRIBUTES

At the completion of the M.Sc. Biotechnology program, the students of our department will be able to:

S.NO	GRADUATE ATTRIBUTES	PROGRAMME OUTCOMES
1.	**Knowledge**	To attain suitable scientific knowledge and technical skills to realize, calibrate and develop innovative processes / skills for creation of inventive products which are beneficial to society.
2.	**Problem Solving, Ethical Practices and Social Responsibility**	To implement discipline, professionalism, team spirit, communication skills, social and ethical commitment in the post graduates in order to embellish leadership roles expediting perfection in different sector with a categorical professional distinctiveness, business savvy, international recognition and imperishable expansion
3.	**Critical thinking**	To be habituated with the emerging expanses of erudition and their applications in several domains of biological sciences and to enlighten the students of its relevance in forthcoming studies
4.	**Usage of modern tools**	To enhance the insight of research-oriented knowledge in conjunction with literature survey, design of experimental methodology, analysis and interpretation of results and draw valid conclusions.
5.	**Independent and Reflective Learning**	To provoke entrepreneurship among the students along with strong ethics and communication skills
6.	**Life-long Learning**	To engage in Lifelong learning and enduring proficient progress

APPENDIX C

BLOOM'S TAXONOMY

Bloom's taxonomy is a classification system used to define and distinguish different levels of human cognition—i.e., thinking, learning, and understanding. Educators have typically used Bloom's taxonomy to inform or guide the development of assessments (tests and other evaluations of student learning), curriculum (units, lessons, projects, and other learning activities), and instructional methods such as questioning strategies. [eduglosarry.org].