Department of Biotechnology

ACADEMIC YEAR 2020–2021

I–VI Semesters

SCHEME AND SYLLABUS

OUTCOME BASED EDUCATION (OBE)

S.NO	CONTENTS	PAGE NO.
1	Vision, Mission and Program Educational Objectives (PEO)	1
2	Program Outcomes (PO) with Graduate Attributes	2
3	Mapping of POs with PEOs	3
	SCHEME	
4	Scheme of First Semester	9
5	Scheme of Second Semester	10
6	Scheme of Third Semester	11
7	Scheme of Fourth Semester	12
8	Scheme of Fifth Semester	13
9	Scheme of Sixth Semester	14
	SYLLABUS	
10	**Syllabus of First Semester:**	15
	CorePaper1:Cell biology	16
	Allied Paper 1:Microbiology	18
	Core Practical I: Cell biology	20
	Allied: **Practical I**: Microbiology	22
	Non-major elective 1-Biotechnology for society	24
11	**Syllabus of Second Semester:**	26
	Core Paper: 2 Molecular Biology	27
	Allied Paper: 2Chemistry in Everyday Life	29
	Core Practical II: Molecular Biology	31
	Allied Practical II: Chemistry in Everyday Life	33
	Non Major Elective 2 – Food Science	35
12	**Syllabus of Third Semester:**	37
	Core Paper 3: Bioinstrumentation	38
	Allied Paper 3: Biochemistry	40
	Core Practical III: Bioinstrumentation	42
	Allied Practical III: Biochemistry	44

13	**Syllabus of Fourth Semester:**	46
	Core Paper 4: Genetic Engineering	47
	Allied paper 4: Fundamentals of Computers and Biostatistics	49
	Core Practical IV: Genetic Engineering	51
	Allied Practical IV: Fundamentals of Computers and Biostatistics	53
14	**Syllabus of Fifth Semester:**	55
	Core Paper 5: Immunology	56
	Core Paper 6: Bioinformatics	58
	Core Paper 7: Bioprocess Technology	60
	Core Paper8: Food Biotechnology	62
	Elective paper: 1A Marine Biotechnology	64
	Elective paper: 1B Agricultural Biotechnology	66
	Elective paper: 1C Basics of Stem Cell Biology	68
	Core Practical V: Immunology, Bioinformatics, Bioprocess Technology & Food Biotechnology	70
15	**Syllabus of Sixth Semester:**	73
	Core Paper 9: Animal Biotechnology	74
	Core Paper 10: Plant Biotechnology	76
	Core Paper 11: Environmental biotechnology	78
	Elective paper: 2A Entrepreneurship, Biosafety, Bioethics and Intellectual property rights	80
	Elective paper: 2B Biofertilizer	82
	Elective paper: 2C Medical Biotechnology	84
	Open Elective paper:3 Public Health and Hygiene	86
	Core Practical VI: Animal Biotechnology, Plant Biotechnology & Environmental Biotechnology	88

DWARAKA DOSS GOVERDHAN DOSS VAISHNAV COLLEGE

(Autonomous)

"College with Potential for Excellence"

(Linguistic Minority Institution),
"Gokulbagh" 833, Periyar E.V.R. Salai,
Arumbakkam, Chennai – 10611

VISION

- Ignites Wisdom
- Challenges Status Quo
- Strengthens Social Equality
- Elevates Human Values and Universal Oneness
- Recognises Indian Tradition and Culture

MISSION

- Curriculum that makes student competent to contribute economically and intellectually.
- Offer an environment of learning that encourages innovation and excellence.
- Promote research and development
- Best of facilities with the Best of technology
- Provide an environment for all round growth of the student
- Quality in every activity undertaken by the student and the faculty
- Instilling pride in serving the society and in being the citizen of this country

DEPARTMENT OF BIOTECHNOLOGY

VISION

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

MISSION

M1	To inculcate original and novel advanced methodologies in the field of biotechnology
M2	To generate opportunities for innovations in the field of biological research.
M3	To expand the scope of Industry -Academia interaction towards commercialization of bioproducts.

PROGRAM OUTCOMES (PO) IN RELATION TO GRADUATE ATTRIBUTES

1	**PO1**	To participate in various types of employment, development activities and public discourses particularly in response to the needs of the community one serves
2	**PO2**	To understand the need and have the competencies to support local, regional and national development
3	**PO3**	To develop critical and analytical thinking
4	**PO4**	To develop conceptual understanding, problem solving and application of skills
5	**PO5**	To provoke entrepreneurship among the students along with strong ethics and communication skills
6	**PO6**	To develop a questioning mind in diverse environments for better outcomes
7	**PO7**	To engage in lifelong learning and enduring proficient progress

PROGRAM SPECIFIC OUTCOMES

PSO1: Acquire basic knowledge in English and language grammar, communication skills, writing skills and creative writing skills.

PSO2: Comprehensive the core concepts and various ideas, analyze, execute and contribute in the field of biotechnology and other related industries.

PSO3: Possess the basic and essential knowledge on various aspects of biotechnology to successfully pursue their higher studies.

PSO4: Obtain prerequisite skills and have the ability to start pursue their employment, entrepreneurship and research activities.

PSO5: Realize and share the importance of professional integrity, ethical and environmental issues related to the field biotechnology.

DWARAKA DOSS GOVERDHAN DOSS VAISHNAV COLLEGE

(Autonomous)

DEPARTMENT OF BIOTECHNOLOGY

(CHOICE BASED CREDIT SYSTEM)

B.Sc., BIOTECHNOLOGY

Eligibility for Admission

- Students who have completed 10+2 pattern with Biology as one of the main subject along with other subjects such as Botany, Zoology, Biochemistry, Microbiology, Nursing, Nutrition and Dietetics, Home science, Siddha, Agricultural science and Veterinary science are eligible to apply for B.Sc. Biotechnology.

Duration of the Programme for B.Sc Biotechnology

- The duration of the course is three years (six semesters). Each academic year shall be divided into two semesters. The odd semesters shall consist of the period from June to November and the even semester from December to April. There shall be not less than 91 working days for each semester.

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 Generic skills towards the end of the semester. End-semester examination will be conducted at the end of each semester.
- A candidate has to secure a minimum of 40 percent of marks (inclusive Two CIA Tests marks, generic skills & End- Semester examination mark) in each paper.
- A candidate should have passed in soft skills, Value education papers and extension activity for successful completion of the course

End Semester Examination

- There shall be one End-semester examination of 3 hours duration carrying 100 marks in each paper covering the entire syllabus prescribed for the course. The End semester examination is normally a written examination for theory and laboratory-based for practical papers. End-semester Practical examinations will be held at the end of even semesters.

- Each theory paper carries 100 marks, 60 marks for end semester examination and 40 marks for continuous internal assessment. Similarly, for practical examinations, each paper carries 100 marks, 60 for external evaluation and 40 marks for the continuous internal assessment.
- The subjects which included in Part IV paper carries 100 marks, 50 marks for end semester examination and 50 marks for continuous internal assessment.

Total Number of papers

Subjects	Papers
Language	4
English	4
Core	11
Elective	3
Allied	4
Core practicals (1 - 6)	6
Allied practicals	4
Soft skill	4
Non major elective	2
Value education	1
Environmental studies	1
Extension activity	-

Course outcome

- Graduates will gain and apply knowledge of biotechnological concepts to solve problems related to life science fields.
- Graduates will be able to identify, analyse and understand problems in science and finding valid conclusions.
- Usage of appropriate tools & techniques for biotechnological manipulation with the knowledge gained, while keeping in mind safety factor for environment and society.
- Graduates will be able to design, perform experiments, analyse and interpret data for investigating complex problems
- Graduates will be able to justify societal, health, safety & legal issues and understand his responsibilities in biotechnological practices.
- Graduates will be able to understand the need and impact of biotechnological solutions on environment and societal context keeping in view need for sustainable solution.
- Graduates will be enlightened on the ethical issues in Biotechnology.

Award of Degree

A Candidate shall be eligible for the award of the degree only if she/he has undergone the prescribed course of study in the college for a period of not less than three academic years and passed the

examinations of all the Six Semesters prescribed earning a minimum of **140 credits** as per the distribution given in Regulations forPartI, II, III, IV & V and also fulfilled such other conditions as have been prescribed thereof.

Note: Autonomous Colleges Continue to follow the existing credits distribution Scheme and have to flexibility of distribution of credits in Part III & IV.

Credit distribution

S.no	Semester	credits
1	I	23
2	II	23
3	III	21
4	IV	23
5	V	26
6	VI	26
Total no of credits		**142**

Subjects	Papers	Credits	Total credits
Language	4	3	12
English	4	3	12
Core theory	11	4	44
Elective	3	5	15
Allied theory	4	3	12
Core practicals	6	3	18
Allied practicals	4	2	8
Soft skill	4	3	12
Non major elective	2	2	4
Value education		2	2
Environmental studies	1	2	2
Extension activity		1	1
Total no of credits			**142**

Extra credits for MOOC Online Course with minimum duration of 8 weeks for which certificate have to be submitted.

Question paper Pattern-Theory Maximum marks (100)

Part – A	Answer any 10 out 12 (10 x 2= 20 marks)
Part – B	Answer any 5 out of 7 (5 x 7 = 35 marks)
Part – C	Answer any 3 out of 5 (3 x 15 = 45 marks)

Question paper pattern – Practical (60 marks)

Practical	: 50 Marks
Record	: 05 Marks
Viva Voce	: 05Marks

CIA Breakup – Theory – 40 Marks

Attendance	: 5 Marks
CIA tests	: 25 Marks
Generic Skills	: 10 Marks

CIA Breakup – Practicals – 40 Marks

Attendance	: 10 Marks
Class room Practicals	: 15 Marks
Model Practicals	: 15 Marks

DEPARTMENT OF BIOTECHNOLOGY
SCHEME OF I SEMESTER BSc PROGRAM

Sl. NO	Course Category	Course Code	Course	Hour Distribution				Overall Credits	Total Contact Hours/Week	Marks		
				L	T	P	S			CIA	ESE	Total
1	Part I		Language/ Tamil Paper 1	4	0	0	0	3	4	40	60	100
2	Part II		English Paper 1	4	0	0	0	3	4	40	60	100
3	Part III		**CorePaper1**: Cell biology	6	0	0	0	4	6	40	60	100
4	Part III		**Allied Paper 1:** Microbiology	6	0	0	0	3	6	40	60	100
5	Part III		**Core**: **Practical I:** Cell biology	0	0	3	0	3	3	40	60	100
6	Part III		**Allied**: **Practical I** Microbiology	0	0	3	0	2	3	40	60	100
7	Part IV		**1.a.** Those who have not studied Tamil upto XII std and taken a non- tamil language under Part – I shall take Tamil comprising of two courses (level will be at 6th std). **b.** Those who have studied Tamil upto XII std and taken a non- Tamil language under Part- I shall take Advanced Tamil comprising of two courses. **c.** Others who do not come under a+b can choose non-major elective comprising of two courses. **Nonmajor elective 1-** Biotechnology for society	2	0	0	0	2	2	50	50	100
8	Part IV		**2. Skill based subject (Elective)** Soft skill I	2	0	0	0	3	2	50	50	100
Total								**23**	**30**	**340**	**460**	**800**

SCHEME OF II SEMESTER BSc PROGRAM

Sl. NO	Course category	Course Code	Course	Hour Distribution				Over all Credits	Total Contact Hours/Week	Marks		
				L	T	P	S			CIE	SEE	Total
1	Part I		Language/ Tamil Paper 2	4	0	0	0	3	4	40	60	100
2	Part II		English Paper 2	4	0	0	0	3	4	40	60	100
3	Part III		**Core Paper**: 2 Molecular Biology	6	0	0	0	4	6	40	60	100
4	Part III		**Allied Paper**: 2 Chemistry in Everyday Life	6	0	0	0	3	6	40	60	100
5	Part III		**Core Practical II:** Molecular Biology	0	0	3	0	3	3	40	60	100
6	Part III		**Allied Practical II:** Chemistry in Everyday Life	0	0	3	0	2	3	40	60	100
7	Part IV		**1. a.** Those who have not studied Tamil upto XII std and taken a non- tamil language under Part – I shall take Tamil comprising of two courses (level will be at 6th std). **b.** Those who have studied Tamil upto XII std and taken a non- Tamil language under Part- I shall take Advanced Tamil comprising of two courses. **c.** Others who do not come under a+b can choose non- major elective comprising of two courses. **Non Major Elective 2** – Food Science	2	0	0	0	2	2	50	50	100
	Part IV		**2. Skill based subject (Elective)** Soft skill II	2	0	0	0	3	2	50	50	100
Total								**23**	**30**	**340**	**460**	**800**

SCHEME OF III SEMESTER BSc PROGRAM

Sl. NO	Course category	Course Code	Course	Hour Distribution				Over all Credits	Total Contact Hours/ Week	Marks		
				L	T	P	S			CIE	SEE	Total
1	Part I		Language/ Tamil Paper 3	4	0	0	0	3	4	40	60	100
2	Part II		English Paper 3	4	0	0	0	3	4	40	60	100
3	Part III		**Core Paper3: Skill Enhancement Course** Bioinstrumentation	6	0	0	0	4	6	40	60	100
4	Part III		**Allied Paper** 3 : Biochemistry	6	0	0	0	3	6	40	60	100
5	Part III		**Core Practical III**: Bioinstrumentation*	0	0	3	0	3	3	40	60	100
6	Part III		**Allied Practical III**: Biochemistry*	0	0	3	0	2	3	40	60	100
7	Part IV		**Skill based subject:** Soft skill III	2	0	0	0	3	2	50	50	100
8	Part IV		Environmental studies	2	0	0	0	-	2	Examination will be held on IV semester		
		Total						21	**30**	**290**	**410**	**700**

SCHEME OF IV SEMESTER BSc PROGRAM

Sl. NO	Course category	Course Code	Course	Credit Distribution				Over allCr edits	Total Cont act Hour s/We ek	Marks		
				L	T	P	S			CIE	SE E	Tot al
1	Part I		Language/ Tamil Paper 4	6	0	0	0	3	4	40	60	100
2	Part II		English Paper 4	4	0	0	0	3	4	40	60	100
3	Part III		**Core Paper** 4: **Skill Enhancement Course** Genetic Engineering	6	0	0	0	4	6	40	60	100
4	Part III		**Allied paper** 4: Fundamentals of Computers and Biostatistics	6	0	0	0	3	6	40	60	100
5	Part III		**Core Practical IV**: Genetic Engineering	0	0	3	0	3	3	40	60	100
6	Part III		**Allied practical IV**: Fundamentals of Computers and Biostatistics	0	0	3	0	2	3	40	60	100
7	Part IV		**Skill based elective:** Soft skill IV	2	0	0	0	3	2	50	50	100
8	Part IV	Environmental studies		2	0	0	0	2	2	50	60	100
		Total						**23**	**30**	**340**	**460**	**800**

SCHEME OF V SEMESTER BSc PROGRAM

Sl. NO	Course category	Course Code	Course	Credit Distribution				Overall Credits	Total Contact Hours/Week	Marks		
				L	T	P	S			CIE	SEE	Total
1	Part III		**Core Paper 5:** Immunology	5	0	0	0	4	5	40	60	100
2	Part III		**Core Paper 6:** Bioinformatics	5	0	0	0	3	5	40	60	100
3	Part III		**Core Paper7:** Bioprocess Technology	5	0	0	0	4	5	40	60	100
4	Part III		**Core Paper8: Skill Enhancement Course :** Food Biotechnology	5	0	0	0	4	5	40	60	100
5	Part III		**Elective paper: 1A** Marine Biotechnology or **Elective paper: 1B** Agricultural Biotechnology or **Elective paper: 1C** Basics of Stem cell Biology	4	0	3	0	5	4	40	60	100
6	Part III		**Core Practical V**: Immunology, Bioinformatics, Bioprocess Technology &Food Biotechnology	0	0	5	0	3	5	40	60	100
8	Part IV		Value Education	0	0	0	0	2	1	50	50	100
Total								**26**	**30**	**290**	**410**	**700**

Elective papers should to be chosen by the candidate.

SCHEME OF VI SEMESTER BSc PROGRAM

Sl. NO	Course category	Course Code	Course	Credit Distribution				Overall Credits	Total Contact Hours /Week	Marks		
				L	T	P	S			CIE	SEE	Total
1	Part III		**Core Paper9:** Animal Biotechnology	5	0	0	0	4	5	40	60	100
2	Part III		**Core Paper10: Skill Enhancement Course** Plant Biotechnology	5	0	0	0	4	5	40	60	100
3	Part III		**Core Paper11**: Environmental Biotechnology	5	0	0	0	3	5	40	60	100
4	Part III		**Elective paper:2A** Entrepreneurship, Biosafety, Bioethics and Intellectual property rights or **Elective paper:2B** Biofertilizer or **Elective paper:2C** Medical Biotechnology	4	0	0	0	5	4	40	60	100
5	Part III		**Open Elective paper:3** Public Health and Hygiene	5	0	0	0	5	5	40	60	100
6	Part III		**Core Practical VI**: Animal Biotechnology, Plant Biotechnology& Environmental Biotechnology	0	0	6	0	3	6	40	60	100
7	Part-V		**Extension Activity**	-	-	-	-	1	-	-	-	-
Total								**26**	**30**	**240**	**360**	**600**

Elective papers should to be chosen by the candidate.

FIRST SEMESTER
(SYLLABUS)

Course Title: Core Paper 1: Cell Biology

Course Code :		**Credits**	**: 04**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	To have an insight of Cell as the fundamental unit of life and to compare the complexity of Eukaryotic cell with the primitive prokaryotic cell, with the identification of specific role of organelles that attribute to the co-ordinated function of cell.
CO2	To analyze the structure and functions of plasma membrane and the various mechanisms that regulates the transport process across cell membranes.
CO3	To selectively categorize the cytoskeletal backbone, cell motility organs and to describe the cell cycle and cell death.
CO4	To predict the response of cells to intra and extracellular environment by studying about the intracellular signaling pathways.
CO5	To specifically examine life processes at the cellular level, such as protein secretion, targeting and protein degradation.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1				3			
CO2		2		3			
CO3			2	3			
CO4				3		2	1
CO5		2		3		2	2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		1	3		
CO2		1	3		
CO3			3		
CO4		1	3	1	
CO5			3	1	

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Cell theory: Cell as the Unit of Life. General characteristics and difference between prokaryotic and eukaryotic cells. Prokaryotic and Eukaryotic cell structure-Plant and animal cell and their characteristics; cell organelles-structure and functions of mitochondria, chloroplast, endoplasmic reticulum, golgi apparatus, ribosomes, lysosomes, peroxisomes, nucleus and molecular organization of chromatin.	18	CO1
2	Membrane and transport- structure and functions of Cell Membrane, Cell membrane permeability, molecular organization of cell membrane. Transport across cell membrane – passive transport, active transport, ATP pumps-sodium and potassium pump, Ca^{2+} ATPase, co-transport –symport and antiport, Endocytosis and Exocytosis.	18	CO2
3	Cytoskeleton- structure and functions, cell motility- cilia and flagella, cellular interactions, cell adhesion molecules, cell division: mitosis and meiosis, cell cycle and its regulation, Programmed cell death.	18	CO3
4	Cell signaling- receptors in cell signaling, autocrine, paracrine and endocrine signaling, signal amplification. cAMP, IP_3, cGMP and G-proteins role in signal transduction, calcium influx and its role in cell signaling.	18	CO4
5	Protein secretion and sorting- secretory pathway, translocation of secretory proteins across the ER membrane, protein folding- chaperones in protein folding and assembly, modification and degradation of proteins.	18	CO5

TEXT BOOKS:

1.	C.B. Powar. (2010).Cell Biology, 3rd Edition, Himalaya publisher.
2.	Dr. P.S. Verma and Dr. V.K. Agarwal. (2016).Cell biology (cytology, biomolecules and molecular biology), S. Chand Publishing.
3.	Lodish*et al*., (2000). Molecular Cell Biology, Fourth Edition, W.H. Freeman & Co.

REFERENCE BOOKS:

1.	De Robertis, E.D.P. and De Robertis, E.M.F., Cell and Molecular Biology (7th Edition) Saunders College/Holt, Rinehart and Winson, Philadelphia, 1980.
2.	Gerald Karp., Cell and Molecular Biology, 4th ed. John Wiley and sons, 2004.
3.	Bruce Alberts., Lewis.J., Johnson A.J., Raff. L.M., Molecular Biology of the Cell: Garland Publishers, 2002.
4.	Cooper M.G and Hausman E.R (2018). The Cell: A Molecular approach (7th Ed.) USA: Oxford University Press.

Course Title: Allied Paper1: Microbiology

Course Code :		**Credits**	**: 03**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Outline the evolution of microbiology and characterize microorganisms.
CO2	Categorize the methods of sterilization and identify the significance of culture media in the growth of different microbes.
CO3	Discover different staining procedures and microscopic techniques used to visualize microbial cells.
CO4	Distinguish between normal flora and pathogens.
CO5	Define and describe the role of microbes in food intoxications and soil fertility

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1			2				
CO2				2			
CO3				3			2
CO4				3		2	2
CO5				3	2	2	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1			3		
CO2		2	3		
CO3		3	2		
CO4			2		
CO5		3		2	2

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Introduction and history of microbiology:** *Evolution of microbiology- Theory of biogenesis*- Contributions of Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Paul Ehrlich and Fleming. Anatomy of prokaryotic and eukaryotic cells. General characteristics used in classification- five kingdom, six kingdom and eight kingdom systems.	18	CO1
2	**Basic microbiological techniques:** Sterilization and disinfection- Principles-Physical methods- dry heat-moist heat- radiation- filtration (membrane & HEPA), Chemical methods-liquids/gas –mode of action. Types of microbiological media- enrichment, selective and differential media. Growth and nutrition- Nutritional requirements- autotrophs, heterotrophs-Microbial growth curve- kinetics of growth- Measurement of microbial growth and enumeration of cells: Pure culture methods: Serial dilution, pour plate, spread plate, streak plate.	18	CO2
3	**Staining and Microscopy:** Definition of auxochrome, chromophore and dye. Staining techniques- Smear preparation- Simple staining, Gram staining and Endospore staining. Microscopy- Principles and applications- Light, Bright field and dark field, Fluorescence, SEM and TEM.	18	CO3
4	**Normal flora and Pathogenic microbes:** Normal flora of human body- Pathogenic attributes of bacteria-Virulence factors. Pathogenic bacteria: Staphylococcus, Streptococcus. Viruses: Pox, rabies. Fungal diseases: Aspergillosis, Blastomycosis. Parasitic infections: Leishmaniasis, Giardiasis.	18	CO4
5	Food-borne intoxications-Botulism, Staphylococcal &Enterococcal food poisoning -Soil microbes and fertility of soil-Distribution of different types of soil microorganisms-Factors influencing microbial population: Moisture, air, temperature, pH & nutrients. Beneficial interactions: symbiosis, commensalism, proto-cooperation. Harmful interactions- amensalism, competition, parasitism.	18	CO5

TEXT BOOKS:	
1.	Pelczar, M.J., Chan, E.C.S. and Kreig, N.R., Microbiology- Concepts and Applications, 5th Edition, *Tata McGraw-Hill, New Delhi, 2002.*
2.	Ananthanarayan, R. and Paniker, Text book of Microbiology, 9th edition, Orient Longman Pvt Ltd., *Universities Press, Hyderabad, India, 2013.*
3.	Ingraham, J.L., and Ingraham, C.A., Introduction to Microbiology 2nd edition, *Brooks/Cole, Thomson Learning, USA, 2000.*

REFERENCE BOOKS:	
1.	Park Talaro and Barry Chess, A., Foundations in Microbiology, 10th edition. *McGraw-Hill Education, New York, 2017.*
2.	Cappuccino, J.G., and Sherman, N., Microbiology- A Laboratory manual, 10th edition. *Pearson Benjamin Cummings, US, 2013.*
3.	Prescott, Joanne Willey, Kathleen Sandman and Dorothy Wood, 11th edition, *New York: McGraw-Hill*, 2020.

Course Title: Core Practical – I: Cell Biology

Course Code : 1912207	**Credits : 03**
L: T: P: S : 0:0:3:0	**CIA Marks : 40**
Exam Hours : 03	**ESE Marks : 60**

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

CO1	Enumerate the different types of blood cells using appropriate techniques.
CO2	Analyze the stages of mitotic and meiotic cell divisions.
CO3	Utilize the techniques involved in cell biology for preservation of specimen.
CO4	Explain the working of different types of microscopes.
CO5	Demonstrate the working principle of cell fractionation.

Mapping of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1				2	2	3	1
CO2				2		3	2
CO3				2	1	2	1
CO4				2	1	3	2
CO5				2	1	3	2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		2	3	3	
CO2			3		
CO3		3			
CO4		3	3		
CO5		3	2		

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	1. Introduction to microscopy 2. Epithelial cell preparation from onion peel and buccal cavity. 3. Measuring size of cells using micrometry. 4. Differential leukocyte Count	15	CO1 CO4
2	5. Enumeration of RBC by haemocytometer 6. Enumeration of WBC by haemocytometer	15	CO1 CO2 CO4
3	7. Enumeration of prokaryotic cell 8. Mitosis preparation from onion root tip	15	CO3 CO4
4	9. Meiosis – from grasshopper testis/ Flower buds 10. Permanent slide preparation- stem section, 11. Cell fractionation (nucleus, mitochondria- Demonstration).	15	CO4 CO5

REFERENCE BOOK:	
1.	K.V. Chaitanya, Cell and molecular biology: Lab manual, PHI publishers, 2013.

Course Title: Allied Practical – I: Microbiology

Course Code	**: 1912208**	**Credits**	**: 02**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Establish basic skills associated with microbiology and biotechnology
CO2	Gain basic knowledge on various pure culture techniques for the isolation of microorganisms from various samples
CO3	Distinguish between various methods of sterilization
CO4	Characterize and differentiate various types of bacteria using different staining techniques.
CO5	Learn how to measure the size of the different types of microorganism using micrometry method.
CO6	Microscopically analyze the morphological features of fungal organisms using lactophenol cotton blue staining.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1				3	3		3
CO2			2	2	2		3
CO3				3	2		2
CO4	2		2	2	3	2	3
CO5	2		3	3		2	2
CO6				2		3	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		2	3	3	
CO2			3		
CO3		3			
CO4		3			
CO5				3	
CO6			2	2	

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	1. Sterilization techniques 2. Preparation of microbiological media.	9	CO1 CO2 CO3
2	3. Pure culture techniques a) Pour plate technique b) Spread plate technique c) Streak plate technique 4. Demonstration of microbial contamination on culture plates.	9	CO4
3	5. Determination of the size of microbes using Micrometry 6. Wet mount preparation: Hay infusion broth	9	CO4 CO5
4	7. Morphological characterization of microbes a) Simple staining b) Gram staining c) Capsule staining d) Spore staining. e) Hanging drop technique 8. Biochemical tests for identification of bacteria a) Catalase test b) Oxidase test c) Indole test d) Methyl red and VogesProskauer test e) Citrate utilization test	9	CO1 CO4
5	9. Morphological identification of Fungi using lactophenol cotton blue staining.	9	CO6

REFERENCE BOOK:	
1.	Brown A. and Smith H., Benson's Microbiological Applications: Laboratory Manual in General Microbiology, 13th Edition, McGraw-Hill Companies, 2015.

Course Title: Non Major Elective 1: Biotechnology For Society

Course Code	**: 1912103**	**Credits**	**: 02**
L:T:P:S	**: 2:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Identify the importance of biotechnology in different agricultural practices.
CO2	Appreciate the role played by microorganisms in the development of food supplements, biological fertilizers and pesticides.
CO3	Gain knowledge about the application of biotechnology in transforming environmental pollutants and learn the detrimental effects of biological weapons.
CO4	Summarize the basics of antibiotics and outline the production of penicillin.
CO5	Know the significance and uses of transgenic plants.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	2	3	2	2	3		
CO2			2	3	3	2	2
CO3	2	2	2	3			
CO4				3		2	
CO5				2			

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		3		3	2
CO2		3	2	3	
CO3		2			3
CO4		2	2		
CO5			2		3

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Introduction to Biotechnology- Role of biotechnology in sericulture- Rearing of silkworms- Importance and applications- Role of biotechnology in apiculture- Bee hive hierarchy- Bee keeping process- Products obtained- Mushroomfarming stages- Cultivation of paddy straw mushroom- Importance of mushroom cultivation.	6	CO1
2	Biofertilizer- Definition- Mass production of *Rhizobium*-Advantages and disadvantages- Biopesticides- Definition- Microbial biopesticides- *Bacillus thuringiensis*- Single cell protein- Introduction- history- production of *Spirulina*SCP- Applications- Advantages & disadvantages.	6	CO2
3	Biodegradation- Definition- Process-role of microorganisms in biodegradation - biodegradable plastics-advantages- Bioweapons- introduction- history- potential agents- delivery methods- harmful effects.	6	CO3
4	Antibiotics- Definition- Introduction and history of antibiotics- sources- classification- spectrum- - production of penicillin- definition of antibiotic resistance.	6	CO4
5	Transgenic plants – Definition of transgene and transgenesis - BT Cotton, Flavr-Savr tomato and Golden rice- history – importance, applications, advantages and disadvantages.	6	CO5

TEXT BOOKS:	
1.	Sathyanarayana, U., Chakrapani, U., (2008). *Biotechnology, First edition*, Books and allied (P) Ltd, Kolkata.
2.	A.K. Chatterji, (2011).*Introduction to Environmental Biotechnology, Third edition*, PHI Learning Pvt Ltd. New Delhi.
3.	R.C. Dubey, (2014). A text book of Biotechnology, *S.Chand& Company, New Delhi*,.

REFERENCE BOOKS:	
1.	H. Patel, (2011).*Industrial Microbiology, 2nd edition*, MacMillan Publishers,
2.	Thakur, I.S., (2019).*Environmental Biotechnology- Basic principles and applications*- 2nd edition- Dreamtech Press

SECOND SEMESTER

Course Title: Core Paper: 2: Molecular Biology

Course Code :		**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Explain the fundamental properties, structure and processes of nucleic acids
CO2	Discuss the molecular mechanism of Replication in prokaryotes
CO3	Elucidate the transcription mechanism in prokaryotes
CO4	Explain the process of Initiation, elongation and termination, and post translational modifications of proteins
CO5	Elaborate the regulation of gene expression using Operon concept

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			2	3	2	2
CO2			2	2		2
CO3			3	2		2
CO4			3	3		2
CO5			2	2	2	3

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		3	3	2	
CO2		3	3	2	
CO3		2	3	3	
CO4		2	2	2	
CO5		2	3	2	

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Molecular Biology: Introduction to molecular aspects of life:** DNA as the genetic material –Griffith's experiment, Hershey–Chase experiment; Nucleic acids: Structure, function and properties of DNA (A, B and Z), their characteristics. Different types of RNA (mRNA, tRNA and rRNA) their structure and function.	18	CO1
2	**DNA Replication:** Enzymology of replication (DNA polymerase I, pol II and III, helicases, topoisomerases, single strand binding proteins, DNA melting proteins, primase. Proof of semiconservative replication, Replication origins, initiation, elongation, and termination. Rolling circle replication of DNA; Inhibitorsof DNA Replication.	18	CO2
3	**Transcription:** Transcription in prokaryotes: Enzymatic Synthesis of RNA, Basic features of RNA synthesis, E.coli RNA polymerase, Classes of RNA molecules, Transcription mechanism in prokaryotes- Promoter, initiation, elongation, proof reading and Rho dependent and Rho independent termination; InhibitorsofTranscription.	18	CO3
4	**Genetic code and Protein synthesis:** Genetic code: Features of genetic code, the adaptor hypothesis, attachment of amino acids to tRNA. Codon-anticodon interaction - the wobble hypothesis. Translation: Prokaryotic and eukaryotic translation, Initiation, elongation and termination, Co and post translational modifications of proteins; InhibitorsofTranslation.	18	CO4
5	**Gene Expression and regulation:**Control of gene expression at transcription and translation level: Negative and positive control of the the Lac operon,The Arabinose operon, The Tryptophan operon, Relative positions of Promoters andOperators, Feedback Inhibition	18	CO5

TEXT BOOKS:	
1.	1. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, HiddePloegh, Angelika Amon, Kelsey C. Martin, (2016). *Molecular Cell Biology* (8th Ed.). US: W. H. Freeman
2.	2. DeRobertis, EDP and E.M.F Robertis (2017).*Cell and molecular biology*, US:Lippincott Williams & Wilkins.
3.	3. Veer BalaRastogi. (2016).*Principles of Molecular Biology*. (2nd Ed.)Medtech publisher.

REFERENCE BOOKS	
1.	1. George M. Malacinski and David Freifelder (2015). "*Essentials of molecular biology*", (4th ed.) Boston: Jones and Bartlett Publishers
2.	2. Geoffrey M. Cooper and Robert E. Hausman (2018) .*The cell molecular approach.*(8th Ed.)UK: Oxford University Press.

Course Title: Allied Paper 2– Chemistry in Everyday Life

Course Code :		**Credits**	**: 03**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Demonstrate the preparation of the chemical solutions such as normal, molar and molal solutions.
CO2	Distinguish the components of air and water and gain insights on air and water pollution.
CO3	Classify and identify the food flavorantsand food preservatives used in food production
CO4	Discuss on the chemicals such as fertilizers and pesticides in agriculture.
CO5	Identify the chemicals used in medicines for the treatment of ailments.
CO6	Analyze and appraise the chemicals used in everyday life and gain insights on green chemistry.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3			3			
CO2	2	3		2		2	
CO3	3	3			2		
CO4			3		3	3	
CO5		3			2	2	
CO6	2		3		2	2	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1			3	2	
CO2			3		2
CO3			3	2	
CO4			3		
CO5			3	2	2
CO6			3	2	2

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Solutions**: Definition, Solute, solvent. Types of solutions – Saturated solution, unsaturated solution, supersaturated solution, aqueous solution, Non-aqueous solution, dilute solution and concentrated solution. **Preparation of Chemical solutions:** Normal solution, Molar solution, Molal solution and Percent solution. Simple dilution (Dilution factor method) and Serial dilution. Buffer: Definition, action of buffer, Types and preparation of buffer solutions. **Fundamental particles of Atom-**Definition and classification;. Periodic Table. Radio isotopes – Applications in medicine and industry.	18	CO1
2	**Components of air** – Water vapour, Oxygen, Nitrogen, Carbon dioxide , Smoke and dust particles. Green house gases and its impact on earth. Air pollution. **Components of water** – Hydrogen & Oxygen. Types: Soft water and hard water. Temporary and permanent hardness. Softening of hard water. Structure of Liquid water and ice. Water at high temperature and pressure. Physical and chemical properties of water. Water pollution. Purification of water for domestic use.	18	CO2
3	**Food additives** – Artificial sweetners- Saccharin ,Cyclomate and aspartate. Food flavorants – Natural, Nature-identical and Artificial flavouring substances. Use of esters, aldehyde and heterocyclic compounds as food flavourants. Food preservatives – Sodium benzoate and antioxidants(BHT and BHA). **Chemicals in food production** – Natural sources, Urea, NPK and super phosphate. Food poison – Natural poison and pesticides (DDT and BHC).	18	CO3
4	**Chemicals in medicines**- Antacids- Sodium bicarbonate, and Milk. Tranquilizers – Nor-adrenaline and Barbituric acid. Analgesic – Narcotic (Morphine and Codeine), Non narcotic (Aspirin), Antipyretics- Paracetamolandanalgin; Antiseptic- Bethional and Iodoform. (Physiological significance only); Anti oxidants in food- Anthocyanin and carotenoids. Adulterants in food.	18	CO4 . CO5
5	**Chemicals in cleansing agents** – Soaps , Types of soaps – Toilet soaps, Floating soaps, Transparent soaps, Medicated soaps, Laundry soaps and Detergents – Anionic detergent and cationic detergent. **Chemicals in Cosmetics** – Emulsifier, Preservatives, Thickeners, Emollient, Glimmer and Shiners. -Creams, Perfumes, Talcum powder, Deodorants. **Chemicals in tooth paste** –Fluoride, antibacterial agent, Desensitizing agent, anti-tarter agent, Sodium bicarbonate, Enzymes and Xylitol. **Green chemistry** – Principles and applications.	18	CO6

Text Books	
1.	Kirpal Singh, Chemistry in Daily life (2012), PHI publisher
2.	David Ball.W. (2011), Introductory Chemistry, Saylor Foundation.

REFERENCE BOOKS:	
1.	ShardenduKislaya,(2011) Chemistry in everyday life , Discovery Publishing house.
2.	David Ball W, John HillW, Rhonda Scott.J(2011), The Basics of General , Organic and Biological Chemistry. Saylor Foundation.

Course Title: Core Practical: II Molecular biology

Course Code :		**Credits**	**: 03**
L:T:P:S	**:0:0:3:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Make use of the conventional and advanced methods in isolating and purifying nucleic acid from various organisms.
CO2	Estimate the concentration of nucleic acid from various biological samples
CO3	Estimate the concentration of protein from various biological samples
CO4	Evaluate the quality of nucleic acids by gel electrophoresis
CO5	Evaluate the quality of nucleic acids by denaturing in formaldehyde gel electrophoresis

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	2		3	3	1	3	3
CO2	1		3	3	3	1	1
CO3	1		3	3	3	2	2
CO4	1		3	3	3	2	2
CO5	1		3	3	3	2	2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		2	3	3	
CO2		3	3	3	
CO3		3	3	3	
CO4		3	3	3	
CO5		3	3	3	

Sl. No	Contents of Module	Hrs	Cos
1.	1. Isolation and purification of genomic DNA from bacteria 2. Isolation and purification of genomic DNA from plant 3. Isolation and purification of Plasmids 4. Isolation and purification of RNA	15	CO1
2.	5. Determination of Tm of DNA by UV – Vis spectroscopy 6. Estimation of DNA by Diphenylamine method 7. Estimation of RNA by orcinol method	15	CO2 CO3
3.	8. Agarose gel electrophoresis of purified DNA 9. RNA electrophoresis in formaldehyde gel electrophoresis 10. Gel documentation	15	CO4 CO5

Reference Books/Manuals:	
1.	Heather Miller D. Scott Witherow Sue Carson (2011) Molecular Biology Techniques, 3rd Edition
2.	Gerald Karp, Janet Iwasa and Wallace Marshall (2016) Cell and Molecular biology – concepts and experiments, 8th edition, Wiley.

Course Title: Allied practical II– Chemistry in Everyday Life

Course Code :		**Credits**	**: 02**
L:T:P:S	**:0:0:3:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Gain insights on the safe handling of laboratory glass wares and laboratory practices
CO2	Prepare of the chemical solutions such as normal, molar and molal solutions.
CO3	Prepare buffer solutions with determined pH
CO4	Estimate the amount of chemicals present in unknown solutions and test the hardness of water.
CO5	Outline the preparation of soaps

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1			2	2			
CO2			3	3		2	
CO3			3	3		2	
CO4			2	2	3		2
CO5			2	3			2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		3	2		2
CO2		3	2		2
CO3		3	2		
CO4		3	2		2
CO5		3	2		

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	1. Safe handling of laboratory glasswares 2. Handling of pipettes and pipetting of chemical solutions	12	CO1
2	3. Preparation of solutions based on normality, molarity, and percent solutions. 4. Preparation of buffer solutions with determined pH – Acetate buffer and phosphate buffer	12	CO2
3	5. Estimation of sodium hydroxide using standard sodium carbonate 6. Estimate of Hydrochloric acid using Oxalic acid 7. Estimation of Ferrous sulphate using Ferrous ammonium sulphate 8. Estimation of Oxalic acid using standard Mohr's salt	12	CO3
4	9. Estimation of hardness of water. 10. Detection of adulterant in food 11. Extraction of antioxidants in food	12	CO4
5	12. Preparation of soap	12	CO5

TEXT BOOKS	
1.	Gupta R.K, Manchanda R.P, Rajesh Kumar, R, Lab manual Chemistry, Saraswathi Book house.
2.	Sintayehu L. Kitaw(2015), Practical Analytical Chemistry, Lab Manual, LAP LAMBERT Academic Publishing

REFERENCE BOOKS	
1.	Paul Kelter, Michael Mosher, Andrew Scott , James Almy, (2007), Chemistry Laboratory Manual: The Practical Science. Houghton Mifflin
2.	Callie Schieffer, Mick Sakamoto, Michael Finnegan, Scot Whereland Ryan Rice(2012), General Chemistry Laboratory Manual Star; Revised Edition edition

Course Title: Non Major Elective 2: Food Science

Course Code :	**Credits : 02**
L:T:P:S : 2:0:0:0	**CIA Marks : 40**
Exam Hours : 03	**ESE Marks : 60**

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

CO1	Study the energy components of food.
CO2	Classify foods and learn the ill effects associated with the consumption of unhealthy foods.
CO3	Learn the process and the importance of food preservation.
CO4	Understand the basic principles of food packaging.
CO5	Identify the signs of spoilage and determine the role of microbes in spoilage of foods.
CO6	Develop basic knowledge on adulterants in food and the related food standards and specifications.

Mapping of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1		3			3	2	2
CO2	3	2	2	2		3	3
CO3			2	3	3		2
CO4			3	2	3		2
CO5	2	2	3		2		2
CO6	3	2			3	3	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		3		3	
CO2		2	2	2	
CO3		2	2	3	
CO4		3	2	3	
CO5			2		
CO6			3	3	

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Introduction to food-definition of food science- food as a primary energy source- nutrients- carbohydrates- fats-proteins-vitamins- minerals-water- fiber- functions of food -influences on food choices -difference between junk food and fast food.	**6**	**CO1 CO2**
2	Food preservation- definition- food types- perishable- non- perishable-principles of food preservation- methods- sun drying- pasteurization-canning- dehydration- freezing- chemicals- radiation.	**6**	**CO3**
3	Food packaging- definition- need of packaging- functions of packaging-packaging materials- paper-paperboard-glass-plastic-metals-aseptic packaging-vacuum packaging-MAP- Biodegradable-active-edible packaging.	**6**	**CO4**
4	Food spoilage- definition- food spoilage by microorganisms-different types of spoilage bacteria- spoilage by fungi and yeast-effect of spoilage on various food products.	**6**	**CO5**
5	Food adulteration- Introduction to food adulteration- definition-adulterants in foods-types of adulteration- quantitative, qualitative and informative- common adulteration tests-The Prevention of Food Adulteration Act.	**6**	**CO6**

TEXT BOOKS:	
1.	Srilakshmi B., *Food Science,* sixth edition, New Age International Pvt. Ltd., (2015).
2.	Reddy, S.M., *Basic Food Science and Technology*, First edition, New Age International Pvt Ltd Publishers, (2015).
3.	Robertson Gordon, L., *Food Packaging-Principles and Practice, Third edition,* CRC Press(2016).

REFERENCE BOOKS:	
1.	Frazier W.C and Westhoff D.C., *Food Microbiology, Fifth edition,* Tata McGraw Hills Publications, New Delhi, (2013).
2.	Gary Tucker S., *Food Preservation and Bio deterioration, second edition,* Wiley- Blackwell Publications, (2016).

THIRD SEMESTER

Course Title: Core Paper 3: Skill Enhancement Course - Bioinstrumentation

Course Code :		**Credits**	**: 04**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Describe the various centrifugation and chromatography used in separating biomolecules based on various characters such as molecular weight, charge etc.
CO2	Apply absorbance and transmittance of light and outline the instruments operating with these light rays for identifying biomolecules.
CO3	Practice the electrophoretic techniques to identify the quality of nucleic acids and proteins.
CO4	Illustrate the importance of advanced electrophoretic techniques in identifying variations in nucleic acid molecules.
CO5	Explain the role of radiography and biosensors in medicine and diagnosis of biological entity.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1			3	3			
CO2			3	3			
CO3			3	3		3	
CO4			3	3		3	
CO5			3	3		3	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		3	3	3	
CO2		3	3	3	
CO3		3	3	3	
CO4		3	3	3	
CO5		3	3	3	

Sl. NO.	CONTENTS OF MODULE	Hrs	Cos
1	Centrifugation: Small bench top centrifuges, large capacity refrigerated, centrifuges, High speed refrigerated centrifuges, preparative and analytical ultracentrifuge, Differential and Density gradient centrifugation.	18	CO1 CO2
2	Chromatography - Fundamentals of Chromatography, van Deemter curve, Dialysis, Paper and Thin layer chromatography, Ion exchange chromatography, Gel filtration chromatography, Reversed-phase chromatography, Affinity chromatography, High performance liquid chromatography, Gas chromatography – Principle, instrumentation and applications.	18	CO2
3	General principles of electrophoretic techniques. Agarose gel electrophoresis of DNA and RNA, Poly Acryl amide Gel Electrophoresis, Iso- electric focusing, Isotachophoresis, 2-D Electrophoresis, Capillary electrophoresis, Blotting techniques – Northern, southern and western blotting – Principle, working and applications.	18	CO3
4	Colorimetry and Spectrphotometry – measurement of transmittance and absorbance, Beer Lambert's law. Principles, instrumentation and applications of UV, visible, infrared, Circular Dichroism, Spectrofluorimetry and mass spectrometry, X-ray diffraction- Bragg's equation, Fourier Transform Infrared Spectroscopy.	18	CO4
5	Radioactive isotopes, radioactive decay and their types, radioactive techniques-RIA, Autoradiography, Applications in Medicine & Diagnosis. Biosensors- Principle and applications of Electrochemical, Thermometric, and Optical biosensors	18	CO5

Text Books:	
1.	David T. Plummer (2017) An introduction to Practical Biochemistry, Tata McGraw Hill, 3rdEdition.
2.	Keith Wilson and John Walker (2010) Practical Biochemistry - Principles and techniques, Cambridge University Press, U.K; 7th Edition.
3.	Upadhayay and Nath (2019) Biophysical chemistry: Principles and Techniques, Himalaya publishing house , 4thReview Edition.
4.	M.L. Srivastava (2011) Bioanalytical Techniques, Narosa Publishing House, New Delhi.

Reference Books:	
1.	Rapley and Walker (2008) Molecular Biomethods Handbook, Humana Press, NewYork.
2.	SVS Rana (2018) Biotechniques: Theory & Practice: Second Edition, Rustogi Publications.
3.	SarojDua And NeeraGarg (2013) Biochemical Methods of Analysis, Narosa Publishing House, New Delhi.

Course Title: Allied Paper 3: Biochemistry

Course Code :		**Credits**	**: 03**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Define and relate the acidity and alkalinity with the biological buffer systems.
CO2	Classify and analyze the structure, composition and function of biomolecules such as carbohydrates and proteins
CO3	Discuss the metabolic pathways and significance of biomolecules such as lipids and nucleic acids
CO4	Discriminate the types and the various roles of prostaglandins and porphyrins.
CO5	Tabulate the sources, structure, function and deficiency diseases relating to fat soluble and water soluble vitamins and minerals

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1		3		2			
CO2		3		3			
CO3		3		3			
CO4			2	2			
CO5					2	3	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		2	2		
CO2		2	2		
CO3		2	3		
CO4		2	2		
CO5		2	3		

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Definition of pH; pOH; buffers; acids; bases; Zwitter ions. Derivation & significance of Henderson-Hasselbalch equation. Measurement of pH. Normality, Molarity & Molality and their biological significance, Buffer systems.	18	CO1
2	Carbohydrates – Classification, Structure and general properties of monosaccharides (glucose, fructose, mannose) and disaccharides (maltose, lactose, sucrose).Polysaccharides-Homopolysaccharides (Starch, glycogen, cellulose) and Heteropolysaccharides (Heparin and chondroitin sulphate). Glycolysis, TCA cycle, Gluconeogenesis. Amino acids – Classification, properties and structure of essential and non-essential amino acids. Proteins-classification, structure (primary, secondary and tertiary) and properties.	18	CO2
3	Lipids – Classification-Simple lipids, fatty acids, Compound lipids, Derived lipids, Properties –physical, chemical and functions. Biosynthesis and Oxidation of fatty acids. Ketogenesis. Nucleic acids: Structures of Purine and pyrimidine bases, nucleosides, nucleotides and polynucleotides. Denovo synthesis of nucleotides- Purines and pyrimidines. DNA structure, types and properties. RNA- types, Structure and functions.	18	CO3
4	Classification of porphyrins, their structure & properties - Metalloporphyrins-haeme and chlorophyll. Prostaglandins – interleukins and interferons. Enzyme: Classification, Nomenclature, and Mechanism of enzyme action: Lock and Key model and Induced fit model.	18	CO4
5	Vitamins – Definition, Classification - Fat soluble vitamins-A, D, E and K; vitamins – B complex and C - biochemical roles, daily requirements and deficiency diseases. Water soluble. Biologically significant minerals-Calcium, Phosphorus, Potassium, Sodium, Iron and Zinc. Hormones – Insulin and Thyroxine hormones.	18	CO5

TEXT BOOKS:	
1.	Satyanarayana .U, Chakrapani.U, (2019). Essentials Of Biochemistry (3rd ed.). Books & Allied PvtLtd
2.	Nelson David L, Cox Michael M, L. Lehninger Albert L. (2017). Lehninger Principles of Biochemistry (7th ed.). NewYork, W. H. Freeman publishers
3.	RajanKatoch (2011). Analytical Techniques in Biochemistry and Molecular Biology. Springer

REFERENCE BOOKS:	
1.	Donald Voet, Judith Voet G. (2010).Biochemistry (4th ed.). New Jersey, John Wiley & Sons, Inc
2.	Jeremy Berg M, John Tymoczko L, LubertStryer (2011). Biochemistry. (7th ed.). Palgrave MacMillan

Course Title: Core Practical – III: Bioinstrumentation

Course Code :		**Credits**	**: 03**
L:T:P:S	**:0:0:3:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Record lab safety rules and apply the same in safe access of laboratory wares.
CO2	Practice, experiment with and apply the basic instruments in the laboratory such as weighing balance, pH meter, shaker, incubator etc. in various research processes.
CO3	Predict the functionality of Beer – Lambart's law in identifying and quantifying a biomolecule such as protein, pigment etc.
CO4	Employ the separation techniques for separating biomolecules based on centrifugal force by centrifugation and chromatography by molecular weight, charge etc .
CO5	Apply electrophoretic techniques to qualify nucleic acid and to identify various proteins based on their molecular weight.
CO6	Observe and record the operation of FTIR, HPLC and GCMS for identifying a compound.

Mapping of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1				3			
CO2				3			
CO3				3		3	
CO4				3			
CO5				3		3	
CO6				3		3	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1			3	3	
CO2		3	3	3	
CO3		3	3	3	
CO4		3	3	3	
CO5		3	3	3	
CO6		3	3	3	

Sl. No	Contents of Module	Hrs	Cos
1.	Laboratory safety rules and Introduction to basic instruments and its uses (Weighing balance, pH meter, Laminar Airflow Chamber, Autoclave, Cyclomixer, Shaker incubator.	**10**	**CO1** **CO2**
2.	Verification of Beer – Lambarts law by Colorimetry. Application of UV – Visible spectroscopy in identifying a compound – Pigment To determine an unknown protein concentration by using UV – Visible spectroscopy.	**10**	**CO3**
3.	Subcellular fractionation by differential centrifugation. Separation of biomolecules by paper chromatography Separation of Lipids by TLC	**10**	**CO4**
4.	Demo on Agarose gel electrophoresis of DNA SDS – PAGE	**8**	**CO5**
5.	Demo on Gel permeation chromatography Separation of plant pigments by gel permeation chromatography	**7**	**CO6**

Reference Books/Manuals:	
1.	Bhomwik (2011) Analytical techniques in Biotechnology – A complete laboratory manual, MGH Publisher,
2.	P. Palanivelu (2017) Analytical Biochemistry and Separation techniques – A laboratory manual, 5th Edition, Twentyfirst century publishers.

Course Title: Allied Practical – III: Biochemistry

Course Code :		**Credits**	**: 02**
L:T:P:S	**: 0:0:3:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Deduce how to standardise various chemical solutions.
CO2	Estimate the amount of chemicals such as glycine, glucose and ascorbic acid volumetrically
CO3	Estimate the amount of glucose and inorganic phosphorus colorimetrically
CO4	Analyze the sugars such as glucose, fructose, lactose and sucrose qualitatively
CO5	Analyze the aminoacids such as Arginine, Cysteine, Tyrosine and Tryptophan qualitatively

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	2		2	3	2	2	
CO2	2		3	3	2	2	
CO3		2	2	2	2	2	
CO4				3	3	3	
CO5				3	2	2	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		2	3	2	
CO2			3	2	
CO3		2	3	2	
CO4			3	2	
CO5		2	3	2	

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	I. Volumetric analysis 1. Estimation of Glycine by formal titration. 2. Estimation of Glucose by Benedict's method. 3. Estimation of Ascorbic acid by dichlorophenol indophenol method	**9**	**CO1** **CO2**
2	II. Colorimetric analysis 4. Estimation of Glucose by ortho toluidine method 5. Estimation of Protein by Lowrys's method	6	**CO3**
3	III. Qualitative analysis of sugars 6. Glucose 7. Fructose 8. Lactose 9. Sucrose 10. Starch	12	**CO4**
4	IV. Qualitative analysis of aminoacids 11. Cysteine 12. Tryptophan 13. Tyrosine 14. Arginine	12	**CO5**

Reference Books/Manuals:	
1.	SoundravallyRajendiranPoojaDhiman. (2019).Biochemistry Practical Manual,(1st ed.). Elsevier India
2.	Vasudevan D.M., Das S.K. (2013).Practical Textbook of Biochemistry for Medical Students,(2nd ed.).Jaypee Brothers Medical Publishers

FOURTH SEMESTER

Course Title: Core Paper 4: Skill Enhancement Course - Genetic Engineering

Course Code :		**Credits**	**: 04**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Demonstrate the basic principles that govern the genetic engineering techniques
CO2	Illustrate the significance of enzymes and nucleic acids in molecular techniques and the specificity of vectors for cloning and advantages.
CO3	Enumerate various recombinant techniques and gene probes and molecular markers identification
CO4	Analyze and detect nucleic acid components from different sources using advanced molecular techniques.
CO5	Exhibit knowledge in sequencing technologies and protein engineering techniques
CO6	Explore the strategies for Gene cloning and its application in research, medicine and agriculture

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	2	3	2	3	3	2
CO2	2	2	3	3	3	2	2
CO3			3	2		2	3
CO4			2	3	2		3
CO5		2		2	2		3
CO6	2		3	2	3		2

Mapping of Course Outcomes with PSO

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	2	3	2	3
CO2		2	3	3	3
CO3		2	3	2	
CO4			2	2	2
CO5		2		2	2
CO6			3	2	3

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Core techniques in gene manipulation. Cutting and joining of nucleic acids, reverse transcriptase, DNA ligase. Types of Restriction enzymes, Modification enzymes nucleic acid manipulating enzymes. Restriction and modification systems in bacteria. Cloning strategies.	18	CO1
2	Introduction to cloning vectors. classification of Plasmids and Properties - Plasmid vectors- pBR322, pUC vectors-pUC8,pUC19 Phage vectors- λ and M13 vectors,Yeast vectors, shuttle vector, Ti plasmid vector, caMV vector,SV40 vector, Artificial chromosome - BAC and YAC	18	CO2
3	Selection and screening of recombinants: Construction of genomic DNA library screening of DNA library and cDNA libraries. Methods of labelling gene probes; Principles and Applications – Restrction Fragment Length Polymorphism, Random Amplification of Polymorphic DNA.	18	CO3 CO4
4	DNA Bar coding – Introduction, components of DNA barcoding, DNA sequencing-Maxam and Gilbert method, Site directed mutagenesis and protein engineering.	18	CO5
5	DNA amplification using polymerase chain reaction (PCR)- Principle, Steps involved in PCR, Types of PCR, application of PCR, DNA finger printing – Methods and its applications.	18	CO6

TEXT BOOKS:	
1.	David Clark Nanette Pazdernik Michelle McGehee (2018) Molecular Biology techniques, 3rd edition.
2.	Anton Byron (2019). Introduction to Gene Cloning Publisher: Oxford Book Company

REFERENCE BOOKS:	
1.	Monika Jain (2012). Recombinant DNA technology, I edition, Alpha Science International.
2.	Primrose.S.B (2014) Principles of gene manipulation, 7th edition, Blackwell Scientific limited, Germany

Course Title: Allied Paper 4: Fundamentals of Computers and Biostatistics

Course Code :		**Credits**	**: 03**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Enumerate the basics of computers architecture and storage devices
CO2	Explain the basics of working with MS-word, Excel and powerpoint
CO3	Demonstrate the basic methods of data collection, graph construction and sampling techniques
CO4	Calculate measures of central tendency and interpret biological data via various probabilistic distribution methods.
CO5	Correlate and analyze biological data through various statistical methods.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	2		2	3	2		2
CO2	2		2	2	2		2
CO3			2	2	3		2
CO4			3	3	2		3
CO5			3	2	2		2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		2	1	3	
CO2		2	1	3	
CO3		2	3	2	2
CO4		2	2	3	3
CO5		2	2	3	3

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Fundamentals of Computers:** Introduction, Characteristics of a Computer, Criteria for Using Computers, History of Computers, Generations of Computer, Classification of Computers, Applications of Computer, Basic Components of PC, Computer Architecture Computer in Biological Research - Components of Computer - storage device, computer peripherals, Computer virus Protection.	18	CO1
2	**MS Office and Internet:** Word Basics- Creating and working with documents, working with text Tables, Using EXCEL-working with work sheet, Creating chart- working with formula and functions, Using power point-working with power point user interface, Using templates and wizard for Slide Presentation, Creating charts and tables, Internet and WWW, Electronic mail- internet browsing	18	CO2
3	**Introduction to biostatistics:** Basic definitions and applications, sampling representative sample size, sampling bias and sampling techniques. Data collection and presentation: types of data, methods of collection of primary and secondary data, methods of data collection, graphical representation by histogram, polygon, ogive curves and pie diagram.	18	CO3
4	**Measures of central tendency and Concept of Test of Hypothesis:** Measures of central tendency – (Arithmetic, harmonic and geometric mean), median and mode, Measures of dispersion – Range, interquartile range, and standard deviation; Variance, Coefficient of Variation, Skewness – Kurtosis. Concept of Test of Hypothesis. Applications of t-test statistics to biological problems/data: Chisquare test, statistic applications in Biology	18	CO4
5	**Regression, correlations and Probability Distribution :** Correlation and regression: positive and negative correlation and calculation of karl pearsons co-efficient of correlation, Spearman's Rank Correlation; Regression – Formation of Regression lines – Uses of Regression lines; Concept of analysis of variance- ANOVA, one and two way classification Probability theory – probability distribution, Binomial, poisson and normal distribution, correlation and regression analysis.	18	CO5

TEXT BOOKS:	
1.	Mohammad AmjadManaullahAbid. (2019). Fundamentals of Computers. (1st Ed.)DreamtechPress
2.	S.P. Gupta (2019). Biostatistical methods (1st Ed.)Sultan Chand and Sons.
3.	Veer BalaRastogi (2018). Biostatistics. Medtech Publisher

REFERENCE BOOKS	
1.	Jerrold H. Zar (2014). Biostatistical Analysis (5th Ed). New Delhi: Pearson Education
2.	PritiSinhaPradeepK.Sinha (2018). Computer Fundamentals (6th Ed.) BPB Publications; Reprint Edition

Course Title: Core PracticalIV: Genetic Engineering

Course Code :		**Credits**	**: 03**
L:T:P:S	**: 0:0:3:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Isolate the Plasmid DNA and Genomic DNA.
CO2	Predict the molecular weight of DNA by agarose gel electrophoresis
CO3	Estimate the DNA using UV-Visible spectrophotometry. Determine the restriction digestion and ligation of DNA
CO4	Determine the restriction digestion of DNA.
CO5	Amplify the DNA using PCR and to explicate the proteins using SDS– PAGE.
CO6	Prepare the competent cells and perform bacterial transformation

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1				2	1	3	2
CO2				1	2	2	
CO3				3	2	2	
CO4				2	2	3	1
CO5				3	2	1	1

Mapping of Course Outcomes to Program Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		3	3	3	3
CO2		2	3	3	1
CO3		3	3	3	1
CO4		3	3	3	2
CO5		3	3	3	1
CO6		3	3	3	2

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	1. Isolation of genomic DNA from various sources 2. Isolation of plasmid DNA from various sources	9	CO1 CO2
2	3. Isolation of RNA from various sources 4. Separation of nucleic acids using agarose gel electrophoresis	9	CO2 CO3
3	5. Estimation of Nucleic acidbySpectrophotometry 6. Restriction digestion of DNA 7. DNA ligation	9	CO3
4	8. PCR amplification of marker gene 9. SDS – PAGE for analysis of protein	9	CO4
5	10. Bacterial Transformation 11. Demo on Blotting techniques (Southern and Western)	9	CO5

Reference book:	
1.	Vennison, S. J. (2009). Laboratory Manual for Genetic Engineering (1st edition). Delhi. PHI Publishers

Course Title: Allied Practical IV: Fundamentals of Computers and Biostatistics

Course Code :		**Credits**	**: 02**
L:T:P:S	**: 0:0:3:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Represent data in to graphical form
CO2	Determine averages of the biological data
CO3	Test the level of significance of biological data and interpret the results
CO4	Enhance skills in working with MS-word, powerpoint and Excel
CO5	Create E-mail and use of various search engines

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	2		3	2	2		
CO2	2		2	3	3		
CO3	2		3	2	2		
CO4	3	2	2	3	2		2
CO5	3	3	2	2	3		2

Mapping of Course Outcomes to Program Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		2	2	3	
CO2		3	2	3	
CO3		2	3	2	3
CO4		2	2	3	2
CO5	2	2	2	2	2

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Representation of statistical data by a) Histogram b) Ogive curve c) Pie diagram	9	CO1
2	Determination of statistical averages / central tendencies. a) Arithmetic mean b) Median c) Mode.	9	CO2
3	Determination of measure of dispersion. a) Mean deviation. b) Standard deviation and coefficient of variation. c) Quartile deviation. Tests of significance-Application of following. a) Chi-square test. b) t-test c) standard error	9	CO3
4	Creating files, folders and directories; Application of computers in biology using MS-office. a) MS-word b) Excel c) Power point.	9	CO4
5	Creating and e-mail account, sending and receiving mails; An introduction to Internet, search engines, websites, browsing and downloading	9	CO5

Reference books:	
1.	Bittu Kumar (2017). Computers Basics. V & S Publishers.
2.	Mendel Suchmacher and Mauro Gueller. (2012). Practical Biostatistics (1st Ed.) Academic Press

FIFTH SEMESTER

Course Title: Core Paper 5: Immunology

Course Code :		**Credits**	**: 04**
L:T:P:S	**: 5:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Grasp the basic concepts of immunity while distinguishing between innate and acquired immunity
CO2	Define the role of various cells/ organs involved in bodily defense mechanisms
CO3	Classify antigens/antibodies and Monoclonal antibody production and learn the pathways of complement systems
CO4	Gain an in-depth understanding of the development of T & B cells and explain the role of MHC in cell and antibody mediated immune response.
CO5	Demonstrate the role of cytokines in immune response and explain the types of hypersensitivity and auto immune diseases
CO6	Demonstrate the antigen –antibody reactions in various immune techniques and also gain knowledge of production of vaccines.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	2	2	2	3		2	2
CO2	2		3	2			2
CO3				2		3	3
CO4		2		3	2		2
CO5			3	2	3	2	3
CO6		2	2		3		3

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		3	2		
CO2			3		
CO3			3		
CO4		2	3		
CO5		2	3	3	
CO6		3	2	2	

Sl. No	CONTENTS OF MODULE	Hrs	Cos
1.	Historical perspective of the immune system; innate immunity and acquired immunity. Structure and functions of primary and secondary Lymphoid organs. Cells of the immune system- granulocytes & agranulocytes-and their functions- Inflammation and Phagocytosis.	15	CO1& CO2
2.	Antigens: Types and properties-Structure, epitope, adjuvant, hapten. Classes and functions of antibodies; Antigenic receptors. Effector components of an immune response. Monoclonal antibody production and its uses. Pathways of complement systems – Classical and Alternate pathway and its biological effects.	15	CO3
3.	An introduction to MHC I and MHC II. Immune response- T cells – receptors, Maturation, activation and differentiation- Cell mediated response. B cells- receptors, maturation and activation of B cells by T cell dependent and independent antigens and differentiation-Antibody mediated response.	15	CO4
4.	Cytokines- types and its functions. Auto immune diseases- organ specific- Rheumatoid arthritis and non-organ specific -Systemic lupus erythematosus. Types of hypersensitivity-Type I, II, II, IV and V-Mechanism with examples.	15	CO5
5.	Antigen and antibody interactions- Antibody affinity, avidity, specificity, cross reactivity. Immunodiffusion-SID & DID agglutination, Immuno electrophoresis-counter current and rocket, ELISA. Infectious diseases – Bacterial and viral. Vaccine production-Recombinant and DNA vaccines.	15	CO6

Text Books:	
1.	Joshi, K.R & Osama, N.O. Immunology, 4th edition, *Agro Botanica Bikaner*, 1998.
2.	D.M.Weir., Handbook of Experimental Immunology, Volume 3,*Blackwell Scientific Publication*, 1978.
3.	Abdul Abbas, Andrew H. Lichtman,ShivPillai, Cellular and Molecular Immunology,9thedition, *Elsevier Publishing Company*, 2017.
4.	Kenneth Murphy, Paul Travers and Mark Walport, Immunobiology, 7th edition, *Garland Science, New York*, 2009.

Reference Books:	
1.	Kuby Immunology, Richard A. Goldsby, Thomas J. Kindt and Barbara A. Osbourne., 6th edition, *W. H. Freeman & Company*, 2006.
2.	Ivan M. Roitt, Seamus J. Martin, Dennis R. Burton and Peter J. Delvis., Essential Immunology, 13thedition , *Wiley Blackwell,USA*, 2017.

Course Title: Core Paper 6: Bioinformatics

Course Code :		**Credits**	**: 04**
L:T:P:S	**: 5:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Discuss about various biological databases and its analysis
CO2	Compare the genomic data from databases and to interpret in meaningful manner.
CO3	Demonstrate the principles of human genome project and genome organization techniques
CO4	Explore the steps in sequence alignment algorithms and various sequence alignment programs used.
CO5	Use various protein databases and proteomics analysis tools
CO6	Identify novel lead compounds using ligand based and structure based drug designing process
CO7	Exhibit knowledge in microarray data analysis using gene expression tools

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	2	2	2	3			
CO2			3	2	2		2
CO3			2	3	2		2
CO4			2	2			3
CO5			2	3	2		
CO6				2	2		2
CO7	3	3	3	3	3		3

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		3	3	3	2
CO2		3	2	3	1
CO3		3	3	2	2
CO4		2	2	2	
CO5		2	2	3	1
CO6		3	2	3	2
CO7		3	2	3	

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Biological Databases:** Bioinformatics - definition, introduction, history and scope. Databanks –. Literature DataBanks – PubMed. Biological databases - nucleic acids – NCBI, EMBL, DDBJ. Protein – Uniprot and PIR; Structural databases – PDB, CATH, SCOP	15	CO1
2	**Genome analysis tools and Genome Sequencing:** Genome Structure, Human Genome Project; Genome Databases-GDB, TIGR, Ensembl genomes, Flybase, SGD, Gene disease database; Comparative Genomics – Determining gene function by sequence comparison. Fragment Assembly, Genome Sequence Assembly; Next Generation Sequencing	15	CO2 CO3
3	**Sequence Analysis:** Analysis- Sequence Alignment: Alignment algorithms - Pair wise alignment-Global and Local – Significance, Dynamic Programming in Sequence Alignment, Dot Matrices, Substitution Matrices – PAM, BLOSUM, Homology search Using FASTA and BLAST Programs; Multiple Sequence Alignment methods	15	CO4
4	**Protein structure prediction and Phylogenetic analysis:** Protein structure prediction methods- Primary, secondary, tertiary structure prediction Protein domains and motifs; Phylogenetics - Tree construction methods –Distance based methods and character based methods	15	CO5 CO6
5	**Microarrays:** Concept of Gene Expression, Types of Microarrays; Making Microarrays; Spotted Microarrays; -Microarrays - Sample Preparation and Labeling, Hybridization, Washing, Image Acquisition; Protein arrays; GEO Database. Application of Microarrays	15	CO7

TEXT BOOKS:	
1.	S. C. Rastogi, NamitaMendiratta, ParagRastogi. (2013). *Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery.* PHI Learning Pvt. Ltd.
2.	Ruchi Singh. (2014)*Bioinformatics: Genomics and Proteomics.* Vikas Publishing House
3.	David Mount. (2004).*Bioinformatics: Sequence and Genome Analysis*(2nd Ed.). Cold Spring Harbor Laboratory Press

REFERENCE BOOKS	
1..	Lesk Arthur. (2019).*Introduction to Bioinformatics.*(5th Ed.). UK:Oxford University Press
2.	Baxevanis, Andreas D. and Francis B.F. Ouellette. (2005). *Bioinformatics- A Practical Guide to the Analysis of Genes and Proteins*. (3rded.) USA: John Wiley.

Course Title: Core Paper 7: Bioprocess Technology

Course Code :		**Credits**	**: 04**
L:T:P:S	**: 5:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Illustrate the significance of cultivation and preservation of different types of industrial microbes.
CO2	Distinguish the principle and application of various fermentors used in different industries.
CO3	Depict the various methods involved in the downstream processing for various metabolites.
CO4	Compare the different methods of extraction, purification and drying process for different metabolites products.
CO5	Summarize the microbial role and economic importance of various primary and secondary metabolites.
CO6	Speculate the role and importance of microorganisms behind the production of Biopesticides and Biofertilisers.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	1	1		1	2	2	3
CO2				1			2
CO3			2				
CO4			2				
CO5	2	1			2	2	2
CO6	2	3			3	3	2

Mapping of Course Outcomes to ProgramSpecificOutcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	3	3	1	2
CO2	1	3	3	1	
CO3	1	3	2		
CO4	1	3	2		
CO5	1	3	2	2	2
CO6	1	3	3	2	2

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	History and scope, applications of bioprocess technology; Fermentation and its types; Screening of industrially important microorganism – Strain improvement – inoculum development – Media formulation, sterilization - Cultivation and preservation of industrial microorganisms	15	CO1
2	Batch culture and continuous culture; Fermentor- Design, parts and their function; Types of fermentor - batch fermentor, continuous stirred tank fermentor, Air lift fermentor, Bubble column, tower fermentor.	15	CO2
3	Downstream Processing: Filtration and its types, Cell disruption – Mechanical and non mechanical, Precipitation, Solid liquid separation – Flotation, Flocculation, Centrifugation and its types	12	CO3
4	Liquid-liquid extraction - aqueous two-phase extraction, supercritical extraction; Chromatography and its types; Membrane process – Ultrafiltration, reverse osmosis, liquid membranes, Drying and its types, Crystallization.	16	CO4
5	Production of primary metabolites: citric acid, Glutamic acid, amylase, protease; Production of secondary metabolites: Penicillin, Steroids, Growth factors; Production of other microbial products: Cheese, beer, ethanol, Biopesticides, Biofertilisers, Biopreservatives (nisin)	17	CO5 CO6

TEXT BOOKS:	
1.	R C Dubey. Advanced Biotechnology, 1st Edition, S. Chand Publishing, 2014
2.	NdukaOkafor, Benedict C. Okeke, Modern Industrial Microbiology and Biotechnology, 2nd Edition, CRC Press, 2018
3.	NeelamTyagi, Industrial Microbiology and Biotechnology, 1st Edition, Agrotech Press, 2012

REFERENCE BOOKS:	
1.	Peter F. Stanbury Allan Whitaker Stephen Hall. Principles of Fermentation Technology, 3rd Edition, Butterworth-Heinemann, 2016
2.	El-Mansi, E, Nielsen, J, Mousdale, D, Carlson, R. Fermentation Microbiology and Biotechnology, 4th Edition. CRC Press, 2019.

Course Title: Core Paper 8- Skill Enhancement Course: Food Biotechnology

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 5:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Discover the role of biotechnology in food processing industries.
CO2	Execute the biotechnological production of commercially important metabolites.
CO3	Apply the principle of downstream processing and explain the various stages involved in downstream processing.
CO4	Evaluate the molecular diagnostic techniques pertaining to identification of food adulterants.
CO5	Assess the safety aspects and social issues related to applications and implications of genetically modified foods.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1			2	2	3		
CO2			2	3	3		
CO3				3			
CO4			3	3	2		
CO5		2	2	2			

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		3		2	
CO2		3		2	
CO3		3			
CO4		3		2	
CO5					3

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Fundamentals of food biotechnology**: Biotechnology relating to the food industry – Role of bio process engineering in biotechnology industry- Regulatory and social aspects of biotechnology in foods- Application of biotechnology in waste treatment of food industries.	15	CO1
2	**Industrial production of food products:** Technological aspects of industrial production of beer and wine, lactic acid, baker's yeast, single cell protein- Bacteriocin production and its use in food preservation- Biotechnological approaches to improve nutritional qualities and shelf life of fruits and vegetables by gene modification.	15	CO2
3	**Downstream processing:** Principle of downstream processing -stages in downstream processing- solid liquid separation- flotation- flocculation- filtration-types-centrifugation-cell disruption-concentration-evaporation –liquid- liquid extraction-membrane filtration- precipitation-adsorption- purification by ion exchange chromatography.	15	CO3
4	**Food adulterants & molecular diagnostic tools:** Types of food adulterants – test to detect adulterants in foods – metal contaminants - contaminants of processed foods- Food products as analytical samples, general aspects of biosensors- biosensors for food contaminant analysis, commercially available biosensors for food analysis.	15	CO4
5	**Food safety and ethical issues:** Risk associated with GM foods – Allergens, toxins, antibiotic resistance, soil contamination - Creation of superbugs and super weeds - Increased risk of immune suppression and cancer- GMOs- current guidelines for the production, release and movement of GMOs; labeling and traceability; trade related aspects.	15	CO5

TEXT BOOKS:	
1.	Joshi, V.K. and Singh, R.S., A., Food Biotechnology- Principles and practices, *I.K.International Publishing House Pvt. Ltd., New Delhi*, 2013.
2.	RavishankarRai, V., Advances in Food Biotechnology, First edition, *John Wiley & Sons, Inc.*, 2015.
3.	Foster, G.N., Food Biotechnology, First edition, *CBS Publishers & Distributors Pvt Ltd*, 2020.

REFERENCE BOOKS:	
1.	Anthony Pometto, KalidasShetty, GopinadhanPaliyath, Robert E. Levin., Food Biotechnology, 2nd edition, *CRC Press*, 2005.
2.	Perry Johnson-Green., Introduction to Food Biotechnology, Special Indian Edition, *CRC Press*, 2018.

Course Title: Elective 1A -Marine Biotechnology

Course Code :	**Credits : 05**
L: T: P: S : 4:0:0:0	**CIA Marks : 40**
Exam Hours : 03	**ESE Marks : 60**

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

CO1	Demonstrate the importance of aquaculture, selection of cultivable species and its commercial importance.
CO2	Discuss the design, construction and management practices of aqua farms.
CO3	Compile the various cultivation methods of marine organisms and to explain the marine pollution and sea food infections.
CO4	Comprehend the uses of marine organisms, their significance, interaction and impacts on the environment.
CO5	Describe the growing use of marine natural products in food, cosmetics, agriculture and to analyze the concepts on bio fouling and antifouling.

Mapping of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1				2	2		1
CO2				1	1		2
CO3				2	2	1	3
CO4				1	2		2
CO5				1	2		2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		2	2	3	1
CO2		2	2	3	3
CO3		1	2	2	2
CO4		1	1	2	3
CO5		2	2	2	2

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Historical background, Overview of present status of marine biotechnology, Importance of coastal aquaculture, Criteria for selecting cultivable species, Commercially important and potential species.	12	CO1
2	Aqua farms - Design and construction of culture systems, management practices-Extensive, Semi intensive and intensive culture practices, mass spawning, Artificial insemination, invitro fertilization.	12	CO2
3	Cultivation of microalgae, macro algae, shrimp, carps, mud crab, live feed culture technique &feed formulation. Sea food microbiology - normal genera associated with fish. Marine pollution - major pollutants, biological indicators (marine microbes, algae& crustaceans).	12	CO3
4	Marine natural products - Chemicals, Marine Biomedical & Bioactive compounds from microalgae & marine organism. Commercial bio products from marine organisms. Marine biotechnology for economic development and environmental problem solving, transgenic marine organism.	12	CO4
5	Bio fouling-marine fouling & boring organism, biofilm formation, bio-remediation, antifouling & antiboring treatments, corrosion process - control of marine structure.	12	CO5

TEXT BOOKS:	
1.	Gloria Sanchez, Elizabeth Hernandez, Environmental Biotechnology and cleaner Bioprocess, 1st edition, CRC Press, 2019. `
2.	Kirchman, D.L.Gasol, J.M., Microbial ecology of the oceans, 3rd edition, Wiley –Blackwell, 2018.

REFERENCE BOOKS:	
1.	Bradach, J.E., H.H. Ryther and W.D. MC Larney, Aquaculture, farming and husbandry and fresh and marine organisms, Wiley lnterscience, New York, 2014.
2.	Kim Se-Kwon, (2019) Essentials in Marine Biotechnology, Springer.

Course Title: Elective Paper 1B: Agricultural Biotechnology

Course Code	**:**	**Credits**	**: 05**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Discuss crop improvement hybridization and plant breeding techniques.
CO2	Demonstrate *in vitro* production of disease free plants and the molecular basis of plant resistance to various abiotic stresses
CO3	Illustrate the plant growth promoting microorganisms and phosphate solubilizing bacteria.
CO4	Describe the impact of transgenic plants in agriculture and Horticulture and produce transgenic plants for fungal, bacterial and viral disease resistance
CO5	Apply the principles of bioethics on GM crops and recall the various plant variety protection acts.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	2	2			3	3	
CO2	2	2		2	3		
CO3	2				2		
CO4	3	2			3		
CO5	3	2			3		

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		2	2	3	1
CO2		2	2	3	2
CO3		2	2	3	2
CO4		3	2	3	1
CO5		3	2	3	2

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Introduction: Scope and application of agriculture. Crop improvement hybridization and plant breeding techniques. Clonal Germplasm: Micro propagation, *In* vitro production of disease free plants; Seed pathology.	12	CO1
2	Plant Resistance: Molecular and biochemical basis of plant disease resistance, Molecular basis of plant resistance to various abiotic stresses like drought, salinity, heavy metals, high temperature. Methods for crop improvement for resistance to biotic and abiotic stress.	12	CO2
3	Plant growth promoting microorganisms: Plant Growth promoting bacteria: Nitrogen fixation- and nodulation genes. Biochemistry of nitrogen fixation, Nif genes. Biofertilizers: Azolla and Anabena, Rhizobium, Phosphate solubilizing bacteria. Biopesticide – Trichoderma and Bt.	12	CO3
4	Applications: Commercial production of Transgenic crops- Impact of transgenic plants in agriculture and Horticulture. Production of transgenic plants for fungal, bacterial and viral disease resistance; herbicide resistance, drought and other abiotic stress resistance.	12	CO4
5	Bioethics: Bioethical issue on GM crops. Biosafety norms and controlled field trials and release of transgenics (GMO). Plant Variety Protection Act: TRIPS and WTO. Regulatory issues of biotechnology improved plants.	12	CO5

TEXT BOOKS:	
1.	NirmalaC.B, Rajalakshmi.G and Karthik.C (2009). Plant Biotechnology(1st ed.). MJP Publishers
2.	Kumar HD. (2016). Agricultural Biotechnology, NewDelhi. Daya Publishing house.
3.	Joshi Rajmohan. (2006). Agricultural Biotechnology, Isha Books

REFERENCE BOOKS:	
1.	Ahindra Nag. (2008). Text book of Agricultural Biotechnology, New Delhi.PHI Learning Private Limited
2.	Arie Altman, Rita Colwell.R.(2001).Agricultural Biotechnology, New York. Marcel Dekker.

Course Title: Elective Paper 1C: Basics in stem cell Biology

Course Code :		**Credits**	**: 05**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Exhibit knowledge on the types and sourcesof embryonic, adult and induced pluripotent stem cells and to differentiate the potential of embryonic stem cells with adult stem cells.
CO2	Understand the properties, differentiation and regulation stem cells.
CO3	Share insights into techniques involved in isolation, expansion and identification of stem cells.
CO4	Evaluate the role of stem cells in clinical applications for human health and improvement. Discuss about animal models for regeneration.
CO5	Acquire a deeper understanding of stem cell banks and its importance .Understand the national & international guidelines of stem cell research and also recent advancements.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	2	2					
CO2		2		2			2
CO3		2			3	2	2
CO4	3	2		3		2	2
CO5	2				2	3	2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		3	3	2	
CO2		2	2	3	
CO3		3	3	3	
CO4		2	2	2	
CO5		2	2	2	

Sl. No	CONTENTS OF MODULE	Hrs	Cos
1.	Introduction to concepts in stem cell biology, unipotent, multipotent, totipotent and pluripotent stem cell. Types and Sources of stem cells- Embryonic stem cells, Adult stem cells, mesenchymal, hematapoietic and induced pluripotent stem cells.	12	CO1
2.	Properties of stem cells- self renewal and differentiation, regulation of stem cell-cell cycle regulation, gene expression, epigenetic regulation and miRNA roles.	12	CO2
3.	Isolation of stem cells by fluorescence based cell sorting, culture and genetic manipulation of stem cells, expansion of stem cells using biochemical and molecular approach. Identification of stem cells using specific markers.	12	CO3
4.	Applications of stem cells: Stem cells used organogenesis in animals and humans. Animal models of regeneration. Stem cells used for therapy- Parkinson's disease, spinal cord injury and Muscular dystrophy.	12	CO4
5.	Stem cell banking- sperm and ova bank and its role. Cryopreservation techniques, National ethical guide lines of stem cell research by ICMR, and international guide lines by International society for Stem Cell Research (ISSCR), advances in stem cell biology.	12	CO5

Text Books:	
1.	Jonathan slack(2012), Stem Cells: A Very Short Introduction , oxford University press.
2.	IndumathiSomasundaram, DhanasekaranMarrappagounder,Pankajkaigade (2019),Stem cell Biology, Evincepub Publishing , ISBN-10: 9389774357
3.	KursadTurksen(2014) A dult and Embryonic Stem Cells -Stem Cell Biology and Regenerative Medicin(2nd edition) ,Humana press
4.	Ann A Kiessling ,Scott C Anderson(2006)Human Embryonic Stem Cells, Jones and Bartlett Publishers, Inc; (2nd Revised edition)

Reference Books:	
1.	Federico Calegari,Claudiawaskov (2014), Stem Cells: From Basic Research to Therapy, Volume 1 Basic Stem Cell Biology, Tissue Formation during Development, and Model Organisms ,CRC Press.
2.	Robert Lanza, Anthony Atala(2013), Essentials of stemcell biology(III ed) copyright:Academic Press ,Hardcover ISBN:9780124095038eBook ISBN: 9780124104273

Course Title: Core Practical V: Immunology, Bioinformatics, Bioprocess Technology & Food Biotechnology

Course Code :		**Credits**	**: 03**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Perform blood grouping and determine blood type and to conduct serological diagnostic tests such as ASO, CRP and RA
CO2	Diagnose syphilis by carrying out TPHA and enteric fever by Widal test.
CO3	Acquire technical skills required for immunodiffusion and know the principle behind the techniques.
CO4	Retrieve biological data from various protein and nucleotide sequence database
CO5	Perform pairwise and multiple sequence analysis using various alignment programs
CO6	Predict sequence similarity, ORF, domains, motif using various sequence analysis tools
CO7	Isolate and screen industrially important microbes for the production of different metabolites.
CO8	Quantify and validate the presence of microbial metabolites using various techniques.
CO9	Perform serial dilution and plating in order to enumerate the microorganisms present in food samples.
CO10	Acquire skills to isolate lactic acid bacteria and manufacture whey.
CO11	Gain basic skills to detect adulterants in food.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3		2	2	3		2
CO2	2			3	3		3
CO3			3	2	2		
CO4				2	2		
CO5				2	3		
CO6	2		3	3	2		2
CO7				3	2	3	
CO8			2	1	2		
CO9	2	2		2	3		2
CO10				3	2		
CO11				3	2	3	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1			2	3	
CO2			3	3	
CO3		2		3	
CO4		3		3	
CO5		3	2	3	
CO6		3	2		
CO7		3	2	3	
CO8		3	3	2	
CO9		2	2	3	
CO10		2	3	3	
CO11				3	

Sl NO	**CONTENTS OF MODULE**	**Hrs**	**Cos**
1	**Immunology** 1. ABO Blood grouping and Rh factor typing by slide agglutination test, Particle agglutination test -ASOC- reactive protein detection by agglutination reaction, 2. Detection of Rheumatoid arthritis (RA) factors by agglutination method- WIDAL-tube and slide agglutination test, Passive haemagglutination- TPHA (*Treponema pallidum* particle agglutination test) 3. Precipitation reaction- RID (Radial Immunodiffusion) 4. Precipitation reaction- ODD (Ouchterlony Double Immunodiffusion) 5. ELISA (demonstration), VDRL- slide flocculation test	15	CO1 CO2 CO3
2	**Bioinformatics** 1. Sequence & Structure Database: Nucleotide: NCBI ; Protein : Uniprot, TrEMBL, PDB 2. Sequence alignment – Global and Local alignment; Multiple sequence alignment – Clustal omega 3. Profile and Domain analysis: Prosite, Pfam 4. Protein Sequence analysis : Protparam, GOR IV, 5. Homology Search tool: BLASTp, BLASTn, Visualization Tool: RasMol,	20	CO4 CO5 CO6
3	**Bioprocess Technology** 1. Isolation of industrially important microorganism. 2. Production & estimation of biomass - dry weight & Wet weight methods. 3. Immobilization of yeast cells, Screening and production of Protease from microbes 4. Production and estimation of ethanol	20	CO7 CO8

4	**Food Technology** 1. Quantitative Enumeration of microorganisms from the given sample by serial dilution technique: Milk, Food, Curd , Bread (Yeast and mold count) 2. Isolation of lactic acid bacteria from curd 3. Determination of adulterants in milk 4. Determination of adulterants in spices	20	CO9 CO10 CO11

REFERENCE BOOKS:	
1.	Frank C. Hay, Westwood M.R., *Practical Immunology*, Fourth edition, Wiley Publications, (2008).
2.	Peter M. Rice, Alan J. Bleasby, Jon C. Ison Lisa Mullan, Guy Bottu. (2020). *EMBOSS User's Guide: Practical Bioinformatics*. Cambridge University press.
3.	Raghuramulu, N., Madhavan Nair, K., and Kalyanasundaram, S. Ed., *A Manual of Laboratory Techniques*, National Institute of Nutrition, ICMR, Hyderabad, 1983.
4.	Aneja K R, *Laboratory Manual of Microbiology and Biotechnology*, MEDTECH, 2014.
5.	Vijaya Ramesh, *Food Microbiology*, MJP Publishers, Chennai, 2007.

SIXTH SEMESTER

Course Title: Core Paper 9: Animal Biotechnology

Course Code :		**Credits**	**: 04**
L:T:P:S	**: 5:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Outline the techniques in assisted reproductive technology, embryo technology and artificial insemination.
CO2	Describe the media preparation, preservation, trypsinization, counting, maintenance and application of cell lines.
CO3	Discuss the strategies for gene transfer, treatment and transgenic animals.
CO4	Acquire knowledge on transgenic animals and animal diseases.
CO5	Explain the genetic modification in medicine and the ethics involved in it.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1				2	2		1
CO2				3	1		2
CO3				3	2		2
CO4				2	2		1
CO5				2	1		2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	1	2	3	3
CO2	1	2	1	2	3
CO3	1	2	2	1	3
CO4	1	2	3	2	3
CO5	1	2	3	2	3

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Basic principles of Biotechnology – manipulation of reproductive process – Artificial insemination – freezing of semen – Embryo technology – in vitro maturation and fertilization – Pregnancy diagnosis – Assisted reproductive technology.	15	CO1
2	Introduction of animal cell culture substrate, culture media, preservation and maintenance of cell lines. Dissagregation of tissue and primary culture, Trypsinization (warm and cold method), cell counting and viability counting, maintenance and culture of primary, secondary and continuous cell lines – applications.	15	CO2
3	Strategies for gene transfer- Transfer to animal cell/embryos, Treatment through microinjection, Retrovirus-gene transfer.	15	CO3
4	Transgenic animals- Mice, cow, sheep, pig, goat, birds, insect, fish. Animal diseases of biotechnological importance - foot and mouth disease, coccidiosis, Trypanosomiasis, Theileriosis.	15	CO4
5	Genetic modification in medicine- gene therapy, types of gene therapy, human genetic engineering, applications, problems and ethics involved in gene therapy.	15	CO5

TEXT BOOKS:	
1.	Satyanarayana U (2017). “Biotechnology “ Books & Allied (P) Ltd.
2.	Dubey, R.C. (2017) “ A Textbook of Biotechnology “ S. Chand & Co. Ltd.
3.	Srivastava A K (2018)Animal Biotechnology Oxford & IBH Publishing Co Pvt. Ltd

REFERENCE BOOKS:	
1.	Freshney R.I; Culture Of Animal Cells- A Manual of Basic Techniques, 5th edition, John Wiley & Sons Pvt Ltd, 2006.
2.	AshishVarma and Anchal Singh, Animal Biotechnology, 1st edition, Elsevier (Academic Press), 2013.

Course Title: Core Paper 10: Skill Enhancement Course: Plant Biotechnology

Course Code :		**Credits**	**: 04**
L:T:P:S	**: 5:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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.
CO2	Explain regulation and control of gene expression
CO3	Illustrate about various culture medium preparation, haploid , triploid plant production and its application.
CO4	Learn in-depth the basic techniques of plant tissue culture and its application.
CO5	Recollect the role of phyto-hormones in plants
CO6	Develop molecular technique skills in plant tissue culture using Ti plasmid vectors in agrobacterium and use of transgenic plants.
CO7	Elaborate the genetic engineering and construction of DNA libraries in development of transgenic plants and its application

Mapping of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1			2	3		2	
CO2			2			3	2
CO3		2	2	3		2	2
CO4			2	3		2	3
CO5			2		3		2
CO6			3			2	3
CO7			2	2		3	3

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		3	3	3	3
CO2		2	3	3	2
CO3		3	3	3	2
CO4		3	3	2	1
CO5		3	2	3	1
CO6		3	3	3	2
CO7		3	3	2	1

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	History of plant biotechnology, Conservation of Plant using Biotechnology. Plant genome organization: structural features of a representative plant gene, gene families in plants. Organization of chloroplast genome and mitochondrial genome, Regulation and control of gene expression.	15	CO1
2	Culture Medium preparation, Dedifferentiation and Redifferentiation, 'Explant' for plant tissue culture - callus formation, Organogenesis (direct and indirect), Suspension culture technique, Production of haploid plants and triploid plants, micropropagation, somatic embryogenesis, Protoplast isolation, applications, Production of Artificial seeds.	15	CO2
3	Plant hormones – Auxins, Cytokinins, Gibberllins, Abscissic acid and Ethylene. Phytochrome – role in morphogenesis, Seed storage proteins.	15	CO3
4	Gene transformation of plants by Agrobacterium – crown gall tumours, Ti plasmid vectors – molecular mechanism of T- DNA transfer, Use of transgenic plants, Symbiotic nitrogen fixation in legumes by Rhizobia – biochemistry and molecular biology.	15	CO4
5	Genetic engineering in plants, selectable markers, reporter genes and promoters used in plant vectors. Construction of genome libraries and cDNA libraries. Recombinants selection and screening – analysis of recombinant DNA. Transgenic plants and their applications, molecular pharming.	15	CO5

TEXT BOOKS:	
1.	Razdan, M.K. (2019). *Plant tissue culture*, (3rd edition).New Delhi.Oxford& IBH Publishing company.
2.	Chawala, H.S. (2010).*Introduction to Plant Biotechnology*. New Delhi.Oxford& IBH Publishing company.
3.	Satyanarayana, U.(2017). Biotechnology, (2nd edition). Kolkata. Books & Allied (P) Ltd.

REFERENCE BOOKS:	
1.	Slater, (2008). *Plant Biotechnology- The Genetic Manipulation of Plants*, (2nd edition). New Jersey.Humana Press.
2.	Das, H.K. (2018).*Text Book of Biotechnology*, (5th edition).New Jersey. Wiley Dreamtech, India Pvt. Ltd.

Course Title: Core Paper 11: Environmental Biotechnology

Course Code :		**Credits**	**: 03**
L:T:P:S	**: 5:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Analyze the scope of environmental Biotechnology and importance of Biogeo cycles
CO2	Explain the different types of environmental pollution and their impacts
CO3	Explain the process of waste water collection and waste water treatment in various methods.
CO4	Establish the role of denitrifying bacteria in maintaining Environment
CO5	Describe the principle and application of reactors used in different industries
CO6	Explain the process of drinking water treatment and summarize the sludge treatment process

Mapping of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1			2	3		2	2
CO2			3	2		3	2
CO3		3	2	3		2	3
CO4		2	2	3		3	2
CO5			3		3	2	2
CO6	3		2	3		3	2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		2	2	3	
CO2		3	3	2	
CO3		3	2	3	
CO4		2	2	3	
CO5		2	3	2	3
CO6			2	3	3

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Concept and scope of environmental Biotechnology, the biogeo cycles of environment (Hydrological, Oxygen, Nitrogen, Phosphate and Sulphur cycle), Air pollutants, sources of water pollution, Water Pollution and its Control.	12	CO1 CO2
2	Waste water collection, Waste water treatment-physical, chemical and biological treatment process. Microbiology of Waste Water Treatments, Aerobic Process; activated sludge, Oxidation ditches, trickling filter, towers, rotating discs, rotating drums oxidation ponds.	12	CO3
3	Bioremediation-in situ and ex situ , Engineering strategies of Bioremediation, Biodegradation, Biodegrading of problem Environmental contaminants-synthetic detergents, pesticides, hydrocarbons	12	CO4
4	Reactors-Reactor types- batch reactor- continuous-flow stirred tank reactor, plug flow reactor, Using alternate rate models, Engineering design of reactors	12	CO5
5	Denitrification; physiology of denitrifying bacteria – Tertiary denitrification- one- sludge denitrification – drinking water treatment: anaerobic treatment by methanogenesis – uses of methanogenic treatment	12	CO6

TEXT BOOKS:	
1.	Pramanik Krishna et.al. (2014)Industrial environmental Biotechnology. Studium Press (India) pvt.ltd.
2.	Sohal,H.S. and Srinvastava,A.K.1994.*Environment and Biotechnonolgy*,Firstedition.Ashish publishing House,New Delhi.
3.	Debajit Borah (2018). Environmental Biotechnology Theory and Lab Practices Hardcover – 2nd edition.Global Vision Publishing House.

REFERENCE BOOKS:	
4.	Bruce Rittmann, Perry Mccarty,(2017).*Environmental biotechnology.Principles and applications*.McGraw-Hill; Indian Edition edition
5.	Daniel Vallero(2015).*Environmental biotechnology*. (2nd edition)*A Biosystems Approach.* Academic Press

Course Title: Elective Paper 2A: Entrepreneurship, Biosafety, Bioethics and Intellectual property rights

Course Code :		**Credits**	**: 05**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Summarize the impact of entrepreneurship in Biotechnology
CO2	Describe the biosafety practices and guidelines for research in transgenic plants and analyze the risk assessment, handling and manufacturing practices of good laboratories.
CO3	Describe the human rights and solve the social issues prevailing in the society
CO4	Analyze the ethical basis concerning, reproduction technologies, prenatal diagnosis, sex selection and abortion.
CO5	Discuss the various forms of Intellectual property rights

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	1			3	1	
CO2	3	2	1		3		
CO3		2		2			
CO4	2	2		3		2	
CO5							

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		2		3	
CO2		2		3	2
CO3			2	1	3
CO4		2		2	3
CO5				3	3

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Entrepreneurship: Definition, Principles of marketing and management. Personality and attitude, Organizational behavior and Leadership. Factors affecting biotech business (finance, infrastructure, equipment, manpower, resources, project location). Marketing research. Industries in Biotechnology.	12	**CO1**
2	Biosafety - General guidelines - Risk assessment studies- Hazardous materials used in Biotechnology – Handling and Disposal – Good manufacturing practices & Good Laboratory practices – Regulation on field experiments and release of GMO's - Labelling of GM foods – Guidelines for rDNA research activity – Containment facilities and Biosafety practices – Guidelines for research in transgenic plants.	12	**CO2**
3	Human Rights: Definition, Classification and Scope of Human Rights. United Nations Commission for Human Rights, National and State Human Rights Commission. Article 21 of Indian Constitution – UDHR. Social issues of Human rights.	12	**CO3**
4	Bioethics-Issues concerning reproduction, Birth, life and Death (Artificial insemination, egg donation, IVF, embryo transplants, Prenatal diagnosis and sex selection & Abortion).	12	**CO4**
5	Intellectual Property Rights: Patents, Trademarks, Copyrights, Trade secrets and Geographical indications. Plant Variety protection. Infringment.	12	**CO5**

TEXT BOOKS:	
1.	Ignacimuthu, S(2009), *Bioethics*, Narosa Publication house.
2.	V. Sree Krishna . V (2007) *Bioethics and Biosafety in Biotechnology*, (1st ed.).New Age International Private Limited

REFERENCE BOOKS:	
1.	Rhona Smith.(2003), *International Human rights*. Blackstone Press
2.	Trayer, P.C, Fredrick.R., and Koch, M.2002. *Biosafety*. Michigan State University

Course Title: Elective Paper 2B: Biofertilizer

Course Code :		**Credits**	**: 05**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Identify the role played by the various soil microbes in enriching soil fertility.
CO2	Understand the process and technology concerned with the mass production of biofertilizers.
CO3	Establish the function of soil bacteria like Azospirillium & Azotobacter as potent nitrogen fertilizers and learn the significance of VA-Mycorrhizal association.
CO4	Predict the role of cyanobacteria as a potent biofertilizer and its application on rice cultivationand crop yield.
CO5	Recycle organic/industrial waste for soil amendment and production of useful compounds like methane gas.

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	2	2			2		
CO2	2	3			2		2
CO3	2	2			3		3
CO4	1	2			2		
CO5	2	2			2	3	2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1			3		
CO2			3	2	
CO3			3	1	
CO4			2	3	1
CO5		1		2	3

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Introduction to Biofertilizers: Definition and types, importance of biofertilizers in agriculture. Characteristics of biofertilizers: Rhizobium, Azotobactor, Azospirillum, Phosphate solubilizing microorganisms, cyanobacteria, Azolla, Mycorrhizae.	12	CO1
2	Production technology: Strain selection, sterilization, growth and fermentation, mass production of various biofertilizers. Application technology: Standards and quality control, application for field and tree crops, nursery plants and seedlings.	12	CO2
3	Azospirillum, isolation and mass multiplication- Career based inoculant, associative effect of different microorganisms. Azotobacter-Classification, characteristics-crop response to azotobacter inoculum, maintenance and mass multiplication. VA-Mycorrhizal association, types of mycorrhizal association, occurrence and distribution-colonization.	12	CO3
4	Cyanobacteria, Azolla and Anabaena association, nitrogen fixation, factors affecting growth, Application of cyanobacteria in rice cultivation. The Use of Cyanobacteria in the Study of the Structure and Function of Photosystem II and The Cytochrome Complex; Photosystem I in Cyanobacteria and its influence on growth and yield of crop plants.	12	CO4
5	Farming: Recycling of biodegradable municipal, agriculture and industrial wastes- Bio compost making methods, types and method of vermicomposting- field application. Renewable bioenergy using microorganisms – Methanogenesis.	12	CO5

TEXT BOOKS:	
1.	Krishnendu Acharya, SurjitSen, ManjulaRai, Biofertilizers and Biopesticides, Techno world, 2019.
2.	SubbaRao, N.S. Soil Microbiology, Oxford & IBH Publishers, New Delhi, 2000.
3.	Dubey R.C., A Text book of Biotechnology S.Chand & Co., New Delhi, 2005.
4.	Kumaresan V., Biotechnology, Saras Publications, New Delhi, 2005.

REFERENCE BOOKS:	
1.	John JothiPrakash, E., Outlines of plant Biotechnology. Embay Publication, New Delhi, 2004.
2.	Kannaiyan S., Biotechnology of Biofertilizers, CHIPS, Texas, 2003.
3.	Mahendra K. Rai, Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York, 2005.

Course Title: Elective Paper 2C: Medical Biotechnology

Course Code :		**Credits**	**: 05**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Discuss the different types of vaccines available in market for treating diseases and the current research processes conducted in vaccine development
CO2	Find various diagnosis techniques used in identifying inborn errors of metabolism
CO3	Describe molecular techniques such as PCR, rDNA technology etc utilized in identifying genetic diseases
CO4	List various types of viral diseases and identify various techniques used in identifying those viral infections and other infectious disease
CO5	Illustrate immuno techniques used for identification of infectious antigens and allergens
CO6	Summarize the production of therapeutic agents such as cytokines and interferon
CO7	Identify the importance of various levels of clinical trials to be performed for successful production of a therapeutic product
CO8	Justify the ethics to be followed in performing clinical trials

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1			2		2		2
CO2			3		2		2
CO3			3		2	2	3
CO4			2		3		2
CO5			3		3		2
CO6			3		2		3
CO7			2		2		2
CO8				3	3		2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	3	3	3	1
CO2	3	2	3	3	1
CO3	3	3	3	3	1
CO4	3	3	3	3	3
CO5	3	3	3	3	1
CO6	3	3	3	3	3
CO7	3	2	3	3	2
CO8	3	3	2	3	3

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Molecular Medicine: Antibodies and vaccines - Therapeutic production of antibodies, antibody mediated drug delivery of vaccines, different kind of vaccines and applications of recombinant vaccines. Diagnosis - Biochemical diagnostics, inborn errors of metabolism, haemoglobinopathies.	12	CO1
2	Molecular Diagnosis - Molecular basis of disease, Recombinant DNA Technology in medicine, gene probes as molecular diagnostic reagents. Polymerase Chain Reaction in clinical diagnostics, DNA sequencing of representative clones to detect mutations.	12	CO2
3	Immunodiagnostics – Diagnosis of infectious diseases, Viral diseases – HIV, influenza; bacterial diseases - enteric diseases, mycobacterium diseases; immunoarrays. FACs immunocytochemical staining, ELISA, FISH techniques.	12	CO3
4	Immunofluorescence technique - Immunoblot analysis of antigens and allergens.Production of therapeutic agents – Productions and application of therapeutic agents, Production of cytokines and interferon.	12	CO4
5	Clinical trial and ethics: Principles of project management in Clinical trials and its application. Principles of research ethics; Ethical issues in clinical trials; Use of humans in Scientific Experiments; Introduction to ethical codes and conduct; Introduction to animal ethics. Animal rights and use of animals in the advancement of medical technology.	12	CO5

TEXT BOOKS:	
1.	Roli, M. (2017). *National Ethical Guidelines for Biomedical and Health Research Involving Human Participants*
2.	Lela, B. and Maribeth, L. F. (2011). *Molecular Diagnostics: Fundamentals, Methods and Clinical Applications*, (1st Edition) . Philadelphia, USA. F A Davis Company.
3.	Bernard, R. G. Terry, L.D. and Cherryl, L.P. (2014). *Medical Biotechnology*, (2nd edition). Washington. DC. ASM Press.

REFERENCE BOOKS:	
1.	Patrick, R.M. Kenneth, S.R. and Michael, A.P. (2016). *Medical Microbiology*, (8th edition). USA. Elsevier Publishers.
2.	Pamela, G. Michelle, M, (2009). *Molecular Therapeutics: 21st century medicine*, (1st Edition). Hoboken, New Jersey. Wiley Publishers.

Course Title: Open Elective 3: Public Health and Hygiene

Course Code :		**Credits**	**: 05**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Describe the scope and importance of public health and hygiene; also the various factors influence the healthy condition among the community
CO2	Distinguish the between the various types of causes and effects of environmental pollution
CO3	Depict the various types of hygiene measures to be followed and links between healthful housing and healthy living.
CO4	Gain knowledge on the causes and preventive measures of various non-communicable diseases.
CO5	Illustrate the significance and development of various organizations related with public health.
CO6	Gain knowledge on the various legal act pertaining to public health and hygiene

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	1	1		1		2	3
CO2		2		2	2		2
CO3	2	2			2	3	2
CO4		2					3
CO5	2	2				3	3
CO6		2				3	2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	2	2	1	3
CO2	1	2	2	1	3
CO3	1	2	2		3
CO4	1	2	2		3
CO5	1	2	1	1	3
CO6	1	2	1	1	3

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	Definition and scope of Public health and Hygiene – basic aspects of personal hygiene – Health and Nutrition- definition, components, principles of health education; factors that influence health; Nutritional needs of body, role of nutrients, foods classification, food groups.	12	CO1
2	Environment and Health - Types of Environmental Pollution - causes and effects of Air Pollution, Water Pollution, Soil Pollution, Noise Pollution; Solid waste and excreta disposal management	12	CO2
3	Hygiene: Definition – personal hygiene, oral hygiene, feminine hygiene, sleep hygiene, Social hygiene, occupational hygiene, medical hygiene; Standards of Housing, Maintenance of Houses for Healthy Living, Ventilation for Houses.	12	CO3
4	Non-Communicable diseases – Causes, symptoms, diagnosis, treatment and preventive measures - Hypertension, Coronary Heart diseases, Stroke, Diabetes, Obesity and Mental ill-health.	12	CO4
5	First Aid and Health awareness - Health organizations - Malaria and AIDs Control- NHP, WHO, UNICEF; Health Education in India – Health care legislation in India – Termination of pregnancy act, Maternity benefit act, Biomedical waste act, ESI act.	12	CO5 CO6

REFERENCE BOOKS:	
1.	S. Lal, Vikas.Public Health Management Principles And Practice, 2nd Edition, CBS Publishers and Distributors Pvt Ltd, 2018
2.	Mary-Jane Schneider. Introduction to Public Health, 5th Edition. Jones & Bartlett Learning, 2016.

TEXT BOOKS:	
1.	Carolyn D. Berdanier, Johanna T. Dwyer, David Heber. Handbook of Nutrition and Food, 3rd Edition, CRC Press, 2013
2.	Sue Reed, Dino Pisaniello, GezaBenke, Kerrie Burton. Principles of Occupational Health and Hygiene: An Introduction, 2nd Revised ed. Edition, Allen &Unwin, 2013
3.	V. Kumaresan, R. Sorna Raj, Public Health and Hygiene, 1st Edition, Saras Publication, 2012

Course Title: Core Practical VI: Animal Biotechnology, Plant Biotechnology & Environmental Biotechnology

Course Code	**: 1912632**	**Credits**	**: 04**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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

CO1	Make use of the techniques used in preparing tissue culture medium and membrane filtration in culturing animal cells and prepare single cell suspension from spleen
CO2	Evaluate cell viability and cell count
CO3	Experiment with cryopreservation
CO4	Examine the importance of trypsinization in monolayer and subculture
CO5	Explain and infer the role of serum in cell culture
CO6	Evaluate the principles and application of plant biotechnology such as cell and tissue culture
CO7	Explain Invitro germination of plants and Organogenesis of plant tissue
CO8	Illustrate Callus Development and Micropropagation of plants
CO9	Develop technical skills in Protoplast isolation and Isolation of genomic DNA from plant samples
CO10	Demonstrate of soli microorganisms mediated gene transfer.
CO11	To identify the coliform bacteria using MPN technique.
CO12	To Analyze the dissolved oxygen concentration of water sample.
CO13	To estimate the chemical oxygen demand

Mapping of Course Outcomes to Program Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1				2	3	2	2
CO2		2	3				
CO3				3			2
CO4				3	2		3
CO5				2		2	3
CO6		2		3		2	3
CO7				2			3
CO8			2	3			2
CO9			2	3			3
CO10				2	2	3	
CO11	3	2		2			2
CO12	2	2		3		1	
CO13		1			2		

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	2	1	3
CO2	1	2	2	1	3
CO3	1	2	2		2
CO4	1	2	2		3
CO5	1	2	1	1	
CO6	1	2	1	1	2
CO7		3			
CO8					3
CO9		2	2	2	
CO10			2	2	2
CO11			1	2	
CO12		1		2	2
CO13		2	2	2	

Sl NO	CONTENTS OF MODULE	Hrs	Cos
1	**Animal Biotechnology** 1. Preparation of Tissue culture medium and membrane filtration. 2. Preparation of single cell suspension from Spleen. 3. Cell counting by Hemocytometer	10	CO1 CO2
2	4. Cell Viability by Tryphan Blue Method. 5. Trypsinization of Monolayer and Subculturing. 6. Cryopreservation and Thawing. 7. Role of Serum in Cell culture	15	CO3 CO4 CO5
3	**Plant Biotechnology** 1. Hands on training in cell and tissue culture and maintenance of culture lines 2. Invitro germination of plants 3. Callus Development	15	CO6 CO7 CO8
4	4. Micropropagation of plants 5. Organogenesis of plant tissue	10	CO9

	6. Protoplast isolation and fusion 7. Cell suspension culture		
5	8. Isolation of genomic DNA from plant samples 9. Agrobacterium mediated gene transfer (Demo) Southern blotting (Demo)	5	CO10
6.	**Environmental Biotechnology** 1. Water analysis by MPN technique – presumptive coliform test – confirmed coliform test and completed coliform test 2. Determination of biological oxygen demand 3. Determination of chemical oxygen demand 4. Microbial degradation of cellulose	20	CO11 CO12 CO13

REFERENCE BOOKS:	
1	S. Lal, Vikas. (2018) Public Health Management Principles And Practice, 2nd Edition, CBS Publishers and Distributors Pvt Ltd.
2	S. Harisha. (2012) Biotechnology procedures and experiments handbook
3	Debajit Borah(2018). Environmental Biotechnology Theory and Lab Practices Hardcover – Global Vision Publishing House; 2nd edition.

Department of Biotechnology

ACADEMIC YEAR 2020–2021

I–IV Semesters
SCHEME AND SYLLABUS

Based on
OUTCOME BASED EDUCTION (OBE) SYSTEM

S.NO	CONTENTS	PAGE NO.
1	College Vision, Mission; Department Vision, Mission and Program Educational Objectives (PEO)	iv & v
2	Program Outcomes (PO) with Graduate Attributes	vi
3	Mapping of POs with PEOs	vi
	SCHEME	
4	Scheme of First Semester	ix
5	Scheme of Second Semester	x
6	Scheme of Third Semester	xi
7	Scheme of Fourth Semester	xii
	SYLLABUS	
10	**Syllabus of First Semester:**	
	CorePaper1: Biochemistry	2
	Core Paper 2: Molecular Cell Biology	4
	Core paper 3: Microbiology	6
	Core Paper – 4: Immunology & Immunotechnology	8
	ElectivePaper – 1A*: Molecular Genetics	**10**
	ElectivePaper – 1B*: Ecology, Evolution and Behavior	**12**
	Elective Paper – 1C*: Developmental Biology	**14**
	Core Practical – I Biochemistry and Molecular Cell Biology	**16 – 18**
	Core Practical – II Microbiology, Immunology & Immunotechnology	**19 – 21**
11	**Syllabus of Second Semester:**	
	Core Paper – 5:Animal Biotechnology	**23**
	Core Paper –6: Plant Biotechnology	**25**
	Core Paper –7: Environmental Biotechnology	**27**
	Extra Disciplinary – 1: Pharmaceutical Biotechnology	**29**
	Elective Paper – 2A*: Forensic Science	**31**
	Elective Paper – 2B*: Marine Biotechnology	**33**
	Elective Paper – 2C*: DNA Bar Coding Technology	**35**

	Elective Paper – 3A*: Animal and Plant Physiology	**37**
	Elective Paper – 3B*: Clinical Trials	**39**
	Elective Paper – 3C*: Stem cell Biology	**41**
	Core Practical – III Animal Biotechnology, Plant Biotechnology and Environmental Biotechnology	**43 – 46**
	Mini project/Internship	
12	**Syllabus of Third Semester:**	
	Core Paper- 8: Genetic Engineering	**48**
	Core Paper – 9: Bioprocess Technology	**50**
	Core Paper – 10: Bioinformatics	**52**
	Core Paper – 11: Enzymes & enzyme Technology	**54**
	Elective Paper – 4A*: Advanced Molecular techniques	**56**
	Elective Paper – 4B*: Nano Biotechnology	**58**
	Elective Paper – 4C*: Tissue Engineering	**60**
	Core Practical-IV: Genetic engineering and Bioprocess Technology	**62 – 64**
	Core Practical-III: Bioinformatics, Enzymes & enzyme Technology	**65 – 68**
13	**Syllabus of Fourth Semester:**	
	Extra Disciplinary – 2: Research Methodology, Bioethics & Biostatistics	**70**
	Open elective 1 – Herbal technology	**72**
	Project dissertation & Viva voce	**74**

Appendix A Outcome Based Education

Appendix B Graduate Attributes

Appendix C Bloom's Taxonomy

DWARAKA DOSS GOVERDHAN DOSS VAISHNAV COLLEGE

(Autonomous)
"College with Potential for Excellence"
(Linguistic Minority Institution),
"Gokulbagh" 833, Periyar E.V.R. Salai,
Arumbakkam, Chennai – 10611

VISION

- Ignites Wisdom
- Challenges Status Quo
- Strengthens Social Equality
- Elevates Human Values and Universal Oneness
- Recognises Indian Tradition and Culture

MISSION

- Curriculum that makes student competent to contribute economically and intellectually.
- Offer an environment of learning that encourages innovation and excellence.
- Promote research and development
- Best of facilities with the Best of technology
- Provide an environment for all round growth of the student
- Quality in every activity undertaken by the student and the faculty
- Instilling pride in serving the society and in being the citizen of this country.

DEPARTMENT OF BIOTECHNOLOGY

VISION

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

MISSION

M1	To inculcate original and novel advanced methodologies in the field of biotechnology
M2	To generate opportunities for innovations in the field of biological research.
M3	To expand the scope of Industry -Academia interaction towards commercialization of bioproducts.

PROGRAM OUTCOMES (PO) IN RELATION TO GRADUATE ATTRIBUTES

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

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 conditions

- 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

- 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).

Course 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, 60 for external evaluation and 40 marks for the continuous assessment.

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, 60 marks (ESE) for final examination and 50 marks as continuous internal assessment (CIA). Similarly, for practical examinations, each course carries 100 marks, 60 for external evaluation and 40 marks for the continuous assessment. And the soft skill examination carries 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 therefor.

DEPARTMENT OF BIOTECHNOLOGY

SCHEME OF FIRST SEMESTER M.SC., PROGRAM

Sl. NO	Course Code	Course	BOS	Hour Distribution				Over all Credits	Marks		
				L	P	T	S		CIE	SEE	Total
1.		Core Paper-1 Biochemistry	BT	4	0	0	0	4	40	60	100
2.		Core Paper-2 Molecular Cell Biology	BT	4	0	0	0	4	40	60	100
3.		Core Paper-3 Microbiology	BT	4	0	0	0	4	40	60	100
4.		Core Paper-4 Immunology	BT	4	0	0	0	4	40	60	100
5.		Elective Paper – 1A* Molecular Genetics	BT	4	0	0	0	3	40	60	100
		Elective Paper – 1B* Ecology, Evolution and Behavior	BT	4	0	0	0	3	40	60	100
		Elective Paper – 1C* Developmental Biology	BT	4	0	0	0	3	40	60	100
6.		Core Practical - I Biochemistry and Molecular Cell Biology	BT	0	5	0	0	2	40	60	100
7.		Core Practical - II* Microbiology, Immunology and Immunotechnology	BT	0	5	0	0	2	40	60	100
8.		Soft Skill – I						2	50	50	100
	Total							25	330	470	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		CIE	ESE	Total
1.		Core Paper-5 Animal Biotechnology	BT	4	0	0	0	4	40	60	100
2.		Core Paper-6 Plant Biotechnology	BT	4	0	0	0	4	40	60	100
3.		Core Paper-7 Environmental Biotechnology	BT	4	0	1	0	4	40	60	100
4.		Extra Disciplinary – 1 Pharmaceutical Biotechnology	BT	3	0	1	0	3	40	60	100
		Elective Paper – 2A* Forensic Science	BT	3	0	1	0	3	40	60	100
		Elective Paper – 2B* Marine Biotechnology	BT	3	0	1	0	3	40	60	100
		Elective Paper – 2C* DNA Bar Coding Technology	BT	3	0	1	0	3	40	60	100
5.		Elective Paper – 3A* Animal and Plant Physiology	BT	3	0	1	0	3	40	60	100
		Elective Paper – 3B* Clinical Trials	BT	3	0	1	0	3	40	60	100
		Elective Paper – 3C* Stem cell Biology	BT	3	0	1	0	3	40	60	100
6.		Core Practical - III Animal Biotechnology, Plant Biotechnology and Environmental Biotechnology	BT	0	6	0	0	2	40	60	100
7.		Soft Skill – II						2	50	50	100
8.		Mini project/Internship*	BT					2			
9.	**Total**							27	330	470	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		CIE	SEE	Total
1.		Core Paper-8 Genetic Engineering	BT	4	0	0	0	4	40	60	100
2.		Core Paper-9 Bioprocess Technology	BT	4	0	0	0	4	40	60	100
3.		Core Paper-10 Bioinformatics	BT	4	0	0	0	4	40	60	100
4.		Core Paper-11 Enzymes & enzyme Technology	BT	4	0	0	0	4	40	60	100
5.		Elective Paper – 4A* Advanced Molecular techniques	BT	4	0	0	0	3	40	60	100
		Elective Paper – 4B* Nano Biotechnology	BT	4	0	0	0	3	40	60	100
		Elective Paper – 4C* Tissue Engineering	BT	4	0	0	0	3	40	60	100
6.		Core Practical - IV Genetic Engineering and Bioprocess Technology	BT	0	5	0	0	2	40	60	100
7.		Core Practical - V Bioinformatics and Enzymes & enzyme Technology	BT	0	5	0	0	2	40	60	100
8.		Soft Skill – I						2	50	50	100
	Total							25	330	470	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		CIE	SEE	Total
1.		Extra Disciplinary – 2 Research Methodology, Bioethics & Biostatistics	BT	5	0	0	0	3	40	60	100
2.		Open Elective – 1 Herbal Technology	BT	5	0	0	0	3	40	60	100
3.		Project dissertation & Viva voce	BT	0	15	0	0	6	40	60	100
4.		Soft Skill – IV						2	50	50	100
	Total							14	170	230	400

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 (100 marks)

Part – A	Answer any 10 out 12 (10 x 2= 20 marks)
Part – B	Answer any 5 out of 7 (5 x 7 = 35 marks)
Part – C	Answer any 3 out of 5 (3 x 15 = 45 marks)

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	40	60
2.	Core Paper – 2	Molecular Cell Biology	I	4	4	3	40	60
3.	Core Paper – 3	Microbiology	I	4	4	3	40	60
4.	Core Paper – 4	Immunology & Immunotechnology	I	4	4	3	40	60
5.	Elective Paper – 1A*	Molecular Genetics	I	4	3	3	40	60
	Elective Paper –1B*	Ecology, Evolution and Behavior	I	4	3	3	40	60
	Elective Paper – 1C*	Developmental Biology	I	4	3	3	40	60
6.	Core Practical – I	Biochemistry and Molecular Cell Biology	I	5	2	6	40	60
7.	Core Practical – II	Microbiology, Immunology and Immunotechnology	I	5	2	6	40	60
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	40	60
2.	Core Paper – 6	Plant Biotechnology	II	4	4	3	40	60
3.	Core Paper – 7	Environmental Biotechnology	II	4	4	3	40	60
4.	Extra Disciplinary – 1	Pharmaceutical Biotechnology	II	4	3	3	40	60
5.	Elective Paper – 2A*	Forensic Science	II	4	3	3	40	60
	Elective Paper – 2B*	Marine Biotechnology	II	4	3	3	40	60
	Elective Paper – 2C*	DNA Bar Coding Technology	II	4	3	3	40	60
6.	Elective Paper – 3A*	Animal and Plant Physiology	II	4	3	3	40	60
	Elective Paper – 3B*	Clinical Trials	II	4	3	3	40	60
	Elective Paper – 3C*	Basics in stem cell Biology	II	4	3	3	40	60
7.	Core Practical – III	Animal Biotechnology, Plant Biotechnology and Environmental biotechnology	II	6	2	6	40	60
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	40	60
2.	Core Paper – 9	Bioprocess Technology	III	4	4	3	40	60
3.	Core Paper – 10	Bioinformatics	III	4	4	3	40	60
4.	Core Paper – 11	Enzymes & enzyme Technology	III	4	4	3	40	60
5.	Elective Paper – 4A*	Advanced Molecular techniques	III	4	3	3	40	60
	Elective Paper – 4B*	Nano Biotechnology	III	4	3	3	40	60
	Elective Paper – 4C*	Tissue Engineering	III	4	3	3	40	60
6.	Core Practical – IV	Genetic Engineering and Bioprocess Technology	III	5	2	6	40	60
7.	Core Practical – V	Bioinformatics and Enzymes & enzyme Technology	III	5	2	6	40	60
		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	40	60
2.	Open Elective – 1	Herbal Technology	IV	5	3	3	40	60
3.	Core Paper	Project dissertation & Viva voce	IV	15	6		40	60
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**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			**3**	**2**		**2**
CO2			**3**	**2**		**2**
CO3			**3**	**2**		**2**
CO4			**3**	**2**		**2**
CO5			**3**	**2**		**2**

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**3**	**2**	**3**	**1**	**2**
CO2	**2**	**2**	**3**		**1**
CO3	**2**	**2**	**3**	**2**	
CO4	**2**	**2**	**3**		**2**
CO5	**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.). New York, W. H. Freeman publishers
2.	Satyanarayana .U, Chakrapani.U,(2019). Essentials Of Biochemistry (3rd ed.). Books & Allied Pvt Ltd
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

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

Course Title: Molecular Cell Biology- Core Paper: 2

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**		**1**			
CO2	**2**		**1**			
CO3	**2**		**1**			
CO4	**2**		**2**	**2**		
CO5	**2**		**2**	**3**		

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		**2**		**3**	**3**
CO2		**2**	**3**	**2**	
CO3		**3**	**2**		**2**
CO4		**2**	**2**	**2**	**2**
CO5		**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, Cell interaction: A practical approach, 2nd Edition, 2002.
2.	Karp, Gerald. Cell and molecular biology: concepts and experiments. 7th edition, John Wiley & Sons, 2013.
3.	Lodish, H., Berk, S., Zipursky, S.L., Matsudaria, P., Baltimore, D. and Darwell, J., Molecular cell biology, W.H.Freeman and company, 8th edition, 2016.

Reference Books:	
1.	Bruce Alberts, Alexander Johnson Julian Lewsis, Martin Raff , Keith Roberts, Molecular Biology of The Cell, 6th Edition, United kingdom, Garland Science, 2014.
2.	Geoffrey. M. Cooper, Robert, E. Hausman. The cell –A molecular approach, 4th Edition, United States, Sinaver associates, 2007.

Course Title: Microbiology- Core Paper: 3

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**					
CO2			**2**	**3**		
CO3	**3**		**2**		**2**	
CO4	**2**	**1**		**3**		
CO5	**1**	**1**		**3**	**2**	**1**
CO6	**1**	**1**		**3**	**2**	**1**

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	**2**	**2**	**2**	**3**	**2**
CO2	**2**	**2**	**3**	**3**	
CO3	**2**	**2**	**3**	**3**	
CO4	**2**	**2**	**2**	**3**	**1**
CO5	**2**	**2**	**2**	**3**	**1**
CO6	**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, Textbook of Microbiology, 10th edition, The Orient Blackswan, 2017
2.	Gary W. Procop, Elmer W. Koneman, Color Atlas and Textbook of Diagnostic Microbiology, 7th eidtion, Lippincott Williams and Wilkins, 2016
3.	D K Maheshwari , R C Dubey, A Textbook of Microbiology, 4th edition, S Chand Publishing, 2013

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

Course Title: Immunology & Immunotechnology- Core Paper: 4

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2		1	2		1
CO2	1		2		2	
CO3	2		1			
CO4	2		1	2		
CO5	1		2	2	1	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**2**	**2**	**3**	**2**	**1**
CO2	**2**	**2**	**3**	**2**	
CO3	**2**	**2**	**3**	**2**	
CO4	**2**	**2**	**3**	**2**	**1**
CO5	**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, BlackwellC (1989) Handbook ofExperimental Immunology. Black well Scientific Publication, oxford.
2.	Abdul K,Abbas,Andrew HH,lichtman,Shiv Pillai,(2014), *Cellular and Molecular Immunology,* (8th edition)
3.	Janeway travers,(2009) *Immunobiology,* IUBM Inc. *(7 th edition)*

Reference Books:	
1.	Jenni Punit, Sharon Stranford, PatriciaJones, Judith A Owen (2018) *Kuby Immunology* (8 th edition)
2.	David Male, Jonathan Brostoff,david roth ,IvanRoitt , (2006)*Immunology(7 th)*. Black well Scientific Publications

Course Title: Molecular Genetics Elective Paper: 1A

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**		**1**			
CO2	**2**					
CO3			**1**	**3**		**2**
CO4	**3**			**2**		
CO5	**2**			**1**		**1**

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**3**				
CO2	**3**			**1**	
CO3	**3**		**2**		**1**
CO4	**3**		**2**		
CO5	**3**		**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, igenetics-A molecular approach, 3rd edition, Pearson education, 2010.
2.	Garden, Simmons and Snustad, Principles of Genetics, 8th edition, John Wiley & Sons, 2005.

Reference Books:	
1.	Benjamin A.Pierce Freeman, Genetics- A conceptual approach, 2nd edition, W.H. Freeman, 2005.
2.	Robert J.Brooker, Genetics –Analysis and Principles, 6 edition, McGraw-Hill Education, 2017.
3.	Anthony J.F. Griffiths, William M. Gilbart, Jeffery H. Miller and Richard C. Lewontin, Modern genetic analysis, W.H. Freeman and company, 2008.

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

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3			2
CO2	2		3			2
CO3	2		3			
CO4	3		3			
CO5	2		3			2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3		2	3	3
CO2	3			3	3
CO3	3			3	3
CO4	3			3	3
CO5	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, ninth edition, Pearson publications.
2.	Charles J Krebs (2007) Ecology, Sixth edition, Pearson publications.
3.	Kanwaljit kaur (2013) Text book of behavioural science, First edition, Lotus publishers.

Reference Books:	
1.	Eugene Odum & Garry W Barret (2004) Fundamentals of Ecology, 5th edition, Brooks publisher.
2.	Brian K hall & Benedict Hallgrimsson (2013) Strickberger's Evolution, fifth edition, Jones and Bartlett learning.

Course Title: Developmental Biology -Core Elective: 1C

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**			**2**		
CO2	**2**		**2**			
CO3	**2**			**2**		
CO4	**3**					
CO5	**2**					

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	**2**	**2**	**2**	**3**	**2**
CO2	**2**	**2**		**3**	
CO3		**3**	**3**	**3**	**2**
CO4	**2**		**2**	**2**	
CO5	**2**	**2**	**2**	**3**	
CO6	**2**	**2**	**2**	**3**	

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.	Developmental Biology: ScottF.Gilbert. (2006) Sinauer Associates
2.	Essential Developmental Biology:Jonathan Slack (2001),Blackwell
3.	Developmental zoology: Arumugam N, (2013) Saras publications

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

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**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**			**2**		**2**
CO2	**3**			**2**		**2**
CO3	**3**			**2**		**2**
CO4	**3**			**2**		**2**
CO5	**3**			**2**		**2**
CO6	**3**			**2**		
CO7	**3**			**3**		
CO8	**2**			**3**		
CO9	**2**			**2**		
CO10	**3**			**3**		

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2		3	
CO2	3	2		3	
CO3	3	2		3	
CO4	3	2		3	
CO5	3	2		3	
CO6		2		3	
CO7		2	3	2	
CO8		3	2		
CO9		2	2	2	
CO10		3	3	2	

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; Preparation of 2. 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
2.	Vasudevan D.M., Das S.K.(2013). Practical Textbook of Biochemistry for Medical Students,(2nd ed.). Jaypee Brothers Medical Publishers
3.	K.V. Chaitanya, Cell and molecular biology: Lab manual, PHI publishers, 2013.

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

Course Code	**:**	**Credits**	**: 02**
L:T:P:S	**:0:0:3:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 IG G 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:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**1**	**2**	**1**		**1**
CO2	**2**		**2**	**1**		
CO3	**2**		**2**	**1**		**2**
CO4	**2**		**2**			
CO5	**2**		**2**	**1**		**1**
CO6	**2**	**1**	**2**			**2**
CO7			**2**		**2**	**2**
CO8			**3**	**2**	**2**	**2**
CO9	**2**		**2**		**3**	**3**
CO10	**2**		**2**		**3**	**3**

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		3	2	3	
CO2		3	2	3	
CO3		3	2	3	
CO4		3	2	3	
CO5		3	2	3	
CO6		3	2	3	
CO7		3	2	3	
CO8		3	2	3	
CO9		3	2	3	
CO10		3	2	3	

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 plantsurface. 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, Microbiology: A Laboratory Manual, Pearson Benjamin Cummings, 10th edition, 2013
2.	Shukla Das and Rumpa Saha, Microbiology Practical Manual, 1st Edition, CBS Publishers and Distributors, 2019
3.	Rabindra Narain,(2012),*Practical Immunology*,Dom & Wisdom publications.
4.	Franck C.Hay,Olwyn MR,Westwood(2010),*Practical Immunology*,Wiley- Blackwell publications.
5.	James P, Gosling(2010).*Immunoassays:A Practical Approach*.Oxford University press, USA.

Second Semester

Course Title: Animal Biotechnology - Core Paper - 5

Course Code :	**Credits : 04**
L:T:P:S : 4:0:0:0	**CIA Marks : 40**
Exam Hours : 03	**ESE Marks : 60**

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:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		2	2		
CO2			2	3		1
CO3	1			3		
CO4			3			
CO5				3	2	1

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2			
CO2		3			
CO3	2	3			
CO4	2	3			
CO5		2	3		

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. Culture of Animal Cells- A Manual of Basic Techniques, 5th edition John Wiley & Sons (Asia) Pvt. Ltd, 2006.
2.	Ramadoss . P and Meerarani S; Textbook of Animal Biotechnology , 2nd edition, Madras Veterinary College, Chennai, 2002.
3.	N. Arumugam, L. M. Narayanan et al., Molecular Biology and Genetic Engineering, Saras Publications, 2014.

Reference Books:	
1.	Nigel Jenkins -Animal Cell Biotechnology –methods and protocols, Humana Press, 1999
2.	A. Phular, Genetic Engineering of Animals- VCH publishers, Weinheim, FRG, 1996

Course Title: Plant Biotechnology - Core Paper: 6

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**					
CO2	**3**		**1**	**2**		
CO3	**2**					
CO4	**2**			**2**	**2**	
CO5	**2**		**2**	**2**	**1**	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**2**	**2**	**2**	**3**	**2**
CO2	**2**	**2**	**3**		
CO3	**1**	**2**			
CO4	**2**		**2**	**3**	**1**
CO5	**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.	Text book of Biotechnology, H.K. Dass. 2005, Second Edition, Wiley Dreamtech, India (P) Ltd.
2.	Inducible gene expression in plants. Reynolds, P.H.S. 1999. CABI publishing, U
3.	Recombinant DNA and Biotechnology: A guide for teachers H.Kreuzer & A.Massey. 2001. Second Edition. ASM press, Washington.

Reference Books:	
1.	Biotechnology Trevan. 2001., Tata McGraw Hill.
2.	Applied Biotechnology & Plant GeneticsM.Sudhir. 2000.. Dominant publishers & Distributors.

Course Title: Environmental Biotechnology -Core Paper: 7

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	3	2	1	3
CO2	3	2	3	3	2	3
CO3	3	3	2	2	3	2
CO4	3	3	2	3	2	3
CO5	3	3	2	3	3	2
CO6	3	1	2	2	2	3

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	1	1	3	3
CO2	3	1	2	3	3
CO3	3	3	3	3	3
CO4	3	1	3	3	1
CO5	3	3	3	3	3
CO6	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.	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, Third edition. Cambridge Low price edition. Cambridge University press.
2.	Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. (2001) Environmental Encyclopedia, Jaico Publ. House, Mumbai
3.	Sohal, H.S. and Srivastava, A.K. (1994) Environmental and biotechnology, First edition. Ashish Publishing House, New Delhi.

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

Course Title: Pharmaceutical Biotechnology - Extra Disciplinary: 1

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**			**2**		**2**
CO2			**3**	**3**		
CO3	**1**		**2**	**2**	**2**	**2**
CO4			**2**	**3**		
CO5			**2**	**3**		
CO6			**2**	**3**	**2**	**2**

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		**2**	**3**	**2**	**2**
CO2		**2**	**3**	**2**	**1**
CO3		**2**	**2**	**2**	
CO4		**3**	**2**	**3**	**2**
CO5		**2**	**2**	**2**	
CO6		**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**.**
2.	Oliver Kayser (Editor), Heribert Warzecha (Editor) (2012). *Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications*, (2nd Edition). Germany: Wiley VCH.
3.	John F. Corpenter and Mark C. Manning (editor), (2012). *Rational Design of stable formulation Theory and Practice*. Plenum, US. (1st edition) US: Springer Science.

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

Course Title: Forensic Science - Elective Paper: 2A

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**			**3**		**1**
CO2	**3**					**2**
CO3	**2**	**1**	**2**	**2**		
CO4	**1**				**2**	**1**
CO5	**2**					

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	3	3	3	1
CO2	3	2	3	3	2
CO3	3	3	3	2	1
CO4	3	3	2	3	3
CO5	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). New Delhi, Select Publishers.
2.	Barbara H. Stuart, (2013). *Forensic Analytical Techniques (Analytical Techniques in the Sciences (AnTs*) (1st edition). UK, Wiley.
3.	C. Champod, C. Lennard, C. Margot, P. and Stoilovic, (2015). M. *Fingerprints and other Ridge Skin Impressions* (7th edition). Boca Raton, CRC Press.

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

Course Title: Marine Biotechnology - Elective Paper: 2B

Course Code	**: 1925213**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**				**3**	
CO2	**1**			**1**	**3**	
CO3	**2**			**1**		
CO4	**2**		**1**	**3**		
CO5	**2**		**2**		**2**	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**3**	**1**			**2**
CO2		**3**	**1**		**2**
CO3			**1**	**2**	**3**
CO4		**2**	**3**		
CO5		**2**			**3**

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, polysaccharaides. 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.	Olguni, E.J. *et al.*, Environmental Biotechnology and cleaner Bioprocess, 2000
2.	William, Introduction to Marine pollution control. John Wiley, 1996.
3.	Rheinhemer, G., Aquatic Microbiology, Johnwiley& Sons, pp. 235, 1980.

Reference Books:	
1.	Ford, T.E., Aquatic microbiology -An ecological approach., Blackwell scientific publications, London, 1993
2.	Bruce, E.Rittmann and Perry L. McCarthy., Environmental Biotechnology, Principles and applications. McGraw Hill.

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

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3		2
CO2	3		3	3		
CO3	3		3	2		
CO4	3		3	3		2
CO5	3	3	2	3	3	2
CO6	3	3	2	2	3	3

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	2	3	3	
CO3	3	3	3	3	
CO4	3	3	3	3	
CO5	3	3	3	3	
CO6	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.
2.	Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., & Donoghue, M. J. (2002). Plant systematics. Sunderland, Massachusetts, USA: Sinauer.
3.	Moritz, C., & Cicero, C. (2004). DNA barcoding: promise and pitfalls. PLoS biology, 2(10), e354.

Reference Books:	
1.	Wheeler, Q.D. (2008). The New Taxonomy. CRC Press.
1.	John Kres.,W .and David L. Erickson “DNA Barcodes: Methods and Protocols”. Humana Press, 2012.

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

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 harmones 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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**					**2**
CO2	**3**		**2**			**2**
CO3	**3**		**2**			**2**
CO4	**2**		**2**			**2**
CO5	**2**		**3**			**2**

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3			3	2
CO2	3				
CO3	3			3	
CO4	3				
CO5	3			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*(8th edition),Jaypee brothers, India
2.	Indu Khurana and Arushi khurana (2018) *Concise textbook of human physiology* (3rd edition),Elsevier India.
3.	Jain VK,(2017) *Fundamentals of plant physiology* (19 th edition), Chand S pubishers, India

Reference Books:	
1.	Gerard J.Tortora, Bryan Derrickson (2014) ,*Principles and anatomy of* physiology(14th edition) ,Wiley &sons,Inc, United states of America.
2.	Lincoln Taiz ,Eduardo Zeiger ,Ian Max Møller, Angus Murphy ,(2018) *Fundamentals of Plant Physiology* ,Sinauer Associates Inc

Course Title: Clinical Trials; Elective Paper: 3B

Course Code	**: 1925427**	**Credits**	**: 03**
L:T:P:S	**: 5:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**					
CO2			**2**	**3**		
CO3		**1**				
CO4	**2**		**1**	**3**		
CO5	**2**	**1**				

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1		2	2	3	3
CO2		2	2	2	2
CO3		3	3	2	2
CO4		2	2	3	2
CO5		2	2	2	

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.
2	ICRIER Health Policy Initiative. (2018). Challenges and Prospects for Clinical Trials in India: A Regulatory Perspective. Academic Foundation

REFERENCES BOOKS:

1	Ali S. Faqi. (2013). *A Comprehensive Guide to Toxicology in Preclinical Drug Development.* (1st Ed.) MA, USA: Academic Press
2	Benjamin Blass. (2015). *Basic Principles of Drug Discovery and Development.* (1st Ed.) USA:Acadeic Press.
3	Michael J. McGraw. (2015). *Principles of Good Clinical Practice,* (1st Ed.) UK: Pharmaceutical Press

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

Course Code :	**Credits : 04**
L:T:P:S : 6:0:0:0	**CIA Marks : 40**
Exam Hours : 03	**ESE Marks : 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2					
CO2	3		2	2		2
CO3			3	2	3	2
CO4			3	2		2
CO5	2		3	2		3

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**3**	**1**	**3**	**2**	**2**
CO2	**3**	**3**	**3**	**2**	**2**
CO3	**3**		**3**	**2**	**3**
CO4	**3**	**2**	**3**	**2**	
CO5	**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, Exvivo expansion used for stem cell characterization. Invitro functional assays- CAFC(Cobblestone area forming cell) and CFC(colony forming cell), 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.
2.	Indumathi Somasundaram, Dhanasekaran Marrappagounder,Pankaj kaigade (2019),*Stem cell Biology*, Evincepub Publishing , ISBN-10: 9389774357
3.	Kursad Turksen(2014) *A dult and Embryonic Stem Cells -Stem Cell Biology and Regenerative Medicin(2nd edition)* ,Humana press

Reference Books:	
1.	Ann A Kiessling, Human Embryonic Stem Cells: An introduction to the Science and therapeutic potential, Jones and Bartett, 2003. A.D.Ho.,R.Hoffiman, Stem Cell Transplantation Biologyprocess Therapy, Willy-VCH,2006.
2.	A.D.Ho.,R.Hoffiman, Stem Cell Transplantation Biologyprocess Therapy, Willy-VCH,2006.

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**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1			3		
CO2	2			3		1
CO3	2			2		1
CO4	2			2		1
CO5	2			2		
CO6	2			3		
CO7	2		1	3	2	
CO8	2			3	2	
CO9	3			2		
CO10	2			3		1
CO11	3		3	3	2	3
CO12	3		3	2	3	3
CO13	3		3	3	3	3
CO14	3			2		3

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3		2	
CO2		3		2	
CO3		3		2	
CO4		3			
CO5	1	3			1
CO6	2	3		2	
CO7		3		2	
CO8		3		2	
CO9		3			
CO10	1	3			1
CO11	3	3	3	3	3
CO12	3	2	3	3	3
CO13	3	3	3	3	3
CO14	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.
2.	R. S. Chawla, Plant Biotechnology: Laboratory Manual For Plant Biotechnology, Oxford and IBH Publishing, 2004.
3.	S.S. Purohit, A Laboratory Manual Of Plant Biotechnology, second edition, Agrobios Publications, 2004
4.	Frederick W Pontinus (1990) Water Quality and Treatment. American water works Association, MC Graw Hill Inc.
5.	Environmental Microbiology, S.K.Agarwal (2009), APH Publishing corporation, New Delhi

Third Semester

Course Title: Genetic Engineering - Core Paper: 8

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**					**1**
CO2	**2**			**1**		
CO3	**1**			**1**		
CO4	**1**			**3**	**1**	
CO5	**1**					**1**
CO6	**3**		**3**			

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**3**	**1**	**3**	**3**	
CO2	**3**	**1**	**3**	**3**	
CO3	**3**	**1**	**3**	**3**	
CO4	**3**	**2**	**3**	**3**	
CO5	**3**	**1**	**3**	**3**	**3**
CO6	**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, polynucleotidekinase, 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, Gene Cloning and DNA Analysis: An Introduction, 7th edition, Wiley-Blackwell, 2016.
2.	Sandhya Mitra, Genetic Engineering, 2nd edition, McGraw Hill Education, 2017
3.	R C Dubey. Advanced Biotechnology, 1st Edition, S. Chand Publishing, 2014

Reference Books:	
1.	Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Lewin's GENES XII, 12th Revised edition, Jones and Bartlett Publishers, 2017
2.	Primrose S.B, Principles Of Gene Manipulation And Genomics, 7th edition, John Wiley Blackwell, 2014.

Course Title: Bioprocess Technology -Core Paper: 9

Course Code	**: 1925316**	**Credits**	**: 04**
L:T:P:S: 4:0:0:0		**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**		**1**			
CO2	**2**		**3**			
CO3	**3**		**3**		**1**	
CO4	**2**		**2**		**2**	
CO5	**2**		**3**			

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**2**	**2**	**1**	**2**	**1**
CO2	**1**		**2**	**2**	
CO3	**2**	**3**	**1**		**2**
CO4		**2**		**2**	**2**
CO5	**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, continous, fedbatch). 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 fermentor 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 FiketKargi, Bioprocess Engineering, PHI Publishers. 2003.
2.	Industrial Microbiology by A.H. Patel, 2011, 2nd edition, Laxmi publications.
3.	Stanbury, P. F., Whitaker, A., & Hall, S. J., 2003, Principles of fermentation Technology, 2nd ed., Elsevier Science Publishers, BV, Amsterdam.

Reference Books:	
1.	R.G.Harrison, P.Todd, SR.Rudge and D.P Petrides. Bioseparation science and engineering. Oxford Press. 2003
2.	Microbiology:Presscot, Harley & Klein, 2002, Fifth edition, McGraw Hill, Newyork

Course Title: Bioinformatics - Core Paper: 10

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 4:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		2	2		
CO2	2		2	3		
CO3	3		2	2	2	
CO4	2		3	2	2	2
CO5	2		2	3	2	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		2	3	2	
CO2		2	2	2	1
CO3		3	2	3	2
CO4		2	2	2	2
CO5		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.
2.	S. C. Rastogi, Namita Mendiratta, Parag Rastogi. (2013). *Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery.* PHI Learning Pvt. Ltd.
3.	R C Dubey. Advanced Biotechnology, 1st Edition, S. Chand Publishing, 2014

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

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

Course Code	**:**	**Credits**	**: 04**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				**3**		
CO2		**2**		**3**	**2**	
CO3		**2**		**3**		
CO4		**2**		**3**	**2**	
CO5				**3**		

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**2**		**3**		**3**
CO2	**2**	**2**	**3**	**2**	**3**
CO3	**2**		**3**		**3**
CO4	**2**	**2**	**3**	**2**	**3**
CO5	**2**		**3**		**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
2.	Satyanarayana.U.(2013). Biotechnology. Books & Allied Ltd
3.	Nicholas C Price, Lewis Stevens. Fundamental of Enzymology. New York. Oxford University Press

Reference Books:	
1.	Reginald Garrett, David Jemiolo K., Steven Theg .M.(2008). Principles of Biochemistry: With a Human Focus. Harcourt College Publishers
2.	Geoffrey Zubay.L . Biochemistry (3rd ed.). McGraw Hill College Division

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

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**			**3**		
CO2	**2**			**3**		**1**
CO3	**3**			**1**		
CO4			**3**	**2**		
CO5				**1**	**2**	**2**

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**3**	**2**	**2**		
CO2		**2**	**1**	**3**	
CO3		**1**		**3**	
CO4			**1**	**3**	
CO5	**1**	**2**	**3**		

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, Principles and Techniques of Practical Biochemistry. 5th Edition. Cambridge University Press, 2000
2.	T. A. Brown, Gene cloning and DNA analysis- An introduction, sixth Edition, Wiley-Blackwell, 2010.
3.	Primrose S B. Twyman R M and Old R W. Principles of Gene Manipulation. 6th Edition, S.B University Press, 2001.

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

Course Title: Nano Biotechnology- Elective Paper: 4B

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 3:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2			3		2
CO2	3		3	3		2
CO3	2			3		
CO4	2		3	3	2	3
CO5	3	2	3	2		2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3			3	3
CO2	3	2	2	3	3
CO3	3	3	3	3	
CO4	3	2	2	3	3
CO5	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, ManashiBagchi, Hiroyoshi Moriyama, FereidoonShahidi (2013) Bio-Nanotechnology: A Revolution in Food, Biomedical and Health Sciences, Wiley-Blackwell.
2.	Rai, Mahendra, and Clemens Posten (2013) eds. Green biosynthesis of nanoparticles: Mechanisms and applications. CABI.
3.	Pradeep T (2012) Textbook of Nanoscience and Nanotechnology, Mcgraw Hill publication.

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

Course Title: Tissue Engineering- Elective Paper: 4C

Course Code	**:**	**Credits**	**: 03**
L:T:P:S: 5:0:0:0		**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		2		1	
CO2	2	3			2	
CO3	2		2			
CO4	3			2		3
CO5	2			3		2

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		3	3	3	3
CO2		2	3	3	2
CO3	2	3	2	3	
CO4	2	2	2	3	2
CO5		3	3	2	

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.
2.	Bernhard, P. Jeffrey A.H. Robert, P., and Joseph D. B. (2019). *Tissue Engineering* (1st edition). Boca Raton. CRC Press.
3.	Anthony, A. Robert, L. Robert, N., and James, A.T. (2010). *Principles of Regenerative Medicine* (3rd edition) Cambridge. Academic press.

Reference Books:	
1.	Paolo, N. (2014). *Biomedical Foams for Tissue Engineering Applications* (1st edition). Cambridge. Academic press.
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.

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

Course Code	**:**	**Credits**	**: 02**
L:T:P:S	**:0:0:3:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**			**1**		
CO2	**1**			**1**		
CO3	**2**			**2**		
CO4	**2**			**2**		
CO5				**3**		
CO6	**3**			**2**		
CO7	**2**		**2**			
CO8	**2**		**2**			
CO9	**2**		**3**			
CO10	**1**		**2**	**3**		
CO11	**1**		**1**		**2**	

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	3	
CO2	2	3	2	3	
CO3	3	3	2	3	
CO4	3	3	2	3	
CO5	3	3	2	3	
CO6	3	3	2	3	1
CO7	2		3		3
CO8	2	2	3	2	3
CO9	2		3		3
CO10	2	2	3	2	3
CO11	2		3		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, Molecular Cloning - A Laboratory Manual, 4th edition, Cold Spring Harbor Laboratory Press, 2012.
2.	Vennison, S. John, Laboratory Manual for Genetic Engineering, Prentice Hall India Learning Private Limited, 2009
3.	Introduction in bioprocess technology laboratory manual, Linnea Fletcher, 1st Edition - 2011
4.	Biotechnology procedure experiments infinity science press ,s Harisha 3rd Edition -2012

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

Course Code	**:**	**Credits**	**: 02**
L:T:P:S	**: 0:0:3:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**		**2**	**2**	**2**	**2**
CO2	**2**		**2**	**3**		**2**
CO3	**3**		**2**	**3**		**3**
CO4			**2**	**2**	**2**	**2**
CO5			**2**	**2**		**3**
CO6			**3**	**3**	**3**	**2**
CO7	**2**			**3**		**2**
CO8	**2**			**3**		**2**
CO9	**2**			**3**		**2**
CO10	**2**			**3**		**2**

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		**2**	**3**	**2**	**2**
CO2		**2**	**2**	**2**	
CO3		**2**	**2**	**3**	**1**
CO4		**1**	**3**	**2**	
CO5		**2**	**2**	**2**	**2**
CO6		**2**	**3**	**2**	**1**
CO7	**2**	**3**		**2**	
CO8	**2**	**3**		**2**	
CO9	**2**	**3**		**2**	
CO10	**2**	**3**		**2**	

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.
2.	Gokhale , B.S, Gaud .R.S, Gupta.G.D, (9th ed.). Practical Biotechnology, Nirali Prakashan publisher(2018)
3.	Thomas Crowley .E (1st ed).Experiments in the purification and characterization of enzymes – A laboratory manual. Academic press (2014).

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**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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 Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2			3		
CO2	2	2	2	2		
CO3	1			3		
CO4	1			3		
CO5	1			3		

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	2	3	3
CO2	1	3	1	2	3
CO3	1	2	1	2	2
CO4	1	1	1	2	2
CO5	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, thesis and research papers.	**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.
2.	Kothari, C.R. and Gaurav, G. (2019). *Research Methodology : Methods And Techniques* (4th edition). New age international publishers. Kolkata
3.	Ignacimuthu, S (2014). *Bioethics* (2nd edition). Narosa Publishing House Pvt. Ltd.New Delhi

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

Course Title: Herbal Technology-Open Elective Paper: 1

Course Code	**:**	**Credits**	**: 03**
L:T:P:S	**: 6:0:0:0**	**CIA Marks**	**: 40**
Exam Hours	**: 03**	**ESE Marks**	**: 60**

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:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**					
CO2			**2**	**3**		
CO3	**3**		**2**		**2**	
CO4	**2**	**1**		**3**		
CO5	**1**	**1**		**3**	**2**	**1**

Mapping of Course Outcomes to Program Specific Outcomes:

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**2**	**2**	**3**	**2**	**2**
CO2	**2**	**2**	**3**	**2**	
CO3	**2**	**2**	**3**	**2**	
CO4	**2**	**3**	**2**	**2**	
CO5	**2**	**2**	**2**	**2**	**3**
CO6	**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, Herbal Drug Technology, 1st Edition, CBS Publishers and Distributors, 2019
2.	Rageeb Md. Usman, Vaibhav M. Darvhekar, Vijay Kumar D, and Akhila S.A, Practical Book of Herbal Drug Technology, 1st Edition, Nirali Prakashan Publishers, 2019.
3.	Pragi and Varun Arora, Herbal Drug Technology, 1st Edition, S Vikas and Company Publisher, 2019

Reference Books:	
1.	Agrawal and Paridhavi, Herbal Drug Technology, 2nd Edition, Orient Blackswan Private Limited, 2012
2.	Shanti Bhushan Mishra, Essentials of Herbal Drug Technology, 1st Edition, Educreation Publishing, 2019.