DAYANANDA SAGAR UNIVERSITY
INNOVATION CAMPUS , KUDLU GATE , HOSUR ROAD
BENGALURU – 560 111, KARNATAKA.

SCHOOL OF BASIC & APPLIED SCIENCES

SCHEME & SYLLABUS
FOR
BACHELOR OF SCIENCE (B.Sc.) – 2022

WITH HONOURS & MINORS

B.SC. HONS IN BIOCHEMISTRY
B.SC. HONS IN BIOTECHNOLOGY
B.SC. HONS IN GENETICS
B.SC. HONS IN MICROBIOLOGY
B.SC. HONS IN CHEMISTRY

(With effect from 2022-23)

SCHEME - B.Sc. - 2022-23 ONWARDS

I SEM - Common to All

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BS1101	ESSENTIALS OF BIOCHEMISTRY	CR	4	–	4	–	6	*	***
2	139	22BS1102	BASIC MICROBIOLOGY	CR	4	–	4	–	6	*	***
3	139	22BS1103	CHEMISTRY-I	CR	4	–	4	–	6	*	***
4	139	22BS1104	ENVIRONMENT AND PUBLIC HEALTH	CR	3	–	–	–	3	*	***
5	139	22BS1105	ENGLISH - 1	CR	2	–	–	–	2	*	***
6	139	22BS1106	KANNADA - 1	CR	2	–	–	–	2	*	***
					19	–	12	–	25		

II SEM - Common to All

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BS1201	CELL BIOLOGY	CR	4	–	4	–	6	*	***
2	139	22BS1202	BASIC GENETICS	CR	4	–	4	–	6	*	***
3	139	22BS1203	MICROBIAL DIVERSITY AND KINETICS	CR	4	–	4	–	6	*	***
4	139	22BS1204	BIOSTATISTICS	CR	3	–	–	–	3	*	***
5	139	22BS1205	ENGLISH - II	CR	2	–	–	–	2	*	***
6	139	22BS1206	KANNADA - II	CR	2	–	–	–	2	*	***
					19	–	12	–	25		

CR — Credit, AU — Audit, L — Lecture, T — Tutorial, P — Practical, S/P — Seminar/Project, C — No. of Credits

SCHEME - B.Sc. - 2022-23 ONWARDS

III SEM - Common to All

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BS2301	BIOPHYSICS AND INSTRUMENTATION	CR	4	–	4	–	6	*	***
2	139	22BS2302	MOLECULAR BIOLOGY	CR	4	–	4	–	6	*	***
3	139	22BS2303	EVOLUTIONARY GENETICS	CR	4	–	4	–	6	*	***
4	139	22BS2304	CHEMISTRY - II	CR	3	–	–	–	3	*	***
5	139	22BS2305	COMPUTER APPLICATIONS	CR	2	–	–	–	2	*	***
6	139	22BS2306	CONSTITUTION OF INDIA	CR	2	–	–	–	2	*	***
					19	–	12	–	25		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits

SCHEME - B.Sc. HONS - BIOCHEMISTRY - 2022-23 ONWARDS

IV SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BY2401	HUMAN ANATOMY & PATHOLOGY	CR	4	–	4	–	6	*	***
2	139	22BY2402	METABOLISM I	CR	4	–	4	–	6	*	***
3	139	22BY2403	NUTRITION	CR	2	–	–	–	2	*	***
4	139	22BS2401	BIOSAFETY AND GOOD LABORATORY PRACTICE	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

V SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BY3501	HUMAN PHYSIOLOGY	CR	4	–	4	–	6	*	***
2	139	22BY3502	METABOLISM II	CR	4	–	4	–	6	*	***
3	139	22BS3501	BIOETHICS AND IPR	CR	2	–	–	–	2	*	***
4	139	22BS3502	BIOINFORMATICS	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

VI SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BY3601	ENZYMOLOGY	CR	4	–	4	–	6	*	***
2	139	22BY3602	IMMUNOLOGY	CR	4	–	4	–	6	*	***
3	139	22BS3601	PRINCIPLES OF ‘MULTI-OMICS’	CR	2	–	–	–	2	*	***
4	139	22BS3602	TOXICOLOGY	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

SCHEME - B.Sc. HONS - BIOCHEMISTRY - 2022-23 ONWARDS

VII SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BY4701	GENETIC ENGINEERING	CR	4	–	4	–	6	*	***
2	139	22BY4702	SIGNAL TRANSDUCTION	CR	4	–	4	–	6	*	***
3	139	22BY4703	PLANT PHYSIOLOGY BIOCHEMISTRY	CR	4	–	4	–	6	*	***
4	139	22BS4701	RESEARCH METHODOLOGY	CR	3	–	–	–	3	*	***
					15	–	12	–	21		

VIII SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BS4801	RESEARCH PROJECT	CR	-	–	–	–	12	*	***
2	139	22BS4802	MOOC / SWAYAM / NPTL / ANY SIMILAR	CR	2	–	–	–	2	*	***
					02	–	–	–	14		

SCHEME - B.Sc. HONS - BIOTECHNOLOGY - 2022-23 ONWARDS

IV SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BT2401	PLANT BIOTECHNOLOGY	CR	4	–	4	–	6	*	***
2	139	22BT2402	GENETIC ENGINEERING	CR	4	–	4	–	6	*	***
3	139	22BT2403	FUNDAMENTALS OF PLANT PHYSIOLOGY AND PATHOLOGY	CR	2	–	–	–	2	*	***
4	139	22BS2401	BIOSAFETY AND GOOD LABORATORY PRACTICE	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

V SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BT3501	IMMUNOLOGY	CR	4	–	4	–	6	*	***
2	139	22BT3502	ANIMAL BIOTECHNOLOGY	CR	4	–	4	–	6	*	***
3	139	22BS3501	BIOETHICS AND IPR	CR	2	–	–	–	2	*	***
4	139	22BS3502	BIOINFORMATICS	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

VI SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BT3601	BIO-PROCESS TECHNOLOGY	CR	4	–	4	–	6	*	***
2	139	22BT3602	ENVIRONMENTAL BIOTECHNOLOGY	CR	4	–	4	–	6	*	***
3	139	22BS3601	PRINCIPLES OF 'MULTI-OMICS'	CR	2	–	–	–	2	*	***
4	139	22BS3602	TOXICOLOGY	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

SCHEME - B.Sc. HONS - BIOTECHNOLOGY - 2022-23 ONWARDS

VII SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BT4701	FOOD TECHNOLOGY	CR	4	–	4	–	6	*	***
2	139	22BT4702	MEDICAL BIOTECHNOLOGY	CR	4	–	4	–	6	*	***
3	139	22BT4703	AGRICULTURAL BIOTECHNOLOGY	CR	4	–	4	–	6	*	***
4	139	22BS4701	RESEARCH METHODOLOGY	CR	3	–	–	–	3	*	***
					15	–	12	–	21		

VIII SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BS4801	RESEARCH PROJECT	CR	-	–	-	–	12	*	***
2	139	22BS4802	MOOC / SWAYAM / NPTL / ANY SIMILAR	CR	2	–	–	–	2	*	***
					02	–	–	–	14		

SCHEME - B.Sc. HONS - GENETICS - 2022-23 ONWARDS

IV SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22GS2401	CYTOGENETICS	CR	4	–	4	–	6	*	***
2	139	22GS2402	DEVELOPMENTAL BIOLOGY	CR	4	–	4	–	6	*	***
3	139	22GS2403	QUANTITATIVE GENETICS	CR	2	–	–	–	2	*	***
4	139	22BS2401	BIOSAFETY AND GOOD LABORATORY PRACTICE	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

V SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22GS3501	MICROBIAL GENETICS	CR	4	–	4	–	6	*	***
2	139	22GS3502	MOLECULAR GENETICS & GENOMICS	CR	4	–	4	–	6	*	***
3	139	22BS3501	BIOETHICS AND IPR	CR	2	–	–	–	2	*	***
4	139	22BS3502	BIOINFORMATICS	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

VI SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22GS3601	HUMAN GENETICS	CR	4	–	4	–	6	*	***
2	139	22GS3602	POPULATION GENETICS	CR	4	–	4	–	6	*	***
3	139	22BS3601	PRINCIPLES OF ‘MULTI-OMICS’	CR	2	–	–	–	2	*	***
4	139	22BS3602	TOXICOLOGY	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

SCHEME - B.Sc. HONS - GENETICS - 2022-23 ONWARDS

VII SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22GS4701	ANIMAL GENETICS	CR	4	–	4	–	6	*	***
2	139	22GS4702	PLANT GENETICS	CR	4	–	4	–	6	*	***
3	139	22GS4703	BEHAVIORAL GENETICS	CR	4	–	4	–	6	*	***
4	139	22BS4701	RESEARCH METHODOLOGY	CR	3	–	–	–	3	*	***
					15	–	12	–	21		

VIII SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BS4801	RESEARCH PROJECT	CR	-	–	–	–	12	*	***
2	139	22BS4802	MOOC / SWAYAM / NPTL / ANY SIMILAR	CR	2	–	–	–	2	*	***
					02	–	–	–	14		

SCHEME – B.Sc. HONS – MICROBIOLOGY– 2022–23 ONWARDS

IV SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22MY2401	MICROBIAL PHYSIOLOGY	CR	4	–	4	–	6	*	***
2	139	22MY2402	IMMUNOLOGY AND IMMUNO-TECHNIQUES	CR	4	–	4	–	6	*	***
3	139	22MY2403	PHARMACEUTICAL MICROBIOLOGY	CR	2	–	–	–	2	*	***
4	139	22BS2401	BIOSAFETY AND GOOD LABORATORY PRACTICE	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

V SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22MY3501	MEDICAL AND CLINICAL MICROBIOLOGY	CR	4	–	4	–	6	*	***
2	139	22MY3502	MICROBIAL GENETICS AND GENETIC ENGINEERING	CR	4	–	4	–	6	*	***
3	139	22BS3501	BIOETHICS AND IPR	CR	2	–	–	–	2	*	***
4	139	22BS3502	BIOINFORMATICS	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

VI SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22MY3601	INDUSTRIAL MICROBIOLOGY	CR	4	–	4	–	6	*	***
2	139	22MY3602	NANO MICROBIOLOGY AND EXTREMOPHILES	CR	4	–	4	–	6	*	***
3	139	22BS3601	PRINCIPLES OF 'MULTI-OMICS'	CR	2	–	–	–	2	*	***
4	139	22BS3602	TOXICOLOGY	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

SCHEME - B.Sc. HONS - MICROBIOLOGY - 2022-23 ONWARDS

VII SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22MY4701	FOOD AND DIARY MICROBIOLOGY	CR	4	–	4	–	6	*	***
2	139	22MY4702	ENVIRONMENTAL MICROBIOLOGY	CR	4	–	4	–	6	*	***
3	139	22MY4703	MICROBIAL-PLANT INTERACTIONS	CR	4	–	4	–	6	*	***
4	139	22BS4701	RESEARCH METHODOLOGY	CR	3	–	–	–	3	*	***
					15	–	12	–	21		

VIII SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BS4801	RESEARCH PROJECT	CR	-	–	–	–	12	*	***
2	139	22BS4802	MOOC / SWAYAM / NPTL / ANY SIMILAR	CR	2	–	–	–	2	*	***
					02	–	–	–	14		

SCHEME – B.Sc. HONS – CHEMISTRY– 2022-23 ONWARDS

IV SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22CY2401	INORGANIC CHEMISTRY	CR	4	–	4	–	6	*	***
2	139	22CY2402	PHYSICAL CHEMISTRY - I	CR	4	–	4	–	6	*	***
3	139	22CY2403	PHARMACEUTICAL CHEMISTRY	CR	2	–	–	–	2	*	***
4	139	22BS2401	BIOSAFETY AND GOOD LABORATORY PRACTICE	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

V SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22CY3501	ORGANIC CHEMISTRY - I	CR	4	–	4	–	6	*	***
2	139	22CY3502	PHYSICAL CHEMISTRY - II	CR	4	–	4	–	6	*	***
3	139	22BS3501	BIOETHICS AND IPR	CR	2	–	–	–	2	*	***
4	139	22BS3502	BIOINFORMATICS	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

VI

VI SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22CY3601	ORGANIC CHEMISTRY - II	CR	4	–	4	–	6	*	***
2	139	22CY3602	SPECTROSCOPY	CR	4	–	4	–	6	*	***
3	139	22BS3601	PRINCIPLES OF 'MULTI-OMICS'	CR	2	–	–	–	2	*	***
4	139	22BS3602	TOXICOLOGY	CR	2	–	–	–	2	*	***
					12	–	08	–	16		

SCHEME - B.Sc. HONS - CHEMISTRY - 2022-23 ONWARDS

VII SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22CY4701	POLYMER CHEMISTRY	CR	4	–	4	–	6	*	***
2	139	22CY4702	INORGANIC CHEMISTRY - II	CR	4	–	4	–	6	*	***
3	139	22CY4703	NANOSCIENCE AND MATERIAL CHEMISTRY	CR	4	–	4	–	6	*	***
4	139	22BS4701	RESEARCH METHODOLOGY	CR	3	–	–	–	3	*	***
					15	–	12	–	21		

VIII SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	139	22BS4801	RESEARCH PROJECT	CR	-	–	–	–	12	*	***
2	139	22BS4802	MOOC / SWAYAM / NPTL / ANY SIMILAR	CR	2	–	–	–	2	*	***
					02	–	–	–	14		

SCHEME – B.Sc. HONS –2022–23 ONWARDS

MINOR COURSES OFFERED FROM IV SEM TO VI SEM

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PRE-REQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
			BIOCHEMISTRY								
1	139	22BY2404	ANATOMY AND PHYSIOLOGY	CR	4	–	4	–	6	*	***
2	139	22BY3503	METABOLISM	CR	4	–	4	–	6	*	***
3	139	22BY3603	ENZYME & PROTEIN CHEMISTRY	CR	4	–	4	–	6	*	***
			BIOTECHNOLOGY								
1	139	22BT2404	PLANT BIOTECHNOLOGY	CR	4	–	4	–	6	*	***
2	139	22BT3503	ANIMAL BIOTECHNOLOGY	CR	4	–	4	–	6	*	***
3	139	22BT3603	INDUSTRIAL BIOTECHNOLOGY	CR	4	–	4	–	6	*	***
			GENETICS								
1	139	22GS2404	GENOMICS	CR	4	–	4	–	6	*	***
2	139	22GS3503	GENETIC TESTING	CR	4	–	4	–	6	*	***
3	139	22GS3603	COMPLEX TRAITS AND GENE NETWORKS	CR	4	–	4	–	6	*	***
			MICROBIOLOGY								
1	139	22MY2404	MICROBIAL FERMENTATION	CR	4	–	4	–	6	*	***
2	139	22MY3503	MEDICAL MICROBIOLOGY AND DIAGNOSTICS	CR	4	–	4	–	6	*	***
3	139	22MY3603	MICROBIOME AND EXTREMOPHILES	CR	4	–	4	–	6	*	***
			CHEMISTRY								
1	139	22CY2404	COORDINATION COMPOUNDS	CR	4	–	4	–	6	*	***
2	139	22CY3503	PHYSICAL CHEMISTRY FOR IOLOGICAL SCIENCES	CR	4	–	4	–	6	*	***
3	139	22CY3603	ORGANIC CHEMISTRY FOR BIOLOGICAL SCIENCES	CR	4	–	4	–	6	*	***

SEMESTER	I					
YEAR	I					
COURSE CODE	22BS1101					
TITLE OF THE COURSE	**ESSENTIALS OF BIOCHEMISTRY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To create in depth understanding about fundamentals of biomolecules, their structure and significance.
• To know about the structural and functional classification of biomolecules

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Will be able to demonstrate the composition and structure of various bio-molecules molecules in the living systems	L1
CO2	Should be able to correlate the structure and functions of bio-molecules, like carbohydrates, lipids, proteins and nucleic acids in biological systems	L2
CO3	Should be able to demonstrate the mechanism of interaction and functions various bio-molecules in living systems.	L3
CO4	Should be able to demonstrate the normal and abnormal structure of various bio-molecules in the context of various medical conditions	L3

COURSE CONTENT:

MODULE 1 — **15Hrs**

BIOCHEMICAL CALCULATIONS

Soultions, Stock Solutions- preparation and dilution of stock solutions. Avogadro Number Molarity, Molality, mole fraction and Normality. Density and Relative Density. Ionic Strength - pKa, pKb and pI. Equilibrium Constants, Dissociation constant, Henderson-Hasselbalch equation and buffer preparations. Electrochemical series, Nernst equation, standard electrode potential. pH, pOH. Law of Rational indices and Miller indices with numerical. Calculation of molecular weight of proteins and nucleic acids.

MODULE 2 — **15Hrs**

CARBOHYDRATES

Simple Carbohydrates: Structure and classification of carbohydrates. Configuration and conformational aspects of monosaccharides and sugar derivatives. Brief structural elucidation by permethylation (MALDI), Glycosidic linkages in disaccharides and glycosides (GC-MS). **Complex Carbohydrates:** Homopolysachharides and heteropolysachharides - starch, glycogen, cellulose chitin, glycosaminoglycans and proteoglycans; Glycoproteins and Glycolipids.

MODULE 3	15Hrs

AMINO ACID AND PROTEINS

Primary structure – Structure, classification and acid-base properties of amino acids, Peptide bond, Primary structure –scheme of determination –amino acid composition analysis, N and C terminal analysis, cleavage of Disulfide bond, chemical and enzymatic fragmentation and sequencing through Edman's reagent.

Secondary structure: α-, PP-, 310 and π-helix, β pleated sheet, β bend, Peptide bond geometry and Ramchandran plot, motifs and domains.

Tertiary structure: Interactions stabilizing tertiary structure; denaturation of proteins, secondary and tertiary structure of fibrous proteins: α-keratin, silk fibroin and collagen.

Quaternary structure: Hemoglobin Structure, molecular basis of Sickle-cell anemia; Cross linking agents to determine subunit composition. Introduction to protein folding

Protein folding: Protein renaturation and denaturation, significance of Anfinson's experiment, Landscape model of folding, accessory proteins- protein molecular chaperones;

MODULE 4	15Hrs

LIPIDS AND NUCLEIC ACID 15Hrs

Lipids: Classification, Nomenculature and biological functions of lipids. Complex lipids - phospholipids, sphingolipids, galactolipids and Eicosanoids and sterols–prostaglandins, thromboxanes and leukotrienes.

Nucleic acids: Nucleosides, nucleotides and polynucleotides; Primary and secondary structure, properties and types of DNA; structure and function of RNA's; Specialized sequences: G-quadruplexes, palindromic and mirror repeats; denaturation and renaturation curves of nucleic acids;

TEXT BOOKS/REFERANCES:

1. Biochemistry 4th Ed. Donald Voet& Judith G. Voet, John Wiley & Sons, Inc.(2010).
2. Lehninger- Principles of Biochemistry; DL Nelson and MM Cox, 6th Ed. Macmillan Publications (2012).
3. Physical Biology of the Cell, 2nd Ed. Rob Phillips, Jane Kondev, Julie Theriot, Hernan Garcia, Garland Publishers (2012).
4. Proteins Structures and Molecular Properties 2nd Ed. Thomas E. Creighton, W H Freeman and Co. (1993).
5. Principles of Protein Structure, Function, & evolution, Dickerson & Geis, 2nd Ed. Benjamin-Cummings (1983).
6. Biochemistry; David Rawn, J, Neil Patterson Publishers (1989).
7. Biochemistry 6th Ed; Jeremy M Berg, John L Tymoczko and LubertStryer, W H Freeman and Co. (2006).
8. Physical Biochemistry, Kensal Edward Van Holde, Prentice Hall.

ESSENTIALS OF BIOCHEMISTRY-PRACTICALS
EXPERIMENTS
1. Qualitative analysis of carbohydrates - Monosaccharides (Glucose, Fructose), Disaccharides (Lactose, Maltose, Sucrose), Polysaccharides (Starch).
2. Qualitative analysis of amino acids (tryptophan, tyrosine, cysteine, methionine, arginine, proline and histidine).
3. Estimation of protein by Lowry method
4. Estimation of sugar by Miller method.
5. Estimation of DNA by DPA method.
6. Determination of free amino acid content in germinating seeds.
7. Determination of Vitamin C content in lemon juice

TEXT BOOKS/ REFERENCES

1. Introductory Practical Biochemistry- Sawhney and Singh. Narosa Publishing house. 2012, 7th ed
2. An Introduction to practical Biochemistry—Plummer D. T, Tata Mc Graw Hill

SEMESTER	I					
YEAR	I					
COURSE CODE	22BS1102					
TITLE OF THE COURSE	**BASIC MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To equip the students about the importance of microorganisms in our global society.
- To create in-depth knowledge of the structural and functional characteristics of prokaryotic and eukaryotic cells and their classification.
- To make students to learn basic microbiological techniques employed for isolation, culturing and identification of prokaryotic and eukaryotic microorganisms.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will be acquainted with fundamental aspects of basic microbiology & isolation techniques	L1
CO2	Enable the students to understand the diversity of microbial, structure, function and their environment	L2
CO3	Students will be able to understand the importance of microorganisms	L3
CO4	Students will be equipped with fundamental knowledge of microbial growth patterns and kinetic studies enabling them to apply the same in various allied fields.	L2

COURSE CONTENT:

MODULE 1	**15Hrs**

HISTORY AND SCOPE OF MICROBIOLOGY

Development of microbiology as a discipline, spontaneous generation and biogenesis. Scope, disciplines and Applications of microbiology. Contributions of Antony von Leeuwenhoek, Joseph Lister, Edward Jenner, Louis Pasteur, Robert Koch, Alexander Fleming, Sumbunath Dey, Ananda Chakroborty, Paul Ehrlich, Selman A. Waksman, Lazaro Spallanzani, Dmitri lwanovsky, Martinus Beijerinck, Sergei Winogradsky, Elie Metchnikoff and Sir Ronald Ross in the field of Microbiology. Difference between prokaryotic and eukaryotic microorganisms. General structure and characteristics of viruses, bacteria, fungi, algae and Protozoa. General account of microbiome.

MODULE 2	**15Hrs**

MICROSCOPY

Principles of microscopy - resolving power, numerical aperture, working distance and magnification. Types- optical and electron microcopy – Basic principle, sample preparation, applications and limitations of Simple, Compound, Dark field, Phase contrast, Confocal, Atomic force microscope (Toppling & sliding mode), Fluorescence and Electron Microscope - TEM and SEM.

Staining techniques: Nature of dyes, Physical and chemical theories of staining, Principles and applications of a) Simple, negative staining b) Differential Staining- Gram's and Acid-fast staining c) Structural staining –cell wall, endospore, flagella, capsular staining, fungal staining.

MODULE 3	**15Hrs**

MICROBIAL TECHNIQUES

Sterilization and Disinfection: Definition, Principles, construction, and applications for physical and chemical methods of sterilization. Physical: Boiling, Pasteurization, Fractional sterilization -Tyndallization and Moist heat under pressure autoclave. Dry heat sterilization - Incineration and hot air oven. Filtration – seitz filter, membrane filter and laminar air flows. Radiation Ionizing radiation and non-ionizing radiation. Chemical methods: Alcohol, aldehydes, phenols, halogen, metallic salts, Quaternary ammonium compounds and sterilizing gases as antimicrobial agents.

Culture media and its types: Components, Types - Simple, Selective, Transport, Enriched, Differential media. Pure culture techniques: Isolation and purification techniques of bacteria and fungi (aerobic and anaerobic).

MODULE 4	**15Hrs**

GROWTH KINETICS

Definition of microbial growth, factors affecting microbial growth (pH, temperature, oxygen concentration, pressure and radiations). Cell division, Growth curve of bacteria, kinetics of growth. Mathematics of growth- generation time and growth rate constant. Measurement of growth: Measurement of cell numbers- Counting chambers, electronic counters, viable counting techniques, membrane filter technique. Measurement of cell mass- dry weight and turbidity measurement. Measurement of cell activity, Batch culture, Continuous culture - Chemostat and Turbidostat. Synchronous culture.

TEXT BOOKS/REFERANCES:

1. Alexopoulos, C.J., Mims, C.W., and Blackwell, M. 2007. Introductory Mycology; Fourth edition, Wiley India Private Limited
2. Aneja, K.R. 2014. Laboratory Manual of Microbiology and Biotechnology. Medtec
3. Atlas R.M. Microbiology- Fundamentals and applications, Macmillan Publishing Company, New York.
4. Benson, H. J. 1994. Microbiological Application. WCB McGraw-Hill of India Private Limited.
5. Brock T.D and Madigan M.T. Biology of Microorganisms 6th Edition. Prentice Hall, Eagle wood cliffs N. J.
6. Lengeler, Joseph W/Drews, Gerhart. Biology of the prokaryotes Blackwell Pub. 1999.
7. Nigel Dimmock, Andrew Easton and Keith Leppard. Introduction to Modern Virology: 5th edition, Blackwell Publishing, 2005
8. Pelczar, M.J., Chan, E.C.S and Kreig N.R. Microbiology Tata McGraw-Hill 5th Edition.Pub.1986.
9. Pommerville, J.C. 2007. Alcamo's Fundamentals of Microbiology. Eighth Edition. Jones and Bartlett Publishers, USA.
10. Prescott, L.M. Microbiology 6th edition. Mc Graw Hill. 2005.
11. Salle, A. J. 1984. Fundamental Principles of Bacteriology. Tata McGraw-Hill Publishing Company Limited, New Delhi.
12. Salle, A.J. Principles of Microbiology, 2nd edition., 1997, Mc Graw Hill.1997.
13. Stainer, R.Y., et al., General Microbiology 5th edition MacMillan Press.2005.

14. Tortora, Funke and Case. Microbiology, 9th Edition. Benjamin Cummings. 2009.

List of Laboratory/Practical Experiments activities to be conducted (if any) :
1) Study of instruments (2 Units) a) Autoclave b) Hot air oven c) Incubator d) pH meter e) High speed centrifuge f) Colorimeter g) UV-Vis Spectrophotometer h) Laminar air flow
2) Media Preparation: a) Basal media (Nutrient agar and broth, PDA media and MRBA) b) Selective media (EMB agar and McConkey agar), c) Enriched media (Blood agar).
3) Isolation of bacteria and fungi by serial dilution technique from soil, water and air.
4) Methods of pure culture techniques a) Pour plate technique b) Spread plate technique c) Streak plate technique
5) Transfer of media and inoculum a) Slant culture technique b) Broth culture technique c) Stab culture technique
6) Microscopic examination of bacterial smear a) Simple staining b) Gram's staining c) Capsule staining d) Endospore staining
7) Microscopic observation of temporary slides a. Algae: Chlamydomonas and Spirulina b. Fungi: Rhizopus, Aspergillus, Penicillium, Yeast. c. Protozoa: Amoeba, Paramecium and Euglena.

REFERENCES

1. Aneja, K.R. 2014. Laboratory Manual of Microbiology and Biotechnology. Medtec
2. Atlas R.M. Microbiology- Fundamentals and applications, Macmillan Publishing Company, New York.
3. Cappuccino, J.G., and Sherman, N. 1999. Microbiology - A Laboratory Manual. Fourth Edition. The Addison Wesley Longman, Inc England.
4. Pelczar, M. J., Chan E.C.S. and Krieg N.R. 1993. Microbiology. McGraw Hill Book Company, New York.
5. Prescott, L.M., Harley, J.P. and Klein, D.A. 2011. Microbiology. WCB McGraw-Hill, NY.

SEMESTER	I					
YEAR	I					
COURSE CODE	22BS1103					
TITLE OF THE COURSE	**CHEMISTRY I**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To make the students to understand basic facts and concepts in chemistry while retaining the exciting aspects of chemistry so as to develop interest in the study of chemistry as a discipline.
- To make the students to familiarize with the basic concepts related to modern atomic theory, quantum chemistry, titrations, periodic table and gaseous state of matter.

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Students will learn about handling of data and basics of different titrations	L1
CO2	Students will learn about advanced principles of atomic structure	L2
CO3	Students will get the knowledge periodic table and classification elements in the periodic table	L3
CO4	Students will learn about various aspects of gaseous state of matter	L2

COURSE CONTENT:

MODULE 1	**15Hrs**

ANALYTICAL CHEMISTRY

Handling of analytical data: SI and CGS units of measurements and physical constants and their inter conversion; Significant figures and calculations, accuracy, precision and errors in quantitative analysis. Stochiometry: atomic weights, molecular weights, mole concept, molarity, molality, normality, mole fraction, ppt, ppb and ppm. Numerical problems related to the above concepts.

Titrimetric analysis: Basic principle of titrimetric analysis. Classification, preparation and dilution of of reagents/solutions. Use of $N_1V_1= N_2V_2$ formula, Preparation of ppm level solutions from source materials (salts), conversion factors.

Acid-base titrimetry: Titration curves, Quantitative applications – selecting and standardizing a titrant, inorganic analysis -alkalinity, acidity.

Complexometric titrimetry: Indicators for EDTA titrations, titration methods employing EDTA -direct, back, displacement and indirect determinations, Application-determination of hardness of water.

Redox titrimetry: Balancing redox equations, titration curves, Theory of redox indicators. Precipitation titrimetry: Titration curves, indicators for precipitation titrations involving silver nitrate

Gravimetric Analysis: Requisites of precipitation, mechanism of precipitation, Factors influencing precipitation, Co-precipitation, post-precipitation.

MODULE 2	**15Hrs**

ATOMIC STRUCTURE Review of Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie'sequation-derivation, Heisenberg's uncertainty principle. Hydrogen atomic spectra. Need of a new approach to Atomic structure. Elements of Quantum chemistry- Schrodinger wave equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Quantum numbers and their Significance. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Rules for filling up of electrons in various orbitals (Aufbau principle, Pauli's exclusion principle, Hund's rule of maximum multiplicity and n+l rule), Electronic configuration of the elements (up to Z=30) and anomalous electronic configurations. Stability of half-filled and completely filled orbitals- concept of pairing and exchange energy.	
MODULE 3	**15Hrs**
PERIODICITY OF ELEMENTS Classification of elements into *s*, *p*, *d*, and *f*-blocks, cause of periodicity. Brief discussion of the following properties of the elements, with reference to *s*-& *p*-block and the trends shown:Effective nuclear charge, shielding or screening effect, Slater rules, variation of. effective nuclear charge in periodic table. Atomic and ionic radiiIonization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods. Electron gain enthalpy and trends in groups and periods. Electronegativity, Pauling's/ Allred Rochow's scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.	
MODULE 4	**15Hrs**
BASIC ORGANIC CHEMISTRY Representation of structural formula of organic compounds: condensed formula and bond line formula of organic compounds, classification of organic compounds based on functional groups with examples. Delocalisation of electrons: Inductive effect, electrometric effect, resonance (mesomeric effect,EWG and EDG, +M and –M effects) and hyper conjugation. Reactive intermediates: Types of bond cleavage, curly arrow rules in representation of mechanistic steps; electrophiles, nucleophiles, carbocations, carbanions, free radicals and carbenes– generation, structures, stability and examples. Types of organic reactions: Types of organic reactions with examples (electrophilic/ nucleophilic substitution/addition/free radical reaction with examples. Aromaticity: Kekule structure of benzene - molecular orbital picture of benzene – resonance energy and stability of benzene - Huckel's rule (aromatic, non-aromatic, and antiaromatic molecules) - aromaticity of benzene and benzenoid compounds – aromaticity of three, four, five, six, seven and eight-membered systems - annulenes.	

TEXT BOOKS/REFERANCES:

1. A New Concise Inorganic Chemistry", J. D. Lee, 5th Ed, Chapman & Hall, London (1996).
2. Organic Chemistry. R.T. Morrison and R.N. Boyd. 6th Ed. Prentice Hall, India (1992)
3. Physical chemistry, 9th Ed., Peter Atkins and Julio de Paula, Oxford University Press (2009)
4. Principles of Inorganic Chemistry B. R. Puri and L. R. Sharma, Jauhar S. P-S. N. Chand & Co., 1998
5. Inorganic Chemistry, ELBS 2nd Edition D. F. Shriver, P. W. Atkins and C. H. Langford, Oxford Univ. Press 2002.
6. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition,1993 prentice Hall, Inc. New Delhi.

EXPERIMENTS
1. Calibration of glassware, pipette, burette and volumetric flask.
2. Determination of sodium carbonate and sodium bicarbonate in a mixture.
3. Determination of iron (II) using potassium dichromate.
4. Determination of chlorine in bleaching powder using iodometric method.
5. Standardization of EDTA solution and determination of hardness of water.
6. Determination of Ba^{2+} as $BaSO_4$ BY gravimetric method.
7. Determination of Fe^{2+}as Fe_2O_3 by gravimetric method.

TEXT BOOKS/ REFERENCES

1. Vogel's Text Book of Practical Organic Chemistry, 5th Edition, A.J. Hannford, A.R.Tatchell, B.S. Hurnis, P.W.G. Smith, Pearson Publication.
2. Enhancing undergraduate chemistry laboratories, J. Carndoff, N. Reid, RS. C.Publication.
3. Experimental Organic Chemistry Laboratory Manual, J.I. Garcia, J.A. Dobado, G.Fransicisco, Elsevier Publication.
4. Chemistry Practical Inorganic Qualitaive Analysis For Under Graduate Students, M.J. Mamtora, S.C. Karad, J.S. Makasana, Lap Lambert Academic Publishing.
5. Advanced Practical Chemistry, K. Chelladurai, K. Subbian, Lap Lambert Academic Publishing.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**22BS1104**					
TITLE OF THE COURSE	**ENVIRONMENT AND PUBLIC HEALTH**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**45**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Develop strong foundations in epidemiology with special focus on infectious diseases, their environmental transmission, and treatment strategies.
• Understand recent advances made in combating or preventing the spread of infectious diseases.
• Understand the effects of human interventions on the dynamics and functioning of ecosystems

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will be able to deliberate on the possible solutions for: global health challenges, improving diseases and overall health status, in economically poor countries.	L1
CO2	Student will be able to propose prudent solution for integrated management of water and food supplies.	L2
CO3	Develop critical thinking and communication skills for the design and executions of research projects.	L3

COURSE CONTENT:	
MODULE 1	**7 Hrs**
Introduction. Infectious diseases: clinical symptoms, epidemiology, treatment, global surveillance and challenges in eradicating major diseases. Interpreting graphic and tabular data; trends, controls, variation, and uncertainty in measurements.	
MODULE 2	**15 Hrs**
INTRODUCTION TO MICROBIAL PATHOGENS Communicable diseases. Complexity of ecosystems and microbial habitats: Cholera and Malaria- clinical symptoms, epidemiology and mechanisms of disease transmission. Pathogen dynamics in the environment. Mode of waterborne disease transmission. Chemical, microbial control practiced in agriculture and human health.	
MODULE 3	**15 Hrs**
HUMAN MICROBIOME AND PUBLIC HEALTH Health status of populations, modelling the dynamics of infection. Modes of disease transmission, major stages in disease process, surveillance, and immunization. Biological, social & economic factors in public health.	

Earth and Human microbiome project. Policies and practices with respect to wild life protection, water and air quality, industrial and household waste disposal.	
MODULE 4	**8 Hrs**
PERSPECTIVES AND INTERVENTIONS IN PUBLIC HEALTH Epidemiological perspectives. Disease burden and surveillance; Alternative systems of medicine. Ayurveda, Yoga, Unani, Siddha and Homeopathy (AYUSH); Universal Immunization Programme (UIP); Reproductive Health-Youth Unite for Victory on AIDS.	

REFERENCES:

1. Park, K. (2011). Preventive and Social Medicine. Benarsi Das Publications. (pp. 16- 19, 24-27)
2. Sadgopal, M., & Sagar, A. (2007, July-September). Can Public Health open up to the AYUSH System and give space for People's Views of Health and Disease? mfc bulletin, 45-50.
3. Sekhsaria, P. (2007). Conservation in India and the Need to Think Beyond 'Tiger vs. Tribal'. Biotropica, 39(5), 575-577.
4. UNDP. (2013). The Human Development Report, The Rise of the South: Human Progress in Diverse World. New York: UNDP. (also available in Hindi)

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**22BS1105**					
TITLE OF THE COURSE	**ENGLISH – I**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To encourage the students to speak English confidently and enable them to communicate for day-to-day needs.
- To build up their confidence in the usage of English and to enhance their written communicative competence also helping them for competitive exams.

COURSE OUTCOME:

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students are confident in oral and written communication	L1
CO2	Have enhanced competence for competitive exams	L2

COURSE CONTENT:

MODULE 1	**7 Hrs**

COMMUNICATION SKILLS

Definition, importance of communication, communication process – source, message, encoding, channel, decoding, receiver, feedback, context, levels of communication, Flow of Communication, Verbal and Non-Verbal Communication, Barriers to Communication - physiological, physical, cultural, language, gender, interpersonal, psychological, emotional. Perspective in communication/ Communication styles: introduction, visual perception, language, other factors affecting our perspective – past experiences, prejudices, feelings, environment

MODULE 2	**7 Hrs**

Elements of communication – introduction, face to face communication – tone of voice, body language (non-verbal communication), verbal communication, physical communication;
Basic listening skills: introduction, self-awareness, active listening, becoming an active listener, listening in difficult situations;
Interview skills: purpose of an interview, do's and dont's of an interview;
Giving presentations: dealing with fears, planning your presentation, structuring your presentation, delivering your presentation, techniques of delivery;
Group discussion: introduction, communication skills in group discussion, do's and don't's of group discussion;

Phonetics: The Organs of Speech, The Description and Classification of Speech Sounds, The Description and Classification of Vowels, The Description and Classification of Consonants, Phonetic symbols and the IPA, Phonemic and Phonetic Transcription Phonology, Phoneme sequences and Consonant Cluster, The Syllable, Word Accent, Accent and Rhythm in Connected Speech, Intonation, Varieties of English Pronunciation.	
MODULE 3	**6Hrs**
EFFECTIVE WRITING SKILLS **Effective written communication:** introduction, when and when not to use written communication – complexity of the topic, amount of discussion required, shades of meaning, formal communication **Writing effectively:** subject lines, put the main point first, and know your audience, organisation of the message, Paragraph Writing, Letter Writing, Report Writing, Book Review, Scientific writing, Making a message – Transitivity/ intransitivity – complementation – talking about closely linked action – using two verbs together (eg: She started laughing),Transforming messages – Making statements, questions, orders and suggestions – denying – rejecting – disagreeing – possibility – ability, permission, obligation etc.	
MODULE 4	**10 Hrs**
GRAMMAR **Word Classes:** Open Word Classes: - Nouns, Verbs, Adjectives, Adverbs, Pronouns; Closed Word Classes: - Pre-determiners, Determiners, Numerals, Enumrators, Prepositions, Conjunctions, Auxiliary Verbs, Interjection; **Morphology:** Bound and Free Morphemes; Affixes, Stems and Roots; Morphological Analysis; **Phrases:** Noun Phrase, Verb Phrase, Genetive Phrase, Adjective Phrase, Adverb Phrase, Prepositional Phrase, Phrases and its types, Clauses and its types, Sentences and its types, Common errors, phonetics; **Clauses:** Clause Elements, Clause Types, Kinds, Concord; **Sentences:** Simple Sentences, Compound Sentences, Complex Sentences; **Sub Ordination:** Sub-Clauses, Finite and Non-Finite Sub-Clauses; **Co-ordination:** Linked and Unlinked Coordination, Synthesis; **Ambiguity:** Types of Ambiguity, Structural and Lexical Ambiguity; **Common Errors:** Nouns and Pronouns, Articles, Verbs, Concord, Adjectives, Adverbs, Prepositions, Vocabulary, Expressing time, Referring to present, past and future time - use of adjuncts - frequency and duration, Talking about manner and place, Information about place, manner - position of adjuncts - types of adverbs (time, frequency, duration etc), Reporting what people say/think, Reporting verbs - reporting someone's actual words - reporting in one's own words, The structure of information, Focusing on the thing affected (passive voice) - selecting focus (left structure) taking the focus off the subject (impersonal 'it' etc.) – Introducing something new (with 'there') - focusing on information using adjuncts.	

TEXT BOOKS:

1. Crystal, David. 1985, Rediscover Grammar with David Crystal. Longman
2. Bakshi, R. N. A Course in English Grammar. Orient Longman
3. Close, R. A. Reference Grammar for Students of English. Orient Longman
4. Krishnaswamy, N. Modern English – A Book of Grammar, Usage & Composition. Macmillan India Ltd.
5. Aroor, Usha (Ed.) WordMaster Learner's Dictionary of Modern English. Orient Longman 17
6. Hewings, M. 1999, Advanced English Grammar. Cambridge University Press
7. Basic communication skills for technology, Andreja J. Ruther Ford, 2nd Edition, Pearson Education, 2011.
8. Communication Skills, Sanjay Kumar, Pushpalata, 1st Edition, Oxford Press, 2011.
9. Brilliant – Comminication Skills, Gill Hasson, 1st Edition, Pearson Life, 2011.
10. Soft Skill and Professional Communication, Francis Peters SJ, 1st Edition, Mc GrawHill Education, 2011.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**22BS1106**					
TITLE OF THE COURSE	**KANNADA KALI – I**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**0**	**0**	**0**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To enable students read and write in Kannada
- To make students to communicate in Kannada helping them to interact with local people for their daily needs

COURSE OUTCOME

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Students should be able to read, write and communicate in Kannada	L3

COURSE CONTENT:

1. **ALPHABETS – AKSHARAMAALE - ಅಕ್ಷರಮಾಲೆ**
2. **SIGNS OF VOWELS AND CONJUNCT CONSONANTS – KAAGUNITHA MATTHU OTTHAKSHARAGALU ಕಾಗುಣಿತ ಮತ್ತು ಒತ್ತಕ್ಷರಗಳು**
3. **DAILY USING WORDS PART – 1 DINANITHYADA PADAGALU BHAAGA – 1 ದಿನನಿತ್ಯದ ಪದಗಳು ಭಾಗ – 1**
4. **WEEKDAY AND MONTH NAMES – VAARADA MATTHU THINGALA HESARUGALU ವಾರದ ಮತ್ತು ತಿಂಗಳ ಹೆಸರುಗಳು**
5. **TASTE – RUCHI – ರುಚಿ**
6. **COLOURS – BANNAGALU – ಬಣ್ಣಗಳು**
7. **NUMBERS – SANKYEGALU - ಸಂಖ್ಯೆಗಳು**
8. **DAILY USING WORDS PART – 2 DINANITHYADA PADAGALU BHAAGA – 2 ದಿನನಿತ್ಯದ ಪದಗಳು ಭಾಗ – 2**
9. **QUESTION PATTERNS – PRASHNEYA VIDHAANAGALU ಪ್ರಶ್ನೆಯ ವಿಧಾನಗಳು**
10. **MEASUREMENTS – ALATHEGALU - ಅಳತೆಗಳು**
11. **EDUCATION WORDS – SHAIKSHANIKA PADAGALU ಶೈಕ್ಷಣಿಕ ಪದಗಳು**
12. **FRUITS – HANNUGALU – ಹಣ್ಣುಗಳು**

SEMESTER	II					
YEAR	I					
COURSE CODE	22BS1201					
TITLE OF THE COURSE	**CELL BIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To familiarize the students with the basic components of prokaryotic and eukaryotic cells with special focus on the physiological processes of the cell organelles and cell.
• To introduce the students to the cell membrane and cell wall and to the very basics of cell cycle and cell death pathways.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Should be able to identify different organelles of the cell	L1
CO2	Should be able to demonstrate/identify the different parts of cell cycle and their function	L2
CO3	Should be able to identify the regulatory steps of the cell cycle	L3
CO4	Should be able to demonstrate the essential importance of cell death pathways	L2

COURSE CONTENT:	
MODULE 1	**15Hrs**
MODULE 1 ULTRA STRUCTURE OF CELL Prokaryotic (Bacteria) and Eukaryotic cells (Animal and Plant) - Characteristics and differences. Cell Wall: Ultrastructure, chemical composition and function. Plasma membrane: Chemical composition (Lipids, Proteins, Carbohydrates), Structure (Fluid mosaic model). Mode of transport across membrane: Active Transport (Pumps) and Passive transport (Osmosis, Diffusion).	
MODULE 2	**15Hrs**
CELL ORGANELLES -I Structure and general functions: Chloroplast (Envelope, Stroma, Thylakoids); Endoplasmic Reticulum (Smooth and Rough); Golgi complex (Cisternae, Tubules, Vesicles); Mitochondria; Ribosomes; Lysosomes (Primary and Secondary); Microsomes.	
MODULE 3	**15Hrs**
CELL ORGANELLES -II Structure and general functions: Cytoskeleton (Microtubules, Microfilaments and Intermediate Filaments); Cilia and Flagella. Structure and general functions of Nucleus (Nuclear envelope, Nucleoplasm and Nucleolus). Chromosomes- Discovery, Structure and functions (Centromere,	

Secondary constrictions, Telomere). Types of Chromatin (Euchromatin and Heterochromatin); Dosage Compensation. Organization of Chromatin: Nucleosomes and Solenoid Model; Giant Chromosomes (Polytene and Lampbrush).	
MODULE 4	**15Hrs**
CELL GROWTH AND CELL DIVISION Cell cycle: Introduction to cell cycle stages (Interphase and M phase); Introduction to Cell cycle control (Cyclins and Cyclin dependent kinases). Mitosis: Mitotic phases; Cytokinesis; Significance of Mitosis. Meiosis: First meiotic division; Second meiotic division, Synaptonemal complex; Significance of meiosis. Introduction to programmed cell death (Apoptosis & Necrosis).	

TEXT BOOKS/REFERANCES:

1. Verma P. S. Cell Biology, Genetics, Molecular Biology: Evolution and Ecology (2006). S Chand Publishers.
2. Gerald Karp. Cell and Molecular Biology. 6th Edition (2009) Wiley Publications.
3. Bruce Alberts et al. Molecular Biology of the cell - (2002) Garland Publications. Ambrose and Esty D. M. Cell Biology - (1997) ELBS Publications.
4. Robertis E. D. F. and Robertis E. M. F. Genetics and Molecular Biology - (2001) Saunders College.

EXPERIMENTS
1. Introduction to Microscopy (Bright Field, Dark Field, Phase Contrast Microscopy)
2. Microscopic measurements using micrometry – calibration of ocular and stage, measurement of onion epidermal cells and yeast by Micrometry.
3. Cell division: Study of mitosis using onion root tips.
4. Chloroplast isolation and their microscopic examination
5. Vital Staining of mitochondria (yeast).
6. Meiosis demonstration using grass hopper testis/onion flower buds
7. Study of model organisms - -Tobacco Mosaic Virus, Lambda Phage, *Neurospora crassa*, *Caenorhabditis elegans*, *Arabidopsis thaliana*, *Drosophila*.

TEXT BOOKS/ REFERENCES

1. Dr. Renu Gupta , Dr. Seema Makhija , Dr. Ravi Toteja. Cell Biology : Practical Manual. Prestige Publishers, 2018.
2. Amit Gupta and Bipin Kumar Sati . Practical laboratory manual- CELL BIOLOGY.LAP Lambert Academic Publishing, 2019.
3. Alberts et al., (2002). Molecular Biology of the Cell, Garland Publishing, Inc., 4th ed.

SEMESTER	II					
YEAR	I					
COURSE CODE	22BS1202					
TITLE OF THE COURSE	BASIC GENETICS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**0**	**4**	**0**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To gain insight on the historical perspective of the evolution of genetics.
• To comprehend and identify the different types of mendelian and non-mendelian inheritance.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will have clarity to the background of genetics before getting into details in the forthcoming semesters	L3
CO2	They will be capable differentiate between mendelian and non mendelian inheritance sources along with associated intricacies.	L3
CO3	Student will gain the ability to analyse and relate phenotype to genotype and potential factors influencing the interaction.	L3

COURSE CONTENT:	
MODULE 1 HISTORY OF GENETICS AND MENDELIAN PRINCIPLES	**15Hrs**
Pre- formation, History and scope of Genetics, Pre- Mendelian genetic concepts epigenesis, pangenesis, germplasm theory. Mendel- Life and his experiments on pea plants. Principle of Dominance (Dominance and Recessiveness); Laws of Inheritance and their applications. Monohybrid Cross, Dihybrid Cross, Back Cross, Test Cross	
MODULE 2 EXTENSIONS OF MENDELISM AND GENE INTERACTIONS	**15Hrs**
Co-dominance and incomplete dominance - definition, examples. Multiple allelism- definition, Eye color in Drosophila, Blood groups and Rh factor in Human; Allelic series; Lethal alleles; Multi-factorial inheritance- Skin colour in Humans; Penetrance and Expressivity; Plieotropy. Epistasis- dominant, recessive. Supplementary and Complementary gene interactions; Non epistatic inter allelic gene interaction, Position effect.	
MODULE 3 SEX DETERMINATION AND EXTRA CHROMOSOMAL INHERITANCE	**15Hrs**
Chromosomal theory of Inheritance - Concepts and evidences. Mechanism of sex determination- XX-XY; XX-	

XO; ZZ-ZW; Bridges genetic balance theory. Environmental and hormonal control of sex determination Gynandromorphs / Intersexes, Super sexes in Drosophila. Sex differentiation and dosage compensation (Drosophila and Man). Sex linked and sex-limited traits in Humans. Hemophilia, Hypertrichosis. Extra Chromosomal inheritance, flower colour in Mirabilis jalapa, kappa particle in Paramecium, sigma factor in Drosophila, Cytoplasmic Male Sterility (CMS) in maize.	
MODULE 4 MODEL ORGANISMS IN GENETICS	**15Hrs**
Bacteria - *E. coli*; Viruses - Tobacco Mosaic Virus; Bacteriophage - Lambda Phage; Fungi- Neurospora species, *N crassa*, *Saccharomyces cerevisiae;* Nematode - *Caenorhabditis elegans*, Plant - Arabdosis thaliana, Fly - *Drosophila melanogaster*, Fish - Zebra fish (*Danio rerio*), Mammal - Mice (*Mus musculus*) and Rat (*Rattus rattus*).	

TEXT BOOK/ REFERENCES:

1. Verma P. S. Cell Biology, Genetics, Molecular Biology: Evolution and Ecology (2006). S Chand Publishers.
2. Strickberger M. W., Genetics. (1968) Macmilla Publishers.
   Mathew Hamilton, (2009) Population Genetics, Wiley-Blackwell
3. Snustad D. P., Simmons M. J., Principles of Genetics. 5th Edition (2008) John Wiley & Sons.
4. Brooker R. B., Genetics Analysis and Principles. Fourth Edition (2009) McGraw-Hill.
5. Tamarin R. H., Principle of Genetics. Seventh Edition. (2002) Tata-McGraw Hill.
6. Hart D and Jones E.W., Genetics Principles and Analysis. 4th Edition (1998) Jones and Bartlett Publication.
7. Atherly A. G., Girton J. R. and Donald M. C. J. F. The Science of Genetics (1999) Sounders College Publication / Harcourt Brace.
8. Sturtevant A. H., A History of Genetics (1965). Harper and Row New York. Mendel G. The First Geneticist by Orel V. (1996) Oxford University Press, New York.
9. Ross S. A first course in Probability. 4th Edition (1994). McMillan, New York.
10. Stansfield W. D., Theory and problems of Genetics (Schaum s Outline Series). (2002) McGraw Hill.
11. Stubbe H., History of Genetics (1972). Harper and Row New York.
12. Prasad S. Fundamentals of Biostatistics (1993). Emkay publications, New Delhi.
13. Khan and Khanum. Fundamentals of Biostatistics. II Revised Edition. (2004). Ukaaz Publication.

EXPERIMENTS
1. Temporary squash preparation of : Grasshopper Testes, Onion flower bud
2. Observation of meiotic stages in permanent slides
3. Blood Typing
4. Sex differentiation in Drosophila
5. Preparation of Barr bodies from buccal smear.
6. Problem solving on : (a) Probability (b) multiple alleles (c) Gene interactions (d) Sex Linkage
7. Studies on mendelian traits: (a) Flower color in *Mirabilis jalapa* (b) Coat color in Mice (c) Comb pattern in fowl.

REFERENCES

1. Brooker, R. J. 1999. Genetics: Analysis and Principles. Benjamin Cummings, Longman, INC.
2. Gardner E. J. M. J. Simmons and D.P. Snustad 1991 Principles of Genetics. John Wiley & Sons. INC.New York.
3. Klug, W. S. and M. R. Cummings 1994 Concepts of Genetics MacMillan Colley Publishing and Company NY.
4. Strickberger M. W. 1996. Genetics. Mac Millan Publishing Co. NewYork
5. Tamarin,. R H. 1999. Principles of Genetics. McGraw-Hill.

SEMESTER	II					
YEAR	I					
COURSE CODE	22BS1203					
TITLE OF THE COURSE	**MICROBIAL DIVERSITY AND KINETICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To understand microbial diversity, classification, structure of different groups of microbes and their functions
- To strengthen the knowledge on cell and cellular organisation of prokaryotic and eukaryotic systems.
- To know about the economic importance of the microbes.

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Enable students to relate the principles in classifying microbes	L1
CO2	Apply the knowledge in identifying different microorganisms and to study their life cycles	L2
CO3	Elucidate the role of beneficial and harmful effects	L3

COURSE CONTENT:

MODULE 1	**15Hrs**

MICROBIAL DIVERSITY AND SYSTEMATICS

Microbial Systematics: Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems. Brief account of Bergey's manual of systematic and determinative bacteriology. Criteria for classification of bacteria. Molecular methods (DNA homology, DNA-RNA homology, G+C ratio), phage typing and Serological methods in taxonomy, Numerical taxonomy.

MODULE 2	**15Hrs**

PROKARYOTIC MICROBIOLOGY

Bacteriology: Ultra structure of Bacteria: Classification, Structure external to the cell wall- Slime layer, Capsule, Flagella, Pilus/ Fimbriae. Cell wall, Cytoplasmic membrane; Cytoplasmic inclusion bodies. Bacterial Chromosome, Plasmids and Episomes, Ribosomes, Exospores, Endospore and Cysts. General account of Archaebacteria, Actinomycetes.

Virology: Classification, General structure, characteristics, cultivation and replication of viruses. Type study: classification, structure, replication, cultivation and application of - TMV and Lambda phage. Viroids and Prions.

MODULE 3	15Hrs
PHYCOLOGY Classification, General characteristics of algae including occurrence, thallus organization. Algal Ultrastructure, pigments, flagella, eyespot food reserves. Reproduction: vegetative, asexual and sexual. Types of life cycles: Haplontic, Diplontic, Haplobiontic and Diplobiontic. Type study of Cyanophyta (*Spirulina*), Chlorophyta (*Spirogyra*), Rhodophyta (*Gracillaria*). Economic importance of algae.	
MODULE 4	**15Hrs**
MYCOLOGY AND PROTOZOOLOGY **Fungi:** Classification, General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra- structure, thallus organization and aggregation, fungal cell wall structure and synthesis. Reproduction asexual and sexual. Type study of Zygomycetes (*Rhizopus)*, Ascomycetes (*Aspergillus),* Basidiomycetes (*Agaricus*) and Deuteromycetes (*Fusarium*). Economic importance of fungi**.** **Protozoa:** General characteristics of protozoa. Type study **-** *Amoeba, Paramecium, Plasmodium*.	

TEXT BOOKS:

1. Alexopoulos, C.J., Mims, C.W., and Blackwell, M. 2007. Introductory Mycology. ; Fourth edition, Wiley India Private Limited
2. Aneja, K.R. 2014. Laboratory Manual of Microbiology and Biotechnology. Medtec
3. Atlas R.M. Microbiology- Fundamentals and applications, Macmillan Publishing Company, New York.
4. Benson, H. J. 1994. Microbiological Application. WCB McGraw-Hill of India Private Limited.
5. Brock, T. D. and Madigan, M.T. 1996. Biology of Microorganisms. Prentice Hall of India Private Limited.
6. Cappuccino, J.G., and Sherman, N. 1999. Microbiology - A Laboratory Manual. Fourth Edition. The Addison Wesley Longman, Inc England.
7. Pelczar, M. J., Chan E.C.S. and Krieg N.R. 1993. Microbiology. McGraw Hill Book Company, New York.
8. Pommerville, J.C. 2007. Alcamo’s Fundamentals of Microbiology. Eighth Edition. Jones and Bartlett Publishers, USA.
9. Prescott, L. M., Harley, J.P. and Klein, D.A. 2011. Microbiology. WCB McGraw-Hill, New York.
10. Salle, A. J. 1984. Fundamental Principles of Bacteriology. Tata McGraw-Hill Publishing Company Limited, New Delhi.
11. Sharma, O. P. 1986. Text Book of Algae. Tata McGraw-Hill Education.
12. Stanier R.Y., and Ingraham J.L. 1991. General Microbiology. Prentice Hall of India PrivateLimited, New Delhi.
13. Vashishta, B.R. 2010. Botany for Degree Students – Algae. S. Chand and Co.

	EXPERIMENTS
1.	Isolation and identification of fungi (Lactophenol cotton blue mount).
2.	Isolation and Identification of algae.
3.	Study of Protozoa by using permanent slides: *Amoeba, Paramecium, Giardia, Plasmodium.*
4.	Study of bacterial growth curve by turbidometric method.
5.	Study of growth curve of fungi by colony diameter method
6.	Cultivation and propagation of bacteriophage.
7.	Cultivation of Algae / Algal growth.

REFERENCES:

1. Aneja, K.R. 2014. Laboratory Manual of Microbiology and Biotechnology. Medtec
2. Atlas R.M. Microbiology- Fundamentals and applications, Macmillan Publishing Company, New York.
3. Cappuccino, J.G., and Sherman, N. 1999. Microbiology - A Laboratory Manual. Fourth Edition. The Addison Wesley Longman, Inc England.
4. Pelczar, M. J., Chan E.C.S. and Krieg N.R. 1993. Microbiology. McGraw Hill Book Company, New York.
5. Prescott, L. M., Harley, J.P. and Klein, D.A. 2011. Microbiology. WCB McGraw-Hill, New York.

SEMESTER	II					
YEAR	I					
COURSE CODE	22BS1204					
TITLE OF THE COURSE	**BIOSTATISTICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**45**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To familiarize the students with basic concepts and principles of statistics
- To understand the applications of statistics in biological sciences.

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Student will be aware of various applied and allied domains like statistics and will be able to think creatively	L2
CO2	Students will be empowered for better prospects leading to project designand execution.	L3

COURSE CONTENT:	
MODULE 1	**5 Hrs**
Measures of Central Tendencies Introduction to Bio-statistics and its significance, use of replicates, Tabulation and graphical representations of data. Different models of data presentations. Frequency distribution. Measures of Central tendency: Arithmetic mean, mode & median.	
MODULE 2	**15Hrs**
Dispersion And Correlation Measures of variability: Range, mean deviation and percentiles. Standard deviation and co-efficient of variation, Standard error Properties of the data: linear regression and correlation-test of significance, skewness and kurtosis and their various measures, Simple linear correlation and regression analysis. Analysis of variance. Sampling methods and their significance.	
MODULE 3	**7 Hrs**
Probability Distributions Probability: types of event, sample space, definition, conditional probability, addition and multiplication rules of probability and some simple problems. Probability distributions- Binomial, Poisson and Normal distributions with simple numerical	
MODULE 4	**8 Hrs**
Testing of hypothesis: Basic concepts and definitions, types of errors, confidence intervals. Tests based on Normal, student's t, chi-square and F distributions, interpretation of "p" value. Statistical package- Features of statistical software, SPSS	

for various applications in Biostatistical program.

TEXT BOOKS/REFERANCES:

1. Daniel (1999). Biostatistics (3 edition) Panima Publishing Corporation.
2. Khan (1999). Fundamentals of Biostatistics, Panima Publishing Corporation
3. Swardlaw, A.C. (1985). Practical Statistics for Experimental Biologists, Joh
4. Bazin, M.J. (1983). Mathematics in microbiology Academic press
5. Green, R.H. (1979). Sampling design & Statistical methods for environmental Biologists, Wiley Int. N.Y.
6. Campbell, R.C. (1974). Statistics for Biologists, Cambridge Univ. Press, Cambridge
7. Bliss, C.I.K. (1967). Statistics in Biology, Vol.1 Mc Graw Hill, New York. Wiley and Sons, Inc. NY.

SEMESTER	I I					
YEAR	I					
COURSE CODE	22BS1205					
TITLE OF THE COURSE	English II					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- **The students will draw inferences relying on the context.**
- **The students will analyze and synthesize information presented in different sources.**

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students should be able to identify words or phrase related to the topic	L1
CO2	Students should be able to distinguish between more important ideas from less important ones.	L2
CO3	Students should be able to identify the figures of speech used	L3
CO4	Students should be able to write effectively concluding paragraphs that include a summary of the main points, repetition of the thesis-argument sentence, and/or their own comments	L2

COURSE CONTENT:	
MODULE 1	**6 Hrs**
Reading Skills Comprehension passage, classification and process analysis, Data interpretation,skimming and scanning,Types of reading, Techniques to improve reading.	
MODULE 2	6 Hrs
Writing skills Referencing skills, Brochure, Advertisements, graphic representation, Data interpretation, letter of appreciation, scientific writing, types of writing, travelogue writing	
MODULE 3	**6 Hrs**
Listening skills Listening Vs Hearing, Non verbal and Verbal signs of active listening, Barriers of listening skills, principles of listening skills, Types of listening, Techniques to improve listening skills	
MODULE 4	**6 Hrs**
Speaking skills Phonetics: basic concepts in phonetics, elocution, interviews, types of speaking, Debate, Group discussion. Narrating a story	

MODULE 5	**6 hrs**
Grammar Linkers, Types of sentence, Gerunds, Question tags, WH questions, Tenses, Common errors, antonyms and synonyms, affix.	

TEXT BOOKS:

1. 1. Crystal, David. 1985, Rediscover Grammar with David Crystal. Longman
2. 2. Bakshi, R. N. A Course in English Grammar. Orient Longman
3. 3. Close, R. A. Reference Grammar for Students of English. Orient Longman
4. 4. Krishnaswamy, N. Modern English – A Book of Grammar, Usage & Composition. Macmillan
5. India Ltd.
6. 5. Aroor, Usha (Ed.) WordMaster Learner's Dictionary of Modern English. Orient Longman 17

<table>
<tr><td>SEMESTER</td><td colspan="6">II</td></tr>
<tr><td>YEAR</td><td colspan="6">I</td></tr>
<tr><td>COURSE CODE</td><td colspan="6">22BS1206</td></tr>
<tr><td>TITLE OF THE COURSE</td><td colspan="6">KANNADA KALI – II</td></tr>
<tr><td rowspan="2">SCHEME OF Instruction</td><td>Lecture Hours</td><td>Tutorial Hours</td><td>Practical Hours</td><td>Seminar/Projects Hours</td><td>Total Hours</td><td>Credits</td></tr>
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Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To enable students read and write in Kannada
• To make students to communicate in Kannada helping them to interact with local people for their daily needs

COURSE OUTCOME

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students should be able to read, write and communicate in Kannada	L3

COURSE CONTENT:

1. **BODY PARTS – DEHADA ANGAANGAGALU**
   ದೇಹದ ಅಂಗಾಂಗಗಳು
2. **HEALTH INFORMATION (HISTORY TAKING) – AAROGYADA MAAHITHI – ಆರೋಗ್ಯದ ಮಾಹಿತಿ**
3. **MEDICAL WORDS AND DISEASES – VAIDYAKEEYA PADAGALU MATTHU KAAYILEGALU**
   ವೈದ್ಯಕೀಯ ಪದಗಳು ಮತ್ತು ಖಾಯಿಲೆಗಳು
4. **PATIENT CASE RECORD – ROGIYA DAAKHALEYA VIVARA**
   ರೋಗಿಯ ದಾಖಲೆಯ ವಿವರ
5. **COMMON PHYSIOTHEREPY WORDS – PHYSIOTHEREPY YA SAAMAANYA PADAGALU**
   ಫಿಜಿಯೋಥೆರಪಿಯ ಸಾಮಾನ್ಯ ಪದಗಳು
6. **DOCTOR & PATIENT CONVERSATION – VAIDHYA & ROGIYA SAMBAASHANE**
   ವೈದ್ಯ & ರೋಗಿಯ ಸಂಭಾಷಣೆ
7. **DENTAL RELATED WORDS – HALLIGE SAMBANDHISIDA PADAGALU**
   ಹಲ್ಲಿಗೆ ಸಂಬಂಧಿಸಿದ ಪದಗಳು
8. **DENTAL TREATMENT INSTRUCTIONS – DANTHA CHIKITHSEYA SUCHANEGALU**
   ದಂತ ಚಿಕಿತ್ಸೆಯ ಸೂಚನೆಗಳು
9. **GENERAL CHECK UP – SAAMAANYA CHIKITHSE**
   ಸಾಮಾನ್ಯ ಚಿಕಿತ್ಸೆ
10. **HEALTH EXAMINATIONS – AAROGYADA PAREEKSHEGALU**
    ಆರೋಗ್ಯದ ಪರೀಕ್ಷೆಗಳು

11. **OPPOSITE WORDS – VIRUDDHA PADAGALU**
    ವಿರುದ್ಧ ಪದಗಳು
12. **VERBS - KRIYAA PADAGALU – ಕ್ರಿಯಾ ಪದಗಳು**
13. **LIQUID ITEMS – NEERINAAMSHADA PADAGALU**
    ನೀರಿನಾಂಶದ ಪದಗಳು
14. **FEELINGS – BHAAVANEGALU – ಭಾವನೆಗಳು**
15. **TENSES – KAALASOOCHAKAGALU – ಕಾಲಸೂಚಕಗಳು**
16. **COMMUNICATION WORDS – SAMBHAASHANEYA PADAGALU**
    ಸಂಭಾಷಣೆಯ ಪದಗಳು

SEMESTER	III					
YEAR	II					
COURSE CODE	22BS2301					
TITLE OF THE COURSE	**BIOPHYSICS AND INSTRUMENTTION**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To create general understanding about theoretical concepts of techniques used to detect and assay biomolecules.
- To familiarize the students with basic concepts and principles of biophysical and biochemical techniques used in biological sciences.
- To give holistic view for understanding the screening, isolation, separation and characterization of molecules

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Student will be scientifically equipped with understanding of the about the different biomolecules and their important functions.	L1
CO2	Student will be aware of the analytical tools and their instrumentation used in biotechnology/biological sciences.	L2
CO3	Students will have a basic understanding of biomedical equipments	L3
CO4	Students will be empowered for better prospects leading to project design and execution.	L2

COURSE CONTENT:

MODULE 1	**15Hrs**

Spectroscopy: Beer-Lambert's law, application and its limitations. Extinction coefficient, Principle, schematics and applications of Colorimeter and UV-Vis Spectroscopy.

Structural elucidation: CD, IR, NMR, x-ray Diffraction & their application in structural analysis of macro molecules, Mass spectroscopy (LC-MS and MALDI).

MODULE 2	**15Hrs**

Chromatography: Principle of Chromatography. Distribution/partition coefficient, Absorption and Adsorption phenomenon, Retention factor (Rf & Rt concepts). Types: Planar and columnar.
Paper and thin layer chromatography, types and their application in separation of biomolecules.
Types of matrices used, separation of biomolecules using gel permeation, ion exchange, affinity and adsorption chromatography with applications. Brief idea about High Performance Liquid Chromatography (HPLC) and Gas Chromatography (GC).

MODULE 3	15Hrs
Electrophoresis: Migration of ions in electric field, Factors affecting electrophoretic mobility. Paper electrophoresis, High voltage electrophoresis and their Applications. Principle, schematics and application of Agarose gel electrophoresis, SDS-PAGE, Isoelectric focusing (IEF) ,2D-PAGE and Capillary electrophoresis	
MODULE 4	**15Hrs**
Isotopic tracer techniques: Radioactive & stable isotopes, Pattern and rate of radioactive decay. Measurement of radioactivity: Geiger-Muller counter, Solid & Liquid scintillation counters (Basic principle, instrumentation & technique), Autoradiography their advantages and limitations. **Centrifugation:** Basic principles, RCF, Svedberg constant and Sedimentation coefficient. Preparative centrifugation: Differential & density gradient centrifugation, Applications. Analytical centrifugation: Determination of molecular weight of biomolecules.	

TEXT BOOKS/REFERANCES:

1. Principles and Techniques of Practical Biochemistry – Keith Wilson and John Walker. Cambridge low price edition.
2. Biophysical Chemistry – Upadhyay, Upadhyay and Nath. Himalaya Publications
3. Analytical Techniques in Biochemistry and Molecular biology – Katoch. Springer.
4. Fundamentals of Analytical Chemistry - Skoog, Holler and West. Saunders
5. Handbook of Analytical Techniques – Gunzler and Williams. Wiley & Sons
6. Immunology – Kuby. Freeman Publishers
7. A Textbook of Practical Biochemistry- Joshi and Saraswat. Jain Publishers.

EXPERIMENTS
1. pH metric titrations of HCl-NaOH / Acetic acid-NaOH.
2. Determination of pI of amino acid (glycine).
3. Determination of extinction coefficient using colorimetry.
4. Determination of lambda maximum of biomolecules using UV spectroscopy.
5. Estimation of pKa of amino acid (glycine).
6. Determination of density & viscosity of given unknown solution.
7. Separation of amino acid by Thin Layer Chromatography (TLC).
8. Column chromatography of phyto-pigments on adsorbent (silica/alumina).

TEXT BOOKS/ REFERENCES

1. Principles and Techniques of Practical Biochemistry – Keith Wilson and John Walker. Cambridge low price edition.
2. Biophysical Chemistry – Upadhyay, Upadhyay and Nath. Himalaya Publications.

SEMESTER	III					
YEAR	II					
COURSE CODE	22BS2302					
TITLE OF THE COURSE	**MOLECULAR BIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Understand the general principles of central dogma, DNA and RNA types structure and their role in cells.
• Explain the mechanisms of DNA replication, RNA synthesis and repair, various levels of gene expression, regulation and protein function.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	To demonstrate the fundamental understanding of central dogma of molecular biology	L1
CO2	To compile the steps involved in DNA replication and display experimental evidence that indicates that it is semi conservative in nature	L2
CO3	To demonstrate the fundamentals of steps involved in transcription and translation	L3

COURSE CONTENT:

MODULE 1	**15Hrs**
THE MOLECULAR BASIS OF LIFE Central dogma, DNA and RNA as genetic material – experimental proof. Evidences for DNA as the genetic material- Griffith's transformation experiment, Hershey and Chase experiment, evidence for RNA as the genetic material of viruses (TMV, Retroviruses). Nucleic acids: DNA structure and types (A, B and Z model), Denaturation and renaturation kinetics of DNA, Types of RNA – mRNA, tRNA and rRNA, mi RNA.	
MODULE 2	**15Hrs**
DNA REPLICATION AND ITS COMPONENTS Replication of DNA (Conservative, Dispersive and Semi Conservative DNA replication, Meselson and Stahl experiment), theta and rolling circle model of replication. Prokaryotic and Eukaryotic – Enzymes and proteins involved in replication. DNA repair.	
MODULE 3	**15Hrs**
DNA TRANSCRIPTION AND ITS COMPONENTS RNA polymerases, Mechanism of transcription – initiation, elongation and termination in prokaryotes and eukaryotes. Post-transcriptional modifications of Eukaryotic mRNA (Poly A tailing, 5' capping and splicing mechanisms)	

MODULE 4	15Hrs
TRANSLATION AND REGULATION OF GENE EXPRESSION Genetic code, wobble hypothesis, Mechanism of translation in prokaryotes and eukaryotes, Post translational modification of Proteins. Regulation of Gene expression in Prokaryotes – Operon concepts, induction, repression, attenuation, examples of Lac and Trp operons. Regulation of Gene expression in Eukaryotes –galactose metabolism in yeast.	

TEXT BOOKS/REFERANCES:

1. Cell & Molecular Biology by Gerald Karp, 3rd Edition, John Wiley & Sons (2009)
2. Molecular Biology of the Gene by James Watson et al, Pearson Education (2013)
3. Molecular Biology of the Cell, Bruce Alberts et al, Garland Science Publication (2007)
4. Principles of Biochemistry by Nelson and Cox, WH Freeman Publications (2008)
5. Textbook of Cell and Molecular Biology by Ajoy Paul, Books and Allied Ltd (2011).
6. Molecular Biology and Genetic Engineering by P K Gupta, Deep and Deep Publications (2008).
7. Cell Biology, Genetics, Molecular Biology, evolution and Ecology by PS Verma and VK Agarwal, S. Chand Publications (2006).

EXPERIMENTS
1. Extraction of DNA from plant/bacteria and animal sources (2 Units)
2. Separation of DNA on agarose gel electrophoresis, Visualization of DNA (2 units)
3. Quantification of DNA by spectrophotometry

TEXT BOOKS/ REFERENCES

1. Recombinant DNA: A Short Course by JD Watson, J. Tooze and DT Kurtz. Scientific American books. USA. 1983.
2. Biotechnology A Laboratory Course by Becker JM, Caldwell GA, Zachgo EA. Second edition. Elsevier. 1996.
3. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer 2011
4. Lab Maunal in Biochemistry, Immunology and Biotechnology by Arti Nigam and Archana Ayyagari. TATA McGraw Hill publishers,2008.

SEMESTER	III					
YEAR	II					
COURSE CODE	22BS2303					
TITLE OF THE COURSE	**EVOLUTIONARY GENETICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To make student understand the forces that have an impact on levels of genetic variations in natural and/or experimental populations for both qualitative and quantitative traits.
• To enable students to choose, apply and evaluate several methods for studying genetic variation in and between species.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	This course will be helpful to the students to conceptualize the existence of genetic variation and speciation.	L1
CO2	Students will be able to describe the basic mechanisms behind evolution of DNA sequences and gene structure	L2
CO3	Student will gain the ability to analyze and relate phenotype to genotype and potential factors influencing the interaction.	L3

COURSE CONTENT:	
MODULE 1	**15Hrs**
CLASSICAL EVOLUTIONARY GENETICS Darwinism, Neo Darwinism and Synthetic Theory. Evolution of Sexual Reproduction. Sex Ratio and Sex Determination. Competition Among Levels of Organization. Speciation and Phylogeny. Coalescent Theory. Drift versus selection in population. Kin and group Selection.	
MODULE 2	**15Hrs**
INHERITANCE OF QUANTITATIVE TRAITS Quantitative versus Qualitative traits. Gene and genotype frequencies, mating patterns, Hardy-Weinberg principle, heterozygotes, extension of H-W principle to multiple alleles, sex-linked alleles. Non-random mating, inbreeding and assortative mating, inbreeding coefficient. Factors that change allelic frequencies	
MODULE 3	**15Hrs**
GENETIC POLYMORPHISMS AMONG POPULATIONS Genetic polymorphism, transient and stable and factors responsible for stable polymorphism. DNA markers and populations differences. Application of population genetics. Role of population genetics in genetic counselling. Genetic origin and evolution of human races. Genetic Demography, age and gender specific	

death and birth rates, intrinsic rate of natural increase. Index of opportunity for natural selection.

MODULE 4	**15Hrs**

Molecular Evolution

Dating major evolutionary events. The Cambrian explosion and the K-T radiation. Aligning DNA and protein sequences. Selection at the molecular level: variations in substitution rates and their causes in nuclear, organellar, and viral DNA. Mechanisms of genomic evolution: Endosymbiosis and lateral gene transfer, Transposition and gene duplications, Domain shuffling and concerted evolution. Genetic assimilation and canalization in development.

TEXT BOOKS/REFERANCES:

1. D.B. Futuyma. Evolutionary Biology, Third Edition. Sinauer, 1997.
2. Hedrick P.W.(2011). Genetics of Populations. Jones and Bartlett Publishers, Massachusetts.
3. Jobling, M., Hollox, E., Hurles, M., Kivisild, T. and Tyler-Smith, C. (2013). Human Evolutionary Genetics. Garland Science.
4. RDM Page and LC Holmes. Molecular Evolution: A Phylogenetic Approach. Blackwell Science, 1998.
5. Relethford, J.H. (2012). Human Population Genetics. John Wiley & Sons.
6. Snusted, D.P., Simmons, M. J. (2010). Principles of Genetics. John Wiley & Sons, New York.
7. Knight, J.C. (2009). Human Genetic Diversity –Functional consequences for Health and Disease. Oxford University Press, USA.

EXPERIMENTS
1. Homology modelling
2. Construction of Phylogenetic trees: roots, nodes, clades etc.
3. Study of Quantitative inheritance in Kernel colour in Wheat/Skin colour in man.
4. Problem solving on: (a) Probability (b) multiple alleles (c) Gene interactions (d) Sex Linkage
5. Linkage mapping
6. Pedigree analysis

TEXT BOOKS/ REFERENCES

1. Brooker, R. J. 1999. Genetics: Analysis and Principles. Benjamin Cummings, Longman, INC.
2. D. Graur and W-H Li. *Fundamentals of Molecular Evolution*. Sinauer, 1999.
3. RDM Page and LC Holmes. *Molecular Evolution: A Phylogenetic Approach.* Blackwell Science, 1998.
4. Nielsen, R. and Slatkin, M. (2013). An Introduction to Population Genetics: Theory and Applications. Sinauer Associates, Inc.

SEMESTER	III					
YEAR	II					
COURSE CODE	22BS2304					
TITLE OF THE COURSE	**CHEMISTRY II**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**45**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To study the basic types of bonding, various theories of chemical bonding and chemical bonds in molecules.
• To make students understand about the liquid state of matter, different properties of liquids, laws governing liquids and colligative properties and their applications.
• To impart knowledge to understand basic concepts of organic chemistry starting from nomenclature to types of organic reactions.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will get in basic knowledge about types of chemical bonding and chemical bonding in molecules.	L1
CO2	Enable to understand in depth knowledge about chemical bonding and various theories related to that.	L2
CO3	Students will learn about the basic principles of organic chemistry	L3
CO4	Students will be equipped with fundamental knowledge of liquid state of matter.	L2

COURSE CONTENT:

MODULE 1	**10 Hrs**

CHEMICAL BONDS – I

Introduction: Need for the atoms to form molecules, and types of chemical bonds with examples IonicBond: Definition and conditions for formation of an ionic bond between atoms, examples of formation of an ionic compound between alkali metal/alkaline earth metals. Lattice energy, its effect on stability and solubility of ionic solids, Born – Haber cycle for NaCl and MgO. Covalent Bond: Definition, octet rule, Lewis dot formulae of a few simple molecules and ions, electron deficient and excess molecules ($BeCl_2$, BF_3, PCl_5, SF_6). Geometry of covalent molecules: (VSEPR concept and hybridisation concepts) basic concepts and definitions: Examples simple inorganic molecules and ions such as NH_3, H_2O, H_3O^+, SF_4.

MODULE 2	**11 Hrs**

CHEMICAL BONDS – II

Theories of covalent bonds (VBT and MOT): Valence bond theory (VBT): postulates and its limitations, directional characteristics of covalent bonds, Application of VBT to $BeCl_2$, BF_3, $SiCl_4$, PCl_5, SF_6 molecules. Molecular orbital theory: postulates, linear combination of atomic orbitals (LCAO), bonding, nonbonding and antibonding molecular orbitals, pictorial representation of formation of s and p MOs from the corresponding atomic orbitals, Molecular orbital energy level diagram and molecular orbital configuration involving s and p orbitals their importance for the following molecules, (H_2, N_2, O_2, HF and CO). Metallic Bond: Definition, properties of metals and band theory. Weak Intermolecular interactions: van der walls forces, dipole-dipole interactions and their significance. Hydrogen Bond: Definition, types, importance.

MODULE 3	**12 Hrs**

GASEOUS STATE

Gaseous state - Elementary aspects of kinetic theory of gases, Ideal and real gases – deviation from ideal behavior- Van der waals equation for real gases, causes of deviation from ideal behavior, Need for Maxwell-Boltzmann distribution law, mathematical expression for both based on this law (no derivation). Mean free path, collision frequency and collision number. Expressions for most probable velocity, rms velocity and average velocity, relationships between them, problems.

Critical phenomenon - Andrew's isotherm on carbon dioxide and explanation of the curves (no experimental details). Explanation of velocity distribution curves. Derivation of critical constants Tc, Pc and Vc from van der Waal's equation and their experimental determination by Cagniard de La Tour method for Tc and Pc. Amagats mean density method for Vc. Problems on the calculation of Tc, Pc and Vc, a and b. Law of corresponding states - statements, reduced equation of state and explanation, Joule-Thomson effect-explanation. Inversion temperature-definition (no derivation).The application of Joule-Thomson effect to the liquefaction of air and hydrogen by Linde's process.

MODULE 4	**12 Hrs**

LIQUIDS AND SOLUTIONS

Properties of liquids-Viscosity, Surface tension and Parachor-Definition, mathematical expression, numerical problems and factors affecting them. Viscosity- Definition, mathematical expression, Coefficient of viscosity, effect of temperature, size, weight, shape of molecules and intermolecular forces on it. Surface Tension-Definition, mathematical expression, effect of temperature and solute on it Parachor-Definition, Sugen equation, calculation and applications. Numerical problems. Liquid Mixture: Review of Raoult's law, ideal and non-ideal solutions. Completely miscible liquids- Fractional distillation Tc curves for all the three types, azeotropic mixtures - examples. Completely miscible liquids-Critical solution temperature (Three types), examples. Effect of addition of salt on CST of phenol-water system. Immiscible liquids, Steam distillation and its applications. Distribution law-Statement, partition coefficient and condition for validity of distribution law. Application-solvent extraction. Dilute solutions- Review of colligative properties and concentration terms. Determination of molecular mass of a solute by: (i) Berkeley- Hartley method(ii) Beckmanns method Tf) and (iii) Landsberger's method. Numerical problems.

TEXT BOOKS/REFERANCES:

1. Vogel's Text Book of Practical Organic Chemistry, 5th Edition, A.J. Hannford, A.R.Tatchell, B.S. Hurnis, P.W.G. Smith, Pearson Publication.
2. Enhancing undergraduate chemistry laboratories, J. Carndoff, N. Reid, RS. C.Publication.
3. Experimental Organic Chemistry Laboratory Manual, J.I. Garcia, J.A. Dobado, G.Fransicisco, Elsevier Publication.
4. Chemistry Practical Inorganic Qualitaive Analysis For Under Graduate Students, M.J. Mamtora, S.C. Karad, J.S. Makasana, Lap Lambert Academic Publishing.
5. Advanced Practical Chemistry, K. Chelladurai, K. Subbian, Lap Lambert Academic Publishing.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**22BS2305**					
TITLE OF THE COURSE	**COMPUTER APPLICATIONS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Graduates of the program will possess strong fundamental concepts in mathematics, science, and technology to address technological challenges
• Acquire an attitude and aptitude for research, entrepreneurship and higher studies in the field of Computer Science and information technology.

COURSE OUTCOME:		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	To analyze, design and implement multifaceted biological problems of any domain with innovative and efficient approaches	L2
CO2	Attain better communication, presentation, time management and team work skills leading to responsible & competent professionals	L2

COURSE CONTENT:	
MODULE 1	**15 Hrs**
CATEGORIES OF COMPUTERS AND OPERATING SYSTEMS Evolution, Generations of computers (I, II, III,IV, V) Classification of computers, Input and output devices, Storage devices: Hard disk, Diskette, Magnetic tape, RAID, ZIP, devices, Digital tape, CD-ROM, DVD (capacity and access time), Main Circuit Board of a PC: Chips, Ports, Expansion. The Minicomputer, Mainframe Computers, Parallel processing Computer & the Super Computer, Operating System concepts, Windows 98/XP and later versions, Windows server NT/2000, Unix/Linux & servers. Introduction to networking: various terminologies, Associated hardware devices, gadgets (Router, Switch) tools, services, and resources, Network Topologies and Protocols, LAN, WAN and MAN World Wide Web (WWW) Network security: fire walls.	
MODULE 2	**15 Hrs**
INTERNET, VIRUSES AND PROGRAMMING CONCEPTS Introduction, Office Automation Software (Open Source Software). What is a virus? Virus symptoms, How do they get transmitted? What are the dangers? General Precautions, Search engines: Google, Yahoo, Concepts in text-based searching, searching Medline, PubMed, bibliographic databases. Algorithms, Flowcharts, Algorithms: Concepts & definitions, converting algorithms to flowchart; Coding: flowcharts to programs, Comparing algorithms, flowcharts & programs.	

TEXT BOOKS/ REFERENCES

1. Computer Fundamentals, 4th edition (2004) P.K. Sinha, BPB publication, India
2. Computer Networks. 4th edition (2008). Tanenbaum. Pearson Education, India
3. Biostatistics: P.N.Arora ,P.K.Malha.
4. Introduction to Database Management Systems, 1st edition, (2004), Atul Kahate, Pearson education, India.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**22BS2306**					
TITLE OF THE COURSE	**CONSTITUTION OF INDIA**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**0**	**0**	**0**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Define a constitution
• Describe the salient features of the Indian Constitution
• Explain different ways of acquiring Indian Citizenship
• List the Fundamental Rights and Fundamental Duties of Indian citizens
• Describe the Directive Principles of State Policy and their significance

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will appreciate the fundamental law of the land	L1
CO2	Students will be aware of what kind of government the country will have.	L1
CO3	Aid in understanding what lays down the rules to govern the country	L2
CO4	It also tells about the rights and also the duties of its citizens	L1

COURSE CONTENT:	
MODULE 1	**6 Hrs**
Framing of the Indian Constitution: Role of the Constituent Assembly. Philosophy of the Constitution: Objectives, resolution, preamble, fundamental Rights and Duties. Human rights and Environmental protection.	
MODULE 2	**6 Hrs**
Special Rights created in the Constitution of Dalits, Backward Classes, Women and Children, and religious and linguistic minorities. Directive Principles of State policy: The need to balance fundamental rights with directive principles.	
MODULE 3	**6 Hrs**
Union Executive: President, Prime Minister and Council of Ministers; powers and functions, coalition Government, problems in their working. Union Legislature: Lok Sabha and Rajya Sabha, powers and functions. Recent trends in their functioning.	

MODULE 4	6 Hrs
State Government: Governor, Chief Minister and Council of ministers, Legislature. Centre – State relations: Political, financial, administrative: Recent Trends.	
MODULE 5	**6 Hrs**
Judiciary: Supreme Court, Judicial Review, Writs, Public interest litigations. Enforcing rights through writs. Emergency provisions (Article 356)	

TEXT BOOKS/ REFERENCES

1. Computer Fundamentals, 4th edition (2004) P.K. Sinha, BPB publication, India
2. Computer Networks. 4th edition (2008). Tanenbaum. Pearson Education, India
3. Biostatistics: P.N.Arora ,P.K.Malha.
4. Introduction to Database Management Systems, 1st edition, (2004), Atul Kahate, Pearson education, India.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22BY2401**					
TITLE OF THE COURSE	**HUMAN ANATOMY AND PATHOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Pre-requisite Courses (if any)

#	Sem/Year	Course Code	Title of the Course
-	I	22BS1101	Essentials of Biochemistry

COURSE OBJECTIVES:

- Students will be able to understand different types of cells and tissues of organs in human system
- Comprehensively able to understand the cellular organization, barriers, targets and functions of different cells and tissues and their pathology

COURSE OUTCOME

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will be able to demonstrate the different cellular and tissue organization of different organ system	L1
CO2	Will be able to explain the functions of different cell types their abnormalities in different organ systems	L2
CO3	Students will be able understand and interpret the cellular abnormalities from the diagnostic data	L3

COURSE CONTENT:

MODULE 1:	**15Hrs**
Scope of anatomy and physiology; levels of structural organization and body systems; Term used in Gross Anatomy; Classification and Types of tissues: Structure, location and functions of epithelial, muscular, nervous and connective tissues; General principles of cell communication; Integumentary system: Structure and functions of skin; Superficial Fascia: Distribution of fat and functions.	
MODULE 2 :	**15Hrs**
Bones: Definition, Classification and functions of bone; Parts, types of epiphyses, Ossification, Blood supply of long bone; Cartilage – Definition, types, structure, distribution, nutrition. **Joints:** Classification, synovial joints, Blood supply & nerve supply. **Muscular system:** Functional classification, Prime movers, Fixators, Antagonists, Synergists.	
MODULE 3:	**15Hrs**
Central Vein System: Classification and structure of blood vessels; **Lymphatic system:** structureand functions of lymph vessels, lymphoid tissue; **Nervous system:** Classification of nervous system, Cell in the nervous system, Structure of a neuron, Structure of a typical spinal nerve.	

Histology of organs: Tongue, Stomach, Liver and Kidney, and Brain

MODULE 4:	15Hrs
Injury and infection; Apoptosis, autophagy and necrosis; Introduction to systemic diseases- Heart diseases, Hemostasis and Thrombosis, Stroke, Diabetes mellitus, Multiple sclerosis, , Immunohistochemistry of tissues.	

TEXTBOOKS/ REFERENCES:

1. BD Chaurasia's Human , 8th Edition, 2019.
2. Anatomy & Physiology For Dummies, Erin Odya, 2002
3. Paramedical Hand Book on Anatomy, Physiology and Biochemistry, P Arun Jyoti, Arya Bhushan, Venugopal, , 2nd Edition, 2016.
4. Human Anatomy and Physiology, Rahul Phate, 2008,
5. Medical Immunology made memorable, 2nd Ed., John H. L. Playfair and P.M. Lydyard, Churchill Livingstone Publications, 2000.
6. Anatomy Histology and Cell Biology by Klein, 4th Edition, 2010.

HUMAN ANATOMY AND PATHOLOGY -PRACTICALS
1. Preparation of the slides for immune-histochemistry.
2. Histology of Tongue and Liver.
3. Histology of Kidney and Stomach.
4. Staining/Localization of biomarkers or the target molecules in the tissues.

REFERENCES:

1. Textbook Of Practical Physiology (5Th Edn), Balakrishna Shetty, H Sweekritha Poonja, 2018.
2. Practical Manual of Histology, 2nd Edition, by Hina Sharma.

SEMESTER	**IV**
YEAR	**II**
COURSE CODE	**22BY2402**
TITLE OF THE COURSE	**METABOLISM- I**

SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	I	22BS1101	Essentials of Biochemistry

COURSE OBJECTIVES:

- To understand the metabolic pathways of bio-molecules of the system.
- To create an understanding of structural and functional defects associated with metabolic pathways.

COURSE OUTCOMES

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Students should identify the various rate determining steps in metabolism.	L1
CO2	Students should be able to interconnect and compare the carbohydrate and lipid metabolic pathway	L2
CO3	Students should be able to understand various diseases associated with metabolic pathways	L3

COURSE CONTENT:

MODULE I: Carbohydrate metabolism	**15Hrs**
Introduction to metabolism (anabolic, catabolic, amphibolic, and intermediary metabolism). Glycolytic pathway; energetics and regulation, aerobic and anaerobic fates of pyruvate, Cori cycle, entry of sugars other than glucose into metabolism, Gluconeogenesis, reciprocal regulation, Pyruvatedehydrogenase complex, TCA cycle: amphibolic nature and regulation, anapleurotic reaction, substrate cycle, pentose phosphate pathway, Degradation, synthesis, and regulation of glycogen. Regulation of blood glucose level by organs and hormones, Diabetes mellitus, carbohydrate metabolic disorders (glycogen storage disorders).	
MODULE 2: Bioenergetics	**15Hrs**
Reduction Potential, Biological redox couplers, Mitochondrial electron transfer system- Sequence and structure of electron carriers. Proton motive force and the Mitchell hypothesis. F0F1-	

ATPase- structure and mechanism, Coupling of electron transfer to ATP synthesis. Mechanism of oxidative phosphorylation. P/O ratios and their use in localization of sites of ATP synthesis along the chain. Uncouplers, inhibitors and ionophores. Microsomal electron transport. Proton motive force in Halobacteria, H+ pumping by bacteriorhodopsin.	
MODULE 3: Lipid metabolism	**15Hrs**
Basic scheme of fat absorption, mobility, degradation and synthesis; Degradation of triacylglycerol and phospholipids- lipases and phospholipases. Fatty acid oxidation- even, odd and unsaturated fattyacids by β-oxidation, scheme and energetics of β-oxidation, peroxisomal β-oxidation, branched chain fatty acids by α-oxidation, medium chain fatty acids by ω-oxidation. Metabolism of ketone bodies with physiological significance, Fatty acid biosynthesis - FAS- multi functional enzyme, chain elongation and desaturation. Biosynthesis of triacylglycerol, phospholipids and sphingolipids, sphingolipid storage disorders**.**	
MODULE 4: Cholesterol and Circulating lipids	**15Hrs**
Cholesterol structure, brief idea of synthesis from acetyl CoA, regulation through HMG CoAreductase and utilization as hormones and bile salts, normal and abnormal levels in the body; Insoluble lipid mobilization by lipoproteins- chylomicrons, HDL, LDL, and VLDL – composition, markers and metabolic fate; Receptor mediated endocytosis of LDL. Regulation of cholesterol metabolism (brief introduction to Non steroidal anti-inflammatory drugs (NSAIDs); Biochemistry of obesity, atherosclerosis and hypercholesterolemia.	

TEXTBOOKS/REFERENCES

1. Biochemistry- Voet, Donald; Voet, Judith G. 3rd Edn, John Wiley and Sons; New York, 2004.
2. Lehninger- Principles of Biochemistry; D L Nelson and M M Cox (Eds), 6th Edn, MacmillanPublications, 2012.
3. Biochemistry- Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. 6th edition, W.H. Freeman, NewYork, 2007.
4. Textbook of Biochemistry with Clinical Corelations – Thomas M. Devlin. 7th edition, John Wiley& Sons, 2010.
5. Biochemistry of Foods - N A Michael Eskin, Fereidoon Shahidi. 3rd edition, Elsevier, 2012.
6. Biochemistry and Molecular Biology - D. Papachristodoulou, A. Snape, W.H. Elliott, and D. C.Elliott. 5th edition, Oxford University Press, 2014.
7. Harpers Illustrated Biochemistry - V.W. Rodwell , D. Bender , K.M. Botham , P. J. Kennelly, P. A.Weil. 30th edition, McGraw-Hill Education, New York, 2015.

Metabolism- I PRACTICALS
1.Estimation of reducing sugar by DNS method / Miller's method.
2.Estimation of serum cholesterol by Zak's method.
3. Estimation of DNA by Diphenylamine Method.
4.Estimation of haemoglobin by SAHLI'S/ acid hematin method.
5. Identification of lipids by Thin layer chromatography.

REFERENCES:

1. Essentials of Practical Biochemistry, Prem Prakash Gupta, Neelu Gupta, 10.5005/jp/books/12972, 2017.
2. A textbook of practical Biochemistry, Joshi and Saraswat, Jain Publishers, New Delhi 2002

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22BY2403**					
TITLE OF THE COURSE	**NUTRITION**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	I	22BS1101	Essentials of Biochemistry

COURSE OBJECTIVES:

- To create an understanding about importance and nutrition value of biomolecules.
- To understand the structural and functional defects due to insufficient/excess nutrients.

COURSE OUTCOMES

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Students should be able to demonstrate the composition and structure of various biomolecules in the living systems	L1
CO2	Students should be able to understand macronutrients and micronutrients of food	L2
CO3	Students should be able to demonstrate the abnormal conditions associated with little/excess of bio-molecules.	L3

COURSE CONTENT:

MODULE 1:	**08 Hrs**

Carbohydrates: Occurrence and physiological functions, factors influencing metabolism. Lactose intolerance. Dental caries. Artificial sweeteners. Role of dietary fiber in health and disease. Disorders related to carbohydrate metabolism. Glycemic index of foods and its uses.

Lipids: Concepts of visible and invisible fats. EFA, SFA, MUFA, PUFA- sources and physiological functions. Role of lipoproteins and cholesterol, triglycerides in health and disease.

Proteins: Concepts of essential and non-essential amino acids- their role in growth and development. Physiological functions of proteins. Requirements, nitrogen balance concept. Protein efficiency ratio. Methods for evaluating protein quality. Protein energy malnutrition -clinical features and biochemical changes.

MODULE 2:	**08 Hrs**

Macro-minerals: Calcium, Phosphorus Magnesium, Sodium, Cobalt, Potassium, Chloride. **Micro minerals:** Iron, Zinc, copper, selenium, chromium, iodine, manganese, Molybdenum and fluoride. T**race minerals:** Arsenic, Boron, Nickel, Silicon, Vanadium & cobalt: Digestion & absorption, Functions, Toxicity, interaction with other nutrients. RDA and food sources. **Vitamins and Energy metabolism:** Fat soluble vitamins: RDA. Vitamin- A, vitamin- D, E & K. Water soluble vitamins: Vitamin-C, Thiamine, Riboflavin, Niacin, Pantothenic acid, Biotin, Folic acid, Vitamin-B12, Vitamin-B6 (Digestion, absorption and transport and excretion, functions, interaction with other nutrients (if any), Deficiency and toxicity, major sources, Assessment of nutritive value and analysis in food material.	
MODULE 3:	**10 Hrs**
Energy metabolism: Basal and resting metabolism- influencing factors. Methods to determine energy requirements & expenditure. Thermogenesis, adaptation to altered energy intake, latestconcepts in energy requirements and recommendations for different age groups. BMR and methods of BMR determination. Factors affecting BMR. Energy requirements for different physical activities. Specific dynamic action (SDA) of food. Regulation of food intake: role of hunger and satiety centers, effect of nutrients. Basis for computing nutrient requirements: latest concepts in dietary recommendations, RDAICMR and WHO: their uses and limitations.	
MODULE 4:	**04 Hrs**
Nutrition in various age groups: Physiological adjustments, Nutritional requirements, Effect of malnutrition, and special needs and nutritional problems in Pregnancy, Lactation, infancy, preschool, adolescent, young adults and elderly adults.	

REFERENCES:

1. Biochemistry - Donald Voet & Judith G. Voet. John Wiley & Sons, Inc, 2010.
2. Lehninger - Principles of Biochemistry - D. L. Nelson and M. M. Cox. 6th Edn, MacMillan Publications, 2012.
3. Nutrition: Science and Applications. Lori A. Smolin, Mary B. Grosvenor, 3rd Edn, Wiley, 2013.
4. Introduction to Human Nutrition- Michael J. Gibney, Susan A. Lanham-New, Aedin Cassidy, Hester
   H. Vorster, Wiley-Blackwell. 2nd Edn John Wiley & Sons.. 2009.
5. Nutrition: Everyday Choices - Mary B. Grosvenor, Lori A. Smolin. 1st Edition, Wiley, 2006.
6. Bioactive Food as Dietary Interventions for Liver and Gastrointestinal Disease- Watson, Elseveir,2012.
7. Nutrition and Metabolism- Lanham S, Mac Donald I and Roche H. 2nd Edn, The Nutrition Society,London, UK, 2012.
8. Introduction to Human Nutrition-Gibney M, Lanham S, Cassidy A and Vorster H. 2nd Edn., TheNutrition Society, London, UK, 2012.
9. Public Health Nutrition- Gibney M, Margetts B, Kearney J and Arab L. The Nutrition Society,London, UK, 2012.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22BS2401**					
TITLE OF THE COURSE	**BIOSAFETY AND GOOD LABORATORY PRACTICE**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	**Sem/Year**	**Course Code**	**Title of the Course**
-	-	-	-

COURSE OBJECTIVES:

- To introduce the students to the concepts of biosafety regulatory frameworks concerning genetically modified organisms at national and international levels.
- To impart knowledge of the principles of GLP and their practical applications.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Gain knowledge of the various safety procedures to be followed in laboratory.	L2
CO2	Gain the skills and knowledge necessary to understand and work in GLP compliant environment.	L2
CO3	This course should generate interest for avenues for pursuing higher studies and careers in these areas	L2

MODULE I – BIOSAFETY	**18 Hrs**
Introduction, Historical Background; risk assessment and lab acquired infections, Introduction to Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms. Recommended Biosafety Levels for Infectious Agents and Infected Animals. Biosafety Guidelines: Biosafety guidelines and regulations (National and International); Definition of GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Recombinant DNA Guidelines (1990); Rules for the manufacture, use/import/export and storage of hazardous microorganisms/ genetically engineered organisms or cells (Ministry of Environment and Forests Notification,1989); Environmental release of GMOs; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.	

MODULE II – GOOD LABORATORY PRACTICE	**12 Hrs**
Introduction to GLP, WHO guidelines on GLP, History, Scope (Resources Characterization, Rules, Results, Quality assurance); Levels of Laboratories; General Rules/Protocols for Lab Safety measures; Precaution and Safety in handling of chemicals, Laboratory tools, glasswares and instruments; Sample storage and disposal; Log Book maintenance, Basic SOPs for instrument handling and Maintenance. Keeping data records, its analysis by using statistical and mathematical tools. Result analysis and its interpretation.GLP as given by OECD, FDA etc (International perspective); Internal and External Audits.	

TEXTBOOKS/REFERENCES:

1. Handbook Good Laboratory Practices-World health organization(WHO)
2. Life science protocol manual (2018)-DBT star college scheme
3. Guidelines for good laboratory practices-Indian council of medical research, NewDelhi (2008)
4. Handbook: Good Laboratory Practices (GLP): quality practices for regulated non-clinicalresearch and development-2nd ed.

SEMESTER	**V**					
YEAR	**III**					
COURSECODE	**22BY3501**					
TITLEOFTHECOURSE	**HUMAN PHYSIOLOGY**					
SCHEME OFINSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Pre-requisite Courses (if any)			
#	Sem/Year	CourseCode	Title of the Course
-	**IV/ II**	**22BY2401**	**HUMAN ANATOMY & PATHOLOGY**

COURSEOBJECTIVES:

- To demonstrate an understanding of the physiology and basic regulatory concepts related to the functioning of life processes

COURSE OUTCOMES:

CO No.	OUTCOMES	Bloom'sTaxonomyLevel
CO1	Will be able to demonstrate an understanding of the physiology and basic regulatory concepts of the organ systems associated with this course and the mechanisms that allow the body to carry out those functions, and predict how a perturbation (e.g., disease, experimental manipulation)will alter function.	L2
CO2	The student will be able to explain homeostasis and explain how homeostatic mechanisms normally maintain a constant interior milieu inside human body	L3

COURSECONTENT:

MODULE 1 — **18Hrs**

Hematology: Blood components and their functions, Formation, and function of blood cells- red blood cells, white blood cells, platelets. Hemostasis and blood clotting: factors affecting blood clotting, role of vitamin K in clotting, hemostatic control mechanisms, Disorders of clotting, Blood groups: the ABO system. role of hemoglobin in oxygen transport. Various buffer systems of the blood, acid base balance, factors affecting acid-base balance.

Skeletal System: Extracellular matrix and its components, Bone-ultrastructure, composition, cells: osteoblasts, osteocytes, and osteoclasts. Bone growth, remodeling, and regulation by hormones.

Muscular System: Overview of muscular tissue; types, functions & properties. Contractile and regulatory proteins ofmuscle structure of actin and myosin. Mechanism of muscle contraction, Contraction, and relaxation of skeletal muscle fibers- sliding filament model; Neuromuscular junction; Muscle metabolism

MODULE 2 — **15 Hrs**

Respiratory System: Components of respiratory system and their functions. Pulmonary ventilation, Lung volumes and capacities, Bohr and Haldane effect, chloride shift; effect of 2, 3- BPG on 02 affinity of Hb; Clinical importance of 2, 3 BPG. Respiratory center. Respiratory Acidosis and Alkalosis. Dyspnoea, Asphyxia, Cyanosis, Decompression sickness, artificial respiratory methods.

Cardiovascular System: Systemic and pulmonary circulations, coronary circulation, Basic understanding of Cardiac cycle. Cardiac output, ECG - its principle and significance. Structure and function of blood vessels. Blood pressure and its regulation Role of the cardiovascular center. Brief outline of cardiovascular disorder (hypertension, arteriosclerosis, myocardial infarction, and congestive heart failure.	
MODULE 3	**12 Hrs**
Digestive System: GIT and accessory organs, Composition, function, and regulation of saliva, gastric, pancreatic, intestinal and bile secretions, Mechanism of breakdown and absorption of carbohydrates, lipids, and proteins. **Renal Physiology:** Structure of nephron, mechanism of urine formation: Glomerular filtration, Tubular re-absorption & Active secretion, Fluid, electrolyte, and Acid-Base homeostasis, Kidney hormones.	
MODULE 4	**15 Hrs**
Endocrine System: Introduction to endocrinology, classification,and mechanism of action of hormones. Glands - Pituitary, Adrenal, Pancreas &Thyroid; hormones - action, regulation, tests, and disorders. Control of calcium metabolism byparathyroid hormone, calcitonin, and vitamin D. **Nervous System:** Organization of nervous system - CNS, PNS. ANS, somatic nervous system; autonomic nervous system-sympathetic and parasympathetic system; enteric nervous system, structure and function of neuron and glial cells, Synapse, generation of action potential, function of voltage-dependent and neurotransmitter-gated ion channels; the role of these ion channels in synaptic transmission, synaptic modification, and neuromodulation; neurotransmitters: glutamate, acetylcholine, glycine, dopamine & serotonin.	

TEXTBOOKS/REFERENCES:

1. Guyton and Hall Textbook of Medical Physiology - J. E. Hall, 12th Ed. 5aunders Elsevier.2010.
2. Biochemistry - Donald Voet & Judith G. Voet. 4th Ed., John Wiley & Sons, Inc. 2010.
3. Textbook of Biochemistry with Clinical Corelations - Thomas M. Devlin. 7th edition, JohnWiley & Sons, 2010.
4. Lehninger - Principles of Biochemistry - DL Nelson and M Ni Cox. 6th Ed, MacmillanPublications, 2012.
5. Molecular Cell Biology - Harvey Lodish, David Baltimore and Arnold Berk, Scientific American Publication, 2000.
6. Molecular biology of the cell - Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., andWalter, P. 4th ed. Garland Science, New York, 2002.
7. Harper's Review of Biochemistry - Murray, Robert K. Mayes, Peter A. Rodwell, Victor W. Granner, Daryl K. McGraw-Hill Medical, 2006.
8. Cellular Physiology of Nerve and Muscle - Gary G Mathew. 4th Edition. Wiley-Blackwell2002.
9. Ganong's review of medical physiology - Kim E. Barrett, William F. Ganong. 24th ed. McGraw-Hill Medical ; McGraw-Hill [distributor], New York, London, 2012.
10. Human Biochemistry - James M. Orten, Otto Wilhelm Neuhaus. 9th edition, C. V. Mosby,1995.
11. Principles of Biochemistry: Mammalian Biochemistry - Emil S. Smith, McGraw-Hill; Subsequent edition, 1982.
12. Principles of Human Physiology - Cindy L. 4th Ed. Stanfield Pearson, 2010.

Human Physiology - Practicals
1. Determination of pulse rate and blood pressure under resting condition and the effect of exercise on it.
2. Determination of bleeding time and clotting time.
3. Urine analysis (Qualitative analysis and abnormal constituents).
4. Titratable acidity of urine
5. Estimation of Inorganic phosphate by Fiske Subbarow method.

TEXT BOOKS/ REFERENCES

1. Practical Clinical Biochemistry - Harold Varley. 4th edn., CBS Publishers, 2018.
2. Practical Clinical Biochemistry: Methods and Interpretation - Ranjna Chawla. Jaypee Brothers Medical Publishers, 2016.
3. Practical and Clinical Biochemistry for Medical Students - T.N. Pattabhiraman. Gajanna Publishers, 2014.
4. Hawk's Physiological Chemistry – Oser. 14th Edn, Tata-McGrawHill, 2006.
5. Biochemistry – Plummer., Tata-McGraw Hill, 2017.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BY3502**					
TITLE OF THE COURSE	**METABOLISM- II**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	I	22BS1101	Essentials of Biochemistry

COURSE OBJECTIVES:
• To understand the importance of amino acid and nucleotide metabolism in the living systems.
• To understand the diseases associated with defects in the metabolic process.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students should be able to identify the metabolic, enzyme-assisted reactions of nitrogen bases and fat to fuel living systems.	L1
CO2	Students should be able to demonstrate the role of lipids play in energy storage and usage.	L2
CO3	Students should be able to integrate and assess the complete metabolic processes in living systems particularly human beings.	L3

COURSE CONTENT:	
MODULE 1: AMINO ACIDS AND PEPTIDES	**15hrs**
General metabolic reaction of amino acids– transamination, deamination, oxidative and nonoxidative deamination, glucose – alanine cycle. Urea cycle– regulation and metabolicdisorders. Biosynthesis of creatine and creatine phosphate, polyamines, glutathione, physiologically active amines (serotonin and α – histamine) and catecholamines (dopamine, epinephrine and norepinephrine). Role of RER and Golgi complex in the synthesis of glycoproteins and GPI anchored proteins. Biogenic amines – polyamines. Bioactive peptides – Bradykinin, angiotensin, oxytocin and vasopressin.	
MODULE 2: METABOLISM OF STANDARD AMINO ACIDS	**15Hrs**
Regulation of amino acid and purine/pyrimidine levels by Glutamine Synthetase. Biosynthesis and degradation of twenty standard amino acids – A, G, T, S, C, E, N, D, Q, R, H, P, V, I, M, L, K, W, F& Y.	

MODULE 3: NUCLEOTIDE METABOLISM	**15 Hrs**
Nitrogen Cycle, nitrogen fixation, nif genes. Structure of nucleoside and nucleotide; Synthesis of purine and pyrimidine nucleotides – the de novo and the salvage pathway and their regulation. Degradation of purine and pyrimidines, DNA and RNA degradation. Heme Metabolism:Biosynthesis and degradation of porphyrin and their regulation.	
MODULE 4: NITROGEN METABOLIC DISORDERS	**15 Hrs**
Disorders associated with amino acid metabolism. Disorders associated with Nucleotide metabolism, degradation: gout, Lesch-Nyhan syndrome, oroticaciduria, and xanthinuria. Disorders related to heme metabolism (porphyrias, jaundice and Hemoglobinopathies).	

REFERENCES

1. Principles of Biochemistry – Lehninger, 6th Edn. W.H. Freeman and Company, New York, 2013
2. Principles of Biochemistry – Zubay, Parson and Vance. 1st Edn., Brown (William C.) Co ,U.S., 1995
3. Biochemistry – Voet and Voet. 4th Edn., Wiley & Sons, 2011.
4. Textbook of Biochemistry with clinical correlations - Devlin, John Wiley & Sons, 7th Ed, 2010.

Metabolism_II- PRACTICALS
1.Estimation of serum bilirubin.
2.Determination of ratio of albumin and globulin in serum.
3.Estimation of uric acid/urea in serum.
4.Estimation of SGPT/SGOT by DNPH method.
5. Estimation of creatinine by Jaffe's method.

REFERENCES:

1. Essentials of Practical Biochemistry, Prem Prakash Gupta, Neelu Gupta, 10.5005/jp/books/12972, 2017.
2. A textbook of practical Biochemistry, Joshi and Saraswat, Jain Publishers, New Delhi 2002

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BS3501**					
TITLE OF THE COURSE	**BIOETHICS AND IPR**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	**Sem/Year**	**Course Code**	**Title of the Course**
-	**-**	**-**	**-**

COURSE OBJECTIVES:

- To recognize, compare, and contrast the general "ways of thinking" of science (biology) and of philosophy (ethics).
- To recognize, compare, and contrast the general "ways of thinking" of science (biology) and of philosophy (ethics).
- To give elementary essential concepts of Bioethics, IPR and patent laws.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Student should develop basic understanding of the concepts of Bioethics, IPR and Patent Laws	L2
CO2	This course should generate interest for avenues for pursuing higher studies and careers in these areas	L2
CO3	General knowledge should create awareness necessary for higher studies in biotechnological fields	L2

COURSE CONTENT:	
MODULE 1: BIOETHICS	**15 Hrs**
Bioethics- The environmental, legal and socioeconomic impacts of biotechnology; Ethical concerns of biotechnology in research and innovation-The GM crop debate – safety, ethics, perception and acceptanceof GM crops; Bioethics of Genetically modified organism; Bioethics of CRISPR technique- for editing human embryos; Bioethics of Gene therapy; Bioethics of Stem cell research; Reproductive medicine and ethics; Use of Animals in Research and Testing, and Alternatives for Animals in Research, Animal Cloning, Human Cloning, and their Ethical Aspects; Public education of the process of biotechnology involved in generating new forms of life for informed decision-making.	
MODULE 2: INTELLECTUAL PROPERTY RIGHTS AND REGULATIONS	**15 Hrs**
Introduction to Intellectual Property and History. Patents, Trademarks, Copyright, Trade secrets, Industrial Design and Rights, Traditional Knowledge, Geographical Indications - importance of IPR – patentable and non-patentable – patenting life – legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO), Pros and Cons of IP protection. Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner. Agreements and Treaties: GATT, TRIPS Agreements; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.	

TEXTBOOKS/REFERENCES:

1. Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBHPublishing Co. New Delhi.
2. Ganguli Prabuddha Gearing up for Patents. The Indian Scenario" , Universities Press (1998)
3. Introduction to Plant Biotechnology, H S Chawla
4. M K Sateesh. Bioethics and Biosafety. Kindle Edition
5. Shomini Parashar, Deepa Goel IPR, Biosafety and Bioethics Pearson India, 2013
6. F. H. Erbisch and K. M. Maredia. Intellectual property rights in agricultural Biotechnology,University Press, 2004.

SEMESTER	**V**
YEAR	**III**
COURSECODE	**22BS3502**
TITLEOFTHECOURSE	**BIONFORMATICS**

SCHEME OFINSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisiteCourses(if any)			
#	Sem/Year	CourseCode	Titleofthe Course
-	-	-	-

COURSEOBJECTIVES:
• To get introduced to the basic concepts of Bioinformatics and its significance in biological data analysis.
• To get an overview about biological macromolecular structures and structure prediction methods.

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Will be able to demonstrate mastery of the core concepts of bioinformatics	L1
CO2	The student will be able to apply basic principles of biology, computer science and mathematics to address complex biological problem	L2
CO3	Should be able to plan basic experiments in microbial genetics concerned with clarifying phenotypes and their relationship with thegenotype	L3

COURSECONTENT:	
MODULE 1 BIOLOGICAL DATA TYPES AND SOURCE	**07Hrs**
Introduction to population and sample, Classification and Presentation of Data. Quality of data, private and public data sources. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Specialized Genome databases: (SGD, TIGR, and ACeDB). Microbial genomic database (MBGD), Cell line database (ATCC), Virus data bank (UICTVdb).	
MODULE 2 SIMILARITY SEARCHING	**10Hrs**
Global and Local sequence alignment, Pair wise comparison of sequences, Multiple Sequence alignment of sequences, scoring matrices. Identification of genes in genomes and Phylogenetic analysis with reference to nucleic acids, Identification of ORFs, Identification of motifs	

MODULE 3 INTERPRETTING the SEQUENCE	07Hrs
Reading DNA from files in FASTA format, reading frames, Regular expressions, restriction maps and restriction enzymes, Genbank libraries, annotation parsing, Annotations indexing, parsing PDB files, parsing BLAST files.	
MODULE 4 SCALING THE HUMAN GENOME	**06Hrs**
UCSC genome browser, RegulomeDB database, ENCODE-ChIA-PET database, transcription factors binding sites. SNP, EST, STS. Regular Expression (REGEX), Hierarchies and Graphical models (including Markov chain and Bayes algorithm). Genetic variability and connections to clinical data.	

TEXTBOOKS/REFERENCES:

1. Bioinformatics. Keith, J. Humana Press, 2008.
2. Computer methods for macromolecular sequence analysis. R. F. Doolittle, Academic Press,1996.
3. Bioinformatics. Sequence and genome analysis. D.W. Mount. Cold Spring Harbor Lab. press.2004.
4. Bioinformatics and functional genomics. J. Pevsner. Wiley-Liss, 2003.
5. Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics, Jorde et al., (eds.) JohnWiley and Sons, 2005.
6. Bioinformatics. Baxavanis, Wiley and Sons, 2020.
7. Biological Data Analysis. A practical Approach, Fry, J. C. IRL Press, Oxford. 1993.
8. The UCSC Genome Browser database: 2015 update. Rosenbloom KR et al, Nucleic Acids Res.2015 Jan 28; 43(Database issue): D670-81.

SEMESTER	**VI**
YEAR	**III**
COURSE CODE	**22BY3601**
TITLE OF THE COURSE	**ENZYMOLOGY**

SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	22BS1101	Essentials of biochemistry

COURSE OBJECTIVES:
• To create an understanding about enzymes, coenzymes and their properties
• To gain knowledge of enzyme assays, enzyme kinetics and drawing enzyme assisted reaction plots.
• To learn about protein isolation and purification methods

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**Bloom's Taxonom**
CO1	Students would understand active site structure and enzyme catalysis	L1
CO2	Students would have a brief idea about regulation of enzyme activity along with enzyme inhibition.	L2
CO3	Students should learn analytical techniques which can be used to isolate and analyze proteins	L3

COURSE CONTENT:

MODULE 1	**15 Hrs**

Introduction to enzymes: Classification and nomenclature, Specificity, active site groups, theories of enzyme action.

Enzyme assay: Principle and types, enzyme units. Monomeric, oligomeric and multifunctional enzymes, multi enzyme complexes. Enzyme localization (chemical and immune-fluorescence method) and purification. Criteria of purity.

Enzyme catalysis: Chemical nature of enzyme catalysis - General acid/base catalysis, electrostatic catalysis, covalent catalysis, Intramolecular catalysis.

MODULE 2	**15 Hrs**

Enzyme kinetics of single substrate reactions: Michaelis-Menten and Briggs and Haldane theory (rapid equilibrium and steady state theory). Effect of substrate, temperature, pH and modulators on enzyme activity.

Kinetic data evaluation: linear transformation of Michaelis-Menten equation. Pre-steady statekinetics. Methods used in the investigation of the kinetics of enzyme-catalyzed reactions, initial velocity studies and rapid reaction techniques. Integrated velocity equation. Haldane equation. King-Altman procedure for deriving the rate equation. Arrhenius plot and determination of activation energy.

MODULE 3	**15 Hrs**
Enzyme Inhibition: Types of reversible inhibitors; competitive, non-competitive, uncompetitive, and mixed inhibitors. Partial, substrate, allosteric and Irreversible inhibition. Allosteric enzymes and metabolic regulation. Study of ATCase as typical allosteric enzyme. Other mechanisms of metabolic regulation reversible covalent modifications, proteolytic cleavage (zymogen activation – digestive enzymes, blood clotting cascade). Enzyme inhibitors as drugs.	
MODULE 4	**15 Hrs**
The investigation of active site structure - The identification of binding sites and catalytic sites – trapping the E-S complex, use of substrate analogs, enzyme modification by treatment with proteolytic enzymes, photo – oxidation and chemical modification of amino acid side chains. Affinity labelling studies, super-reactive amino acid side chains, X-ray crystallographic and NMR studies. Coenzymes (mechanistic role of NADH, FAD and TPP)	

TEXTBOOKS /REFERENCES:

1. Enzymes - Biochemistry, Biotechnology, Clinical Chemistry, Palmer and Bonner, ElsevierPress, 2007.
2. Biochemistry - Voet and Voet, 4th Ed, Wiley, 2010.
3. Fundamentals of Enzymology - Price and Stevens, 3rd Edn., Oxford University Press, 2000.
4. Fundamentals of Enzyme Kinetics - Bowden, 3rd Edn., Portland Press, 2004.
5. Biophysical Chemistry Part II, Charles R. Cantor - Paul R. Schimmel, W.H. Freeman &Companys, 2008.
6. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis - Robert A.Copeland, Wiley-VCH Publishers, 2000.
7. Biochemical Calculations - Irwin H. Segel, 2nd Ed.John Wiley and Sons, 2010.

Enzymology- Practicals
1. Introduction to enzymology Lab and product curve determination.
2. Isolation of enzymes (amylase/ phosphatase) from biological source and activity determination through time curve.
3. Determination of kinetic constants through LB plot.
4. Effect of pH on enzyme activity.
5. Effect of temperature on enzyme activity.
6. Determination of Arrhenius constant.
7. Effect of activators and inhibitors on enzyme activity.

TEXTBOOKS/ REFERENCES:

1. Practical Enzymology – Hans Bisswanger, 3 rd Edn., Wiley-VCH, 2019,
2. Introductory Practical Biochemistry - Sawhney and Singh. 1st Edn., Narosa Publishing house, 2001,
3. Principles and Techniques of Practical Biochemistry – Wilson, Wilson and Walker, CambridgeUniversity Press, 2000.
4. Introduction to practical Biochemistry - Plummer, 2nd Ed, Tata McGraw-Hill Education, 2001.
5. Basics of Enzyme Immobilization – Alka Dwevedi, 1st Edn., Springer International Publishing, 2016.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22BY3602**					
TITLE OF THE COURSE	**IMMUNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	22BS1101	Essentials of biochemistry

COURSE OBJECTIVES:

- Students will be able to understand the role of different cells and organs of immune system.
- Students will be able to understand the significance of immune system and immunotherapy in treating diseases

COURSE OUTCOMES:

CO No.	OUTCOMES	Bloom's Taxonomy
CO1	Student would be acquainted with the basic understanding of immune system as a whole and	L2
CO2	Student would gain fundamental knowledge about the consequences of immune system failure	L3
CO3	Student would be able to demonstrate the significance of immunology diagnosis and therapeutics of the diseases and interpret the diagnostic data in correlation with the patho-physiology	L4

COURSE CONTENT:

MODULE 1: Introduction and Basic concepts in immunology	**15 Hrs**

Introduction: Basic concepts in immunology, role of immune system, principles of innate andadaptive immunity.
Innate immunity: Different lines and layers of defence, secretions: skin, lysozyme, pH, mucous. Pattern recognition in innate immune system, the complement system: activation through classical, alternate and lectin pathway, Induced innate immune responses to infections. Functions of natural killers, monocytes, macrophages, eosinophils, neutrophils and basophils.

MODULE 2 : Antigen Antibody interactions	**15 Hrs**

Antigen recognition by B-cells: Clonal selection, effector and memory cells, Antibody types, structure, functions, isotypes, allotype, idiotype, Interaction between the antibody and specific antigen, epitope, paratope, affinity, avidity, radio-equilibrium dialysis study, Diversity of Immunoglobulins. Antigen recognition by T cells: TH, TC and TReg cells, T-specific markers, TCR,MHC, Types, functions, gene structure, receptor structure, antigen processing and presentation, exogenous and endogenous antigen.

MODULE 3: Lymphocyte development and inflammation	15 Hrs
Development and survival of lymphocytes: Lymphocytes in bone marrow and thymus, positive and negative selection of lymphocytes, survival and maturation of lymphocytes, self/non self- recognition. Transplantation and Network theory: Transplant rejection, immunosuppressants. Immuno-surveillance, idiotypes and immune network theory.	
MODULE 4: Pathoimmunology&Immunotechniques	**15 Hrs**
Pathoimmunology: Effector mechanisms in allergic reactions and IgE, hypersensitivity diseases; Autoimmune diseases- Rheumatoid arthritis, multiple sclerosis. Immuno-techniques: Generation of monoclonal antibodies, Immuno-diffusion techniques, RIA, ELISA. Immuno-electrophoresis, immuno-staining techniques, Immuno-florescence and flow cytometry.	

TEXTBOOKS/REFERENCES:

1. Cellular and Molecular Immunology - Abbas and Lichtman. 7th Edn., Saunders Publishers,2011.
2. Immunology - Golsby, Kindt, Osborne and Kuby. 5th Edn, Freeman Publishers, 2003.
3. Roitt's Essential Immunology, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M.Roitt, 12th Edn., Wiley-Blackwell, 2011.
4. Medical Immunology made memorable, 2nd Ed., John H. L. Play fair and P.M. Lydyard,Churchill Livingstone Publications, 2000.
5. Textbook of Immunology - Sai Leela K, Mohanty S K, Veerendra Reddy P. Jaypee Publishers, 2007.
6. Cell and Molecular Biology: Concepts and Experiments - Karp. 7th Ed., Wiley & Sons 2013.
8. Molecular Cell Biology - Harvey Lodish, David Baltimore and Arnold Berk, 3rd Ed., Scientific American Publishers, 1995.

IMMUNOLOGY-PRACTICALS
1. Serum Separation from whole blood and isolation of immunoglobulins from serum.
2. Study of different cells in whole blood using Giemsa/Leishman stain.
3. Blood grouping
4. ELISA/Dot ELISA
5. Radial Immunodiffusion/Ouchterlony Double Diffusion
6. Rocket Immuno Electrophoresis
7. WIDAL/RPR Test

TEXTBOOKS/REFERENCES:

1. Essential Immunology - Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M.Roitt.12th edition, ELBS, Blackwell Scientific Publishers, London, 2011.
2. Fundamentals in Immunology - William E Paul. 7th edition, Raven Press, 2012.
3. Immunology - Kuby J, Judy Owen, Jenni Punt, Sharon Stranford. 7th Edition. W.H. Freemanand Company, 2013.

SEMESTER	**VI**					
YEAR	**III**					
COURSECODE	**22BS3601**					
TITLEOFTHECOURSE	**PRINCIPLES OF 'MULTI-OMICS'**					
SCHEME OFINSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	TotalHours	Credits
	2	**-**	**-**	**-**	**30**	**2**

PerquisiteCourses(if any)			
#	Sem/Year	CourseCode	Titleofthe Course
-	-	-	-

COURSEOBJECTIVES:
• To acquaint students with various aspects of biotechnology and bio-engineering using omics technologies
• To provide key insights into omics approaches in personalized and precision medicine

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will have knowledge in specific methods used in genomics, proteomics and metabolomics used in analytical processes.	L1
CO2	Students will be able to perform statistical analysis crucial for interpretation of experimental results	L2
CO3	Students will be able to apply specialized research methods necessary for the analysis of proteins, genes and metabolites	L3

COURSECONTENT:	
MODULE1: Genome & Genomics	**07Hrs**
Genome mapping: Physical and Genetic Map, Genome Sequencing, Next generation sequencing methods ,Genome Annotation, Functional Genomics	
MODULE2: Transcriptomics	**07Hrs**
Search for transcription factor binding sites, RNA-Seq, Microarrays, Regulatory RNAs: small or large, Computational prediction of miRNA target genes, RNA Darkmatter	

MODULE3: Proteomics and Metabolomics	10Hrs
Basic concepts , Tools of proteomics- SDS PAGE, 2D PAGE , Liquid chromatography , Mass Spectrometry (ESI and MALDI) ,Protein identification by peptide mass fingerprinting ,Applications of proteomics. Fundamental concept, Tools of metabolomics- Capillary electrophoresis, Gas chromatography, Electrochemical detectors, Case studies	
MODULE4: 'OMICS': applications and future perspectives	**06Hrs**
Multi-omics in disease prediction and health. Multi-omics technologies for crop improvement and sustainable agriculture. Applications in Biomedical and Environmental sciences	

TEXTBOOKS/REFERANCES:

1. Bioinformatics - Keith, J., Humana Press, 2008.
2. Computer methods for macromolecular sequence analysis - R. F. Doolittle, Academic Press, 1996.
3. Introduction to Proteomics -Tools for the New Biology by Daniel C. Liebler, Humana Press..
4. Bioinformatics and functional genomics - J. Pevsner. Wiley-Liss, 2003.
5. Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics - Jorde et al., (eds.) John Wiley and Sons, 2005.
6. Metabolomics - Methods and Protocols by Wolfram Weckwerth, Humana Press.
7. Biological Data Analysis. A practical Approach - Fry, J.C. Biological Data Analysis. A practical Approach. IRL Press, Oxford, 1993.
8. Transcriptomics: Expression Pattern Analysis, Virendra Gomase, Somnath Tagore; VDM Publishing, 2009 – Science

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22BS3602**					
TITLE OF THE COURSE	**TOXICOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	**22BY2401**	**Human anatomy and pathology**

COURSE OBJECTIVES:
• To learn various toxicants present and their exposure level on day-to-day basis.
• To study the effects of toxins on the physiologic, metabolic, reproductive, and developmental processes.

COURSE OUTCOMES

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students would learn and understand all substances can be toxic depending on the means and level of exposure	L1
CO2	Students would learn the basic concepts of cellular toxicity and chemical actions on cells and body organs	L2
CO3	Students would learn the importance and diversity of drug interactions with various organs	L3

COURSE CONTENT:	
MODULE 1: Introduction of toxicology	**10 Hrs**
Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins. Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms. Toxicant proceeding *in vivo*: Absorption, Distribution, Excretion an Metabolism of foreign/toxic compounds.	
MODULE –II: Environmental toxicology	**5 Hrs**
Environmental pollution- Sources and types of pollution, Important pollution events, Priority pollutants. Air pollution- Classification and properties of air pollutants, Behaviour and fate of air pollutants, Photochemical smog, Acid Rain, health effects of air pollution. Water pollution- origin of	

Wastewater, Domestic Water Pollution, Industrial water pollution, Agricultural water pollution, Toxic water pollutants and their health effects, Groundwater pollution, marine pollution	
MODULE III: Industrial toxicology	**5 Hrs**
Industrial Chemicals: Government Regulation of Chemicals, Ways of exposure, Toxic effects, Long-term consequences and developmental toxicity. Food Additives and Contaminants types of food additives, Preservatives, Saccharin. Toxicity of trace elements- Iodine, iron, zinc, copper, manganese, selenium, molybdenum, and cobalt Cyto-toxicity of heavy metals- Cadmium, mercury, arsenic, chromium and lead. Brief introduction to toxicity of pesticides and inseciticides.	
MODULE - IV: Organ Toxicology	**10 Hrs**
Basics of organ toxicity- Target organs, Organ selectivity and specificity, gender specific diversity of toxins. Hepatotoxicity - Actions of toxins on the liver, Chronic liver injury; Cardiotoxicity - pathology of cardiac toxicity, mechanisms of cardiotoxicity; Respiratory Toxicity - Systematic lung toxins, Lung pathology; Reproductive System – Teratogenicity; Neurotoxicity- Effect of toxic agents on neurons, Ion channel neurotoxins and Nephrotoxicity- susceptibility of kidney to toxic insult, chemically induced renal injury.	

TEXTBOOKS/ REFERENCES:

1. Pharmacology - Whalen, Finkel, and Panavelil. 6th ed., Lippincott Williams & Wilkins,2015.
2. Lieberman and Peet, Mark's Basic Medical Biochemistry: A Clinical Approach, 5th ed.Wolters Kluwer, 2018.
3. A Textbook of Modern Toxicology - Hodgson. 4th ed., J Wiley & Sons, 2010.
4. Molecular and Biochemical Toxicology, Smart and Hodgson, eds. 4th ed., J Wiley & Sons,2008.
5. The Dose makes the Poison: A Plain-language Guide to Toxicology - Frank and Ottoboni,3rd ed. eBook, J Wiley & Sons, 2011.
6. A-Z Guide to Drug-Herb-Vitamin Interactions, Gaby, Batz, Chester and Constantine, 2nded., Three Rivers Press, 2006.
7. Gilbert- A Small Dose of Toxicology - The health effects of common chemicals, CRC Press,2004.
8. Multiple Chemical Sensitivities: A survival guide - Gibson, New Harbinger Publications,2000.
9. Toxicology and Clinical Pharmacology of Herbal Products - Cupp and Karch, eds.,Springer-Verlag, 2000.
10. Staying Well in a Toxic World - Lawson, Lynwood Press, 2000.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22BY4701**					
TITLE OF THE COURSE	**GENETIC ENGINEERING**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	II & III	22BS1202 & 22BS2302	Basics Genetics &Molecular Biology

COURSE OBJECTIVES:

- To understand the concepts of genetic engineering including the tools, techniques, protocols and applications.
- To have knowledge on how to design recombinant molecules using different vectors specific for a particular species and understand the concept of protein expression.
- To be able to learn the applications of rDNA technology and apply the knowledge to their future research.

COURSE OUTCOME

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Student will gain fundamental knowledge about the tools and strategies used ingenetic engineering.	L2
CO2	Students will be able to design, screen, isolate, amplify DNA and also learn the concept of protein expression and apply the knowledge in problemsolving and in practice	L3
CO3	The students will understand the applications of rDNA technology from academic and industrial perspective.	L4

COURSE CONTENT:	
MODULE 1: Introduction and Basic Concepts	**15 Hrs**
Introduction: Overview of major steps involved in genetic engineering. **Molecular Tools**: Restriction endonucleases: Types and characteristic features; Modification of cut ends. DNA ligases, Alkaline phosphatase, Polynucleotide kinase, DNase I, DNA polymerase and Klenow fragment, Terminal nucleotidyl transferase, RNA dependent DNA Polymerase. Basic principles of gene editing – CRISPR/CAS9.	
MODULE 2: Vectors and Gene transfer	**15Hrs**
Properties of an ideal vector. **Cloning vectors**: Prokaryotic vectors (pBR322; pUC18;Lambda phage, Cosmids). Eukaryotic vectors: YAC vector, Shuttle vector, Plant Vectors – (Ti Plasmid-Binary and Co integrated vectors); Animal Vectors: SV 40, retroviral vectors. **Expression vectors**in Prokaryotes and Eukaryotes – Basic features and role of promoters, terminator and RBS. **Methods of Gene transfer**: Transformation, Transfection, Microinjection, Electroporation, Microprojectile, Liposome Fusion	
MODULE 3: Selection of Recombinants	**15Hrs**
Isolation of the desired gene: cDNA library, Genomic library. **Selection and screening of recombinants**: Identification and selection of transformed cells:<u>Direct methods</u> - Insertional inactivation, Visual screening method, Plaque formation, Complementation of mutation/nutrition <u>Indirect methods</u> - Colony hybridization, Immunochemical detection. **Use of selectable and scorable genes**: Selectable genes: Plants-npt; Animals-TK. Scorable genes: Plants-Gus; Animals- GFP/RFP.	
MODULE 4: rDNA TECHNIQUES and Applications	**15Hrs**
Techniques: Gel Electrophoresis, Hybridization – Southern, Northern, Western, Sanger's di-deoxy DNA Sequencing, PCR and its types (Real Time PCR and Multiplex PCR), Basics of NewGeneration Sequencing. **Applications:** Production of Insulin, Recombinant Vaccines, hGH, Transgenic animals: Mouse (Knock-out; Methodology, applications); A briefaccount of Transgenic Sheep, Poultry, Fish, Cow, with value added attributes. Transgenic Plants: Resistance to diseases, Pathogens and insects (Bt gene transfer); Nif gene and its role.	

TEXTBOOKS/REFERENCES

1. Principles of Gene Manipulation - S. B. Primrose, R. M. Twyman and R.W.Old. 6th Edition, S.B.University Press, 2001.
2. Molecular Cloning: A Laboratory Manual - J. Sambrook and D.W. Russel, Vols 1-3, CSHL, 2001.
3. Genomes - Brown TA, 3rd ed. Garland Science, 2006
4. Molecular Biotechnology - Glick and Pasternak, 2nd Ed, ASM press, Washington DC, 1998
5. Elements of Biotechnology - Gupta PK, 2nd Ed, Rastogi publication, Merrut, 2003.
6. Principles of Gene Manipulation - Primrose, Twyman and Old, 6th Ed, Blackwell Science Ltd, 2002.
7. Gene Cloning and DNA analysis - Brown TA. 6th edition, Wiley-Blackwell Publication, 2013.
8. Molecular Biology and Genetic Engg - Singh BD, Kalyani Publishers, 2005.
9. Satyanarayana U, Biotechnology, Books and Allied Ltd, 2008
10. Recombinant DNA: Genes and Genomes - Watson, Caudy, Myers Wilkowsky. 3rd Ed, WH Freeman, 2007.

GENETIC ENGINEERING - PRACTICALS	
1.	PCR amplification and analysis by agarose gel electrophoresis.
2.	Preparation of plasmid DNA from *E. coli*.
3.	Restriction digestion and Ligation
4.	Preparation of competent cells and transformation.
5.	Restriction mapping problems.

REFERENCES:

1. Principles of Gene Manipulation - S. B. Primrose, R. M. Twyman and R.W.Old. 6thEdition, S.B.University Press, 2001.
2. Molecular Cloning: A Laboratory Manual - J. Sambrook and D.W. Russel, Vols 1-3,CSHL, 2001.
3. Genomes - Brown TA, 3rd ed. Garland Science, 2006.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22BY4702**					
TITLE OF THE COURSE	**SIGNAL TRANSDUCTION**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	**V**	**22BY3501**	**Human Physiology**

COURSE OBJECTIVES:
• To understand the concepts of endocrinology, mode of action, function and disorders related to hormones.
• To acquire knowledge of ligand receptor interaction and molecular mechanisms behind the transduction of outside signal to inside of the cell.
• To learn about cell cycle and programmed cell death and apply the knowledge to their future research.

COURSE OUTCOME:		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will learn how hormones control the physiology of an organism.	L2
CO2	They will have a greater understanding of signalling mechanisms and associated disorders which can be applied in disease diagnosis and problem solving.	L3

COURSE CONTENT:	
MODULE 1: Receptors and their Ligands	**15 h**
Introduction –Hormones, autocrine, paracrine and endocrine signalling, receptor specificity and activation, G-protein coupled receptors, (G-protein, effectors- adenylate cyclase and PLC, cAMP - synthesis and degradation, cGMP, inositol triphosphate, DAG and calcium release) Receptor tyrosine kinases (Insulin, MAP kinase and PI3K pathways), phosphatases, Ion channel receptors. **Nuclear signalling**: Steroid, thyroid, Vitamin-D and retinoic acid receptors (RAR receptors). .	
MODULE 2: Cell Cycle and Apoptosis	**15h**
Cell cycle: Cyclins and cyclin-dependent kinases, entry of cell from G2 to M – phase, cell cycle arrest at G1, role of Rb proteins in cell cycle, Growth factors, cytokines and cell cycle check points.	

Apoptosis: Caspases, structure, function and activation. Intrinsic and Extrinsic apoptosis pathways. Anti-apoptotic proteins, Tumor suppressors and Inhibition of cancer.	
MODULE 3: Plant Signaling	**15h**
Introduction, Plant hormones and their functions, Auxin signaling, Cytokininsignaling, Ethylene signaling, Gibberellin signaling, Abscisic acid signaling, Light signaling by phytochromes and cryptochromes. Serine/Threonine Kinase receptors in plants. Calcium as secondary messengers, Role of MAP's (mitogen activated proteins, transcription factors and phytohormones in plant immunity. Symbiotic Interactions of plants and bacteria (nitrogen fixation).	
MODULE 4: Microbial signaling	**15h**
Introduction, Types of bacterial signaling (One-component, two-component and alternative sigma factors). One component system signalling- pH sensor CadC, Two component system – Regulation of K+ ion concentration. Alternative sigma factors- General features of σ^{70} family and its subfamiles. Extracytoplasmic sigma factors – mode of action and functions. Bacterial chemotaxis by chemoreceptors and phototaxis by photoreceptors. Quorum sensing (Bioluminscence and Biofilm formation).	

REFERENCES

1. Biochemistry - Donald Voet & Judith G. Voet, John Wiley & Sons, Inc. 2010.
2. Lehninger- Principles of Biochemistry - D. L. Nelson and M.M. Cox, 6th Edn. MacmillanPublications , 2012.
3. Text Book of Biochemistry with Clinical correlations; Thomas M. Devlin. 6th Edn., Wiley-Liss, 2012.
4. Cell and Molecular Biology Concepts and experiment - Gerald Karp 6th Edn., Wileypublications.
5. The cell – A molecular approach - Geoffery M Coooper, 8thEdn, 2018.
6. Molecular Biology of the Cell - Alberts B, Johnson A, Lewis J, et al. 4th edition, NewYork: Garland Science, 2002.
7. Cell signalling - Hancock, John T. Oxford University Press, 2017.
8. Auxin signalling - Kou *et al.,* Appl. Sci. 12*(3),*1360; **2022** https://doi.org/10.3390/app12031360.
9. Microbial signalling and communication - England, R. Vol. 57. Cambridge University Pre 1999.
10. Fundamentals of Biochemistry IV – Special topics. Henry Jakubowski and Patricia F LibreTexts, e Open Education Resource (OER) LibreTexts Project (https://LibreTexts.org)
11. Winans, Steve C. "Cell-cell signalling in microbial communities: Microbial signalling a communication, edited by R. England et al." Trends in Microbiology 7.12 (1999): 506.
12. Staron, A.; Sofia, H.J.; Dietrich, S.; Ulrich, L.E.; Liesegang, H.; Mascher, T. The third pillar bacterial signal transduction: Classification of the extracytoplasmic function (ECF) sig factor protein family. *Mol.Microbiol.* 2009, *74*, 557–5 https://doi.org/10.3390/microorganisms11041012.
13. Biochemistry -David Rawn. Panima Publishers, 1989.
14. Biochemistry - Geoffrey Zubey. WCB Publishers, 1998.
15. Biochemistry- R. Garret, Charles M Grisham, Belmont. 2013

SIGNAL TRANSDUCTION - PRACTICALS	
1.	Identification of pathways based on activated proteins.
2.	Permanent slides for demonstration of fluorescent staining of receptors.
3.	Slide preparation of tissues by H&E and DAPI staining.
4.	Study of different stains used in identification of cellular components and receptors.
5.	Videos on pathways/disorders/techniques with reflection notes.

TEXTBOOKS/REFERENCES:

1. Biochemistry - Donald Voet & Judith G. Voet. John Wiley & Sons, Inc, 2010.
2. Lehninger- Principles of Biochemistry - D. L. Nelson and M.M. Cox 6th Edn. MacmillanPublications, 2012.
3. Routine Cytological Staining Technique - Mathilde E. Boon & Johanna S. Drijver. Macmillan Publishers Limited, 1986. DOI: https://doi.org/10.1007/978-1-349-18250-3.
4. Manual of Histological Techniques - Santosh Kumar Mondal , 2^{nd}Edn., Jaypee BrothersMedical Publishers (P) Ltd.
5. Fundamental Techniques in Cell Culture Laboratory Handbook. 4^{th}Edn. The EuropeanCollection of Authenticated Cell Cultures (ECACC).

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22BY4703**					
TITLE OF THE COURSE	**PLANT PHYSIOLOGY AND BIOCHEMISTRY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	**I**	**22BS1101**	**Essentials of Biochemistry**

COURSE OBJECTIVES:
• To understand various levels of organization in a plant body with an outlook in the relationship between the structure and function
• To understand the Phytoconstituents and processes in plants

COURSE OUTCOME:		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students should be able to differentiate various tissue systems of the plants	L1
CO2	Should be able to understand and extract various constituents present in the plant body	L2

COURSE CONTENT:

MODULE 1: **15 h**

Plant cell structure - nature of plant cell wall. Tissue and tissue systems - meristematic tissue, permanent tissue and secretary cells. Classification of meristem: (apical, intercalary and lateral), primary and secondary meristem.

Plant and water relation: Colligative properties of water, free energy concept. Water uptake, conduction, transpiration, mechanism and its regulation by environmental variables.
Mineral nutrition: Macro, and micronutrients, their role, deficiency and toxicity symptoms, mechanism of ion uptake and translocation.

MODULE 2: **15h**

Photosynthesis: Significance, historical aspects, photosynthetic pigments, Concept of two photosystems, Photophosphorylation, Calvin cycle, C4 pathway, CAM plants photorespiration

MODULE 3: **15h**

Respiration: aerobic and anaerobic respiration, respiratory pathways glycolysis, krebs 'cycle, electron transport, oxidative phosphorylation, pentose phosphate pathway, photorespiration, cyanide resistant respiration. Lipid biosynthesis and its oxidation.	
MODULE 4:	**15h**
Atmospheric nitrogen fixation, nitrogen cycle, nitrogen assimilation, Growth: general aspects of phytohormones, inhibitors-auxins. kinetin, gibberellins, and ethylene: action and their application; photoperiodisin and vernalization. Germination, growth movements, parthenocarpy, abscission and senescence.	

TEXTBOOKS/REFERENCES:

1. Esau's Plant Anatomy: Meristem, Cells, and Tissues of the Plant Body: Their Structure, Functionand Development - Evert, R.F. John Wiley and Sons, Inc, 2006.
2. Plant Anatomy - Vashishta . P.C. Pradeep Publications – Jalandhar, 1984.
3. Plant Anatomy - Vashishta, P.C, Pradeep Publications, 1997
4. Plant Physiology - Taiz, L. and Zeiger, E. 5th edition. Sinauer Associates Inc., U.S.A. 2010
5. Introduction to Plant Physiology - Hopkins, W.G. and Huner, N.P. 4th edition. John Wiley &Sons, U.S.A., 2009.
6. Experiments in Plant Physiology - A Laboratory Manual. Bajracharya, D. Narosa PublishingHouse, New Delhi, 1999.
7. A text book of plant physiology -V. Verma and Verma. S Chand Publishers, 1995.
8. Fundamental of Plant physiology - V. K. Jain. S Chand Publishers, 2017.
9. Plant physiology. Text book of biochemistry - Ross and Salisbury, Thomson Press (India) Ltd.

PLANT PHYSIOLOGY AND BIOCHEMISTRY-PRACTICALS
• Study of meristem and simple tissues (Permanent slides/ Photographs).
• Extraction of phytochemicals using soxhlet extractor using polar and nonpolar solvents.
• Qualitative analysis of phytochemicals- alkaloids, flavnoids, terpenoids.
• Estimation of total flavnoid content.
• Estimation of methionine/tryptophan/lysine from cereal grains.
• Estimation of β- carotene.
• Determination of starch in plant tissues.

REFERENCES:

1. Experiments in Plant Physiology – A Laboratory Manual - Bajracharya, D. . . New Delhi: Narosa Publishing House,1999.
2. Biochemistry and Molecular Biology of Plants - Buchanan, B., Gruissem, W, and Jones, R. 12th ed. John Wiley & Sons. Ltd, 2015

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22BS4701**					
TITLE OF THE COURSE	**RESEARCH METHODOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**45**	**3**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To provide an overview of essential research steps to be followed when conducting research / project work.
• To understand chief ingredients to be incorporated in conduct as well as writing of scientific reports/dissertation/thesis
• To know the implication professional research ethics and common misconduct details of researcher and research work

COURSE OUTCOME		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Show and explain the concepts of meaning ofresearch, scope of research including different types of research, scientific research process and research methodology steps	L1
CO2	Perform review of literature using electronic media, selecting research problem formulate research problem statement, writing hypothesis, explain criteria of forming objectives, materials and methods, results and discussion	L2
CO3	Identify and explain experimental research designs for both qualitative and quantitative research	L2
CO4	Explain different sampling methods and sampling design, basic statistical methods for treatment of data and observations	L2

CO5	Demonstrate ingredients and components of a research report, dissertation and thesis and explain integral components of research article and research proposal	L2
CO6	Explain professional research ethics and elaborate on misconduct in research	L2

COURSE CONTENT:	
MODULE 1:	**12hrs**
INTRODUCTION TO RESEARCH: Meaning, Objectives and Characteristics of research – Scientific Method Types of research - Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs.Qualitative, Conceptual vs. Empirical - Research process - Criteria of good research **PROBLEM STATEMENT:** Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem; **LITERATURE SURVEY:** Importance of literature review in defining a problem **- S**urvey of literature - Primary and secondary sources - web as a source - searching the web - Identifying gap areas from literature review **HYPOTHESIS:** Definition of hypothesis**,** Basic concepts , variables-Dependent and independent variables, Development of working hypothesis; Ingredients of Research Objectives, deriving objectives of research	
MODULE 2:	**12hrs**
Sampling, Material and Methods: Sample- Sampling - Types of sampling; Material - Experiments, Data – Basics of Analysis; Writing materials and method chapter of a research report **Results and Discussion**: Representation of results; Tables, graphs; Discussion, Purpose and Function of Discussion **Research Designs:** Research design; Need of research design - Basic Principles; Features of good design – Important concepts relating to research design; Max-min-con principle, **Common Research Designs**: Cross-sectional, Case-control, Longitudinal and Cohort research designs, advantages and disadvantages of each of research designs **Summary and Conclusion:** Writing of Summary, conclusions of research findings, Acknowledgement section of a research report and an article.	
MODULE 3:	**10Hrs**
Research Ethics: Values, Ethics and Morals**,** Research Professionalism**,** Tenets of Ethics; Conducting and reporting of science/engineering; Relationship in research groups; Hazards to good scientific practice; Scientific misconduct: Fabrication, Falsification and Plagiarism. **Report and Article Writing:** Structure and components of scientific reports; Abstract-Key words**;** Types of reports; Significance of reporting; Different steps in the preparation of reports; Layout, structure and Language of typical reports; References; Citation styles- APA and MLA styles of citation, intext and end text citations	

Oral Presentation: Importance of effective communication.Planning; Preparation; Practice; Making presentation; Use of visual aids.	
MODULE 4:	**11Hrs**
Scientific Article Writing: Title preparation – Importance of title; need for specific titles; List of authors and addresses – order of names; defining the order with example; types of abstracts; economy of words; How to write introduction- Rules; exceptions; citations and abbreviations Materials and methods: Purpose; materials; methods; tables and figures; form and grammar; Result and Discussion writing: content of results; handling numbers; clarity; avoiding redundancy; Discussion writing: Components of discussion; factual relationships; strengths and limitations; significance of paper; Stating Acknowledgements: Ingredients of the acknowledgements; courtesy; Citation of theReferences: Rules; electronics aid; in-text citation; styles of referencing **Research Proposal Fundamentals:**What is a grant proposal? Why proposals fail?; Developing and writing of grant proposals; overview of steps to develop grant proposals; Proposal Development Process: Standard Proposal Parts; writing Budget section. **Intellectual Property Rights:** IPRs- Invention and Creativity- Intellectual Property-Importance and Protection of Intellectual Property Rights (IPRs); A brief summary of: Patents, Copyrights, Trademarks	

REFERENCES:

1. Bruce Tuckman, Brian E Harper, Conducting Educational Research, 6th Edition, 2012 byRowman& Littlefield Publishers, Inc. ISBN 978-1-4422-0965-7 (electronic)
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to ResearchMethodology, RBSA Publishers.
4. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt.,Ltd., New Delhi
5. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications.2volumes.
6. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic DogPublishing. 270p.
7. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
8. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. SagePublications
9. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.

MINOR PAPERS OFFERED

SEMESTER	**IV**					
YEAR	**II**					
COURSECODE	**22BY2404**					
TITLEOFTHECOURSE	**ANATOMY AND PHYSIOLOGY**					
SCHEME OFINSTRUCTI ON	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**4**

Pre-requisiteCourses(if any)			
#	Sem/Year	CourseCode	Titleofthe Course
-	**IV/ II**	**22BY2401**	**HUMAN ANATOMY & PATHOLOGY**

COURSEOBJECTIVES:

- Students will be able to understand different types of cells and tissues of organs in human system
- To demonstrate an understanding of the physiology and basic regulatory concepts related to the functioning of life processes.

COURSE OUTCOMES:

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Will be able to demonstrate an understanding of the physiology and basic regulatory concepts of the organ systems associated with this course and the mechanisms that allow the body to carry out those functions, and predict how a perturbation (e.g., disease, experimental manipulation) will alter function.	L2
CO2	The student will be able to explain homeostasis and explain how homeostatic mechanisms normally maintain a constant interior milieu inside human body	L3
CO3	Students will be able to demonstrate the different cellular and tissue organization of different organ system	L3
CO4	Will be able to explain the functions of different cell types their abnormalities in different organ systems	L3

COURSECONTENT:

MODULE1	**12 Hrs**
Scope of anatomy and physiology; levels of structural organization and body systems; Classification and Types of tissues: Structure, location and functions of epithelial, muscular, nervous and connective tissues; General principles of cell communication; **Integumentary system**:Structure and functions of skin. **Cartilage** – Definition, types, structure, distribution, nutrition.	

MODULE2	**Hrs**
Bones: Definition, Classification and functions of bone; Parts, types of epiphyses, Ossification, Blood supply of long bone; **Joints:** Classification,synovial joints, Blood supply & nerve supply. **Blood vessels and Lymph nodes:** Classification and structure of blood vessels; structure and functions of lymph vessels, lymphoid tissue	
MODULE3	**12 Hrs**
Hematology: Blood components and their functions, Blood groups: the ABO system. role of hemoglobin in oxygen transport. Various buffer systems of the blood, acid base balance, factors affecting acid-base balance. Blood Disorders **Cardiovascular System:** Systemic and pulmonary circulations, Basics of Cardiac cycle. ECG - its principle and significance. Blood pressure and its regulation. Brief outline of cardiovascular disorder (hypertension, arteriosclerosis, myocardial infarction, and congestive heart failure.	
MODULE4	**12 Hrs**
Muscular System: Overview of muscular tissue; types, functions & properties. Structure of actin and myosin. Mechanism of muscle contraction: Contraction, and relaxation of skeletal muscle fibers- sliding filament model; Neuromuscular junction; **Digestive System:** GIT and accessory organs, Composition, function, of saliva, gastric, pancreatic, intestinal and bile secretions, Mechanism of breakdown and absorption of carbohydrates, lipids, and proteins. **Endocrine System:** Basic structure and functions of Glands - Pituitary, Adrenal, Pancreas & Thyroid; hormones -	
MODULE5	**12 Hrs**
Respiratory System: Components of respiratory system and their functions.Pulmonary ventilation, Lung volumes and capacities, Bohr and Haldane effect, chloride shift; effect of 2, 3- BPG on the affinity of Hb; Artificial respiratory methods. **Renal Physiology:** Structure of nephron, mechanism of urine formation: Glomerular filtration, Tubular re-absorption & Active secretion, Kidney hormones. **Nervous System: Basic o**rganization of nervous system - CNS, PNS. ANS, generation of action potential, neurotransmitters.	

TEXTBOOKS/ REFERENCES:

1. Gray's Basic Anatomy, by Richard Drake FAAA (Author), A. Wayne Vogl FAAA (Author),
2. Guyton and Hall Textbook of Medical Physiology; 12th Ed., J.E.Hall , 5aunders Elsevier , 2010.
3. Anatomy & Physiology For Dummies, Erin Odya, 2002.
4. Molecular Cell Biology - Harvey Lodish , David Baltimore and Arnold Berk, Scientific AmericanPublication 1995.
5. Molecular Biology of Cell - Albertis et. al., Garland Science, 2002.
6. Cellular Physiology of Nerve and Muscle - Gary G Mathew. 4th Edition. Wiley-Blackwell 2002. Human Biochemistry - James M. Orten, Otto Wilhelm Neuhaus. 9th edition, C. V. Mosby, 1995.
7. Principles of Biochemistry: Mammalian Biochemistry - Emil S. Smith, McGraw-Hill; Subsequent edition, 1982.
8. Principles of Human Physiology - Cindy L. 4th Ed. Stanfield Pearson, 2010.

ANATOMY and PHYSIOLOGY - PRACTICALS
1. Histology of Tongue and Liver using permanent slides
2. Histology of Kidney and Stomach- using permanent slides
3. Blood film preparation and Leishman's staining and identification of the blood corpuscles.
4. Differential count of W.B.C.
5. Separation of serum and plasma from blood.
6. Qualitative analysis of Urine components.
7. Identification of abnormal constituents of Urine: albumin, ketone, sugar (glucose), bile salt and blood.
8. Titratable acidity of urine

TEXT BOOKS/ REFERENCES:

1. Practical Clinical Biochemistry - Harold Varley, 4th edn. CBS Publishers, 2018.
2. Practical Clinical Biochemistry: Methods and Interpretation - Ranjna Chawla, Jaypee Brothers Medical Publishers, 2006.
3. Practical and Clinical Biochemistry for Medical Students - T.N. Pattabhiraman, Gajanna Publishers, 2004.
4. Hawk's Physiological Chemistry - Oser, 14th Edn., Tata-McGraw Hill, 2016.
5. Biochemistry - Plummer Tata-McGraw Hill, 2007.
6. Textbook Of Practical Physiology - Balakrishna Shetty, H Sweekritha Poonja,(5Th Edn), 2018.

EMESTER	V					
YEAR	III					
COURSE CODE	22BY3503					
TITLE OF THE COURSE	METABOLISM					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	-	-	-	60	6

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	I	22BS1101	Essentials of Biochemistry

COURSE OBJECTIVES:

- To understand the metabolic pathways of bio-molecules within the system
- To create an understanding of structural and functional defects associated with metabolic pathways

COURSE OUTCOMES

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Students should identify the various rate determining steps in metabolism.	L1
CO2	Students should be able to interconnect and compare the carbohydrate and lipid metabolic pathway	L2
CO3	Students should be able to understand various diseases associated with metabolic pathways	L3

COURSE CONTENT:

MODULE I: Carbohydrate metabolism	15Hrs
Introduction to metabolism (anabolic, catabolic, amphibolic, and intermediary metabolism). Glycolytic pathway; energetics and regulation, aerobic and anaerobic fates of pyruvate, Pyruvate dehydrogenase complex, TCA cycle. Regulation of blood glucose level by organs and hormones. Diabetes mellitus- classification, biochemical and clinical changes associated with DM. Diagnosis by glycated hemoglobin test (A1-C test).	

MODULE 2: Lipid metabolism	**15Hrs**
Basic scheme of fat absorption, mobility, degradation and synthesis; Degradation of triacylglycerol and phospholipids- lipases and phospholipases. Fatty acid oxidation- even, odd and unsaturated fatty acids by β-oxidation, scheme and energetics of β-oxidation .Fatty acid biosynthesis - FAS- multi functional enzyme, chain elongation and desaturation. Cholesterol structure, brief idea of synthesis from acetyl CoA, regulation through HMG CoAreductase and utilization as hormones and bile salts, normal and abnormal levels in the body;	
MODULE 3: Amino acid metabolism	**15Hrs**
General metabolic reaction of amino acids– transamination, deamination, oxidative and nonoxidative deamination, glucose – alanine cycle. Urea cycle– regulation and metabolic disorders. Biosynthesis and degradation of amino acids.	
MODULE 4: Nucleotide Metabolism	**15Hrs**
Structure of nucleoside and nucleotide; Synthesis of purine and pyrimidine nucleotides – the de novo and the salvage pathway and their regulation. Degradation of purine and pyrimidines, DNA and RNA degradation.Heme metabolism.	

TEXTBOOK/REFERENCES

1. Biochemistry- Voet, Donald, Voet, Judith G. 3rd Edn, John Wiley and Sons; New York,2004.
2. Lehninger- Principles of Biochemistry; D L Nelson and M M Cox (Eds), 6th Edn,Macmillan Publications, 2012.
3. Biochemistry- Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. 6th edition, W.H.Freeman, New York, 2007.
4. Textbook of Biochemistry with Clinical Corelations - Thomas M. Devlin. 7th edition,John Wiley
   i. & Sons, 2010.
5. Biochemistry of Foods - N A Michael Eskin, Fereidoon Shahidi. 3rd edition, Elsevier,2012.
6. Biochemistry and Molecular Biology - D. Papachristodoulou, A. Snape, W.H. Elliott,and D. C. Elliott. 5th edition, Oxford University Press, 2014.
7. Harpers Illustrated Biochemistry - V.W. Rodwell , D. Bender , K.M. Botham , P. J.Kennelly, P. A. Weil. 30th edition, McGraw-Hill Education, New York, 2015.

METABOLISM - PRACTICALS
1.Estimation of reducing sugar by DNS method / Miller’s method.
2.Estimation of serum cholesterol by Zak’s method.
3.Determination of ratio of albumin and globulin in serum.
4.Estimation of uric acid/urea in serum.
5. Identification of lipids by Thin layer chromatography

REFERENCES:

1. Essentials of Practical Biochemistry, Prem Prakash Gupta, Neelu Gupta, 10.5005/jp/books/12972, 2017.
2. A textbook of practical Biochemistry, Joshi and Saraswat, Jain Publishers, New Delhi 2002

SEMESTER	**VI**
YEAR	**III**
COURSE CODE	**22BY3603**
TITLE OF THE COURSE	**ENZYME AND PROTEIN CHEMISTRY**

SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	22BS1101	Essentials of biochemistry

COURSE OBJECTIVES:
• To learn about enzyme properties along with enzyme and inhibition kinetics.
• To understand the protein structure along with analytical techniques to characterize them.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students would describe the classification and function of various Proteins along with their structural hierarchy.	L1and L2
CO2	Students would understand about regulation of enzyme activity along with enzyme inhibition.	L3
CO3	Students should analyze results obtained after protein characterization	L4

COURSE CONTENT:	
MODULE 1:	**15 Hrs**
Classification & nomenclature of enzymes, Active site: definition and theories including Lock & key, induced fit model and strain theory- with lysozyme as example; Enzyme specificity: bond, group, absolute and stereo-chemical specificity. Enzyme catalysis: Proximity & Orientation effect, Enzyme activity regulation through allosteric and covalent modification; Units - Katal& IU; Effect of pH, temperature, substrate concentration, enzyme dilution, activators and inhibitors on enzyme activity; Isoenzymes – definition and significance with LDH as example; Clinical and Biotechnological applications of enzyme.	
MODULE 2:	**15 Hrs**
Derivation of Michaelis-Menten equation with Briggs Haldane modification, Catalytic constants – Km, Vmax, turnover number and catalytic efficiency; Single & double reciprocal plots, Reversible and Irreversible inhibitors, Inhibition kinetics of Competitive, Noncompetitive& Uncompetitive inhibitors with examples; Feeedback inhibition with examples; Enzyme assay – continuous/	

discontinuous methods, coupled enzyme assays; Specific activity, enzyme purification – cytosolic, extracellular and membrane bound, criteria for enzyme purity. Coenzyme, cosubstrate and prosthetic groups; Structure and biological significance of selective Coenzymes**:** Nicotinamide derivatives (NADH, NADPH), riboflavin derivatives (FADH2, FMNH2), folic acid and ascorbic acid.	
MODULE 3:	**15 Hrs**
Classification based on composition, shape and function, Peptide bond - properties, Structural organization of proteins: primary structure – N and C-terminals, secondary structures -alpha, pi and polyproline helices, β sheet, turns and bends with forces stabilizing secondary structures; Ramachandran plot and determination of secondary structures; Tertiary and quaternary structures explained with respect to Hemoglobin, Collagen and Keratin; Forces stabilizing Tertiary and quaternary structures, Denaturation of proteins – salting out; Hofmeister series.	
MODULE 4:	**15 Hrs**
Protein assay – UV absorbance by peptide bond and aromatic residues, FolinCiocalteu, Biuret and Bradford method; Isolation and purification of proteins (non enzymatic) through gel permeation, ion exchange and affinity chromatography; Sequence determination by Sanger and Edman methods; Hydropathy plot to determine transmembrane regions, Mass spectroscopy of proteins: introduction to MALDI-TOF, ESI-MS and MS/MS techniques.	

TEXTBOOKS/ REFERENCES:

1. Enzymes - Biochemistry, Biotechnology, Clinical Chemistry, Palmer and Bonner,Elsevier Press, 2007.
2. Biochemistry - Voet and Voet, 4th Ed, Wiley, 2010.
3. Fundamentals of Enzymology - Price and Stevens, 3rd Edn., Oxford University Press,2000.
4. Fundamentals of Enzyme Kinetics - Bowden, 3rd Edn., Portland Press, 2004.
5. Biophysical Chemistry Part II, Charles R. Cantor - Paul R. Schimmel, W.H. Freeman &Companys, 2008.
6. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis - RobertA.

   Copeland, Wiley-VCH Publishers, 2000.
7. Biochemical Calculations - Irwin H. Segel, 2nd Ed.John Wiley and Sons, 2010.

Enzymology- Practicals
1. Introduction to enzymology Lab and product curve determination.
2. Isolation of enzymes (amylase/ phosphatase) from biological source and activity determination through time curve.
3. Determination of kinetic constants through LB plot.
4. Effect of pH on enzyme activity.
5. Effect of temperature on enzyme activity.
6. Determination of Arrhenius constant.
7. Effect of activators and inhibitors on enzyme activity.

TEXTBOOKS/ REFERENCES:

1. Practical Enzymology - Hans Bisswanger, 3 rd Edn., Wiley-VCH, 2019,
2. Introductory Practical Biochemistry - Sawhney and Singh. 1st Edn., Narosa Publishing house,2001.
3. Principles and Techniques of Practical Biochemistry - Wilson, Wilson and Walker,Cambridge University Press, 2000.
4. Introduction to practical Biochemistry - Plummer, 2nd Ed, Tata McGraw-Hill Education,2001.
5. Basics of Enzyme Immobilization - Alka Dwevedi, 1st Edn., Springer InternationalPublishing, 2016.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22BT2401**					
TITLE OF THE COURSE	**PLANT BIOTECHNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To equip the students with fundamentals of culturing plant cells/tissues, culture environment, cell proliferation, differentiation and media formulation.
- To familiarize the student with various important applications of plant tissue culture.
- To equip the students with knowledge on various recombinant DNA techniques and genetically modified organisms with the novel traits.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will be able to explain the basic requirements of plant tissue culture.	L1
CO2	Students will be able to describe the various applications of plant biotechnology for crop improvement.	L2
CO3	Students will be able to describe various tissue culture methods and their applications.	L2
CO4	Students will be able to apply the technical skills – media preparation, sterilization and inoculation of plant material for callus induction to establish nurseries for horticultural and agricultural crops	L3

COURSE CONTENT:

MODULE 1	**15Hrs**

INTRODUCTION: Importance, history and developments of plant tissue culture. Concept of cellular totipotency. *In-vitro* methods in plant tissue culture, design of plant tissue culture Lab. Aseptic Techniques, Nutrient media: General composition and types of media (MS, Gamborg & Nitsch). Sterilization and pre-treatment to explants, use of growth regulators (auxins, cytokines and gibberellins). Adjuvants in plant culture media.

MODULE 2	**15Hrs**

PRINCIPLES OF TISSUE CULTURE: Callus Culture-Definition of callus, types of callus. Initiation, maintenance sub culture and organogenesis.
Micropropagation in plants: Advantages, methods, stages of micropropagation, applications. Soma clonal variation for disease resistance and desired agronomic traits.

Somatic embryogenesis: Embryoid and embryogenesis. Protocol and importance of somatic embryogenesis. Synthetic Seeds and its applications.	
MODULE 3	**15Hrs**
ORGAN CULTURE AND SOMATIC HYBRIDIZATION: Culture protocols and importance of root, meristem, ovary and ovule culture. Factors affecting organogenesis, Cytodifferentiation, dedifferentiation differentiation and factors affecting differentiation. Anther culture for double haploids: Applications in crop improvement. Protoplast culture and fusion: Definition of protoplast, isolation principle, culture protocol, action of enzymes, regeneration of plants, protoplast fusion, somatic cell hybridization and its application. Cybrids and its applications. Suspension culture: Batch and continuous cell suspension culture. Importance of suspension culture in production of secondary metabolites.	
MODULE 4	**15Hrs**
PLANT TRANSGENICS: Technique of transformation-Agrobacterium mediated and physical methods (Micro projectile and electroporation). Plant viral vectors. Gene edition techniques - CRISPR and TALLEN. Application of transgenic plants. Transgenic Plants: Resistance to diseases (Pathogen resistant-viral, fungal and bacterial); insects (Bt gene transfer); Fertilizer management- Nif gene transfer. Edible vaccines from Plants – Banana, Watermelon. Plant antibodies.	

TEXT BOOKS/ REFERENCES:

1. Chawla HS. 2020. Introduction to Plant Biotechnology 3rd Edi. OXFORD & IBH PUBLISHING.
2. Purohit SD. 2012. Introduction to Plant Cell, Tissue and Organ Culture. Prentice Hall India Learning Pvt Ltd.
3. Satyanarayana U. 2020. Biotechnology, Books and Allied Ltd.
4. Slater A, Scott NW and Fowler MR. 2008. Plant Biotechnology – genetic manipulation of plants 2nd Ed. Oxford Publishing.
5. Singh BD. 2014. Biotechnology: Expanding horizons. Kalyani Publishers.
6. Halford NG. 2006. Plant biotechnology: current and future applications of genetically modified crops. John Wiley Publishers.

EXPERIMENTS

1. Preparation of plant culture media
2. Sterilization and inoculation of plant material for callus induction
3. Plant protoplast isolation
4. Preparation of synthetic seeds
5. Isolation of DNA from plant source by CTAB method
6. Anther and embryo culture
7. Demonstration of cell suspension culture.

REFERENCES:

1. Lindsey K. 2007. Plant Tissue Culture Manual. Springer.
2. Nagar S and Aadhi M. 2010. Practical Book of Biotechnology and Plant Tissue Culture, S Chand Publications.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22BT2402**					
TITLE OF THE COURSE	**GENETIC ENGINEERING**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To provide basic understanding and knowledge on the various tools and techniques used for recombinant DNA technology.
• To equip the students with knowledge on enzymes, vectors used in different steps of gene cloning besides detection and characterization methods.
• To familiarize students with various applications of recombinant DNA technology in research and development.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will display clear understanding on the use of different enzymes and vector for genetic manipulation.	L1
CO2	Students will be able to explain the steps involved in cloning.	L2
CO3	Students will be able to explain various techniques used in recombinant DNA technology.	L3
CO4	Students will display comprehensive knowledge on various application and evolving scope of this technology.	L2

COURSE CONTENT:

MODULE 1 — **15Hrs**

INTRODUCTION TO GENETIC ENGINEERING

History and fundamentals of r-DNA technology. Molecular tools for gene cloning: Nucleases -Endo and Exonucleases – Nomenclature, Types and characteristic features. Modification of cut ends. DNA ligases and DNA Recombinases. DNA Modifying Enzymes - Alkaline phosphatase, Polynucleotide kinase, DNase, RNase, DNA polymerase and Klenow fragment, terminal nucleotidyl transferase, RNA dependent DNA Polymerase.

MODULE 2 — **15Hrs**

VEHICLES FOR CLONING

Properties of an ideal vector. Types: Cloning and expression vectors. Cloning vectors: Prokaryotic vectors: Plasmids- pBR 322; pUC 18; Bacteriophages - Lambda phage, Cosmids. Eukaryotic vectors: YAC vectors; Shuttle vectors- Yeast and *E. coli*. For higher plants: Integrative DNA transfer-

Agrobacterium vectors-Ti Plasmid-Binary and Co-integrated vectors; Non integrative DNA transfer-Plant viral vectors (CaMV). For animals: Animal viral vectors- SV 40 (3 types); Expression vectors in Prokaryotes and Eukaryotes.	
MODULE 3	**15Hrs**
GENE ISOLATION AND TRANSFER Isolation of passenger DNA. Cutting of DNA molecules - Physical methods, chemical and enzymatic methods. Joining of DNA molecules-Homopolymer tails, Linkers, Adapters. Transformation. Indirect methods - Colony hybridization, Immunochemical detection. Use of selectable and scorable genes: Selectable genes: Plants-npt; Animals-TK. Scorable genes: Plants-Gus; Animals-lux.	
MODULE 4	**15Hrs**
CHARACTERIZATION OF CLONED DNA Electrophoresis: Gel electrophoresis, Hybridization: Southern; Northern; Western; Dot blots, Autoradiography, DNA sequencing: Sanger's Dideoxy method, Molecular probes. **Applications of rDNA technology**: Transgenic animals: Mouse (Knock-out; Methodology, applications); A brief account of Transgenic Sheep, Poultry, Fish, Cow, with value added attributes. Transgenic Plants: Resistance to diseases (Pathogen resistant-viral, fungal and bacterial); insects (Bt gene transfer); Fertilizer management- Nif gene transfer.	

TEXT BOOKS/REFERANCES:

1. Gupta PK. 2003. Elements of Biotechnology, 2nd Ed. Rastogi publication, Merrut,
2. Singh BD. 2005. Molecular Biology and Genetic Engineering. Kalyani Publishers
3. Glick BR, Pasternak JJ and Patten CL. 2010. Molecular Biotechnology, 4th Ed. Wiley, Washington DC.
4. Howe C. 2007. Gene Cloning and Manipulation. Cambridge University Press.
5. Brown TA. 2013. Gene Cloning and DNA analysis, 6th Edi. Wiley-Blackwell Publications.
6. Primrose SB and Twyman RM. 2002. Principles of Gene Manipulation, 6th Ed. Blackwell Science Ltd.
7. Watson JD, Caudy AA, Myers RM and Wilkowsky JA. 2007. Recombinant DNA: Genes and Genomes, 3rd Ed. WH Free.

EXPERIMENTS
1. Extraction of DNA from plant/bacteria and animal sources 2. Quantification of DNA by spectrophotometry 3. Preparation of competent cells using $CaCl_2$ 4. Bacterial transformation by chemical method 5. Isolation of plasmid from transformed bacterial cells 6. Linearization of plasmid DNA and its visualization by agarose gel electrophoresis 7. Demonstration of physical methods of transformation using virtual videos
TEXT BOOKS/ REFERENCES 1. Ayyagari NA. 2007. Lab Manual in Biochemistry Immunology and Biotechnology. New Delhi: Tata McGraw-Hill Pub. 2. Kumar A. 2011. Molecular Biology and Recombinant DNA Technology: A Practical Book. Narendra Publishing House.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22BT2403**					
TITLE OF THE COURSE	**FUNDAMENTALS OF PLANT PHYSIOLOGY AND PATHOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To familiarize student about the mechanism and physiology life processes in plants.
- To study the economic and pathological importance of microorganisms

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Students will acquire knowledge on proper functioning of plant.	L1
CO2	Students can describe various topics of plant physiology like: plant-water relation, mineral nutrients essential for plant and their translocation etc.	L2
CO3	Students will be able to explain various plant pathogens and role of toxin and enzyme in plant disease	L2
CO4	Student will be able to describe some important plant disease, its etiology and control	L3

COURSE CONTENT:

MODULE 1	**8 Hrs**

Photosynthesis

Light harvesting complexes, Mechanisms of electron transport, Photoprotective mechanisms, CO_2 fixation, C3pathway, C4 pathway, CAM pathway.

Respiration and photorespiration: Citric acid cycle, Plant mitochondrial electron transport, ATP synthesis, Alternate oxidase, Photorespiratory pathway.

Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes, phototropins. stomatal movement, photoperiodism, biological clocks.

MODULE 2	**8 Hrs**

Solute transport and photoassimilate translocation

Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem, Transpiration, Mechanisms of loading and unloading of photoassimilates.

Stress physiology

Responses of plants to Biotic (pathogen and insects) stress, Abiotic (water, temperature and salt) stress, mechanisms of resistance to biotic stress and tolerance to abiotic stress. Nitrogen assimilation: Biological nitrogen fixation.

MODULE 3	8 Hrs

Introduction to plant pathology

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases. Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

Host parasite interaction, recognition concept and infection, symptomatology, disease development - role of enzymes, toxins, growth regulators; defence strategies- oxidative burst; phenolics, phytoalexins, PR proteins, elicitors.

MODULE 4	6 Hrs

Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; Disease management strategies.

Study of diseases of crop plants

Potato Spindle Tuber Disease, Tobacco Mosaic Disease, Bacterial blight of Paddy, Citrus canker, Rust of coffee, Powdery mildew of cucurbits, Wilt of Tomato, Phloem Necrosis of Coffee.

TEXT BOOKS/REFERANCES:

1. Hopkins WG & Huner NPA. 2004. Introduction to plant physiology. John Wiley & Sons.
2. Mukherji S & Ghosh A K. 2005. Plant Physiology. New Central Book Agency, Kolkata.
3. Pathak VN. 1972. Essentials of Plant Pathology. Prakash Pub., Jaipur
4. Agrios GN. 2010. Plant Pathology. Acad. Press.
5. Singh RS. 2008. Plant Diseases, 8th Ed. Oxford & IBH. Pub. Co.
6. Mehrotra RS & Aggarwal A. 2007. Plant Pathology, 7th Ed. Tata McGraw Hill Publ. Co. Ltd.
7. Nene YL & Thapliyal PN. 1993. Fungicides in Plant Disease Control, 3rd Ed. Oxford & IBH, New Delhi.

SEMESTER	**IV**
YEAR	**II**
COURSE CODE	**22BS2401**
TITLE OF THE COURSE	**BIOSAFETY AND GOOD LABORATORY PRACTICE**

SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	**Sem/Year**	**Course Code**	**Title of the Course**
-	-	-	-

COURSE OBJECTIVES:

- To introduce the students to the concepts of biosafety regulatory frameworks concerning genetically modified organisms at national and international levels.
- To impart knowledge of the principles of GLP and their practical applications.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Gain knowledge of the various safety procedures to be followed in laboratory.	L2
CO2	Gain the skills and knowledge necessary to understand and work in GLP compliant environment.	L2
CO3	This course should generate interest for avenues for pursuing higher studies and careers in these areas	L2

COURSE CONTENT:

MODULE I – BIOSAFETY	**18 Hrs**

Introduction, Historical Background; risk assessment and lab acquired infections, Introduction to Biological Safety Cabinets& their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms. Recommended Biosafety Levels for Infectious Agents and Infected Animals. Biosafety Guidelines: Biosafety guidelines and regulations (National and International); Definition of GMOs/LMOs-Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Recombinant DNA Guidelines (1990); Rules forthe manufacture, use/import/export and storage of hazardous microorganisms/ genetically engineeredorganisms or cells (Ministry of Environment and Forests Notification,1989); Environmental release of GMOs; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.

MODULE II – GOOD LABORATORY PRACTICE	12 Hrs
Introduction to GLP, WHO guidelines on GLP, History, Scope (Resources Characterization, Rules, Results, Quality assurance); Levels of Laboratories; General Rules/Protocols for Lab Safety measures; Precaution and Safety in handling of chemicals, Laboratory tools, glassware and instruments; Sample storage and disposal; Log Book maintenance, Basic SOPs for instrument handling and Maintenance. Keeping data records, its analysis by using statistical and mathematical tools. Result analysis and its interpretation. GLP as given by OECD, FDA etc (International perspective); Internal and External Audits.	

REFERENCES:

- Handbook: Good Laboratory Practices. 2001. World health organization (WHO).
- Life science protocol manual. 2018. DBT star college scheme.
- Guidelines for good laboratory practices. 2008. Indian council of medical research, New Delhi.
- Handbook: Good Laboratory Practices (GLP): quality practices for regulated non-clinical research and development, 2nd ed. 2008. World health organization (WHO).

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BT3501**					
TITLE OF THE COURSE	**IMMUNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To provide basic understanding on Immune system: Cells and organs of the immune system
- To give basic framework and knowledge on structure and functions of antibodies, antigens and antigen specificity of antibodies. antigen -antibody interactions, generation of immune response
- To equip the students with knowledge on immunological techniques and vaccines

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Students will be able to identify different immune cells, lymphoid organs and explain their functions	L1
CO2	Students will be able to demonstrate/identify the working of innate vs adaptive immune system	L2
CO3	Students will be able to depict the basic structures of antibodies and the nature of their interaction with antigens. Should display basic functions of antibodies via their effector mechanisms, isotypes of antibodies.	L3
CO4	Students will be able to explain immunotechniques and vaccines	L2

COURSE CONTENT:

MODULE 1 **15Hrs**

COMPONENTS, CELLS AND TISSUES OF THE IMMUNE SYSTEM

Elements of Immune System: History and scope of Immunology, Innate, and Acquired immunity, Humoral and Cell mediated Immunity. Cells and organs of immune system and their functions – Primary and secondary lymphoid organs, T cells, B Cells, macrophage, NK cells Basic outline or scheme of clonal selection in the humoral (B cell) and cellular (T cell) branches of immunity. Immunological memory.

MODULE 2 **15Hrs**

ANTIGENS AND ANTIBODIES

Antigens and Antibodies: Antigens – types, epitopes, haptens, factors affecting immunogenicity, adjuvant concept; Antibodies – structure, isotypes, and functions of Immunoglobulins. Antibody production: Polyclonal and monoclonal. Complement system – components, functions, activation pathways (classical,

alternative, lectin mediated).	
MODULE 3	**15Hrs**
IMMUNE RESPONSES Antigen presenting cells (APCs), target cell concept; Major Histocompatibility Complex (MHC) – MHC I and II. Antigen processing and presentation- endogenous and exogenous antigen processing. Interleukins and Interferons – brief introduction and their important functions. Products and factors produced by T-cell activation; dendritic cells; cytokines (interleukins and interferons) Primary and secondary Immune response.	
MODULE 4	**15Hrs**
MODULE IV: IMMUNOLOGICAL TECHNIQUES AND VACCINES 12Hrs Principles in brief of Antigen-Antibody reactions – Precipitation, Hemagglutination – Blood grouping, ELISA, Immunofluorescence. Vaccines and Immunization: Passive and Active immunization, immunization schedules. Types of Vaccines – Inactivated, Attenuated, and Recombinant vaccines.	

TEXT BOOKS/REFERANCES:

1. Kindt TJ, Osborne BA, Goldsby RA. 2006. Kuby Immunology, 6th Ed. New York: W. H. Freeman & Company.
2. Vaman Rao C. 2007. Immunology, 2nd Ed. Narosa Publishing.
3. Roitt IM. 2001. Essentials of Immunology, Blackwell Scientific Publishers, London.
4. Murphy K and Weaver C. 2016. Janeway's Immunobiology, 9th Ed. W.W. Norton & Company. https://doi.org/10.1201/9781315533247
5. Abbas AK, Lichtman AH, Pilliai S. 2011. Cellular and Molecular Immunology. 7th Ed, Elsevier Health.

EXPERIMENTS

1. Agglutination Reactions: Blood group identification and Rh Typing
2. Precipitation Reactions Demonstration:
   - I. Radial Immuno Diffusion
   - II. Ouchterlony double diffusion
   - III. Rocket Immuno Electrophoresis
3. Serum separation and quantification of serum proteins
4. Enzyme linked Immunoassay: Qualitative Vs Quantitative
   - a. Concepts of specificity of antibodies with the enzyme-based calorimetry
   - b. Different types of ELISA: Direct (sandwich type) scheme; Indirect Antibody ELISA;
   - c. Demonstration of qualitative Dot ELISA
5. Determination of the concentration of viable cells in a suspension by Haemocytometer counting and determination of parentage viability (trypan blue).
6. Study of different cells in whole blood using Giemsa/Leishman stain.

TEXT BOOKS/ REFERENCES

1. Balakrishnan S, Karthik K, Duraisamy S. 2015. Practical Immunology- A Laboratory Manual. DOI:10.13140/RG.2.1.4075.4728.

2. Hay FC, Westwood OMR. 2002. Practical Immunology, 4th Ed. Wiley-Blackwell, Malden, MA.

3. Nigam A. 2008. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw-Hill Pub., (India).

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BT3502**					
TITLE OF THE COURSE	**ANIMAL BIOTECHNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**-**	**4**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To provide basic understanding on the set up/conditions and techniques necessary for animal cell culture.
- To give knowledge on the basic components of tissue engineering and different methods to produce transgenic animals.
- To aware the student with various important applications of animal biotechnology.

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Students will be able to determine the basic requirements of animal cell culture.	L1
CO2	Students will be able to explain the pre requisites of tissue engineering and determine the ways to produce transgenic animals with modified genetic traits.	L2
CO3	Will be able to illustrate the various applications of animal biotechnology in various fields to improve the welfare of society.	L2
CO4	Students will be able to apply the technical skills – media preparation, primary culture of animal cells from tissue, and subculturing.	L3

COURSE CONTENT:

MODULE 1	**15Hrs**

BASICS OF ANIMAL TISSUE CULTURE

Introduction, cell culture laboratory-design and layout. Equipment and Instrumentation. Types of culture media (natural and chemically defined). Importance of serum in the media. Methods of sterilization, Detection of Mycoplasma contaminants.

Primary Cell Culture: Isolation techniques (explant method, mechanical, enzymatic). Secondary Cell Culture: Transformed and continuous cell lines (Hela).

MODULE 2	15Hrs
STEM CELLS AND TISSUE ENGINEERING Stem cells – Adult, Embryonic, Induced pluripotent stem cells. Isolation and characterization of adult stem cells. Three-dimensional tissue culture and Tissue engineering, Scaffolds requirement and Biomaterials (Natural and Synthetic) for tissue engineering, transplantation of engineered cells.	
MODULE 3	**15Hrs**
TRANSGENIC ANIMALS Principal methods for production of transgenic animals (DNA microinjection, embryonic stem cell-mediated gene transfer and retrovirus-mediated gene transfer), importance and applications of transgenic animals. Gene knock out and mice models for tackling human diseases. IVF technology.	
MODULE 4	**15Hrs**
APPLICATIONS OF ANIMAL BIOTECHNOLOGY Pharmaceutical products produced by mammalian cells (plasminogen activator, erythropoietin, interleukins, interferons), Livestock pharming products. Cell culture-based vaccines.	

TEXT BOOKS/REFERENCES:

1. Freshney R Ian. 2010. Culture of Animal Cells, 6th Ed, Wiley-Blackwell.
2. John Davis. 2011. Animal Cell Culture Essential Methods, Wiley & Sons.
3. Satyanarayana U. 2008. Biotechnology, Books and Allied Ltd.
4. Glick BR, Pasternak JJ, Patten CL. 2010. Molecular Biotechnology, 4th Ed. American Society for Microbiology.

EXPERIMENTS

1. Laboratory requirements and safety measures for animal cell culture.
2. Preparation of balanced salt solution
3. Preparation of cell culture media (serum/non-serum supplemented/DMEM).
4. Primary cell culture from fibroblast cells/liver cells/chick embryo
5. Subculture by trypsinization
6. Assessment of viability and counting using trypan blue exclusion method

#Virtual videos of the experiments should supplement wet lab experiments.

TEXT BOOKS/ REFERENCES

- Freshney R Ian. 2010. Culture of Animal Cells, 6th Ed), Wiley-Blackwell.
- Davis JM. 2011. Animal Cell Culture: Essential Methods, Wiley.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BS3501**					
TITLE OF THE COURSE	**BIOETHICS AND IPR**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	**Sem/Year**	**Course Code**	**Title of the Course**
-	**-**	**-**	**-**

COURSE OBJECTIVES:

- To recognize, compare, and contrast the general "ways of thinking" of science (biology) and of philosophy (ethics).
- To recognize, compare, and contrast the general "ways of thinking" of science (biology) and of philosophy (ethics).
- To give elementary essential concepts of Bioethics, IPR and patent laws.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Student should develop basic understanding of the concepts of Bioethics, IPR and Patent Laws	L2
CO2	This course should generate interest for avenues for pursuing higher studies and careers in these areas	L2
CO3	General knowledge should create awareness necessary for higher studies in biotechnological fields	L2

COURSE CONTENTS	
MODULE I – BIOETHICS	**15 Hrs**
Bioethics- The environmental, legal and socioeconomic impacts of biotechnology; Ethical concerns of biotechnology in research and innovation-The GM crop debate – safety, ethics, perception and acceptance of GM crops; Bioethics of Genetically modified organism;Bioethics of CRISPR technique-for editing human embryos; Bioethics of Gene therapy; Bioethics of Stem cell research;Reproductive medicine and ethics;Use of Animals in Research and Testing, and Alternatives for Animals in Research, Animal Cloning, Human Cloning, and their Ethical Aspects; Public education of theprocess of biotechnology involved in generating new forms of life for informed decision-making.	

MODULE II – INTELLECTUAL PROPERTY RIGHTS AND REGULATIONS	15 Hrs
Introduction to Intellectual Property and History. Patents, Trademarks, Copyright, Trade secrets, Industrial Design and Rights, Traditional Knowledge, Geographical Indications - importance of IPR – patentable and non-patentable – patenting life – legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO), Pros and Cons of IP protection. Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner. Agreements and Treaties: GATT, TRIPS Agreements; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV &Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.	

REFERENCES:

1. Beier FK. Crespi RS and Straus T. 1985. Biotechnology and Patent protection. Oxford and IBHPublishing Co. New Delhi.
2. Ganguli P. 1998. Gearing up for Patents….The Indian Scenario. Universities Press.
3. HS Chawla. 2020. Introduction to Plant Biotechnology, 3rd Ed. OXFORD & IBH PUBLISHING.
4. Sateesh M K. 2010. Bioethics and Biosafety. Arihant publications.
5. Parashar S, Goel D. 2013. IPR, Biosafety and Bioethics. Pearson India.
6. Erbisch FH and Maredia KM. 2004. Intellectual property rights in agricultural Biotechnology, University Press.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BS3502**					
TITLE OF THE COURSE	**BIONFORMATICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To get introduced to the basic concepts of Bioinformatics and its significance in biological data analysis.
- To get an overview about biological macromolecular structures and structure prediction methods.

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Will be able to demonstrate mastery of the core concepts of bioinformatics	L1
CO2	The student will be able to apply basic principles of biology, computer science and mathematics to address complex biological problem	L2
CO3	Should be able to plan basic experiments in microbial genetics concerned with clarifying phenotypes and their relationship with the genotype	L3

COURSE CONTENT:

MODULE 1	**07Hrs**
BIOLOGICAL DATA TYPES AND SOURCE: Introduction to population and sample, Classification and Presentation of Data. Quality of data, private and public data sources. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Specialized Genome databases: (SGD, TIGR, and ACeDB). Microbial genomic database (MBGD), Virus data bank (UICTVdb)	
MODULE 2	**10Hrs**
SIMILARITY SEARCHING: Global and Local sequence alignment, Pair wise comparison of sequences, Multiple Sequence alignment of sequences, scoring matrices. Identification of genes in genomes and Phylogenetic analysis with reference to nucleic acids, Identification of ORFs, Identification of motifs	

MODULE 3	07Hrs
INTERPRETTING THE SEQUENCE: Reading DNA from files in FASTA format, reading frames, Regular expressions, restriction maps and restriction enzymes, Genbank libraries, annotation parsing, Annotations indexing, parsing PDB files, parsing BLAST files.	

MODULE 4	06Hrs
SCALING THE HUMAN GENOME: UCSC genome browser, RegulomeDB database, ENCODE-ChIA-PET database, transcription factors binding sites. SNP, EST, STS. Regular Expression (REGEX), Hierarchies and Graphical models (including Markov chain and Bayes algorithm). Genetic variability and connections to clinical data.	

TEXT BOOKS/REFERANCES:

1. Keith J. 2008. Bioinformatics. Humana Press.
2. Doolittle RF. 1996. Computer methods for macromolecular sequence analysis. Academic Press.
3. Mount DW. 2004. Bioinformatics. Sequence and genome analysis. Cold Spring Harbor Lab. press.
4. Pevsner J. 2003. Bioinformatics and functional genomics. John Wiley & Sons Inc.
5. Dunn MJ, Jorde LB, Little PFR, Subramaniam S. 2005. Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics. John Wiley and Sons.
6. Baxavanis A and Ouellette F. 1998. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. John Wiley & Sons, New York.
7. Fry JC. 1993. Biological Data Analysis. A practical Approach. IRL Press, Oxford.
8. Rosenbloom KR *et al.* 2015. The UCSC Genome Browser database: 2015 update. Nucleic Acids Res. 2015 Jan 28; 43 (Database issue): 670-81.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22BT3601**					
TITLE OF THE COURSE	**BIOPROCESS TECHNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To impart basic understanding of principles and key concepts relevant to industrial biotechnology
• To describe the design aspects of bioreactor including the upstream and downstream processing
• To apply the biotechnological concept in the production of biologicals

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Student will be able to describe the isolation and screening of industrially important strains.	L1
CO2	Students can determine fermentation process and different types of fermentation media.	L2
CO3	Students will be able to analyse different bioreactor systems and their components	L3
CO4	Student will be to apply the principles of different upstream and downstream processes involved in bioprocesses	L3
CO5	Apply the concept of microbial technologies in food processing and biorefineries as well as production of biologicals	L3
CO6	The course will enable the student to apply the knowledge in various aspects of fermentation or industrial biotechnology processes.	L4

COURSE CONTENT:

MODULE 1	**15 Hrs**

INTRODUCTION: History, Scope and Development of Fermentation technology; Isolation and screening of industrially important microorganisms − primary and secondary screening; Strain improvement: Mutant selection and Recombinant DNA technology. Preservation of industrially important microbes. Culture collection centers.

MODULE 2	15 Hrs
FERMENTATION PROCESS AND FERMENTER: Types of fermentation - Microbial growth in batch, fed-batch and continuous fermentation. Other types like surface, submerged and solid state fermentation. Different parameters affecting fermentation - pH, temperature, dissolved oxygen, foaming and aeration. Basic components, design of fermenters. Types of fermenter-Laboratory, pilot- scale and production fermenters; constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.	
MODULE 3	**15 Hrs**
UPSTREAM AND DOWNSTREAM PROCESSING: Upstream processing: Formulation of fermentation media, Nutrients: growth factors, carbon, nitrogen, energy and mineral sources, buffers, inhibitors, precursors, inducers, oxygen requirements, antifoam agents and others. Methods of sterilization, inoculum preparation. Downstream processing: Steps in recovery and purification of fermented products, Solid matter, Foam separation, Precipitation, Filtration, Centrifugation, Cell disruption, Liquid Liquid extraction, Solvent recovery, Supercritical fluid extraction, chromatography, Membrane processes, Drying, Crystallization, Whole broth processing, Effluent treatment.	
MODULE 4	**15 Hrs**
INDUSTRIAL BIOPROCESSING: Production of alcohol beverages (wine, beer), organic acid (citric acid), antibiotics (penicillin), amino acid (glutamic acid), vitamins (Vitamin B12), enzyme (amylase), hormone (insulin), fermented dairy products (Yoghurt, cheese), Single Cell Protein (SCP).	

TEXT BOOKS/REFERANCES:

1. Stanbury PF, Whitaker A, Hall SJ. 2016. Principles of Fermentation Technology. Butterworth-Heinemann Press. UK.
2. Peppler HJ, Perlman D. 2014. Microbial Technology: Fermentation Technology. Academic Press.
3. Smith JE. 2009. Biotechnology. Cambridge University Press.UK.
4. Todaro CM, Vogel HC. 2014. Fermentation and Biochemical Engineering Handbook. William Andrew Press. Norwich, NY.
5. Lancini G, Lorenzetti R. 2014. Biotechnology of Antibiotics and other Bioactive Microbial Metabolites. Springer publications, Germany.
6. Satyanarayana U. 2008. Biotechnology. Books and Allied Ltd.

EXPERIMENTS
1. Study of fermenter (Demonstration using video or model or Industrial visit)
2. Isolation of Amylase producing microorganisms and production of Amylase using solid state/submerged fermentation and estimation of Amylase activity
3. Production of ethanol /alcohol using Grapes/ Ginger/ Pomegranate/molasses and estimation of alcohol by specific gravity method
4. Immobilization of yeast by calcium alginate gel entrapment and assay for enzyme-Invertase and Catalase
5. Microbial production of antibiotics
6. Algal culture– Spirulina
7. Production and Estimation of citric acid from *Aspergillus niger*.
8. Preservation Techniques.

TEXT BOOKS/ REFERENCES:

1. Aneja KR. 2014. Laboratory Manual of Microbiology and Biotechnology. Scientific international.
2. Atlas RM. 1984. Microbiology- Fundamentals and applications, Macmillan Publishing Company, New York.
3. Brock TD and Madigan MT. 1996. Biology of Microorganisms. Prentice Hall of India Private Limited.
4. Cappuccino JG and Sherman N. 1999. Microbiology - A Laboratory Manual, 4^{th} Ed. The Addison Wesley Longman, Inc England.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22BT3602**					
TITLE OF THE COURSE	**ENVIRONMENTAL BIOTECHNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To familiarize the student with biotechnological methods in detection of environmental pollution.
- To impart the knowledge on use of microorganisms in waste treatment.
- To equip the students with knowledge on biotechnology tools and its environmental applications.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will learn about environmental quality evaluation, monitoring, and remediation of contaminated environments.	L1
CO2	Students will be able to describe the waste management and xenobiotic degradation methods.	L2
CO3	Students will be able to perform the experiments to assess the quality of the water, to isolate the xenobiotic degrading bacteria.	L3
CO4	Students will be able to critically analyze the environmental issues and apply the biotechnology knowledge in resolving the problems.	L4

COURSE CONTENT:	
MODULE 1	**15Hrs**
INTRODUCTION: Conventional fuels and their environmental impact – Firewood, Coal and Gas. Modern fuels and their environmental impact – Methanogenic bacteria, Biogas, Microbial hydrogen Production, Conversion of sugar to alcohol Gasohol. Biotechnological methods of pollutiondetection-General bioassay, cell biological methods, immunoassays, DNA-based methods, use of biosensors.	
MODULE 2	**15Hrs**
BIOREMEDIATION: Concepts and principles, bioremediation using microbes, *in-situ* and *ex-situ* bioremediation, biosorption and bioaccumulation of heavy metals. Phyto-remediation. Xenobiotics: Degradation by microorganisms with reference to pesticides, herbicides, polyaromatic hydrocarbons.	
MODULE 3	**15Hrs**
WASTE TREATMENT: Waste water treatment- conventional wastewater treatment, use of algae, Bioreactors for waste-water treatment, eutrophication, use of cell immobilization. Solid waste management- Waste as a source of energy, biotechnology in paper and pulp industry, production of oil and fuels from wood waste, anaerobic and aerobic composting, vermiculture, biofuels.	
MODULE 4	**15Hrs**
BIOHYDROMETALLURGY AND BIOMINING: Bioleaching, biosorption, Enrichment of oresby microorganisms (Gold, Copper and Uranium). Environmental significance of genetically modified microbes, plants and animals.	

TEXT BOOKS/ REFERENCES:

1. Jördening HJ and Winter J. 2004. Environmental Biotechnology: Concepts and Applications, 1st Ed. Wiley-Blackwell publications.
2. Evams G M. 2003. Environmental Biotechnology-Theory and applications. John Wiley and sons Ltd.
3. Mohapatra PK. 2013. Textbook of Environmental Biotechnology. I.K. International Publishing House Pvt. Limited.
4. Thakur IS. 2006. Environmental Biotechnology: Basic concepts and Applications. I K Internationals Publishing House Pvt. Ltd.
5. Satyanarayana U. 2020. Biotechnology. Books and Allied Ltd.

EXPERIMENTS
1. Detection of coliforms for determination of the purity of potable water by MPN Method. 2. Isolation of xenobiotic degrading bacteria by selective enrichment techniques. 3. Calculation of Total Dissolved Solids (TDS) of water sample. 4. Determination of sulphates in the water by turbidometric method. 5. Calculation of BOD and COD of sewage water sample. 6. Effect of heavy metals (Cd /Cr/Zn/Cu) on seed germination and plant growth.
REFERENCES: 1. Pillai S. 2009. A Comprehensive Laboratory Manual for Environmental Science and Technology. New Age International (P) Limited, Publishers. 2. Thakur I S. 2006. Environmental Biotechnology: Basic concepts and Applications. I K Internationals Publishing House Pvt. Ltd.

SEMESTER	**VI**
YEAR	**III**
COURSE CODE	**22BS3601**
TITLE OF THE COURSE	**PRINCIPLES OF 'MULTI-OMICS'**

SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To acquaint students with various aspects of biotechnology and bio-engineering using omics technologies
• To provide key insights into omics approaches in personalized and precision medicine

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will have knowledge in specific methods used in genomics, proteomics and metabolomics used in analytical processes.	L1
CO2	Students will be able to perform statistical analysis crucial for interpretation of experimental results	L2
CO3	Students will be able to apply specialized research methods necessary for the analysis of proteins, genes and metabolites	L3

COURSE CONTENT:	
MODULE 1	**07Hrs**
GENOME & GENOMICS: Genome mapping: Physical and Genetic Map, Genome Sequencing, Next generation sequencing methods ,Genome Annotation, Functional Genomics	
MODULE 2	**07Hrs**
TRANSCRIPTOMICS: Search for transcription factor binding sites, RNA-Seq, Microarrays, Regulatory RNAs: small or large, Computational prediction of miRNA target genes, RNA Darkmatter	

MODULE 3	10Hrs
PROTEOMICS AND METABOLOMICS: Basic concepts , Tools of proteomics- SDS PAGE, 2D PAGE , Liquid chromatography , Mass Spectrometry (ESI and MALDI) ,Protein identification by peptide mass fingerprinting ,Applications of proteomics. Fundamental concept, Tools of metabolomics- Capillary electrophoresis, Gas chromatography, Electrochemical detectors, Case studies	
MODULE 4	**06Hrs**
'OMICS': APPLICATIONS AND FUTURE PERSPECTIVES: Multi-omics in disease prediction and health. Multi-omics technologies for crop improvement and sustainable agriculture. Applications in Biomedical and Environmental sciences	

TEXT BOOKS/REFERANCES:

1. Bioinformatics. Keith, J. Humana Press, 2008.

2. Computer methods for macromolecular sequence analysis. R.F.Doolittle, Academic Press, 2096.

3. Introduction to Proteomics -Tools for the New Biology by Daniel C. Liebler, Humana Press.

4. Bioinformatics and functional genomics. J. Pevsner. Wiley-Liss, 2003.

5. Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics, Jorde et al., (eds.) John Wiley and Sons, 2005.

6. Metabolomics- Methods and Protocols by Wolfram Weckwerth, Humana Press.

7. Fry, J.C. (2093). Biological Data Analysis. A practical Approach. IRL Press, Oxford.

8.Transcriptomics: Expression Pattern Analysis, Virendra Gomase, Somnath Tagore; VDM Publishing, 2009 – Science

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22BS3602**					
TITLE OF THE COURSE	**TOXICOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
1. To learn various toxicants present and their exposure level on day-to-day basis.
2. To study the effects of toxins on the physiologic, metabolic, reproductive, and developmental processes.

COURSE OUTCOMES

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Students will learn and understand all substances can be toxic depending on the means and level of exposure	L1
CO2	Students will learn the basic concepts of cellular toxicity and chemical actions on cells and body organs	L2
CO3	Students will learn the importance and diversity of drug interactions with various organs	L3

COURSE CONTENT:	
MODULE 1	**10 Hrs**
INTRODUCTION OF TOXICOLOGY: Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins. Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms. Toxicant proceeding *in vivo*: Absorption, Distribution, Excretion an Metabolism of foreign/toxic compounds.	

MODULE II	5 Hrs
ENVIRONMENTAL TOXICOLOGY: Environmental pollution- Sources and types of pollution, Important pollution events, Priority pollutants. Air pollution- Classification and properties of air pollutants, Behaviour and fate of air pollutants, Photochemical smog, Acid Rain, health effects of air pollution. Water pollution- origin of Wastewater, Domestic Water Pollution, Industrial water pollution, Agricultural water pollution, Toxic water pollutants and their health effects, Groundwater pollution, marine pollution	
MODULE III	**5 Hrs**
INDUSTRIAL TOXICOLOGY: Industrial Chemicals: Government Regulation of Chemicals, Waysof exposure, Toxic effects, Long-term consequences and developmental toxicity. Food Additives and Contaminants types of food additives, Preservatives, Saccharin. Toxicity of trace elements- Iodine, iron, zinc, copper, manganese, selenium, molybdenum, and cobalt Cyto-toxicity of heavy metals- Cadmium, mercury, arsenic, chromium and lead. Brief introduction to toxicity of pesticides and inseciticides.	
MODULE IV	**10 Hrs**
ORGAN TOXICOLOGY: Basics of organ toxicity- Target organs, Organ selectivity and specificity, gender specific diversity of toxins. Hepatotoxicity - Actions of toxins on the liver, Chronic liver injury; Cardiotoxicity - pathology of cardiac toxicity, mechanisms of cardiotoxicity; Respiratory Toxicity - Systematic lung toxins, Lung pathology; Reproductive System – Teratogenicity; Neurotoxicity- Effect of toxic agents on neurons, Ion channel neurotoxins and Nephrotoxicity- susceptibility of kidney to toxic insult, chemically induced renal injury.	

Reference books:

1. Whalen, Finkel, and Panavelil, Pharmacology, 6th ed. (Lippincott Williams & Wilkins: 2015).
2. Lieberman and Peet, Mark's Basic Medical Biochemistry: A Clinical Approach, 5th ed. (Wolters Kluwer: 2018).
3. Hodgson, A Textbook of Modern Toxicology, 4th ed. (J Wiley & Sons: 2010).
4. Molecular and Biochemical Toxicology, 4th ed., Smart and Hodgson, eds. (J Wiley & Sons: 2008).
5. Frank and Ottoboni, The Dose makes the Poison: A Plain-language Guide to Toxicology, 3rd ed. eBook, (J Wiley & Sons: 2011).
6. Ottoboni, The Dose makes the Poison: A Plain-language Guide to Toxicology, 2nd ed., (J Wiley & Sons: 1997).
7. A-Z Guide to Drug-Herb-Vitamin Interactions, 2nd ed., Gaby, Batz, Chester and Constantine, eds. (Three Rivers Press: 2006).
8. Gilbert, A Small Dose of Toxicology: The health effects of common chemicals, (CRC Press: 2004).
9. Gibson, Multiple Chemical Sensitivities: A survival guide, (New Harbinger Publications: 2000).
10. Toxicology and Clinical Pharmacology of Herbal Products, Cupp and Karch, eds. (Springer-Verlag: 2000).
11. Lawson, Staying Well in a Toxic World, (Lynwood Press: 2000).

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22BT4701**					
TITLE OF THE COURSE	**FOOD TECHNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To comprehend basic concepts of food sciences and properties of foods, and the factors (chemical and enzymatic) affecting these properties.
• To equip the students with fundamentals of food processing and preservation.
• To provide understanding on emerging concepts in food technology

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Student will be able to explain the basic concepts of food sciences and properties of foods, and the chemical and enzymatic factors affecting these properties.	L1
CO2	Students will be able to comprehend different food standards for various categories of foods.	L2
CO3	Students will be able to understand different analytical techniques employed across various categories of foods	L3
CO4	Students will be able to describe the effect of food constituents on food quality	L2
CO5	Students will be able to determine the fundamentals of food processing and preservation	L2
CO6	Students will be able to understand some emerging concepts in food technology	L3

COURSE CONTENT:	
MODULE 1	**15 Hrs**
INTRODUCTION TO FOOD SCIENCE AND TECHNOLOGY Basics of chemistry of food constituents- carbohydrates, proteins, lipids, vitamins, minerals, water (different forms of water present in foods and their effect on quality and preservation of foods), minor constituents affecting texture, colour, taste, odour; Food microbiology, Food biochemistry, Food additives, General food composition and effect of food constituents on food quality.	
MODULE 2	**15 Hrs**
FOOD ANALYSIS Food adulterations, standards of identity, purity and methodology for analysis of a) Cereals, legumes, oil seeds and their products; b) Fruits, vegetables, tubers, and their products; c) Tea, coffee, cocoa, chocolate, spices, sugar, condiments; d) Milk and milk products; e) Meat, fish and poultry products; f) Miscellaneous foods e.g., fermented products.	
MODULE 3	**15 Hrs**
FOOD PROCESSING AND PRESERVATION **Food processing: Introduction** to food processing of various foods including dairy, bakery, brewing, fruit and vegetable products, plantation products, oilseeds, meat, fish, poultry; pro and prebiotics and nutraceuticals. **Food preservation:** Principles of food preservation by dehydration, thermal treatments like pasteurization, sterilization, canning, retorting etc., low temperature i.e., chilling and freezing, chemical preservation/ bio-preservation, traditional methods like salting/ syruping, pickling, fermentation etc., non- thermal processes like MAP, irradiation, high pressure processing etc., and hurdle technology.	
MODULE 4	**15 Hrs**
ENZYMES AND GENETICALLY MODIFIED FOODS **Enzymes:** Enzymes used in food industry, recovery of enzymes from natural sources, cheese making and whey processing, enzymatic processing of fruit juices. Role of enzymes in baking, meat and meat processing; comparative methods of toxicity test in (novel) foods; biosensors; enzymatic approach to tailor made fats; catabolic processes and oxygen-dependent reactions in food; use of lipases and reactions in organic solvents and two phases. **Genetically modified foods:** Need for GM foods, Potential benefits in agriculture, Crop engineered for input and output traits, nutritional improvement, animal foods, issues of concern, tests for detecting GM foods, safety of GM foods.	

TEXT BOOKS/REFERANCES:

1. Lee BH. 2014. Fundamentals of Food Biotechnology. John Wiley and sons
2. Lloyd RA, Pentzer WT. 2017. Handling transportation and storage of fruits and vegetables, Medtech scientific international PVT LTD (Vol 1 & 2).
3. Potter NN, Hotchkiss JH. 1995. Food Science, 5th Ed. Springer US
4. Manay NS, Shadaksharaswami M. 2004. Foods: Facts and Principles, 4th Ed. New Age Publishers.
5. Srilakshmi B. 2002. Food Science. New Age Publishers.
6. Meyer LM. 2004. Food Chemistry. New Age Publishers.
7. Deman JM. 1990. Principles of Food Chemistry, 2nd Ed. Van Nostrand Reinhold, NewYork.
8. Ramaswamy H and Marcott M. 2005. Food Processing Principles and Applications. CRC Press.

EXPERIMENTS

1. Food analysis methods
   a) Moisture determination
   b) Ash determination
   c) Crude protein determination
   d) Crude fat determination
2. Fermented Foods
   a) Production of vegetable pickles
   b) Production of yogurt
3. Estimation of food bioactive (phenolics, pigments etc)
4. Fruit and vegetable processing
5. Milk processing (Video/ Industry Visit)
6. Microbial production of enzyme and its application in food industry (Amylase/Pectinase/ Lipase etc)

TEXT BOOKS/ REFERENCES

1. AOAC International. 2003. Official methods of analysis of AOAC International. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities
2. Kirk RS and Sawyer R. 1991. Pearson's Chemical Analysis of Foods. 9th Ed. Harlow, UK, Longman Scientific and Technical.
3. Leo ML. 2004. Handbook of Food Analysis. 2nd Edition. Vol 1,2 and 3, Marcel Dekker.
4. Linden G. 1996. Analytical Techniques for Foods and Agricultural Products. VCH.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22BT4702**					
TITLE OF THE COURSE	**MEDICAL BIOTECHNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To provide knowledge on the cause and molecular mechanism of human diseases.
- To equip students with technologies/techniques that targets/uses biomolecules (nucleic acids and proteins) for a specific disease diagnosis and treatment.
- To familiarize students with features of nanomaterials and its various applications in medical field (diagnosis and treatment).

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will be able to illustrate the cause and molecular basis of different diseases.	L1
CO2	Students will be able to explain different techniques that use biomolecules (DNA, RNA, protein) for disease diagnosis.	L2
CO3	Students will be able to describe wide range of therapeutic strategies using biomolecules/genetic material.	L2
CO4	Students will be able to demonstrate skills to diagnose diseases by molecular methods.	L3
CO5	Students will be able to explain and demonstrate the applications of nanomaterials in disease diagnoses and treatment.	L2

COURSE CONTENT:

MODULE 1	**15Hrs**

DISEASES- MOLECULAR MECHANISM

Infectious disease (**Bacterial** Infection- Tuberculosis, Salmonellosis, **Viral** infection – Corona, Dengue, Parasitic disease- Amoebiosis and Malaria); Genetic characteristics of causative agent, pathogenesis, symptoms. **Metabolic disease** (Example: Diabetes), **Genetic disorders** (Example: Sickle Cell anemia); **Cancer** (Example: Breast cancer). Antimicrobial Resistance (AMR).

MODULE 2	15Hrs

MOLECULAR DIAGNOSTICS

Immunological approaches (ELISA to detect HIV, Dengue), **DNA based approaches** (PCR/Real Time PCR/Next generation sequencing to detect HIV, *Salmonella typhimurium*), **RNA signatures of diseases** (changes in gene expression using transcriptome analyses- TB, Cancer).

MODULE 3	15Hrs

MOLECULAR THERAPEUTICS

Protein therapeutics: Pharmaceutical (Insulin), Recombinant Antibodies (Monoclonal antibodies), Enzymes [Glucocerebrosidase (GCase) for Gaucher disease]. **Nucleic acid therapeutics:** Targeting specific mRNA and DNA (Antisense RNA, Aptamers), **Gene Therapy**: Gene delivery systems as viral [adenoviral, herpes simplex virus], nonviral delivery systems (physical: DNA bombardment, electroporation) and (chemical: Cationic lipids, cationic polymers). In vivo and Ex-vivo delivery (Cytokine IL-12 in cancer). **Genome Editing:** (CRISPR Cas9 system for genetic disorder). **Advanced Immunotherapy**: Chimeric Antigen receptor (CAR-T) cell therapy.

MODULE 4	15Hrs

NANOBIOTECHNOLOGY

Introduction to Nanomaterials, Biological synthesis of Nanomaterials: Synthesis using microorganisms, synthesis using plant extracts (silver nano particles), Nanoformulations.

Characterization Methods: Microscopy (Scanning Electron Microscopy – Transmission Electron Microscopy), Spectral analyses (FTIR, UV-visible)

Applications: Nanomaterials in diagnosis and treatment. Biosensors and Biochips.

TEXT BOOKS/REFERENCES:

1. Glick GR, Delovitch TL, Pattern CL. 2014. Medical Biotechnology, 1st Edi. ASM Press.
2. Pongracz J and Keen M. 2008. Medical Biotechnology, 1st Edi. Elsevier publications.
3. Prajapat R, Kasturi M, Manivannan B, Mishra A. 2021. Fundamentals of Medical Biotechnology. Nova Science Publishers, Inc.

EXPERIMENTS

1. Detection of bacteria (*E. coli/S. aureus*) by Polymerase Chain Reaction (PCR).
2. ELISA/WIDAL test for antigen/antibody detection (Demo)
3. Synthesis of silver nano particle from aloe vera extract
4. Evaluation of antimicrobial activity of silver nanomaterial
5. Bioinformatics Tools for gene editing using CRISPR-Cas9 system
6. Sickling test to identify sickle shaped RBCs

7. Determine susceptibility of bacteria to beta-lactam antibiotics by Kirby Bauer disc diffusion method.
    a. [#]Virtual videos of the experiments should supplement wet lab experiments.

TEXT BOOKS/ REFERENCES

- Susweta *et al.*, 2015. Duplex PCR for specific detection of *Escherichia coli* and its differentiation from other Enterobacteriaceae. The Indian Journal of Animal Sciences, 85(8). https://epubs.icar.org.in/index.php/IJAnS
- ELISA detection kit – Hand Book. Himeda.
- Kuntauruk *et al.*, 2010. Sandwich ELISA for hemoglobin A2 quantification and identification of beta-thalassemia carriers. *Int J Hematol*, 91(2):219-28. doi: 10.1007/s12185-009-0490-3.
- Anju *et al.,* 2021. Green synthesis of silver nanoparticles from *Aloe vera* leaf extract and its antimicrobial activity https://doi.org/10.1016/j.matpr.2021.02.665
- CHOP-CHOP web tool for selecting target site for CRISPR Cas9 - https://chopchop.cbu.uib.no

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22BT4703**					
TITLE OF THE COURSE	**AGRICULTURAL BIOTECHNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To equip the students with knowledge on biocontrol agents and bio-fertilizers, and its formulation.
- To familiarize the student with hybrid seed production technology.
- To equip the students with knowledge on various recombinant DNA techniques and genetically modified organisms with the novel traits.

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Students will be able to demonstrate the biocontrol agents and bio-fertilizers formulation.	L3
CO2	Students will be able to explain the hybrid seed production technology.	L2
CO3	Students will be able to describe the gene transformation techniques in plants.	L2
CO4	Students will be able to describe the various applications of transgenics and molecular farming.	L2

COURSE CONTENT:

MODULE 1	**15Hrs**

INTRODUCTION: Conventional crop improvement techniques and their limitations, biotechnology for crop improvement, future prospects of biotechnology for agriculture.

Biopesticides: Baculovirus, *Bacillus thuringenesis* and mycopesticides (Trichoderma). Isolation, Identification, Mode of action, Characterization, Mass production Technology, formulations, and methods of applications. Integrated pest management -Insect pheromones.

Biofertilizers: Importance of biofertilizers, types of biofertilizers, microorganisms used as biofertilizers (special emphasis to *Rhizobium*, VAMs), mode of action, methods of Application, mass production and commercial importance.

MODULE 2	15Hrs

Seed BIOTECHNOLOGY:

Seed development and structure: Development of the male and female gametophytes, pollination, fertilization, and formation of the zygote; molecular basis of embryogenesis. Seed structure and composition, determinants of seed structure.

Hybrid seed production technology*:* Variability and its conservation in crop plants, mode of reproduction in relation to plant breeding, breeding systems, controlling pollination, genetic principles, qualitative and quantitative traits, different methods of breeding for self and cross pollinated crops, plant introduction and acclimatization, wide crosses, male sterility, apomixes, polyploidy. Terminator gene technology. High technology green house; Climate management.

MODULE 3	15Hrs

GENETIC ENGINEERING OF CROP PLANTS: Gene transfer techniques for desirable traits in crop plants. Selectable markers, reporter gene and promoters used in plant transformation vectors.
Biotic stress tolerance; insect, pest and pathogen resistance. Abiotic stress tolerance; salt, water and drought tolerance. Herbicide tolerance. Post-harvest Protection: Antisense RNA technology for extending shelf life of fruits and shelf life of flowers. Artificial Intelligence in smart farming.

MODULE 4	15Hrs

MOLECULAR FARMING: Transgenic plants as production systems-production of alkaloids, steroids, colouring agents, flavoring agents, biodegradable plastics, industrial enzymes, therapeutic proteins, biopharmaceuticals. Beta carotene production in rice (Golden rice) and potato.
Intellectual Property Rights (IPR): IPRs and agricultural technology implications for India, Plant Breeder's Rights, legal implications, commercial exploitation of traditional knowledge and protection. Ethical issues associated with consumption of GM food, labelling of GM crops and foods.

TEXT BOOKS/ REFERENCES:

1. Purohit SS. 2018. Agricultural Biotechnology, 3rd Edi. Agrobios (India) publishers.
2. Chawl HS. 2020. Introduction to Plant Biotechnology, 3rd Ed. OXFORD & IBH PUBLISHING.
3. Allard RW. 1999. Principles of plant breeding, 2nd edition. Wiley publisher.
4. Buchanan BB, Jones RL and Gruissem W. 2015. Biochemistry and Molecular Biology of Plants. Wiley.
5. Lyrett G W and Grierson D. 1990. Genetic Engineering of Crop Plants. Butterworths publishers.

EXPERIMENTS

1. Seed viability testing
2. Testing the biochemical composition of a seed – total carbohydrate, total protein and total nitrogen.
3. Seed inoculation with *Rhizobium* culture and observation for root nodulation
4. Preparation and formulation of bio-control agent
5. Preparation and formulation biofertilizer
6. Demonstration of hybridization techniques (Emasculation and Pollination)
7. Preparation of vermi-compost using agricultural waste/ Production of edible mushroom.

REFERENCES:

1. Purohit SS. 2018. Agricultural Biotechnology, 3rd Edi. Agrobios (India) publishers.
2. Nagar S and Aadhi M. 2010. Practical Book of Biotechnology and Plant Tissue Culture. S Chand Publications.
3. Singh B, LaL GM. 2022. Practical Manual of Genetics & Plant Breeding. Sathish serial publishing house.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	22BS4701					
TITLE OF THE COURSE	RESEARCH METHODOLOGY					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	45	3

Perquisite Courses (if any)

#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
To provide an overview of essential research steps to be followed when conducting research / project work.
To understand chief ingredients to be incorporated in conduct as well as writing of scientific reports/dissertation/thesis
To know the implication professional research ethics and common misconduct details of researcher and research work

COURSE OUTCOME

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Show and explain the concepts of meaning ofresearch, scope of research including different types of research, scientific research process and research methodology steps	L1
CO2	Perform review of literature using electronic media, selecting research problem formulate research problem statement, writing hypothesis, explain criteria of forming objectives, materials and methods, results and discussion	L2
CO3	Identify and explain experimental research designs for both qualitative and quantitative research	L2
CO4	Explain different sampling methods and sampling design, basic statistical methods for treatment of data and observations	L2
CO5	Demonstrate ingredients and components of a research report, dissertation and thesis and explain integral components of research article and research proposal	L2
CO6	Explain professional research ethics and elaborate on misconduct in research	L2

COURSE CONTENT:	
MODULE 1:	**12 hrs**
INTRODUCTION TO RESEARCH: Meaning, Objectives and Characteristics of research – Scientific Method Types of research - Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical - Research process - Criteria of good research **PROBLEM STATEMENT:** Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem; **LITERATURE SURVEY:** Importance of literature review in defining a problem **- S**urvey of literature - Primary and secondary sources - web as a source - searching the web - Identifying gap areas from literature review. **HYPOTHESIS:** Definition of hypothesis**,** Basic concepts, variables-Dependent and independent variables, Development of working hypothesis; Ingredients of Research Objectives, deriving objectives of research.	
MODULE 2:	**12 hrs**
Sampling, Material and Methods: Sample- Sampling - Types of sampling; Material - Experiments, Data – Basics of Analysis; Writing materials and method chapter of a research report **Results and Discussion**: Representation of results; Tables, graphs; Discussion, Purpose and Function of Discussion **Research Designs:** Research design; Need of research design - Basic Principles; Features of good design – Important concepts relating to research design; Max-min-con principle, **Common Research Designs**: Cross-sectional, Case-control, Longitudinal and Cohort research designs, advantages and disadvantages of each of research designs **Summary and Conclusion:** Writing of Summary, conclusions of research findings,Acknowledgement section of a research report and an article.	
MODULE 3:	**10Hrs**
Research Ethics: Values, Ethics and Morals**,** Research Professionalism**,** Tenets of Ethics; Conducting and reporting of science/engineering; Relationship in research groups; Hazards to good scientific practice; Scientific misconduct: Fabrication, Falsification and Plagiarism. **Report and Article Writing:** Structure and components of scientific reports; Abstract-Key words**;** Types of reports; Significance of reporting; Different steps in the preparation of reports; Layout, structure and Language of typical reports; References; Citation styles- APA and MLA styles of citation, intext and end text citations. **Oral Presentation:** Importance of effective communication. Planning; Preparation; Practice; Making presentation; Use of visual aids.	
MODULE 4:	**11Hrs**
Scientific Article Writing: Title preparation – Importance of title; need for specific titles; List of authors and addresses – order of names; defining the order with example; types of abstracts; economy of words; How to write introduction- Rules; exceptions; citations and abbreviations Materials and methods: Purpose; materials; methods; tables and figures; form and grammar; Result and Discussion writing: content of results; handling numbers; clarity; avoiding redundancy; Discussion writing: Components of discussion; factual relationships; strengths and limitations; significance of paper;	

Stating Acknowledgements: Ingredients of the acknowledgements; courtesy; Citation of the References: Rules; electronics aid; in-text citation; styles of referencing
Research Proposal Fundamentals: What is a grant proposal? Why proposals fail?; Developing and writing of grant proposals; overview of steps to develop grant proposals; Proposal Development Process: Standard Proposal Parts; writing Budget section.
Intellectual Property Rights: IPRs- Invention and Creativity- Intellectual Property-Importance and Protection of Intellectual Property Rights (IPRs); A brief summary of: Patents, Copyrights, Trademarks

REFERENCES:

1. Tuckman B, Harper BE. 2012. Conducting Educational Research, 6th Edition. Rowman& Littlefield Publishers, Inc. ISBN 978-1-4422-0965-7 (electronic).
2. Kothari CR. 1990. Research Methodology: Methods and Techniques. New AgeInternational.
3. Garg BL, Karadia R, Agarwal F and Agarwal UK. 2002. An introduction to ResearchMethodology. RBSA Publishers.
4. Anderson TW. 1974. An Introduction to Multivariate Statistical Analysis, Wiley EasternPvt., Ltd., New Delhi
5. Sinha SC and Dhiman AK. 2002. Research Methodology, Ess Publications.2 volumes.
6. Trochim WMK. 2005. Research Methods: the concise knowledge base. Atomic DogPublishing. 270p.
7. Day RA. 1992. How to Write and Publish a Scientific Paper. Cambridge University Press.
8. Fink A. 2009. Conducting Research Literature Reviews: From the Internet to Paper. SagePublications.
9. Coley SM and Scheinberg CA. 1990. Proposal Writing. Sage Publications.

MINOR COURSES OFFERED

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22BT2404**					
TITLE OF THE COURSE	**PLANT BIOTECHNOLOGY (MINOR)**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To equip the students with fundamentals of culturing plant cells and tissues, culture environment, cell proliferation, differentiation and media formulation.
- To familiarize the student with various important applications of plant tissue culture
- To equip the students with knowledge on various recombinant DNA techniques and genetically modified organisms with the novel traits.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will be able to explain the basic requirements of plant tissue culture.	L1
CO2	Students will be able to describe the various applications of plant biotechnology for crop improvement.	L2
CO3	Students will be able to describe various tissue culture methods and their applications.	L2
CO4	Students will be able to apply the technical skills – media preparation,, sterilization and inoculation of plant material for callus induction to establish nurseries for horticultural and agricultural crops	L3

COURSE CONTENT:

MODULE 1	**15Hrs**

INTRODUCTION: Importance, history and developments of plant tissue culture. Concept of cellular totipotency. *In-vitro* methods in plant tissue culture, design of plant tissue culture Lab. Aseptic Techniques, Nutrient media: General composition and types of media (MS, Gamborg & Nitsch). Sterilization and pre-treatment to explants, use of growth regulators (auxins, cytokines and

gibberellins). Adjuvents in plant culture media.	
MODULE 2	**15Hrs**
PRINCIPLES OF TISSUE CULTURE: Callus culture-Definition of callus, types of callus. initiation, maintenance sub culture and organogenesis. Micropropagation in plants: Advantages, methods, stages of micropropagation, applications.Somaclonal variation for disease resistance and desired agronomic traits. Somatic embryogenesis: Embryoid and embryogenesis. Protocol and importance of somatic embryogenesis. Synthetic Seeds and its applications.	
MODULE 3	**15Hrs**
ORGAN CULTURE AND SOMATIC HYBRIDIZATION: Culture protocols and importance of root, meristem, ovary and ovule culture. Factors affecting organogenesis, Cytodifferentiation, dedifferentiation differentiation and factors affecting defferentiation. Anther culture for double haploids: Applications in crop improvement. Protoplast culture and fusion: Definition of protoplast, isolation principle, culture protocol, action of enzymes, regeneration of plants, protoplast fusion, somatic cell hybridization and its application. Cybrids and its applications Suspension culture: Batch and continuous cell suspension culture. Importance of suspension culture in production of secondary metabolites.	
MODULE 4	**15Hrs**
PLANT TRANSGENICS: Technique of transformation-Agrobacterium mediated and physical methods (Micro projectile and electroporation). Plant viral vectors. Gene edition techniques - CRISPR and TALLEN. Application of transgenic plants. Transgenic Plants: Resistance to diseases (Pathogen resistant-viral, fungal and bacterial); insects (Bt gene transfer); Fertilizer management- Nif gene transfer. Edible vaccines from Plants – Banana, Watermelon. Plant antibodies.	

TEXT BOOKS/ REFERENCES:

1. Chawla HS. 2020. Introduction to Plant Biotechnology 3rd Edi. OXFORD & IBH PUBLISHING.
2. Purohit SD. 2012. Introduction to Plant Cell, Tissue and Organ Culture. Prentice Hall India Learning Pvt Ltd.
3. Satyanarayana U. 2020. Biotechnology, Books and Allied Ltd.
4. Slater A, Scott NW and Fowler MR. 2008. Plant Biotechnology – genetic manipulation of plants 2nd Ed. Oxford Publishing.
5. Singh BD. 2014. Biotechnology: Expanding horizons. Kalyani Publishers.
6. Halford NG. 2006. Plant biotechnology: current and future applications of genetically modified crops. John Wiley Publishers.

EXPERIMENTS

1. Preparation of plant culture media
2. Sterilization and inoculation of plant material for callus induction
3. Plant protoplast isolation
4. Preparation of synthetic seeds
5. Isolation of DNA from plant source by CTAB method
6. Anther and embryo culture
7. Demonstration of cell suspension culture

REFERENCES:

1. Lindsey K. 2007. Plant Tissue Culture Manual. Springer.
2. Nagar S and Aadhi M. 2010. Practical Book of Biotechnology and Plant Tissue Culture, S Chand Publications.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BT3503**					
TITLE OF THE COURSE	**ANIMAL BIOTECHNOLOGY (MINOR)**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**-**	**4**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To provide basic understanding on the set up/conditions and techniques necessary for animal cell culture.
- To give knowledge on the basic components of tissue engineering and different methods to produce transgenic animals.
- To aware the student with various important applications of animal biotechnology.

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Students will be able to determine the basic requirements of animal cell culture.	L1
CO2	Students will be able to explain the pre requisites of tissue engineering and determine the ways to produce transgenic animals with modified genetic traits.	L2
CO3	Will be able to illustrate the various applications of animal biotechnology in various fields to improve the welfare of society.	L2
CO4	Students will be able to apply the technical skills – media preparation, primary culture of animal cells from tissue, and subculturing.	L3

COURSE CONTENT:

MODULE 1	**15Hrs**

BASICS OF ANIMAL TISSUE CULTURE

Introduction, cell culture laboratory-design and layout. Equipment and Instrumentation. Types of culture media (natural and chemically defined). Importance of serum in the media. Methods of sterilization, Detection of Mycoplasma contaminants.

Primary Cell Culture: Isolation techniques (explant method, mechanical, enzymatic). Secondary Cell

Culture: Transformed and continuous cell lines (Hela).	
MODULE 2	**15Hrs**
STEM CELLS AND TISSUE ENGINEERING Stem cells – Adult, Embryonic, Induced pluripotent stem cells. Isolation and characterization of adult stem cells. Three-dimensional tissue culture and Tissue engineering, Scaffolds requirement and Biomaterials (Natural and Synthetic) for tissue engineering, transplantation of engineered cells.	
MODULE 3	**15Hrs**
TRANSGENIC ANIMALS Principal methods for production of transgenic animals (DNA microinjection, embryonic stem cell-mediated gene transfer and retrovirus-mediated gene transfer), importance and applications of transgenic animals. Gene knock out and mice models for tackling human diseases. IVF technology.	
MODULE 4	**15Hrs**
APPLICATIONS OF ANIMAL BIOTECHNOLOGY Pharmaceutical products produced by mammalian cells (plasminogen activator, erythropoietin, interleukins, interferons), Livestock pharming products. Cell culture-based vaccines.	

TEXT BOOKS/REFERENCES:

1. Freshney R Ian. 2010. Culture of Animal Cells, 6th Ed, Wiley-Blackwell.
2. John Davis. 2011. Animal Cell Culture Essential Methods, Wiley & Sons.
3. Satyanarayana U. 2008. Biotechnology, Books and Allied Ltd.
4. Glick BR, Pasternak JJ, Patten CL. 2010. Molecular Biotechnology, 4th Ed. American Society for Microbiology.

EXPERIMENTS

1. Laboratory requirements and safety measures for animal cell culture.
2. Preparation of balanced salt solution
3. Preparation of cell culture media (serum/non-serum supplemented/DMEM).
4. Preparation of hepatocytes
5. Primary cell culture by explant method
6. Sub culturing by trypsinization
7. Assessment of viability and counting using trypan blue exclusion method

#Virtual videos of the experiments should supplement wet lab experiments.

TEXT BOOKS/ REFERENCES

- Freshney R Ian. 2010. Culture of Animal Cells, 6th Ed), Wiley-Blackwell.
- Davis JM. 2011. Animal Cell Culture: Essential Methods, Wiley.

SEMESTER	**VI**
YEAR	**III**
COURSE CODE	**22BT3603**
TITLE OF THE COURSE	**INDUSTRIAL BIOTECHNOLOGY (MINOR)**

SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To impart basic understanding of principles and key concepts relevant to industrial biotechnology
- To describe the design aspects of bioreactor including the upstream and downstream processing
- To apply the biotechnological concept in the production of biologicals

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Student will be able to describe of isolation and screening of industrially important strains	L1
CO2	Students can determine fermentation process and different types of fermentation media	L2
CO3	Students will be able analyse different bioreactor systems and their components	L3
CO4	Student will be apply the principles of different upstream and downstream processes involved in bioprocesses	L3
CO5	Apply the concept of microbial technologies in food processing and biorefineries as well as production of biologicals	L3
CO6	The course will enable the student to apply the knowledge in various aspects of fermentation or industrial biotechnology processes.	L4

COURSE CONTENT:

MODULE 1	**15 Hrs**

History, Scope and Development of Fermentation technology; Isolation and screening of industrially important microorganisms – primary and secondary screening; Strain improvement: Mutant selection and Recombinant DNA technology. Preservation of industrially important microbes. Culture collection

centers.	
MODULE 2	**15 Hrs**
Fermentation Process and Fermenter: Types of fermentation - Microbial growth in batch, fed-batch and continuous fermentation. Other types like surface, submerged and solid state fermentation. Different parameters affecting fermentation - pH, temperature, dissolved oxygen, foaming and aeration. Basic components, design of fermenters. Types of fermenter-Laboratory, pilot- scale and production fermenters; constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.	
MODULE 3	**15 Hrs**
Upstream and Downstream Processing Upstream processing: Formulation of fermentation media, Nutrients: growth factors, carbon, nitrogen, energy and mineral sources, buffers, inhibitors, precursors, inducers, oxygen requirements, antifoam agents and others. Methods of sterilization, inoculum preparation. Downstream processing: Steps in recovery and purification of fermented products, Solid matter, Foam separation, Precipitation, Filtration, Centrifugation, Cell disruption, Liquid Liquid extraction, Solvent recovery, Supercritical fluid extraction, chromatography, Membrane processes, Drying, Crystallization, Whole broth processing, Effluent treatment.	
MODULE 4	**15 Hrs**
Industrial Bioprocessing : Production of alcohol beverages (wine, beer), organic acid (citric acid), antibiotics (penicillin), amino acid (glutamic acid), vitamins (Vitamin B12), enzyme (amylase), hormone (insulin), fermented dairy products (Yoghurt, cheese), Single Cell Protein (SCP).	

TEXT BOOKS/REFERANCES:

1. Stanbury PF, Whitaker A, Hall SJ. 2016. Principles of Fermentation Technology. Butterworth-Heinemann Press. UK.
2. Peppler HJ, Perlman D. 2014. Microbial Technology: Fermentation Technology. Academic Press.
3. Smith JE. 2009. Biotechnology. Cambridge University Press.UK.
4. Todaro CM, Vogel HC. 2014. Fermentation and Biochemical Engineering Handbook. William Andrew Press. Norwich, NY.
5. Lancini G, Lorenzetti R. 2014. Biotechnology of Antibiotics and other Bioactive Microbial Metabolites. Springer publications, Germany.
6. Satyanarayana U. 2008. Biotechnology. Books and Allied Ltd.

EXPERIMENTS
1. Study of fermenter (Demonstration using video or model or Industrial visit)
2. Isolation of Amylase producing microorganisms and production of Amylase using solid state/submerged fermentation and estimation of Amylase activity
3. Production of ethanol /alcohol using Grapes/ Ginger/ Pomegranate/molasses and estimation of alcohol by specific gravity method
4. Immobilization of yeast by calcium alginate gel entrapment and assay for enzyme-Invertase and Catalase
5. Microbial production of antibiotics
6. Algal culture– Spirulina
7. Production and Estimation of citric acid from *Aspergillus niger*.
8. Preservation Techniques.

TEXT BOOKS/ REFERENCES

1. Aneja KR. 2014. Laboratory Manual of Microbiology and Biotechnology. Scientific international.
2. Atlas RM. 1984. Microbiology- Fundamentals and applications, Macmillan Publishing Company, New York.
3. Brock TD and Madigan MT. 1996. Biology of Microorganisms. Prentice Hall of India Private Limited.
4. Cappuccino JG and Sherman N. 1999. Microbiology - A Laboratory Manual, 4th Ed. The Addison Wesley Longman, Inc England.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22GS2401**					
TITLE OF THE COURSE	**CYTOGENETICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Understand chromatin structure, higher-order organization, cell cycle checkpoints, and regulatory proteins.
• Differentiate meiosis and mitosis, explain genetic controls, and analyze mitotic machinery.
• Study epigenetic modifications, environmental impact on transcription, RNAi mechanisms, and their roles.

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will be able to describe chromatin organization and distinguish mitosis and meiosis.	L1
CO2	Students will be able to assess chromosomal domains' effects and analyze cell cycle regulation.	L2
CO3	Should be able to evaluate environmental transcription impact and RNAi mechanisms.	L3
CO4	Should be able to assess epigenetic study methods and evaluate RNAi's genetic analysis utility.	L4

COURSE CONTENT:

MODULE 1 — **15Hrs**

CHROMATIN STRUCTURE AND ORGANIZATION

Histones, DNA, Nucleosome, and higher-level organization. Chromosome organization: Metaphase chromosome: centromere and kinetochore, telomere and its maintenance; Holocentric chromosomes and supernumerary chromosomes Chromosomal domains (matrix, loop domains) and their functional significance Chromatin remodelling and epigenetics, Heterochromatin and euchromatin, position effect variegation, boundary elements, Functional states of chromatin and alterations in chromatin organization. Structural and functional organization of interphase nucleus, Giant chromosomes, Polytene chromosomes, Lampbrush chromosomes.

MODULE 2 — **15Hrs**

CHROMOSOMAL ANOMALIES: STRUCTURAL AND NUMERICAL VARIATION

Structural and numerical variations of chromosomes and their implications; euploidy, haploids, diploids and polyploids; Utilization of aneuploids in gene location; Variation in chromosome behaviour, somatic segregation and chimeras, endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations, balanced lethal and chromosome complexes; Chromosome Breakage: Types of chromosome breaks: Single-strand breaks, double-strand breaks, and chromosomal rearrangements, Molecular and cellular consequences of unrepaired breaks, DNA damage sources: Ionizing radiation, chemicals, and replication stress, techniques for studying chromosome breaks: Comet assay, DNA repair assays.

MODULE 3	**15Hrs**

TECHNIQUES FOR STUDYING CHROMOSOMES

Classical Chromosome Staining Techniques: Giemsa Staining: Principles and applications in karyotyping, Aceto-orcein and Feulgen Staining: Detection of DNA and chromosomal structure C-banding and G-banding: Differential staining of constitutive heterochromatin and chromosome banding patterns, AgNOR Staining: Visualization of nucleolar organizer regions, Fluorescence In Situ Hybridization (FISH): Principles of FISH: Probe design and target specificity, Types of FISH: DNA FISH, RNA FISH, and Comparative Genomic Hybridization (CGH), FISH applications: Chromosome mapping, gene localization, and chromosomal abnormalities detection, Multicolor FISH (mFISH) and Spectral Karyotyping (SKY) for complex chromosomal analysis, Chromosome Painting and Genomic Probing: Chromosome painting techniques: Whole chromosome and chromosome arm painting, Genomic probes and microarrays: Array Comparative Genomic Hybridization (aCGH) and high-resolution mapping.

MODULE 4	**15Hrs**

APPLICATIONS OF CYTOGENETICS

Molecular cytogenetics: Applications in cancer research, prenatal diagnosis, and genetic mapping, cancer cytogenetics, Advances in genomic probing: Next-generation sequencing and its impact on chromosome studies. Chromosome manipulations in Plants: in-vitro techniques to overcome the fertilization barriers in crops; Polyploidy. Genetic consequences of polyploidization and role of polyploids in crop breeding. Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids.

TEXT BOOKS/REFERANCES:

1. "Genes IX" by Benjamin Lewin
2. "Cytogenetics" by Rebeca S. Hunt and Mariano Rocchi
3. "Principles of Genetics" by D. Peter Snustad and Michael J. Simmons
4. "Genetic Analysis: An Integrated Approach" by Mark F. Sanders and John L. Bowman
5. "Human Molecular Genetics" by Tom Strachan and Andrew P. Read
6. Modern Genetic Analysis, Griffiths AJF et al., - Freeman

EXPERIMENTS
1. Sample collection and harvesting of cells for chromosome analysis. 2. Chromosome preparation and staining: using various techniques such as Giemsa, Wright, or G-banding. 3. Study of polytene chromosomes of *Drosophila melanogaster*. 4. Study of metaphase chromosomes of *Drosophila melanogaster*. 5. Study of inversion and other chormosomal aberrations. 6. Genetic crosses and analysis of P1, P2, F1, F2 & test cross progeny in Drosophila - Sex linked inheritance and Interaction of genes 7. Chromosome breakage analysis

TEXT BOOKS/ REFERENCES

1. "Cytogenetic Laboratory Management: Chromosomal, FISH and Microarray-Based Best Practices and Procedures" by Marilyn S. Arsham (Wiley-Blackwell)
2. This book provides comprehensive guidance on managing a cytogenetic laboratory and covers various techniques including FISH and microarray analysis.
3. "Cytogenetics: Basic and Applied Aspects" by Uma Rao (CRC Press)
4. This book covers both the basic principles of cytogenetics and its practical applications, making it useful for those looking for laboratory techniques.
5. "Human Cytogenetics: A Practical Approach" by Rooney, D. E., & Czepulkowski, B. H. (Oxford University Press)
6. This practical guide focuses on human cytogenetics and provides protocols and techniques for various cytogenetic analyses.
7. "Atlas of Human Cytogenetics" by L. D. Müller-Höcker and C. E. Alman (Springer)
8. While more visual in nature, this atlas provides images of various chromosomal abnormalities and cytogenetic techniques.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22GS2402**					
TITLE OF THE COURSE	**DEVELOPMENTAL BIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To introduce students to the fundamental principles of developmental biology, including the mechanisms of cell differentiation, morphogenesis, and tissue patterning.
• To provide students with a detailed understanding of the molecular and genetic basis of embryonic development, including the role of signaling pathways and gene regulation.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will be able to explain the major stages of embryonic development, including the formation of the germ layers, organogenesis, and morphogenesis.	L1
CO2	Students will be able to describe the molecular and genetic mechanisms underlying key developmental processes, such as cell fate determination, differentiation, and patterning.	L2
CO3	Students will be able to design and carry out experiments to investigate specific questions related to developmental biology.	L3

COURSE CONTENT:	
MODULE 1	**15Hrs**
INTRODUCTION TO DEVELOPMENTAL BIOLOGY: Definition and scope of developmental biology, Historical perspectives and major contributors: Hans Spermann, Scott Gilbert, Ernset McCulloch etc., Importance of developmental biology to medicine and biotechnology. Origin of life: a) Haldane's Experiment, origin of biomolecules, primitive life forms b) RNA world, concept of ribozyme and evolution of enzymes c) Endosymbiotic origin of mitochondria and chloroplast d) Law of thermodynamics and sustenance of life.	
MODULE 2	**15Hrs**
EARLY EMBRYONIC DEVELOPMENT: **Basic concepts of development:** Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic	

equivalence and the cytoplasmic determinants; imprinting. **Gametogenesis, fertilization and early development:** Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.

MODULE 3	**15Hrs**
POST EMBRYONIC DEVELOPMENT : **Morphogenesis and organogenesis in plants**: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum. **Morphogenesis and organogenesis in animals**: Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila. **Neurulation and organogenesis:** Development of brain, eye, heart in frog; Extra-embryonic membranes. Placentation in mammals. Programmed morphogenetic histogenetic cell death (apoptosis); Erythropoesis, mylopoesis; Ageing.	

MODULE 4	**15Hrs**
GENETIC CONTROL OF DEVELOPMENT AND AND REGENERATIVE MEDICINE : **Genetic control of development:** Organizer concept and embryonic induction. Concept of neoteny and paedogenesis-Regeneration in Planarians and Amphibians. Metamorphosis in Amphibians. **Regenerative Medicine: Regenerative Medicine:** Introduction to stem cell and regenerative medicine. Embryonic stem cells (ESC), Human ESCs in regenerative medicine, Stem cell bioengineering, Extracellular microenvironments (ECM), Engineering cancer microenvironments	

TEXT BOOK/ REFERENCES:

1. "Developmental Biology" by Scott F. Gilbert and Michael J. F. Barresi (Sinauer Associates, Inc., 2016).
2. "Principles of Development" by Lewis Wolpert, Cheryll Tickle, and Alfonso Martinez Arias (Oxford University Press, 2015).
3. "Essential Developmental Biology" by Jonathan M. W. Slack (Wiley-Blackwell, 2012).
4. "From Egg to Embryo: Regional Specification in Early Development" by Rosa Beddington (Cambridge University Press, 1996).
5. "The Embryo: Normal and Abnormal Development and Growth" by Ronan O' Rahilly and Fabiola Muller (Wiley-Liss, 2001).
6. "Developmental Biology" by Carlos A. F. De Souza and Anna Lucia M. M. Junqueira (Springer, 2015).
7. "Developmental Biology: A Very Short Introduction" by Lewis Wolpert (Oxford University Press, 2011).
8. "Developmental Biology Protocols" edited by Rocky S. Tuan and Cecilia W. Lo (Humana Press, 2000).
9. Cell biology, Genetics, Molecular biology, evolution and ecology, Minkoff, E. C. (2083). Evolutionary biology. Reading, MA: Addison- Wesley Publishing Company.
10. Sober, E. (2004). Conceptual issues in evolutionary biology. Cambridge, MA:MIT Press.

11. Fundamentals of ecology by Eugene Odum,Cengage; 5 edition (2005).
12. Ecology & Environment by P.D. Sharma, Rastogi Publications (3 August 2015).
13. Development Biology by Scott F Gilbert, Sinauer Associates; 10th edition (10 July2013).

EXPERIMENTS
1. Blastoderm mounting in chick embryo.
2. Slides of different stages of chick embryo-18 hours [primitive streak stage], 24 hours, 48 hours 72 hours and 96 hours.
3. Study of the developmental stages and life cycle of Drosophila from stock culture.
4. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages).
5. Examination of gametes from frog/rat sperm and ova through permanent slides or photomicrographs.
6. Immunohistochemical staining to study the expression pattern of gap and pair rule gene proteins.
7. Study of different types of placenta.

REFERENCES

1. Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press.
3. Carlson, R. F. Patten's Foundations of Embryology.
4. Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers.
5. Lewis Wolpert (2002). Principles of Development. II Edition, Oxford University Press.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22GS2403**					
TITLE OF THE COURSE	**QUANTITATIVE GENETICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To help students understand the forces that have an impact on levels of genetic variations in natural and/or experimental populations for both qualitative and quantitative traits.
• To familiarize students with the principles and applications of different statistical methods used in biological research.
• To impart knowledge about detecting variations at the genetic level.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOM YLEVEL**
CO1	Students will get in basic knowledge about population genetics and association mapping.	L1
CO2	Enable to obtain in depth knowledge about the principles and applications of various statistical tools used in research.	L2
CO3	Students will learn about the basic principles involved in variations at a genetic level.	L3
CO4	Students will be equipped with functional knowledge about identification of diseased gene/locus for various diseases.	L2

COURSE CONTENT:

MODULE 1	**7 Hrs**
INTRODUCTION AND HISTORICAL BACKGROUND Multiple factor hypothesis, Qualitative and quantitative characters; Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic; Nature of gene action- additive, dominance and epistatic, linkage effect; Principles of analysis of variance and linear model, Expected variance components, Random and fixed effect model, Comparison of means and variances for significance.	
MODULE 2	**8 Hrs**
DESIGNS FOR PLANT BREEDING EXPERIMENTS: Designs for plant breeding experiments- principles and applications; Variability parameters, the concept of selection; simultaneous selection modes and selection of parents, MANOVA; Association analysis- Genotypic and phenotypic correlation; Path analysis; Discriminate function and principal component analysis, Genetic divergence analysis- Metroglyph and D2; Generation mean analysis; Parent progeny regression analysis; Mating designs- classification, Diallel, partial diallel; L × T; NCDs;	

and TTC; Concept of combining ability and gene action; G × E interaction-Adaptability and stability.	
MODULE 3	**7 Hrs**
METHODS AND MODELS FOR STABILITY ANALYSIS: Basic models- principles and interpretation, Bi-plot analysis; QTL mapping, Strategies for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis; Markers, Marker-assisted selection and factors influencing the MAS; Simultaneous selection based on marker and phenotype.	
MODULE 4	**8 Hrs**
VARIABILITY PARAMETERS: Analysis and interpretation of Index score and Metroglyph; Clustering and interpretation of D2 analysis; Genotypic and phenotypic correlation analysis and interpretation; Path coefficient analysis and interpretation; Estimation of different types of heterosis, inbreeding depression and interpretation; A, B, and C Scaling test; L × T analysis and interpretation; QTL analysis; Use of computer packages; Diallel analysis; G × E interaction and stability analysis.	

TEXT BOOKS/REFERANCES:

1. "Introduction to Quantitative Genetics" by D. S. Falconer and T. F. C. Mackay
2. "Statistical Genetics of Quantitative Traits: Linkage, Maps and QTL" by Rongling Wu and George Casella
3. "Quantitative Genetics in the Wild" by Anne Charmantier and Dany Garant

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22BS2401**					
TITLE OF THE COURSE	**BIOSAFETY AND GOOD LABORATORY PRACTICE**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	**Sem/Year**	**Course Code**	**Title of the Course**
-	-	-	-

COURSE OBJECTIVES:

- To introduce the students to the concepts of biosafety regulatory frameworks concerning genetically modified organisms at national and international levels.
- To impart knowledge of the principles of GLP and their practical applications.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Gain knowledge of the various safety procedures to be followed in laboratory.	L2
CO2	Gain the skills and knowledge necessary to understand and work in GLP compliant environment.	L2
CO3	This course should generate interest for avenues for pursuing higher studies and careers in these areas	L2

MODULE I	**18 Hrs**
BIOSAFETY: Introduction, Historical Background; risk assessment and lab acquired infections, Introduction to Biological Safety Cabinets& their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms. Recommended Biosafety Levels for Infectious Agents and Infected Animals. Biosafety Guidelines: Biosafety guidelines and regulations (National and International); Definition of GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture;Recombinant DNA Guidelines (1990); Rules forthe manufacture, use/import/export and storage of hazardous microorganisms/ genetically engineeredorganisms or cells (Ministry of Environment and Forests Notification,1989); Environmental release of GMOs; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.	

MODULE II	**12 Hrs**
GOOD LABORATORY PRACTICE: Introduction to GLP, WHO guidelines on GLP, History, Scope (Resources Characterization, Rules, Results, Quality assurance);Levels of Laboratories; General Rules/Protocols for Lab Safety measures; Precaution and Safety in handling of chemicals,	

Laboratory tools, glasswares and instruments;Sample storage and disposal; Log Book maintenance, Basic SOPs for instrument handling and Maintenance. Keeping data records, its analysis by using statistical and mathematical tools. Result analysis and its interpretation.GLP as given by OECD, FDA etc (International perspective); Internal and External Audits.

REFERENCES:

- Handbook Good Laboratory Practices-World health organization(WHO)
- Life science protocol manual (2018)-DBT star college scheme
- Guidelines for good laboratory practices-Indian council of medical research, NewDelhi (2008).
- Handbook: Good Laboratory Practices (GLP): quality practices for regulated non-clinical research and development-2nd ed.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22GS3501**					
TITLE OF THE COURSE	**MICROBIAL GENETICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To provide students with a solid foundation in microbial genetics, covering DNA structure, replication, transcription, translation, and gene regulation.
- To introduce students to the concepts of mutation, mutagenesis, horizontal gene transfer, and microbial evolution.
- To equip students with practical skills in recombination, genetic engineering techniques, and genomic analysis.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will be able to explain the molecular basis of genetic information storage, processing, and regulation in microbial organisms.	L1
CO2	Students will grasp the mechanisms underlying genetic variation, mutation repair, and the role of horizontal gene transfer in shaping microbial diversity.	L2
CO3	Students will be able to perform experiments related to cloning, gene expression analysis, and genomic comparisons, fostering an understanding of applications in biotechnology and research.	L3

COURSE CONTENT:

MODULE 1	**15Hrs**

FUNDAMENTALS OF MICROBIAL GENETICS

Introduction to Microbial Genetics: Definition, scope, and significance of microbial genetics.Historical overview and key discoveries. DNA Structure and Replication

Molecular structure of DNA: DNA replication: enzymes, mechanisms, and fidelity.

RNA Transcription and Gene Expression: Transcription initiation, elongation, and termination. Genetic code and translation process.

Regulation of Gene Expression: Operons and regulatory elements in prokaryotes. Eukaryotic gene regulation: transcription factors, enhancers, and silencers.

MODULE 2	15Hrs

GENETIC VARIATION AND MUTATION

Mutagenesis and DNA Repair: Types of mutations: point mutations, insertions, deletions. Mutagenic agents and their mechanisms of action. DNA repair pathways: mismatch repair, base excision repair.

Horizontal Gene Transfer: Transformation, transduction, conjugation. Mobile genetic elements: plasmids, transposons.

Microbial Evolution and Adaptation: Mechanisms of microbial evolution. Adaptive radiation, speciation, and niche specialization.

MODULE 3	15Hrs

MICROBIAL GENOMICS

Genomic Analysis Techniques: Whole-genome sequencing methods and technologies. Comparative **genomics and functional annotation.**

Bioinformatics Tools in Microbial Genetics: Sequence alignment algorithms and databases. Phylogenetics and evolutionary analysis.

Applications of Microbial Genomics: Pathogenomics: understanding virulence and drug resistance. Metagenomics and ecological insights.

MODULE 4	15Hrs

MICROBIOME

Introduction to Microbiomes: Definition and significance of microbiomes,

Gut Microbiome: Composition and function of the gut microbiome

Skin and Oral Microbiomes: Skin microbiome: diversity and role in health, Oral microbiome and its connection to oral health.

Therapeutic Applications and Future Directions: Fecal microbiota transplantation (FMT) and its use in medicine, Probiotics, prebiotics, and postbiotics.

TEXT BOOKS/REFERANCES:

1. "Microbial Genetics" by Stanley Maloy, John Cronan, and David Freifelder.
2. "Genetics: A Conceptual Approach" by Benjamin A. Pierce.
3. "Principles of Genetics" by Snustad and Simmons.
4. "Recombinant DNA: Genes and Genomes - A Short Course" by James D. Watson.
5. "Microbial Genomics" by David W. Ussery.
6. "Introduction to Genetic Analysis" by Anthony J. F. Griffiths.
7. "Bioinformatics Algorithms: An Active Learning Approach" by Phillip Compeau and Pavel Pevzner.
8. "Microbial Evolution and Coevolution" by Joshua S. Weitz and Richard E. Lenski.
9. "Molecular Evolution: A Phylogenetic Approach" by Roderick D.M. Page and Edward C. Holmes.
10. "The Human Microbiome Handbook" by Kelly S. Bender and Jack A. Gilbert.

EXPERIMENTS
1) DNA Extraction and Gel Electrophoresis Isolate DNA from bacterial cells and visualize its size using gel electrophoresis.
2) Polymerase Chain Reaction (PCR) and DNA Amplification Perform PCR to amplify a specific DNA fragment using primers and a DNA polymerase.
3) Plasmid Transformation in Bacteria Introduce a recombinant plasmid into bacterial cells and select for transformed cells.
4) Mutagenesis and Mutation Detection Induce mutations in bacterial cultures using mutagenic agents and screen for mutant phenotypes.
6) Construction of Recombinant Plasmids Clone a specific DNA fragment into a plasmid vector for expression or analysis.
7) Gene Expression Analysis using Reporter Assays Measure gene expression by fusing a reporter gene (e.g., GFP) to a regulatory sequence and quantifying reporter activity.
8) Comparative Genomics and Phylogenetic Analysis Analyze DNA sequences from different microbial species to construct phylogenetic trees and infer evolutionary relationships.

REFERENCES

1. Mullis, K. B., & Faloona, F. A. (1987). Specific synthesis of DNA in vitro via a polymerase-catalyzed chain reaction. Methods in Enzymology, 155, 335-350.
2. Cohen, S. N., Chang, A. C., & Hsu, L. (1972). Nonchromosomal antibiotic resistance in bacteria: Genetic transformation of Escherichia coli by R-factor DNA. Proceedings of the National Academy of Sciences of the United States of America, 69(8), 2110-2114.
3. Ames, B. N., McCann, J., & Yamasaki, E. (1975). Methods for detecting carcinogens and mutagens with the Salmonella/mammalian-microsome mutagenicity test. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis, 31(6), 347-364.
4. Cohen, S. N., Chang, A. C., Boyer, H. W., & Helling, R. B. (1973). Construction of biologically functional bacterial plasmids in vitro. Proceedings of the National Academy of Sciences of the United States of America, 70(11), 3240-3244.
5. Chalfie, M., Tu, Y., Euskirchen, G., Ward, W. W., & Prasher, D. C. (1994). Green fluorescent protein as a marker for gene expression. Science, 263(5148), 802-805.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22GS3502**					
TITLE OF THE COURSE	**MOLECULAR GENETICS & GENOMICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**0**	**4**	**0**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To provide students with a comprehensive understanding of the structures and components of genes, genomes, chromosomes, and chromatin
• To enable students with a Understand modern technologies used for analyzing structure and function of • genes
• To familiarize students with the genetic basis of human diseases and the application of molecular genetics and genomics in clinical practice.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will be able to explain the basic principles and concepts of molecular genetics and genomics.	L1
CO2	Students will be able to describe the molecular mechanisms of gene expression, regulation, and transmission.	L2
CO3	Students will be able to evaluate the genetic basis of human diseases and apply molecular genetics and genomics knowledge to clinical practice.	L3

COURSE CONTENT:	
MODULE 1	**15Hrs**
MOLECULAR BASIS of HEREDITY: DNA as genetic material, Experiments of Griffith; Avery, Mc Cleod; Mc Carthy and Harshey Chase. RNA as genetic material- Experiment of Fraenkel and Singer. Nucleic acids: DNA structure and types, RNA types and structure, Ribozymes, DNA Replication and repair: DNA Replication in prokaryotes and eukaryotes. Mutations	
MODULE 2	**15Hrs**
GENOME ORGANIZATION: Prokaryotic genome:- Chromosomal and plasmid, Eukaryotic genome:- Eukaryotic nuclear genomes: Arabidopsis, rice, yeast, Drosophila, C. elegans and mouse genome. Eukaryotic organelle genomes - Chloroplast and Mitochondria. Fine structure of the Gene: Cistron, muton and recon. Gene Expression and its control: Genetic code, RNA processing, translation in prokaryotes and eukaryotes. Comparative genomics: Whole genome	

analysis, Genome sequence, molecular phylogeny, Base Composition, C-value, CpG islands, Junk DNA. Comparative genomics as an aid to gene mapping and study of human disease genes.

MODULE 3	**15Hrs**

ACCESSING THE GENOME:
Genomic Physical mapping: Genetic Linkage, Recombination, Map unit, Genetic marker: DNA markers RFLPs, SSLPs, SNPs., Restriction mapping. Strategies for Sequencing Genomes: Genomic Libraries, From shot gun sequencing to NGS. Interpreting a genome sequence. Human Genome Project: History, organization and goals of human genome project. Organization of human genome. RNAi-Discovery of RNA interference (RNAi): PTGS, RNAi and related phenomena.Categories of small non-coding RNAs: dsRNAs, siRNAs, shRNAs, piRNAs and miRNAs, Detection of small RNAs. Molecular basis of RNAi /siRNA /miRNA mediated gene silencing. RNAi in defense and the regulation of chromatin structure and gene expression; RNAi suppressors. Large-scale genetic analysis using RNAi.

MODULE 4	**15Hrs**

MOLECULAR GENETICS OF DISEASE MANIFESTATION:
Genetic and Epigenetic changes to genome. Single factorial disorders (Sickle cell anemia and Cystic Fibrosis) and Multi-factorial genetic disorders (Alzheimer's Disease), Teratogens' and Congenital Malformations (Developmental Diseases), Genetic Disease Diagnosis: Karyotyping, Fluorescent in situ hybridization (FISH), Cancer Genetics: Mechanism of transformation of cells. Physical and chemical carcinogenic agents, Viral and cellular oncogenes, tumor suppressor genes (examples from breast/colon cancer).

TEXT BOOK/ REFERENCES:

1. Molecular Biology of the Cell, 6th Edition by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter (2015).
2. Principles of Genetics, 6th Edition by Robert H. Tamarin (2015).
3. An Introduction to Genetic Analysis, 11th Edition by Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll, and John Doebley (2015).
4. Genomes 4 by T.A. Brown (2013).
5. Genes VIII by Benjamin Lewin (2013).
6. Molecular Genetics of Bacteria, 4th Edition by Larry Snyder and Wendy Champness (2013).
7. Human Molecular Genetics, 4th Edition by Tom Strachan and Andrew P. Read (2010).
8. Plant Molecular Biology, 2nd Edition by Chris Bowler and Paul Chory (2010).
9. Epigenetics: How Environment Shapes Our Genes by Richard C. Francis (2012).
10. The Epigenetics Revolution: How Modern Biology is Rewriting Our Understanding of Genetics, Disease, and Inheritance by Nessa Carey (2013).
11. Genetics and Analysis of Quantitative Traits by Michael Lynch and Bruce Walsh (1998).
12. The Selfish Gene: 30th Anniversary Edition by Richard Dawkins (2006).

EXPERIMENTS
1. Isolation of genomic DNA from bacteria, plant and whole blood samples.
2. Electrophoresis: Agarose gel electrophoresis for genomic and PCR DNA.
3. Polymerase chain reaction (PCR): Amplification of specific DNA sequences using PCR.
4. Restriction fragment length polymorphism (RFLP): Digestion of DNA with restriction enzymes followed by gel electrophoresis to detect polymorphisms.
5. Cloning: Insertion of a DNA fragment into a vector for replication and expression in a host organism.
6. Bioinformatics analysis: Using various software tools to analyze DNA sequences, identify mutations, and predict the effects of genetic variants.
7. Comparative genomics: Comparing the genomes of different organisms to identify evolutionary relationships and functional differences (Phylogenetic tree construction).

REFERENCES

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the Cell (6th ed.). Garland Science.
2. Griffiths, A. J. F., Miller, J. H., Suzuki, D. T., Lewontin, R. C., & Gelbart, W. M. (2000). An Introduction to Genetic Analysis (7th ed.). W. H. Freeman.
3. Hartl, D. L., & Jones, E. W. (2017). Genetics: Analysis of Genes and Genomes (9th ed.). Jones and Bartlett Publishers.
4. Weaver, R. F. (2011). Molecular Biology (5th ed.). McGraw-Hill.
5. Felsenfeld, G., & Davies, D. R. (2012). Genes, Chromosomes, and Disease: From Simple Traits to Complex Traits to Personalized Medicine (2nd ed.). Cold Spring Harbor Laboratory Press.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BS3501**					
TITLE OF THE COURSE	**BIOETHICS AND IPR**					
SCHEME OF INSTRUCTION	**Lecture Hours**	**Tutorial Hours**	**Practical Hours**	**Seminar/ Projects Hours**	**Total Hours**	**Credits**
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	**Sem/Year**	**Course Code**	**Title of the Course**
-	**-**	**-**	**-**

COURSE OBJECTIVES:

- To recognize, compare, and contrast the general "ways of thinking" of science (biology) and of philosophy (ethics).
- To recognize, compare, and contrast the general "ways of thinking" of science (biology) and of philosophy (ethics).
- To give elementary essential concepts of Bioethics, IPR and patent laws.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Student should develop basic understanding of the concepts of Bioethics, IPR and Patent Laws	L2
CO2	This course should generate interest for avenues for pursuing higher studies and careers in these areas	L2
CO3	General knowledge should create awareness necessary for higher studies in biotechnological fields	L2

COURSE CONTENTS	
MODULE I	**15 Hrs**

BIOETHICS

Bioethics- The environmental, legal and socioeconomic impacts of biotechnology; Ethical concerns of biotechnology in research and innovation-The GM crop debate – safety, ethics, perception and acceptance of GM crops; Bioethics of Genetically modified organism;Bioethics of CRISPR technique- for editing human embryos; Bioethics of Gene therapy; Bioethics of Stem cell research;Reproductive medicine and ethics;Use of Animals in Research and Testing, and Alternatives for Animals in Research,Animal Cloning, Human Cloning, and their Ethical Aspects; Public education of theprocess of biotechnology involved in generating new forms of life for informed decision-making.

MODULE II	15 Hrs
INTELLECTUAL PROPERTY RIGHTS AND REGULATIONS Introduction to Intellectual Property and History. Patents, Trademarks, Copyright, Trade secrets, Industrial Design and Rights, Traditional Knowledge, Geographical Indications - importance of IPR – patentable and non-patentable – patenting life – legal protection of biotechnological inventions – WorldIntellectual Property Rights Organization (WIPO), Pros and Cons of IP protection. Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner. Agreements and Treaties: GATT, TRIPS Agreements; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV &Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.	

REFERENCES:

1. Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBHPublishingCo. New Delhi.
2. Ganguli Prabuddha Gearing up for Patents. The Indian Scenario" , Universities Press (1998)
3. Introduction to Plant Biotechnology, H S Chawla
4. M K Sateesh. Bioethics and Biosafety. Kindle Edition
5. Shomini Parashar, Deepa Goel IPR, Biosafety and Bioethics Pearson India 2013
6. F. H. Erbisch and K. M. Maredia. Intellectual property rights in agricultural Biotechnology, UniversityPress.
7. SivamiahShantharam, Jane F. Montegomery. Biotechnology, Biosafety and Biodiversity, Oxford &IBHPubl. New Delhi.
8. Jecker Nany S, Jones &Barlet Bioethics: An Introduction to the History Methods and Practice, NewDelhi.
9. Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan
10. K. Sell Cambridge University Press, 2000.
11. Essentials of Intellectual Property: Law, Economics, and Strategy By Alexander I.
12. Poltorak; Paul J. Lerner Wiley, 2011 (2nd edition).
13. Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4th Edition. ASM 2006.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BS3502**					
TITLE OF THE COURSE	**BIONFORMATICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To get introduced to the basic concepts of Bioinformatics and its significance in biological data analysis.
• To get an overview about biological macromolecular structures and structure prediction methods.

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Will be able to demonstrate mastery of the core concepts of bioinformatics	L1
CO2	The student will be able to apply basic principles of biology, computer science and mathematics to address complex biological problem	L2
CO3	Should be able to plan basic experiments in microbial genetics concerned with clarifying phenotypes and their relationship with the genotype	L3

COURSE CONTENT:	
MODULE 1	**07Hrs**
BIOLOGICAL DATA TYPES AND SOURCE: Introduction to population and sample, Classification and Presentation of Data. Quality of data, private and public data sources. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Specialized Genome databases: (SGD, TIGR, and ACeDB). Microbial genomic database (MBGD), Virus data bank (UICTVdb).	
MODULE 2	**10Hrs**
SIMILARITY SEARCHING: Global and Local sequence alignment, Pair wise comparison of sequences, Multiple Sequence alignment of sequences, scoring matrices. Identification of genes in genomes and Phylogenetic analysis with reference to nucleic acids, Identification of ORFs, Identification of motifs	

MODULE 3	07Hrs
INTERPRETTING the SEQUENCE: Reading DNA from files in FASTA format, reading frames, Regular expressions, restriction maps and restriction enzymes, Genbank libraries, annotation parsing, Annotations indexing, parsing PDB files, parsing BLAST files.	
MODULE 4	**06Hrs**
SCALING THE HUMAN GENOME: UCSC genome browser, RegulomeDB database, ENCODE-ChIA-PET database, transcription factors binding sites. SNP, EST, STS. Regular Expression (REGEX), Hierarchies and Graphical models (including Markov chain and Bayes algorithm). Genetic variability and connections to clinical data.	

TEXT BOOKS/REFERANCES:

1. Bioinformatics. Keith, J. Humana Press, 2008.
2. Computer methods for macromolecular sequence analysis. R.F.Doolittle, Academic Press, 1996.
3. Bioinformatics. Sequence and genome analysis. D.W.Mount. Cold Spring Harbor Lab. press. 2004.
4. Bioinformatics and functional genomics. J. Pevsner. Wiley-Liss, 2003.
5. Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics, Jorde et al., (eds.) John Wiley and Sons, 2005.
6. Baxavanis (1998). Bioinformatics.
7. Fry, J.C. (1993). Biological Data Analysis. A practical Approach. IRL Press, Oxford.
8. Rosenbloom KR et al, The UCSC Genome Browser database: 2015 update. Nucleic Acids Res. 2015 Jan 28; 43(Database issue): D670-81

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22GS3601**					
TITLE OF THE COURSE	**HUMAN GENETICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To Understand the Fundamental Concepts of Human Genetics.
• To Explore Molecular Genetics and Genetic Disorders
• To Analyze Complex Traits, Genetic Basis of Common Diseases, and Ethical Considerations

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will be able to define and explain the scope and significance of human genetics, as well as identify key historical developments in the field.	L1
CO2	Students will be able to discuss the significance of the Human Genome Project and understand the impact of functional genomics on gene expression profiling using microarrays.	L2
CO3	Students will be able to explain gene-environment interactions and understand the mechanisms of epigenetic modifications, including DNA methylation and histone modification.	L3

COURSE CONTENT:

MODULE 1	**15Hrs**

INTRODUCTION TO HUMAN GENETICS

Overview of Human Genetics: Definition, scope, and importance of human genetics. Historical developments and key milestones. Genetic mapping of human chromosomes, mapping of genetic disease to chromosome location, multi-locus mapping of human chromosomes, physical mapping of human genome. gene structure predictions, gene ontology consortium recommendations.

Human Genome Project and Functional Genomics: Human Genome Project overview and impact. Functional genomics: gene expression profiling and microarrays.

MODULE 2	15Hrs
GENETIC DISORDERS **Overview of genetic disorders: types and classifications**: Single Gene Disorders, multifactorial disorders **Polygenic Inheritance and Quantitative Traits:** Polygenic traits, continuous variation, and heritability. Threshold model and multifactorial traits. Genetic Disorders Affecting Blood: Hemoglobinopathies: sickle cell disease and thalassemias. **Neurogenetic Disorders:** Neurological genetic disorders: Huntington's disease, amyotrophic lateral sclerosis (ALS), etc. **Genetic Basis of Common Diseases:** Complex diseases: diabetes, cardiovascular diseases, and cancer. GWAS and identification of susceptibility genes.	
MODULE 3	**15Hrs**
GENETIC COUNSELING AND PEDIGREE ANALYSIS Introduction to Genetic Counseling: Definition and importance of genetic counseling, Types of genetic counseling. Basics of Pedigree Analysis: Introduction to pedigrees as a visual tool for genetic inheritance, Standard symbols and conventions used in pedigree charts. Advanced Pedigree Analysis and Genetic Counseling: Consanguinity and its implications in pedigrees	
MODULE 4	**15Hrs**
REPRODUCTIVE GENETICS AND GENETIC ENGINEERING **Reproductive Technologies and Prenatal Diagnosis:** In vitro fertilization, preimplantation genetic diagnosis, and genetic screening. Prenatal testing methods: amniocentesis, chorionic villus sampling. **Gene Therapy and CRISPR-Cas9:** Principles of gene therapy and its applications. CRISPR-Cas9 technology for genome editing and potential implications. **Ethical, Legal, and Social Issues in Human Genetics:** Ethical dilemmas in genetic testing, privacy, and consent. Legal frameworks and societal considerations.	

TEXT BOOKS/REFERANCES:

1. "Human Genetics: Concepts and Applications" by Ricki Lewis.
2. "Principles of Human Genetics" by D. Peter Snustad and Michael J. Simmons.
3. "Introduction to Genetic Analysis" by Anthony J.F. Griffiths, Susan R. Wessler, et al.
4. "Human Molecular Genetics" by Tom Strachan and Andrew P. Read.
5. "Medical Genetics" by Lynn B. Jorde, John C. Carey, Michael J. Bamshad.
6. "Genetics: Analysis and Principles" by Robert J. Brooker.
7. "Genes VIII" by Benjamin Lewin.
8. "Genetics in Medicine" by Thompson & Thompson.
9. "Genetic Disorders and the Fetus: Diagnosis, Prevention, and Treatment" by Aubrey Milunsky and Jeff M. Milunsky.
10. "Essentials of Medical Genetics for Health Professionals" by Laura M. Gunder McClary.

List of Laboratory/Practical Experiments

1) **Karyotyping and Chromosomal Aberrations**
   Prepare karyotypes from human cell samples and identify chromosomal abnormalities.
2) **Pedigree Analysis and Genetic Counseling**
   Analyze pedigrees to trace inheritance patterns and assess the risk of genetic diseases.
3) **Mendelian Genetics Simulation**
   Use simulation software to explore Mendelian inheritance patterns and generate offspring based on genetic traits.
4) **Calculating Hardy-Weinberg Equilibrium**
   Use allele frequencies to calculate expected genotype frequencies and test for Hardy-Weinberg equilibrium.
5) **Genetic Diversity Analysis using DNA Sequences**
   Analyze DNA sequences from different individuals to calculate genetic diversity indices and construct phylogenetic trees.
6) **Quantitative Trait Analysis using Statistical Tools**
   Analyze quantitative traits in a population using statistical tools to estimate heritability and assess the contribution of genetics.
7) **Prenatal Diagnosis Techniques**
   Explore non-invasive prenatal testing methods such as amniocentesis and chorionic villus sampling to detect chromosomal abnormalities.

REFERENCES

1. Rooney, D. E., & Czepulkowski, B. H. (Eds.). (2001). "Human Cytogenetics: Constitutional Analysis." Oxford University Press.
2. Nathaniel, T. I., & Lewis, C. (2013). "Genetic Counseling Practice: Advanced Concepts and Skills." Wiley-Blackwell.
3. Virtual Genetics Education Centre (VGEC). (www.virtualgenetics.org)
4. Hartl, D. L., & Clark, A. G. (2006). "Principles of Population Genetics." Sinauer Associates.
5. Nei, M., & Kumar, S. (2000). "Molecular Evolution and Phylogenetics." Oxford University Press.
6. Lynch, M., & Walsh, B. (1998). "Genetics and Analysis of Quantitative Traits." Sinauer Associates.
7. DeCherney, A. H., Nathan, L., Laufer, N., Roman, A. S. (Eds.). (2019). "Current Diagnosis & Treatment: Obstetrics & Gynecology." McGraw-Hill Education.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22GS3602**					
TITLE OF THE COURSE	**POPULATION GENETICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**0**	**4**	**0**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To explain the core concepts of population genetics, including allele and genotype frequencies, the Hardy-Weinberg equilibrium, and the impact of microevolutionary forces on genetic variation within populations.
• To provide students with a detailed understanding for applying molecular markers and statistical techniques to assess genetic diversity, determine genetic differentiation among populations, and interpret population structure using real-world data.

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COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will be able to define key terms in population genetics, such as gene pool, allele frequency, and genetic drift. Explain the fundamental principles of the Hardy-Weinberg equilibrium and its assumptions	L2
CO2	Students will be able to analyze genetic diversity within populations by interpreting molecular marker data. Apply statistical methods to assess genetic differentiation and infer population structure based on empirical datasets.	L3
CO3	Students will be able to evaluate the impact of evolutionary forces like selection and genetic drift on population dynamics. Synthesize molecular evolution concepts to interpret evolutionary relationships, divergence times, and molecular adaptations.	L4
CO4	Students will be able to design and present a research project that applies population genetics principles to address a real-world question or issue. Reflect on the ethical considerations and practical implications of using population genetics in diverse contexts such as medicine, conservation, and forensics.	L5

COURSE CONTENT:	
MODULE 1	**15Hrs**
INTRODUCTION TO POPULATION GENETICS: Definition and scope of population genetics, Key concepts: gene pool, allele frequency, genotype frequency, Historical development and significance. Genetic drift: definition, types, and effects, Gene flow: impact on genetic diversity. Mutation: role in generating genetic variation. Natural selection: mechanisms and outcomes. Polygenic traits vs. Mendelian traits. Heritability and its estimation. Phenotypic variation: genetic vs. environmental components. Response to selection and selective breeding. Linkage and Linkage Disequillibrium; Haplotype frequency estimation with unphased genotypes; genetic association and multiple testing corrections.	
MODULE 2	**15Hrs**
GENETIC VARIATION AND EVOLUTION: DNA sequence variation: SNPs, indels, and CNVs, Molecular markers in population genetics (microsatellites, SNPs). Applications of molecular markers in studying genetic diversity. Population subdivision and its causes. FST and related indices for measuring genetic differentiation. Genetic structure analysis: clustering methods, Principal Component Analysis (PCA). Molecular clocks and their applications. Molecular phylogenetics and constructing phylogenetic trees. Examples of rapid evolution in response to environmental changes. Evolutionary arms race and coevolution. Human evolution: insights from population genetics.	
MODULE 3	**15Hrs**
APPLIED POPULATION GENETICS: Genetic diversity and conservation of endangered species. Minimum Viable Population (MVP) and effective population size (Ne). Inbreeding depression and its management. Studying ecological interactions using genetic data. Landscape genetics and gene flow patterns. Identifying source populations and migration routes. Genetic basis of diseases and their prevalence in populations. Genome-wide association studies (GWAS) and identifying disease-associated variants. Personalized medicine and its ethical considerations. Human genetic diversity and migration patterns. Genetic admixture and its implications. Population genetics and forensic applications.	
MODULE 4	**15Hrs**
ADVANCED TOPICS IN POPULATION GENETICS: Coalescent theory: concepts and applications. Coalescent simulations and their significance. Molecular clock and coalescent-based dating methods. Positive selection and detecting adaptive evolution. Molecular basis of adaptation in specific organisms. Evolution of gene families and functional divergence. Comparative genomics and studying genome evolution. Horizontal gene transfer and its impact on genomes. Evolution of non-coding DNA and regulatory elements. Emerging techniques in population genetics: Next-generation sequencing and its applications in population genetics. Single-cell genomics and its potential insights.	

TEXT BOOK/ REFERENCES:

1. "Principles of Population Genetics" by Daniel L. Hartl and Andrew G. Clark.
2. "Population Genetics: A Concise Guide" by John H. GillespieCarlson, R. F. Patten's Foundations of Embryology.
3. "Population Genetics and Microevolutionary Theory" by Alan R. Templeton.
4. "An Introduction to Population Genetics Theory" by James F. Crow and Motoo Kimura

EXPERIMENTS
1. Hardy-Weinberg equilibrium simulation.
2. Microsatellite analysis for genetic diversity.
3. Genetic drift simulation with populations of different sizes.
4. SNP genotyping and population structure analysis.
5. Molecular clock estimation.
6. GWAS analysis using computational tools.

REFERENCES:

1. "Population Genetics: A Laboratory Guide" by David L. Duffy (Wiley)
2. "Population Genetics: A Concise Guide" by John H. Gillespie (Johns Hopkins University Press)
3. "Principles of Population Genetics" by Daniel L. Hartl and Andrew G. Clark (Sinauer Associates)
4. "Molecular Population Genetics" by Matthew W. Hahn (Sinauer Associates)

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22BS3601**					
TITLE OF THE COURSE	**PRINCIPLES OF 'MULTI-OMICS'**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To acquaint students with various aspects of biotechnology and bio-engineering using omics technologies
• To provide key insights into omics approaches in personalized and precision medicine

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will have knowledge in specific methods used in genomics, proteomics and metabolomics used in analytical processes.	L1
CO2	Students will be able to perform statistical analysis crucial for interpretation of experimental results	L2
CO3	Students will be able to apply specialized research methods necessary for the analysis of proteins, genes and metabolites	L3

COURSE CONTENT:	
MODULE 1	**07 Hrs**
GENOME & GENOMICS: Genome mapping: Physical and Genetic Map, Genome Sequencing, Next generation sequencing methods ,Genome Annotation, Functional Genomics	
MODULE 2	**07 Hrs**
TRANSCRIPTOMICS: Search for transcription factor binding sites,RNA-Seq, Microarrays, Regulatory RNAs: small or large, Computational prediction of miRNA target genes, RNA Darkmatter	

MODULE 3 PROTEOMICS AND METABOLOMICS	07Hrs
Basic concepts , Tools of proteomics- SDS PAGE, 2D PAGE , Liquid chromatography , Mass Spectrometry (ESI and MALDI) ,Protein identification by peptide mass fingerprinting ,Applications of proteomics. Fundamental concept, Tools of metabolomics- Capillary electrophoresis, Gas chromatography, Electrochemical detectors, Case studies.	

MODULE 4 'OMICS': APPLICATIONS AND FUTURE PERSPECTIVES	06Hrs
Multi-omics in disease prediction and health. Multi-omics technologies for crop improvement and sustainable agriculture. Applications in Biomedical and Environmental sciences	

TEXT BOOKS/REFERANCES:

1. Bioinformatics. Keith, J. Humana Press, 2008.
2. Computer methods for macromolecular sequence analysis. R.F.Doolittle, Academic Press, 2096.
3. Introduction to Proteomics -Tools for the New Biology by Daniel C. Liebler, Humana Press..
4. Bioinformatics and functional genomics. J. Pevsner. Wiley-Liss, 2003.
5. Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics, Jorde et al., (eds.) John Wiley and Sons, 2005.
6. Metabolomics- Methods and Protocols by Wolfram Weckwerth, Humana Press.
7. Fry, J.C. (2093). Biological Data Analysis. A practical Approach. IRL Press, Oxford.
8. Transcriptomics: Expression Pattern Analysis, Virendra Gomase, Somnath Tagore; VDM Publishing, 2009 – Science

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22BS3602**					
TITLE OF THE COURSE	**TOXICOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
1. To learn various toxicants present and their exposure level on day-to-day basis.
2. To study the effects of toxins on the physiologic, metabolic, reproductive, and developmental processes.

COURSE OUTCOMES

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will learn and understand all substances can be toxic depending on the means and level of exposure	L1
CO2	Students will learn the basic concepts of cellular toxicity and chemical actions on cells and body organs	L2
CO3	Students will learn the importance and diversity of drug interactions with various organs	L3

COURSE CONTENT:

MODULE 1	**10 Hrs**

INTRODUCTION OF TOXICOLOGY:
Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins. Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms. Toxicant proceeding *in vivo*: Absorption, Distribution, Excretion an Metabolism of foreign/toxic compounds.

MODULE II	**5 Hrs**

ENVIRONMENTAL TOXICOLOGY:
Environmental pollution- Sources and types of pollution, Important pollution events, Priority pollutants. Air pollution- Classification and properties of air pollutants, Behaviour and fate of air pollutants, Photochemical smog, Acid Rain, health effects of air pollution. Water pollution- origin of Wastewater, Domestic Water Pollution, Industrial water pollution, Agricultural water pollution, Toxic water pollutants and their health effects, Groundwater pollution, marine pollution

MODULE III	5 Hrs

INDUSTRIAL TOXICOLOGY:

Industrial Chemicals: Government Regulation of Chemicals , Ways of exposure, Toxic effects, Long-term consequences and developmental toxicity. Food Additives and Contaminants types of food additives, Preservatives, Saccharin. Toxicity of trace elements- Iodine, iron, zinc, copper, manganese, selenium, molybdenum, and cobalt Cyto-toxicity of heavy metals- Cadmium, mercury, arsenic, chromium and lead. Brief introduction to toxicity of pesticides and inseciticides.

MODULE - IV –	10 Hrs

ORGAN TOXICOLOGY:

Basics of organ toxicity- Target organs, Organ selectivity and specificity, gender specific diversity of toxins. Hepatotoxicity - Actions of toxins on the liver, Chronic liver injury; Cardiotoxicity - pathology of cardiac toxicity, mechanisms of cardiotoxicity; Respiratory Toxicity - Systematic lung toxins, Lungpathology; Reproductive System – Teratogenicity; Neurotoxicity- Effect of toxic agents on neurons, Ion channel neurotoxins and Nephrotoxicity- susceptibility of kidney to toxic insult, chemically induced renalinjury.

Reference books:

1. Whalen, Finkel, and Panavelil, Pharmacology, 6th ed. (Lippincott Williams & Wilkins: 2015).
2. Lieberman and Peet, Mark's Basic Medical Biochemistry: A Clinical Approach, 5th ed. (Wolters Kluwer: 2018).
3. Hodgson, A Textbook of Modern Toxicology, 4th ed. (J Wiley & Sons: 2010).
4. Molecular and Biochemical Toxicology, 4th ed., Smart and Hodgson, eds. (J Wiley & Sons: 2008).
5. Frank and Ottoboni, The Dose makes the Poison: A Plain-language Guide to Toxicology, 3rd ed. eBook, (J Wiley & Sons: 2011).
6. Ottoboni, The Dose makes the Poison: A Plain-language Guide to Toxicology, 2nd ed., (J Wiley & Sons: 1997).
7. A-Z Guide to Drug-Herb-Vitamin Interactions, 2nd ed., Gaby, Batz, Chester and Constantine, eds. (Three Rivers Press: 2006).
8. Gilbert, A Small Dose of Toxicology: The health effects of common chemicals, (CRC Press: 2004).
9. Gibson, Multiple Chemical Sensitivities: A survival guide, (New Harbinger Publications: 2000).
10. Toxicology and Clinical Pharmacology of Herbal Products, Cupp and Karch, eds. (Springer-Verlag: 2000).
11. Lawson, Staying Well in a Toxic World, (Lynwood Press: 2000).

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22GS4701**					
TITLE OF THE COURSE	**ANIMAL GENETICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To Develop a Comprehensive Understanding of Animal Genetics Fundamentals
• To Explore Molecular Genetics and Genetic Improvement Strategies
• To Explore Reproductive Genetics, Biotechnology, and Ethical Considerations

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will be able to apply the principles of Mendelian inheritance to animals, including the understanding of dominance, segregation, and independent assortment.	L1
CO2	Students will be able to explain the use of molecular markers for trait mapping and selection in animal breeding.	L2
CO3	Students will be introduced to the concept of transgenic animals and gene editing technologies, particularly CRISPR-Cas9, in animal genetics. They will also understand the ethical and regulatory aspects surrounding gene editing.	L3

COURSE CONTENT:

MODULE 1	**15Hrs**
FUNDAMENTALS OF ANIMAL GENETICS **Introduction to Animal Genetics:** Definition, scope, and importance of animal genetics. Historical developments and key contributors. Basic genetic concepts relevant to animal breeding. **Mendelian Inheritance in Animals:** Mendel's laws of inheritance and their application in animals. Patterns of inheritance: dominance, segregation, and independent assortment. Pedigree analysis and its significance in animal breeding. **Genetic Variation and Population Genetics:** Sources of genetic variation in animal populations. Hardy-Weinberg equilibrium and its application to animal populations. Factors influencing genetic diversity and allele frequencies. **Quantitative Genetics and Selection:** Introduction to quantitative traits and heritability. Principles of selection: genetic gain, response to selection, and selection methods. Breeding value estimation and selection indexes.	

MODULE 2	15Hrs
MOLECULAR GENETICS AND GENETIC IMPROVEMENT **Genome Structure and Function:** Chromosomal structure and organization in animals. DNA replication, transcription, and translation. Genetic code and gene expression regulation. **Marker-Assisted Selection and Genomic Selection**: Use of molecular markers for trait mapping and selection. Introduction to genomic selection and its advantages. Case studies of successful genomic selection programs in animal breeding. **Genetic Disorders and Genetic Improvement:** Identification and management of genetic disorders in animal populations. Strategies for reducing the incidence of genetic disorders through breeding. Genetic improvement programs for disease resistance and production traits.	
MODULE 3	**15Hrs**
REPRODUCTIVE GENETICS AND BIOTECHNOLOGY **Reproductive Technologies in Animal Breeding:** Artificial insemination, embryo transfer, and in vitro fertilization. Cloning, its applications, and ethical considerations. Challenges and opportunities in using reproductive technologies. **Transgenic Animals and Gene Editing:** Introduction to transgenic animals and their applications. Overview of gene editing technologies (CRISPR-Cas9) in animals. Ethical and regulatory aspects of gene editing. **Genetic Diversity Conservation:** Importance of conserving genetic diversity in livestock and endangered species. Role of cryopreservation, gene banks, and assisted reproductive technologies. Case studies of successful genetic diversity conservation efforts.	
MODULE 4	**15Hrs**
APPLIED ANIMAL BREEDING AND ETHICAL CONSIDERATIONS **Breeding Objectives and Strategies:** Defining breeding objectives for different animal production systems. Strategies for balanced selection of multiple traits. Considerations for optimizing breeding goals. **Breeding Programs and Genetic Evaluation:** Design and implementation of breeding programs. Genetic evaluation methods: BLUP, GEBVs, and genetic trends. Challenges in incorporating molecular and genomic information. **Ethical and Societal Aspects of Animal Genetics:** Ethical considerations in animal breeding and biotechnology. Public perception, animal welfare, and environmental concerns.Regulatory frameworks and responsible use of genetic technologies.	

TEXT BOOKS/REFERANCES:

1. B. D. Singh. (2006). "Introduction to Animal Genetics and Breeding."
2. F. Nicholas. (2001). "Introduction to Veterinary Genetics."
3. T. A. Brown. (2017). "Gene Cloning and DNA Analysis: An Introduction."
4. J. F. Medrano, H. T. Reinschmidt, and J. E. Womack. (2019). "Genetics for Animal Scientists."
5. R. Fries and A. Ruvinsky. (2011). "The Genetics of Cattle."
6. D. P. Sponenberg and A. C. Kennedy. (2013). "Sheep and Goat Medicine."
7. W. G. Hill. (2010). "Understanding Animal Breeding."
8. D. R. Notter. (2017). "The Genetics of Sheep."
9. M. F. Rothschild and A. Ruvinsky. (2010). "The Genetics of Pigs."
10. H. M. S. Gregory. (2019). "Genetics: The Continuity of Life."

EXPERIMENTS
1) Phenotype Observation and Mendelian Traits Observe phenotypic traits in a population of animals and determine if they follow Mendelian inheritance patterns.
2) Allele Frequencies and Hardy-Weinberg Equilibrium Collect data on specific phenotypic traits, calculate allele frequencies, and determine if the population is in Hardy-Weinberg equilibrium.
3) Heritability Estimation Using Parent-Offspring Data Collect data on a quantitative trait from parents and their offspring, and estimate heritability using the parent-offspring regression.
4) Punnett Square and Monohybrid Cross Perform a monohybrid cross between two animals with known genotypes and predict the phenotypic ratio using Punnett squares.
5) Gel Electrophoresis for Molecular Markers Use gel electrophoresis to visualize PCR-amplified DNA fragments and identify genetic variations.
6) Observation of Drosophila Eye Color Mutations Observe different eye color mutations in Drosophila melanogaster and understand the genetic basis of the variations.
7) Simulation of Genetic Drift Using Beanbags Simulate genetic drift in a small population using beanbags as "alleles" and observe how allele frequencies change over generations.

REFERENCES

1. Hartl, D. L., & Jones, E. W. (2005). "Genetics: Analysis of Genes and Genomes."
2. Freeman, S., & Herron, J. C. (2007). "Evolutionary Analysis."
3. Falconer, D. S., & Mackay, T. F. (1996). "Introduction to Quantitative Genetics."
4. Snustad, D. P., & Simmons, M. J. (2015). "Principles of Genetics."
5. Brown, T. A. (2017). "Gene Cloning and DNA Analysis: An Introduction."
6. Miko, I. (2008). "Mendel and the Laws of Genetics."
7. Smith, J. M. (1989). "Evolutionary Genetics."

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22GS4702**					
TITLE OF THE COURSE	**PLANT GENETICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**0**	**4**	**0**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To comprehend fundamental genetic concepts in plants, including Mendelian inheritance, chromosome structure, and gene expression.
• To evaluate various plant breeding and biotechnology approaches to enhance plant traits and productivity.

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COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will be able to apply molecular techniques learned in the course, such as DNA extraction, PCR, and gel electrophoresis, to analyze plant genetic material and trait inheritance patterns.	L3
CO2	Students will be able to evaluate the benefits and limitations of different plant breeding strategies, including classical breeding and biotechnology approaches. Synthesize information to propose innovative genetic improvement strategies for specific plant traits.	L4
CO3	Students will be able to design and present a hypothetical plant breeding project that addresses a real-world agricultural challenge, incorporating genetic principles and biotechnological methods. Reflect on the ethical considerations and societal implications of using genetic modification in plant agriculture.	L5

COURSE CONTENT:	
MODULE 1	**15Hrs**
INTRODUCTION TO PLANT SYSTEMS: Plant Systems: Biochemical and molecular basis of Growth and differentiation: Concept of growth and differentiation vs. morphogenesis; Site and cell types involved in growth and differentiation. Kinematics of growth, Spatial and material basis of growth, mechanism of differentiation. Genetic basis: Identity of a gene that control development in Arabidopsis; three stages of development from embryo, axial pattern, apical basal pattern, radial pattern and requirement of gene expression for the development of the above structure in Arabidopsis. The role of homeobox genes.	

MODULE 2	**15Hrs**
PLANT TISSUE CULTURE AND SOMATIC CELL GENETICS: Organogenesis and Somatic embryogenesis; Endosperm culture and triploid production; Anther and pollen culture, production of haploid and doubled haploid plants; Protoplast culture and fusion, Somatic hybrids; Organelle transfer and cybrids; Micropropagation, artificial seed and bioreactor technology, Virus-free plants by meristem culture; Use of somaclonal and gametoclonal variation for crop improvement; In vitro mutagenesis and mutant selection; Preservation of plant germ plasm in-vitro.	
MODULE 3	**15Hrs**
PLANT TRANSFORMATION VECTORS AND METHODS: Plant transformation vectors - T-DNA and viral vectors, direct gene transfer vectors; Selectable marker and reporter genes, Plant transformation by Agrobacterium sp., non-Agrobacterium sp., and in planta transformation, c) Molecular mechanism of T-DNA transfer; Direct gene transfer methods in plants - Gene gun and other methods; Chloroplast transformation; Transgene analysis, silencing and targeting; Marker-free and novel selection strategies, Multigene engineering; Gene tagging; Gene knock-down by ribozymes, antisense RNA and RNA interference. Comparative genomics and cloning, positional cloning	
MODULE 4	**15Hrs**
APPLICATIONS OF PLANT TRANSGENIC TECHNOLOGY: Transgenic crops for resistance against biotic and abiotic stresses; Engineering crops for male sterility and modification of flower colour, flowering, fruit ripening and senescence, GM crops for nutritional quality and quantity; RNAi-mediated crop improvement; Molecular pharming; Metabolic engineering and hairy root culture for secondary plant products; Global status and biosafety of transgenic plants.	

TEXT BOOK/ REFERENCES:

1. "Plant Biotechnology and Genetics: Principles, Techniques, and Applications" by C. Neal Stewart Jr.
2. "Plant Genes, Genomes and Genetics" by Erich Grotewold (Editor).
3. "Molecular Plant Breeding" by Yunbi Xu, Hongwei Cai (Editors)
4. "Genetics, Genomics, and Breeding of Vegetable Brassicas" by Yan Long, Guusje Bonnema (Editors)

EXPERIMENTS
1. Mendelian genetics and trait inheritance.
2. Genetic mapping with linkage and recombination.
3. Nucleic acids extraction and gel electrophoresis.
4. Extract chloroplast DNA from plant sources.
5. Amplify and sequence a specific plant gene.
6. Introduce foreign DNA into plant cells through transformation.

REFERENCES:

1. "Plant Genotyping: The DNA Fingerprinting of Plants" by Robert J. Henry
2. "Experiments in Plant Tissue Culture" by Dennis W. Gray
3. "Plant Genomics and Proteomics" by Christopher A. Cullis
4. "Plant Genetic Transformation and Gene Expression: A Laboratory Manual" by Peter M. Gresshoff.
5. "Molecular Biology Techniques in Plant Science" by John M. Walker and Ralph Rapley

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22GS4703**					
TITLE OF THE COURSE	**BEHAVIORAL GENETICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**0**	**4**	**0**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To comprehend the complex relationship between genetic factors and behavioral traits, including the influence of genes, environmental factors, and gene-environment interactions.
• To critically evaluate the ethical considerations and societal implications of studying behavioral genetics, including the responsible use of genetic information and the potential for stigmatization.
• To analyze the role of genetics in the development of behavioral disorders, understanding how genetic variations contribute to conditions such as schizophrenia, depression, and ADHD.

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COURSE OUTCOMES:

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Students will be able to apply knowledge of genetic and environmental influences to analyze specific behavioral traits and disorders. Analyze twin and adoption studies to estimate heritability and environmental influences on behavior.	L3
CO2	Students will be able to evaluate the genetic basis of complex behaviors such as intelligence and cognitive abilities. Synthesize information from evolutionary psychology and animal behavior to explain the adaptive significance of behaviors.	L4
CO3	Students will be able to design an ethical framework for using genetic information in educational and societal contexts. Reflect on the potential ethical dilemmas and social consequences of genetic testing for behavioral traits.	L5

COURSE CONTENT:	
MODULE 1	**15Hrs**
INTRODUCTION TO BEHAVIORAL GENETICS: Definition and scope of behavioral genetics. Historical development and significance of the field. Nature vs. nurture debate. Genetics Basics for Behavioral Traits: Genes, alleles, and heritability. Identifying hereditary patterns. Gene-environment interactions. Twin and Family Studies: Twin studies: monozygotic vs. dizygotic twins. Family studies and heritability estimation. Limitations and interpretation of twin and family studies. Adoption studies and their insights. Combining adoption and	

twin studies to tease out genetic and environmental effects. *Drosophila*: genetics meets behaviour	
MODULE 2	**15Hrs**
BRAIN AND BEHAVIOR: Approaches and methods in study of behavior; Proximate and ultimate causation; Development of behavior; Social communication; Habitat selection, Social dominance, Mating systems, Parental investment and Reproductive success; Aggressive behavior, Migration, orientation and navigation, Photo-periodism, Circadian Rhythm– Sleep and arousal. Neural basis of Complex Behaviors: Learning, memory, Emotions, Stress and Adaptation, Altruism and evolution. , Identifying genes for controlling behavior, induced mutations, Quantitative trait loci, Synteny/orthology, Investigating the genetics of human behaviour, Twin and adoption study designs, interpreting heritability.	
MODULE 3	**15Hrs**
MOLECULAR AND EVOLUTIONARY ASPECTS: Molecular Mechanisms in Behavioral Genetics: Role of genes and proteins in neural development. Epigenetics and its influence on behavior. Evolutionary Psychology, Evolutionary explanations for human behaviors. Genetic basis of mating preferences, aggression, and altruism. Animal Behavior and Genetics: Genetic basis of animal behaviors: mating, parenting, social interactions. Comparing behavioral genetics across species. Genes, Environment, and Complex Traits: Genetic and environmental influences on complex behaviors. Gene-environment correlation and interaction. Genetic Counseling and Behavior: Role of genetic counseling in behavior-related issues. Discuss ethical considerations in genetic counseling.	
MODULE 4	**15Hrs**
GENETICS OF PSYCHIATRIC DISEASES: Neurodegenerative and Neurochemical Disorders Ageing Brain - Senile dementia - Dementia of Alzheimer’s Type, Parkinson’s disease, Reperfusion –Seizures and Epilepsy – Autism - Diseases involving myelin, Multiple Sclerosis. Chemical imbalances of the Brain: Personality Disorders - Anxiety disorders - Disorders of Mood, depression, bipolar disorder - Pharmacology of neuroleptics, anxiolytics, antidepressants – Disorders of thought - Schizophrenia, Pharmacology of antipsychotics, Narcotics and Addiction.	

TEXT BOOK/ REFERENCES:

1. "Behavioral Genetics" by Robert Plomin, John C. DeFries, Valerie S. Knopik, and Jenae M. Neiderhiser.
2. "Genetics of Psychological Well-Being: The Role of Heritability and Genetics in Positive Psychology" by Michael Pluess and Brendan M. Rooney.
3. "Genes, Behavior, and the Social Environment: Moving Beyond the Nature/Nurture Debate" by Institute of Medicine (U.S.) and Board on Health Sciences Policy.

4. "Genetic and Environmental Influences on Human Behavioral Differences" by Thomas J. Bouchard Jr. and Matt McGue.
5. "Evolutionary Behavioral Genetics" by David T. Lykken.
6. "The Genetics of Behavior" by John L. Fuller and Elizabeth C. Fullerton.

EXPERIMENTS

1. Aversive Phototaxic Suppression Assay using adult *Drosophila*
2. Larval Crawling Assay using *Drosophila* third instar larvae
3. Courtship and Mating Assay
4. Rapid Iterative Negative Geotaxis
5. Case studies on genetics of addiction.

TEXT BOOK/ REFERENCES:

1. Laboratory Exercises in Developmental Biology by William C. Gibson
2. Behavioral Genetics: A Practical Approach by Robert Plomin, John C. DeFries, Valerie S. Knopik, and Jenae M. Neiderhiser
3. Methods in Behavioral Research by Paul C. Cozby and Scott C. Bates
4. Methods for Behavioral Research: A Systematic Approach by Paul D. Cherulnik
5. Animal Behavior: Concepts, Methods, and Applications by Michael D. Breed and Janice Moore

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22BS4701**					
TITLE OF THE COURSE	**RESEARCH METHODOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**45**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
To provide an overview of essential research steps to be followed when conducting research / project work.
To understand chief ingredients to be incorporated in conduct as well as writing of scientific reports/dissertation/thesis
To know the implication professional research ethics and common misconduct details of researcher and research work

COURSE OUTCOME

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Show and explain the concepts of meaning ofresearch, scope of research including different types of research, scientific research process and research methodology steps	L1
CO2	Perform review of literature using electronic media, selecting research problem formulate research problem statement, writing hypothesis, explain criteria of forming objectives, materials and methods, results and discussion	L2
CO3	Identify and explain experimental research designs for both qualitative and quantitative research	L2
CO4	Explain different sampling methods and sampling design, basic statistical methods for treatment of data and observations	L2
CO5	Demonstrate ingredients and components of a research report, dissertation and thesis and explain integral components of research article and research proposal	L2
CO6	Explain professional research ethics and elaborate on misconduct in research	L2

COURSE CONTENT:	
MODULE 1:	**12 hrs**
INTRODUCTION TO RESEARCH: Meaning, Objectives and Characteristics of research – Scientific Method Types of research - Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical - Research process - Criteria of good research **PROBLEM STATEMENT:** Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem; **LITERATURE SURVEY:** Importance of literature review in defining a problem **- S**urvey of literature - Primary and secondary sources - web as a source - searching the web - Identifying gap areas from literature review. **HYPOTHESIS:** Definition of hypothesis**,** Basic concepts, variables-Dependent and independent variables, Development of working hypothesis; Ingredients of Research Objectives, deriving objectives of research.	
MODULE 2:	**12 hrs**
Sampling, Material and Methods: Sample- Sampling - Types of sampling; Material - Experiments, Data – Basics of Analysis; Writing materials and method chapter of a research report **Results and Discussion**: Representation of results; Tables, graphs; Discussion, Purpose and Function of Discussion **Research Designs:** Research design; Need of research design - Basic Principles; Features of good design – Important concepts relating to research design; Max-min-con principle, **Common Research Designs**: Cross-sectional, Case-control, Longitudinal and Cohort research designs, advantages and disadvantages of each of research designs **Summary and Conclusion:** Writing of Summary, conclusions of research findings,Acknowledgement section of a research report and an article.	
MODULE 3:	**10Hrs**
Research Ethics: Values, Ethics and Morals**,** Research Professionalism**,** Tenets of Ethics; Conducting and reporting of science/engineering; Relationship in research groups; Hazards to good scientific practice; Scientific misconduct: Fabrication, Falsification and Plagiarism. **Report and Article Writing:** Structure and components of scientific reports; Abstract-Key words**;** Types of reports; Significance of reporting; Different steps in the preparation of reports; Layout, structure and Language of typical reports; References; Citation styles- APA and MLA styles of citation, intext and end text citations. **Oral Presentation:** Importance of effective communication. Planning; Preparation; Practice; Making presentation; Use of visual aids.	
MODULE 4:	**11Hrs**
Scientific Article Writing: Title preparation – Importance of title; need for specific titles; List of authors and addresses – order of names; defining the order with example; types of abstracts; economy of words; How to write introduction- Rules; exceptions; citations and abbreviations Materials and methods: Purpose; materials; methods; tables and figures; form and grammar; Result and Discussion writing: content of results; handling numbers; clarity; avoiding redundancy; Discussion writing: Components of discussion; factual relationships; strengths and limitations; significance of paper; Stating Acknowledgements: Ingredients of the acknowledgements; courtesy; Citation of the References: Rules; electronics aid; in-text citation; styles of referencing **Research Proposal Fundamentals:** What is a grant proposal? Why proposals fail?; Developing and writing of grant proposals; overview of steps to develop grant proposals; Proposal Development Process: Standard Proposal Parts; writing Budget section.	

Intellectual Property Rights: IPRs- Invention and Creativity- Intellectual Property-Importance and Protection of Intellectual Property Rights (IPRs); A brief summary of: Patents, Copyrights, Trademarks

REFERENCES:

1. Bruce Tuckman, Brian E Harper, Conducting Educational Research, 6th Edition, 2012 by Rowman &Littlefield Publishers, Inc. ISBN 978-1-4422-0965-7 (electronic)
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
4. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., NewDelhi
5. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications.2 volumes.
6. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing.270p.
7. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
8. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. SagePublications
9. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.

MINOR COURSES OFFERED

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22GS2404**					
TITLE OF THE COURSE	**GENOMICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**0**	**4**	**0**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To go through basic and specialized knowledge and understanding the aspects of genomics and proteomics is essential to understanding Genetics and its architecture.
• To take the students through foundations in genomics and disease gene mapping.

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COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Student will be able to understand how genomes are organised and contemplate on the mapping of monogenic and polygenic traits.	L1
CO2	Students should be endowed with strong theoretical knowledge of genomics.	L2
CO3	In conjunction with the practical in bioinformatics, the students should be able to take up biological research as well as find placement in the relevant biotech industry.	L3

COURSE CONTENT:	
MODULE 1:	**15Hrs**
PROKARYOTIC AND EUKARYOTIC GENOME ORGANIZATION: Prokaryotes: Bacteria and Bacteriophages. Eukaryotic nuclear genomes: Arabidopsis, rice, yeast, Drosophila, C. elegans and mouse genome. Eukaryotic organelle genomes - Chloroplast and Mitochondria.	
MODULE 2:	**15Hrs**
GENOME MAPPING TECHNIQUES: Genetic mapping: Cross breeding and pedigree analysis, DNA markers – RFLPs, SSLPs, SNPs. Physical mapping: Restriction mapping, Fluorescent in situ hybridization. germination.	

MODULE 3:	**15Hrs**
THE HUMAN GENOME : History, organization and goals of human genome project. DNA segment nomenclature, Human genome diversity, Organization of human genome, Mitochondrial genome, Gross base composition of nuclear genome, Gene density, CpG islands, RNA-encoding genes, Functionally identical genes, Diversity in size and organization of genes.	
MODULE 4:	**15Hrs**
COMPARATIVE GENOMICS: Whole genome analysis, Genome sequence, micro assay, molecular phylogeny, C-value, number of genes and complexity of genomes, Conservation and diversity of genomes, Comparative genomics as an aid to gene mapping and study of human disease genes. Comparative genomics of mitochondria and chloroplast genomes.	

TEXT BOOK/ REFERENCES:

1. "Developmental Biology" by Scott F. Gilbert and Michael J. F. Barresi (Sinauer Associates, Inc., 2016).
2. "Principles of Development" by Lewis Wolpert, Cheryll Tickle, and Alfonso Martinez Arias (Oxford University Press, 2015).
3. "Essential Developmental Biology" by Jonathan M. W. Slack (Wiley-Blackwell, 2012)
4. "From Egg to Embryo: Regional Specification in Early Development" by Rosa Beddington (Cambridge University Press, 1996).
5. "The Embryo: Normal and Abnormal Development and Growth" by Ronan O' Rahilly and Fabiola Muller (Wiley-Liss, 2001).
6. "Developmental Biology" by Carlos A. F. De Souza and Anna Lucia M. M. Junqueira (Springer, 2015).
7. "Developmental Biology: A Very Short Introduction" by Lewis Wolpert (Oxford University Press, 2011).
8. "Developmental Biology Protocols" edited by Rocky S. Tuan and Cecilia W. Lo (Humana Press, 2000).
9. Cell biology, Genetics, Molecular biology, evolution and ecology, Minkoff, E. C. (2083). Evolutionary biology. Reading, MA: Addison- Wesley Publishing Company.
10. Sober, E. (2004). Conceptual issues in evolutionary biology. Cambridge, MA:MIT Press.
11. Fundamentals of ecology by Eugene Odum,Cengage; 5 edition (2005).
12. Ecology & Environment by P.D. Sharma, Rastogi Publications (3 August 2015).
13. Development Biology by Scott F Gilbert, Sinauer Associates; 10th edition (10 July2013).

EXPERIMENTS
1. Physical mapping by Restriction mapping of plasmid DNA
2. Genetic mapping by RFLP analysis
3. RAPD analysis
4. DNA isolation from blood/liver and electrophoresis
5. Primer Design and Polymerase chain reaction
6. Protein database study SCOP, DALIDD, CATH

REFERENCES

1. Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press.
3. Carlson, R. F. Patten's Foundations of Embryology.
4. Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers.
5. Lewis Wolpert (2002). Principles of Development. II Edition, Oxford University Press.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22GS3503**					
TITLE OF THE COURSE	**GENETIC TESTING**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To Develop a Comprehensive Understanding of Genetic Testing Fundamentals
- To Explore Molecular Techniques Used in Genetic Testing
- To Analyze Clinical Applications and Ethical Considerations in Genetic Testing

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOM YLEVEL
CO1	Students will be able to define and explain the concept of genetic testing, recognizing its importance in healthcare and various applications.	L1
CO2	Students will be capable of explaining the principles of polymerase chain reaction (PCR) and its applications in detecting mutations and variants in genetic testing.	L2
CO3	Students will be able to describe the role of genetic testing in identifying hereditary cancer syndromes and its application in assessing cancer risk.	L3

COURSE CONTENT:

MODULE 1	**15Hrs**

INTRODUCTION TO GENETIC TESTING

Overview of Genetic Testing: Definition and importance of genetic testing. Historical development and key milestones. Ethical, legal, and social implications of genetic testing.

Types of Genetic Testing: Preconception and prenatal testing. Diagnostic testing vs. predictive testing. Carrier testing and newborn screening.

Genetic Counseling and Informed Consent: Role of genetic counselors. Importance of informed consent in genetic testing.

Regulatory Frameworks and Quality Assurance: FDA regulations for genetic testing**.** Accreditation and quality assurance in genetic testing labs.

MODULE 2	15Hrs

MOLECULAR TECHNIQUES IN GENETIC TESTING
PCR-Based Genetic Testing: Principles of polymerase chain reaction (PCR). Applications in detecting mutations and variants.
Sequencing Technologies: Sanger sequencing and next-generation sequencing (NGS). Whole exome sequencing and whole genome sequencing.
Microarray Analysis: Principles of microarray technology. Array comparative genomic hybridization (aCGH) and SNP arrays.
Bioinformatics in Genetic Testing: Data analysis and interpretation of sequencing results. Variant annotation and classification.

MODULE 3	15Hrs

CLINICAL APPLICATIONS OF GENETIC TESTING
Cancer Genetic Testing: Hereditary cancer syndromes. Role of genetic testing in cancer risk assessment.
Mendelian Disorders and Carrier Testing: Genetic testing for autosomal recessive, dominant, and X-linked disorders. Importance of carrier testing in family planning.
Pharmacogenetic Testing: Personalized medicine and drug response prediction. Testing for genetic variants affecting drug metabolism.
Non-Invasive Prenatal Testing (NIPT): Detection of fetal genetic abnormalities from maternal blood. Ethical considerations and limitations of NIPT.

MODULE 4	15Hrs

EMERGING TRENDS AND PRACTICAL ASPECTS OF GENETIC TESTING
Direct-to-Consumer Genetic Testing: Pros and cons of consumer genetic testing kits. Privacy and ethical concerns.
Genome Editing and Gene Therapy: CRISPR-Cas9 technology for gene editing. Clinical applications and ethical considerations.
Economic and Social Impact of Genetic Testing: Healthcare costs, insurance, and access to genetic testing.
Genetic testing in public health and disease surveillance.
Case Studies and Future Directions: Real-world examples of successful genetic testing applications. Exploration of emerging trends in the field.

TEXT BOOKS/REFERANCES:

1. "Medical Genetics" by Lynn B. Jorde, John C. Carey, and Michael J. Bamshad.
2. "Genetics: Analysis and Principles" by Robert J. Brooker.
3. "Introduction to Genetic Analysis" by Anthony J. F. Griffiths et al.
4. "Essential Medical Genetics" by Edward S. Tobias and Michael Connor.
5. "Genetic Testing: Care, Consent, and Liability" by Angus J. Macdonald.
6. "Genomic Medicine: Principles and Practice" by Dhavendra Kumar.
7. "Genetic Testing and the Use of Information" by Martin Richards and Peter S. Harper.
8. "Genomic and Precision Medicine: Foundations, Translation, and Implementation" by Geoffrey S. Ginsburg and Huntington F. Willard.
9. "Clinical Genomics: Practical Applications in Adult Patient Care" by Michael J. Dougherty.
10. "Genomic Medicine: An Introduction and Application Guide" by Dhavendra Kumar.

EXPERIMENTS
1. DNA Extraction from Cheek Cells.
2. PCR Amplification of a Target Gene
3. Gel Electrophoresis of PCR Products
4. Restriction Fragment Length Polymorphism (RFLP) Analysis
5. Sanger Sequencing of a Genetic Variant
6. Microarray Analysis of Copy Number Variations
7. Bioinformatics Analysis of NGS Data

REFERENCES

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). Molecular Biology of the Cell (4th ed.). Garland Science. Chapter 5.
2. Innis, M. A., Gelfand, D. H., Sninsky, J. J., & White, T. J. (1990). PCR Protocols: A Guide to Methods and Applications. Academic Press.
3. Sambrook, J., Fritsch, E. F., & Maniatis, T. (1989). Molecular Cloning: A Laboratory Manual (2nd ed.). Cold Spring Harbor Laboratory Press. Chapter 7.
4. Russel, P. J. (2002). iGenetics: A Molecular Approach. Benjamin Cummings. Chapter 9.
5. Sanger, F., Nicklen, S., & Coulson, A. R. (1977). DNA sequencing with chain-terminating inhibitors. Proceedings of the National Academy of Sciences, 74(12), 5463-5467.
6. Wang, D. G., Fan, J. B., Siao, C. J., Berno, A., Young, P., Sapolsky, R., ... & Lander, E. S. (1998). Large-scale identification, mapping, and genotyping of single-nucleotide polymorphisms in the human genome. Science, 280(5366), 1077-1082.
7. Ashley, E. A., Butte, A. J., Wheeler, M. T., Chen, R., Klein, T. E., Dewey, F. E., ... & Bustamante, C. D. (2010). Clinical assessment incorporating a personal genome. The Lancet, 375(9725), 1525-1535.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22GS3603**					
TITLE OF THE COURSE	**COMPLEX TRAITS AND GENE NETWORKS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To develop an understanding of the underlying genetic complexity of complex traits and diseases, including the role of quantitative traits, linkage disequilibrium, and the influence of various genetic elements on disease susceptibility.
- To develop the skills to analyze the genetic architecture of complex traits through the study of non-coding DNA elements, polymorphisms, structural variations, and the application of quantitative trait locus (QTL) mapping and genome-wide association studies (GWAS).
- To gain insights into gene regulatory networks (GRNs) by exploring genome evolution, understanding gene-level control mechanisms, and applying molecular techniques like CRISPR-based genome editing and chromatin immunoprecipitation (ChIP) assays.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will be able to explain the concepts of quantitative traits, linkage disequilibrium, and the genetic basis of complex diseases, demonstrating an understanding of the fundamental principles underlying complex traits.	L2
CO2	Students will be able to analyze genetic data, identify relevant polymorphisms, and perform statistical analyses for QTL mapping and GWAS. They will interpret results to draw conclusions about the genetic factors contributing to complex traits.	L3
CO3	Students will design and execute laboratory experiments, such as CRISPR-based genome editing and ChIP assays, to manipulate and study gene regulation. They will integrate information from various sources to infer gene regulatory networks and assess their impact on complex diseases.	L4
CO4	Students will design and propose novel experimental approaches to study the 3D chromatin conformation using techniques like 3C and Hi-C. They will synthesize information from different modules to propose potential therapeutic strategies for complex diseases based on their understanding of genetic and regulatory mechanisms.	L5

COURSE CONTENT:	
MODULE 1	**15Hrs**
COMPLEX TRAITS AND DISEASES Quantitative traits, linkage disequilibrium (LD), Quantitative Trait Locus. Complex diseases: Alzeimer’s and Parkinson’s disease, multiple sclerosis, and autotoimmune diseases.	
MODULE 2	**15Hrs**
GENETIC ARCHITECTURE OF COMPLEX TRAITS Non-coding DNA elements and the junk genome, Structure of the Human polymorphic DNA: synonymous vs. nonsynonymous single nucleotide variant (SNV), Variable Number of Tandem Repeats (VNTRs, e.g., mini- and microsatellites), transposable elements (e.g., Alu repeats), structural alterations, and copy number variations, Single Nucleotide Polymorphisms (SNPs), haplotypes, QTL mapping and Genome wide association Studies (GWAS), LD plots	
MODULE 3	**15Hrs**
GENE REGULATORY NETWORKS Genome Evolution. Genome level control and introduction to Gene Regulatory Networks (GRNs). Genome Editting: Engineered Nucleases (Meganucleases, Zn-finger nucleases), Transcription Activator like Nucleases (TALEN), CRISPR in *Drosophila*.	
MODULE 4	**15Hrs**
CHARACTERIZATION OF COMPLEX DISEASE TRAITS Scaling the human genome: UCSC genome browser, RegulomeDB database, Dual Luciferase Reporter (DLR) assay. Estimating DNA-protein interactions: Chromatin Immunoprecipitation (ChIP) assay, Electrophoretic mobility Shift Assay (EMSA) and affinity pull down assays, 3D view of the Genome: Chromatin Conformation Capture (3C) and Hi-ChIP assays.	

TEXT BOOKS/REFERENCES:

1. "Genetics: A Conceptual Approach" by Benjamin A. Pierce
2. "Principles of Genetics" by D. Peter Snustad and Michael J. Simmons
3. "Statistical Methods in Genetic Epidemiology" by Duncan C. Thomas
4. "Essential Medical Genetics" by Edward S. Tobias and Michael Connor.
5. "Genome-Wide Association Studies and Genomic Prediction" by Cedric Gondro, Julius H.J. van der Werf, and Ben J. Hayes
6. "Molecular Biology of the Gene" by James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, and Richard Losick
7. "Epigenetics: How Environment Shapes Our Genes" by Richard C. Francis

EXPERIMENTS
1) EMSA assay via chemiluminescence (Virtual Demonstration)
2) CRISPR guide RNA and PAM site prediction tools: comparative analysis
3) Custom digestion of genome sequence using NEB cutter tool.
4) Chromatin Conformation Capture assay (Virtual Demonstration)
5) Primer design and in silico PCR
6) In silico study of UCSC genome browser.

REFERENCES

1. "Laboratory Manual for Human Genetics" by Michael R. Cummings and William S. Klug
2. "Genetics: A Laboratory Manual" by Benjamin A. Pierce
3. "Essential Techniques in Genetics: A Laboratory Manual" by Michael R. Cummings
4. "Molecular Biology Techniques: A Classroom Laboratory Manual" by Heather Miller, D. Scott Witherow, Sue Carson, and Michael L. Corbo
5. "Essential Genetics: A Genomic Perspective" by Daniel L. Hartl and Elizabeth W. Jones
6. "Experiments in Modern Genetics" by Charlotte A. Spencer, David F. Kelly, and Michael Hadfield
7. "Genetics Laboratory Investigations" by Thomas L. Vandergon
8. "Molecular Biology Techniques: An Intensive Laboratory Course" by Reinhard Lührmann and David S. J. Allan

SEMESTER	**IV**						
YEAR	**II**						
COURSE CODE	**22MY2401**						
TITLE OF THE COURSE	**MICROBIAL PHYSIOLOGY**						
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To equip the students about the importance of microorganisms in our global society.
- To create in-depth knowledge of the metabolic pathways, energetics in microorganisms.
- To make students to learn basic microbiological techniques employed for biochemical tests and estimations of various molecules in prokaryotic and eukaryotic microorganisms.

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Students will be acquainted with fundamental aspects of microbial physiology basically the metabolism and their energetics	L1
CO2	Enable the students to understand the diversity of microbial, structure, function and their environment	L2
CO3	Students will be able to understand the importance of microorganisms.	L3
CO4	Students will be equipped with fundamental knowledge of microbial growth patterns enabling them to apply the same in various allied fields.	L2

COURSE CONTENT:

MODULE 1: MICROBIAL METABOLISM	**15Hrs**

Carbohydrate and Protein Metabolism: Glycolysis, Entner – Doudoroff. TCA cycle, Gluconeogenesis, Transamination, oxidative deamination, decarboxylation, Urea cycle.

Photosynthesis: Photosynthetic microorganisms, photosynthetic pigments, Cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria. Carbon dioxide fixation pathways, Fungal and bacterial secondary metabolism: Brief account on biosynthesis and action of secondary metabolites antibiotics, fungal and bacterial toxins, pigments, Bioluminescence.

MODULE 2: ENZYMOLOGY	**15Hrs**

Enzymes: Definition, classification, nomenclature, specificity, active sites, coenzymes, activators and inhibitors, activity unit-prosthetic groups. Effect of temperature, pH and substrate concentration on reaction rate. Isozymes, Enzyme Kinetics and co-enzyme action. Michaelis-Menten equation, Determination of kinetic parameters, hyperbolic and LB plot. Regulation of enzymes: Covalent and

noncovalent modification; Enzyme inhibition - types of inhibitors - competitive, noncompetitive and uncompetitive. Ribozymes and abzyme.	
MODULE 3: MICROBIAL RESPIRATION AND BIOENERGETICS	**15Hrs**
Principles of thermodynamics, high energy compounds- ATP, NAD, FAD, FMN, quinones, components and mechanisms of respiratory chain. Bacterial aerobic respiration: Components of electron transport chain, free energy changes and electron transport, oxidative phosphorylation. Theories of ATP formation, generation and maintenance of PMF and inhibition of electron transport chain. Anaerobic respiration. Nitrate, carbonate and sulfate as electron acceptors.	
MODULE 4: MICROBIAL CELL MEMBRANE PHYSIOLOGY	**15Hrs**
Metabolite transport: Passive diffusion, facilitated diffusion, different mechanisms of active diffusion (PTS, role of permeases in transport). Transport of amino acids and inorganic ions in microbes and their mechanisms. Stress physiology: Osmotic stress and osmoregulation by glutamate. Aerobic to anaerobic transitions in facultative microorganisms (E. coli); Oxidative stress - superoxide dismutase and catalase, Regulation of the Oxidative Stress, Response, pH stress and acid tolerance; Thermal stress and heat shock response (genes); Nutrient stress and starvation stress.	

TEXT BOOKS/REFERENCES:

1. Arora, D.K. and Seema Gupta. (1996). Bacterial Physiology. Anmol Publications. New Delhi.
2. Brun, Y.V. and Shimkets, L.J. (2000). Prokaryotic Development, ASM Press.
3. Byung Hong Kim and Geoffrey Michael Gadd. (2008). Bacterial Physiology. Cambridge.
4. Caldwell, D.R. (2000). Microbial Physiology and Metabolism, Brown Publishers.
5. Deb, A.C. (2006). Fundamentals of Biochemistry, New Central Book Agency Pvt. Ltd., Kolkata.
6. Donald Voet and Judith G. Voet. (2011). Biochemistry. Third Edition, John Wiley and Sons, Inc. New York.
7. Stryer, L. (2010). Biochemistry, Seventh Edition, W.H. Freeman and Company, New York.
8. El-Sharoud, Walid (Ed.) (2007). Bacterial Physiology a molecular approach. Springer.
9. Moat, A.G. & Foster, J.W. (1995). Microbial physiology, Wiley-Liss.
10. Moat, A.G. and Foster, W. (2002). Microbial Physiology, Fourth Edition, John Wiley and Sons, New York. Postgate,J. Nitrogen Fixation, third edition, Cambridge University Press.
11. Salisbury, F.W. and W.Ross, (1991). Plant Physiology, fourth edition, Wardsworth Publishing Company, California.
12. Smith and Wood (1991). Energy in Biological Systems. Chapman and Hall.
13. Srivastava, M.L. 2008. Microbial Biochemistry, Narosa Publishing House, New Delhi.

PRACTICALS
1. Biochemical test (5 Units) a) Catalase b) IMViC c) Starch hydrolysis d) Casein hydrolysis e) Sugar fermentation test (Acid / Gas)
2. Estimation of DNA.
3. Estimation of maltose by DNS method.
4. Estimation of proteins
5. Estimation of enzyme activity – amylase.

REFERENCES

1. Aneja, K.R. (2014). Laboratory Manual of Microbiology and Biotechnology. Medtec
2. Atlas R.M. (1998). Microbiology- Fundamentals and applications, Macmillan Publishing Company, New York.
3. Cappuccino, J.G., and Sherman, N. (1999). Microbiology - A Laboratory Manual. Fourth Edition. The Addison Wesley Longman, Inc England.
4. Pelczar, M. J., Chan E.C.S. and Krieg N.R. (1993). Microbiology. McGraw Hill Book Company, New York.
5. Prescott, L.M., Harley, J.P. and Klein, D.A. (2011). Microbiology. WCB McGraw-Hill, NY.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22MY2402**					
TITLE OF THE COURSE	**IMMUNOLOGY AND IMMUNO-TECHNIQUES**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
To demonstrate the basic knowledge of immunological processes at a cellular and molecular level
To outline, compare and contrast the key mechanisms and cellular players of innate and adaptive immunity and how they relate
To understand key events and cellular players in antigen presentation, and how the nature of the antigen will shape resulting effector responses
It will also provide opportunities for a student to develop diagnostic skills in microbiology, including the practical application and interpretation of laboratory tests

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	The course will provide the conceptual basis for understanding how the immune response works	L2
CO2	Students will acquire and demonstrate competency in routine and specialized microbiological laboratory skills applicable to immunological methods, including accurately reporting observations and analysis.	L3
CO3	The course will enable the student to apply the knowledge in various aspects of fermentation or industrial microbiology	L3

COURSE CONTENT:	
MODULE 1: ELEMENTS OF IMMUNE SYSTEM	**15Hrs**
History and scope of immunology, Definition and types of immunity (innate and adaptive). Structure, Functions and Properties of: Immune Cells (Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell and Dendritic cell) and Immune Organs– Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT. Immune responses- Primary and Secondary Immune Response, Humoral and cell mediated immunity. Complement system – Components, function and activation pathways, Major Histocompatibility Complex.	
MODULE 2: ANTIGENS AND ANTIBODIES	**15Hrs**
Characteristics of an antigen, Types, Haptens, Superantigens, Epitopes (T & B cell epitopes), Structure of T-cell and B-cell receptors. Structures of antigen presenting cells. Cluster of differentiation,	

Cytokines, Adjuvants. Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic). Immunoglobulin family and class switch mechanism. Clonal selection theory of antibody production.
MODULE 3: IMMUNOLOGICAL DISORDERS 15Hrs
Hypersensitivity reactions - Definition and types, Autoimmune disorders - Type-1 diabetics, Rheumatoid arthritis and Myasthenia gravis, Transplantation immunology – Graft, types and rejection of graft. Brief concept of cancer immunology.
MODULE 4: IMMUNOLOGICAL TECHNIQUES 15Hrs
Production and application of Monoclonal antibodies. Types and Principles of Ag-Ab reactions - Precipitation, Agglutination, Complement fixation and its applications. Immunodiffusion, Immunoelectrophoresis, ELISA, RIA, Immunofluorescence, Western Blotting (Immunoblotting), Flow cytometry and Immunoelectron microscopy.

TEXTBOOKS/REFERNCES:

1. Kuby J (2006) Immunology 6th Edition. W.H. Freeman and company, New York. 4. Warren Levinson (2000) Medical Microbiology and Immunology, Examination and Board Review. 8th Edition. McGraw Hill.
2. Anathnarayana and Panikar (2013) Text Book of Microbiology, 9th Edition. University press.
3. Richard A, Goldsby, Thomas J, Kindt, Barbara A and Osborne (2000). Kuby Immunology. 4th Edition. W.H. Freeman and Company, New York.
4. Tortora, Funke, Case (2009) Microbiology, 9th Edition. Benjamin Cummings.
5. Fritz H Kayser (2005) Medical microbiology. ThiemeVerlag.
6. Funke, B. R., Tortora, G. J., Case, C. L. (2013). Microbiology: An Introduction. United Kingdom: Pearson.
7. Frank and Steven A (2002). Immunology and evolution of Infectious Diseases. Princeton University Press.
8. Kenneth Murphy, Casey Weaver, and Paul Travers Janeway. (2020). Immunobiology. Garland 9th Edition.
9. Abul K. Abbas, Andrew H. Lichtman, and Shiv Pillai. (2020). "Cellular and Molecular Immunology" Elsevier, (10th Edition).

PRACTICALS	
1	Serological reactions: a) Agglutination - Blood grouping and Rh typing b) Precipitation reactions: Radial ImmunoDiffusion, c) (c) Ouchtlerlony Double Diffusion
2	Identification of various Blood cells.
3	Counting of WBC using Hemocytometer.
4	Dot ELISA.
5	Measurement of blood cells using micrometry.

REFERENCES:

1. Mackie and McCarthey. (1973). Medical Microbiology vol 1, Microbial infection, vol 2, Practical Medical Microbiology, Churchil Livingstone.
2. Frank and Steven A. (2002). Immunology and evolution of Infectious Diseases. Princeton University Press.
3. Wadher and Bhoosreddy. (2005). Manual of Diagnostic Microbiology. Himalaya Publisher.
4. Leslic Collier, John Oxford. (2000). Human virology a text book for students of medicine, dentistry and microbiology. 2nd edition. Oxford University Press.
5. Jenson, Wright Robinson. (1973). Microbiology Vol 1, Microbial Infection Vol 2, Practical Medical Microbiology, Churchill Living Stone.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22MY2403**					
TITLE OF THE COURSE	**PHARMACEUTICAL MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To make students understand the applications of microorganisms in production of pharmaceutically active compounds.
- To know the importance of microbiology knowledge in maintaining the microbial standards in pharmaceutical productions.

CO No.	**OUTCOMES**	**Bloom's TaxonomyLevel**
CO1	Should be able to identify different antimicrobial agents, antibiotics produced by them and it's mode of action.	L1
CO2	Should be able to outline the process involved in drug discovery and development	L2
CO3	Should be able to understand regulatory guidelines in pharmaceuticals product production.	L2

COURSE CONTENT:

MODULE 1: ANTIBIOTICS	**15Hrs**
History of Chemotherapy, classification of antibiotics - β-lactam, aminoglycosides, tetracyclines, ansamycins, macrolides. Antifungal antibiotics: Griseofulvin; Antiviral drugs: Amantidines; Nucleoside analogues, Interferons, Peptide antibiotics. Synthetic antibiotics: Sulphonamides; Chloramphenicol; Quinolone. Chemical disinfectants, antiseptics and preservatives. Therapeutic and prophylactic usage of drugs. Adverse reactions of drugs. Drug resistance – mechanism and consequences. Development of new therapeutics - Antimicrobial peptides, phage therapy, plant-based therapeutics. Immobilization procedures for pharmaceutical applications (liposomes). Macromolecular, cellular and synthetic drug carriers.	
MODULE 2: MICROBIAL FORMULATION AND APPLICATIONS OF MICROBIAL ENZYMES	**15Hrs**
Biochemical and molecular basis of screening for the active ingredients from microbes. Application of microbial enzymes in therapeutics. Microbial fermentation for the production of pharmaceutical compounds (Streptomycin, Influenza vaccine). Formulation of drugs, Packaging of products. Preservation of pharma – ideal preservatives, antimicrobial preservatives. Database for Drug designing; Preclinical, clinical trials and	

Toxicology (LD50 and ED50).

Regulatory Aspects in Pharmaceuticals

FDA regulations, GMP and GLP in pharmaceuticals, Quality control through WHO; Good Regulatory Practices, Clinical Research Regulations. Regulation and legislation for drugs, cosmetics, medical devices, biologicals and herbals formulation.

TEXT BOOKS/REFERENCES:

1. Hugo, WB and Russell, AD. Pharmaceutical Microbiology, (2003). Blackwell Science, Oxford, UK.
2. Krogsgaard L, Lilijefors T. and Madsen, U. (2004). Textbook of Drug Design and Discovery, Taylor and Francis, London.
3. Geoffrey Hanlon and Norman Hodges. (2013). Essential Microbiology for pharmacy and pharmaceutical science. Wiley Blackwell.
4. S. P. Vyas & V. K. Dixit. (2003). Pharmaceutical Biotechnology. CBS Publishers & Distributors, New Delhi.
5. Bhatia R and Ichhpujani RL. (1995). Quality Assurance in Microbiology. CBS Publishers, New Delhi.
6. Gregory Gregoriadis. (2001). Drug Carriers in biology & Medicine. Academic Press New York.
7. Davis, B. D., Dulbecco, R, Eisen, H. N., Ginsberg, R. S. (1990). Microbiology. Harper and Row Publishers, Singapore.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22BS2401**					
TITLE OF THE COURSE	**BIOSAFETY AND GOOD LABORATORY PRACTICE**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	**Sem/Year**	**Course Code**	**Title of the Course**
-	**-**	**-**	**-**

COURSE OBJECTIVES:

- To introduce the students to the concepts of biosafety regulatory frameworks concerning genetically modified organisms at national and international levels.
- To impart knowledge of the principles of GLP and their practical applications.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Gain knowledge of the various safety procedures to be followed in laboratory.	L2
CO2	Gain the skills and knowledge necessary to understand and work in GLP compliant environment.	L2
CO3	This course should generate interest for avenues for pursuing higher studies and careers in these areas	L2

MODULE I – BIOSAFETY	**18 Hrs**
Introduction, Historical Background; risk assessment and lab acquired infections, Introduction to Biological Safety Cabinets& their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms. Recommended Biosafety Levels for Infectious Agents and Infected Animals. Biosafety Guidelines: Biosafety guidelines and regulations (National and International); Definition of GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Recombinant DNA Guidelines (1990); Rules for the manufacture, use/import/export and storage of hazardous microorganisms/ genetically engineered organisms or cells (Ministry of Environment and Forests Notification,1989); Environmental release of GMOs; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.	
MODULE II – GOOD LABORATORY PRACTICE	**12 Hrs**
Introduction to GLP, WHO guidelines on GLP, History, Scope (Resources Characterization, Rules, Results, Quality assurance); Levels of Laboratories; General Rules/Protocols for Lab Safety measures; Precaution and Safety in handling of chemicals, Laboratory tools, glasswares and instruments;Sample storage and disposal; Log Book maintenance, Basic SOPs for instrument handling and Maintenance.	

Keeping data records, its analysis by using statistical and mathematical tools. Result analysis and its interpretation. GLP as given by OECD, FDA etc (International perspective); Internal and External Audits.

REFERENCES:

1. Handbook Good Laboratory Practices-World health organization (WHO).
2. Life science protocol manual (2018). DBT star college scheme.
3. Guidelines for good laboratory practices-Indian council of medical research, New Delhi (2008).
4. Handbook: Good Laboratory Practices (GLP): quality practices for regulated non-clinical research and development-2nd ed.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22MY3501**					
TITLE OF THE COURSE	**MEDICAL AND CLINICAL MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
This course provides an overview on the role of microbiome in human health and disease
To introduce basic principles and application relevance of clinical disease for students
The course will provide the conceptual basis for understanding pathogenic microorganisms and particularly address the fundamental mechanisms of their pathogenicity
It will also provide opportunities for a student to develop diagnostic skills in microbiology, including the practical application and interpretation of laboratory tests for the diagnosis of infectious diseases

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Enable the students to understand the normal microbiome and its relevance to human health.	L2
CO2	The course will provide the conceptual basis for understanding pathogenic microorganisms and particularly address the fundamental mechanisms of their pathogenicity.	L1
CO3	Students will acquire and demonstrate competency in laboratory safety and in routine and specialized microbiological laboratory skills applicable to microbiological research or clinical methods, including accurately reporting observations and analysis.	L3

COURSE CONTENT:	
MODULE 1: NORMAL MICROBIAL FLORA	**15Hrs**
Factors determining the nature of the normal flora. Normal flora of skin, respiratory system, nervous system, digestive system and urinary and reproductive systems. Beneficial effects of the normal flora. Attributes of microbial pathogenicity: Pathogenicity, Virulence factors, invasion. Toxins: Exotoxins, Enterotoxins and Endotoxins. Types of infections (non-communicable and communicable infections. Nosocomial infection, zoonotic diseases, opportunistic pathogens). Routes of transfer. Factors affecting host susceptibility to disease. Immune response to infection.	
MODULE 2: ANTIBIOTICS AND VACCINES	**15Hrs**

Mode of antimicrobial action – antibacterial, antimycobacterial, antifungal, antiviral, antiprotozoal, antihelminthic. Microbial resistance to antibiotics. Molecular principles of drug targeting; Drug delivery system in gene therapy. Vaccine: Inactivated Attenuated, Conjugated, Recombinant vaccines - synthetic peptide vaccines, Multivalent subunit vaccines, DNA vaccines. Immunisation schedule and its significance. Secondary metabolites from microorganisms.
MODULE 3: INFECTIOUS DISEASES 15Hrs
Type study: symptoms, Epidemiology, etiology, pathogenesis, diagnosis, treatment and prophylaxis of the following: **Bacteria**–*Staphylococcus aureus*, *Salmonella typhi* **Viruses –** Rabies, HIV **Fungi–** *Aspergillosis*, *Candida albicans* ***Protozoa*** – *Leishmania donovani*, *Entamoeba histolytica*
MODULE 4: DIAGNOSTICS AND BIOMEDICAL MANAGEMENT 15Hrs
Diagnostic Microbiology: Collection, transport and storage guidelines; biosafety in diagnostic laboratory and regulations, specific procedures for collection of specimens, processing of specimens. Molecular diagnosis: RT-PCR, RAT (Rapid Antigen Test), TrueNat (TB and Covid-19). Biomedical waste segregation, treatment and management.

REFERENCES:

1. Anathnarayana and Panikar. (2013). Text Book of Microbiology, 9th Edition. University press.
2. Warren Levinson. (2000). Medical Microbiology and Immunology, Examination and Board Review. 8th Edition. McGraw Hill. 5. Tortora, Funke, Case (2009) Microbiology, 9th Edition. Benjamin Cummings.
3. Connie R Mahon. (2010). Text book of diagnostic Microbiology. 3rd edition, Pearson.
4. Kayser FH. (2005). Medical Microbiology.
5. Mackey, T. J., & McCarthey, J. Y. (1989). Practical Medical Microbiology.
6. Frank and Steven A. (2002). Immunology and evolution of Infectious Diseases. Princeton University Press.
7. Kufe, D. W., Pollock, R. E., Weichselbaum, R. R., Bast, R. C., Gansler, T. S., Holland, J. F., & Frei, E. (2003). Cancer Medicine; ed.; BC Decker. *Inc.: Lewiston, NY.*Leslic Collier, John Oxford (2000) Human virology a text book for students of medicine, Dentistry and Microbiology. 2nd Edition. Oxford University Press.
8. Jenson, Wright Robinson. (1973). Microbiology Vol 1, Microbial Infection Vol 2, Practical Medical Microbiology, Churchill Living Stone.
9. Credric, A Mims. (2004). Medical Microbiology, 3rd Edition. Mohshy Inc.
10. Nester Roberts Pearsall Anderson. (2021). Microbiology- A Human Perspective, 2nd Edition, McGraw-Hill.

PRACTICALS	
1	Isolation and identification of normal microflora on simple, selective and enrichment media (throat, skin and nasal sample). (**3 units)**
2	Dental caries susceptibility assay by Snyder's agar test.
3	Determination of effectiveness of antiseptics by thumb impression method.
4	WIDAL Test
5	VDRL

REFERNCES:

1. Funke, B. R., Tortora, G. J., Case, C. L. (2013). Microbiology: An Introduction. United Kingdom: Pearson.
2. Mackie and McCarthey. (1996). Medical Microbiology vol 1, Microbial infection, vol 2, Practical Medical Microbiology, Churchil Livingstone.
3. Frank and Steven A. (2002). Immunology and evolution of Infectious Diseases. Princeton University Press.
4. Wadher and Bhoosreddy. (2005). Manual of Diagnostic Microbiology. Himalaya Publisher.
5. Credric, A Mims. (2004). Medical Microbiology, 3rd Edition. Mohshy Inc.
6. James G. Cappuccino, Natalie Sherman. (2014). Microbiology: A Laboratory Manual. Pearson.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22MY3502**					
TITLE OF THE COURSE	**MICROBIAL GENETICS AND GENETIC ENGINEERING**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**		**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To understand the genetic basis of microbial life. Also, to use that knowledge in fields of molecular biology, applied microbiology and genetic engineering.
• To learn about the tools involved in gene manipulation and apply it in the process of genetic engineering.

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Should be able to understand genetic elements that govern microbial life processes.	L2
CO2	Should be able to use gene manipulation techniques in various fields of applied biology	L3
CO3	Should be able to demonstrate experiment in microbial genetics concerned with clarifying phenotype and their relationship with the genotype.	L2

COURSE CONTENT:

MODULE 1	**15Hrs**

MICROBIAL GENETICS

Morphology of Prokaryotic and Eukaryotic genetic material. Chemical basis of heredity: Evidence for DNA and RNA as genetic material (Griffith's experiment and Hershey and Chase experiment and Singer's experiment). Properties of genetic code and Wobble hypothesis. Transformation, Conjugation and Transduction. Transposons in recombination. Extra chromosomal genetic elements and their importance. Classical Microbial Genetics: complementation, recombination, and mapping.

MODULE 2	**15Hrs**

Concept of Gene – Muton, Recon, Cistron. One gene-one enzyme, One gene- One polypeptide, One gene – One product hypothesis. Types of RNA and their functions. Outline of RNA biosynthesis in prokaryotes. Genetic code. Structure of ribosomes and protein synthesis in prokaryotes. Types of genes - structural, constitutive and regulatory. Operon concept. *Lac* operon.
Molecular basis of mutations: Nature, types of mutations (point and frame shift mutations), DNA repair mechanisms.

MODULE 3 **15Hrs**

INTRODUCTION AND TOOLS FOR GENETIC ENGINEERING

Introduction to Genetic Engineering: Overview of major steps involved. Tools for Genetic Engineering: Enzymes: Restriction endonucleases, DNA ligases. Other enzymes: A brief account of Alkaline phosphatase, Polynucleotide kinase, Exonuclease III, DNase I, DNA polymerase and Klenow fragment, Terminal nucleotidyl transferase, RNA dependent DNA Polymerase. Vectors – plasmids (pBR 322, pUC 18), bacteriophages, cosmids, YAC, shuttle vectors. cDNA, PCR.

Gene transfer - Chemical methods, Lipofection, Electroporation, Microinjection, Ballistic method (Particle shot gun method). Selection and screening of recombinants: Identification and selection of transformed cells: Direct methods - Insertional inactivation, Visual screening method, Plaque formation, Complementation of mutation nutrition Indirect methods - Colony hybridization, Immunochemical detection.

MODULE 4 **15Hrs**

GENETIC ENGINEERING TECHNIQUES

Technique for Genetic Engineering: Gel electrophoresis: Agarose Gel Electrophoresis, SDS-PAGE, Hybridization: Southern, Northern, Western. Dot blots, Autoradiography. DNA sequencing: Sanger's Dideoxy method, Molecular probes.

APPLICATIONS: Transgenics - Resistance to diseases (Pathogen resistant-viral, fungal and bacterial); insects (Bt gene transfer); Fertilizer management- Nif gene transfer.

TEXT BOOKS/REFERENCES:

1. Sandhya M. (2008). Genetic engineering: Principles and practice, MacMillan India Ltd.
2. Primrose, S. B., and R. M. Twyman. (2006). Principles of gene manipulation and Genomics, Blackwell Publishing MA. USA.
3. Nicholl D. S. T. (2008). An introduction to Genetic engineering (2^{nd} ED), Cambridge University Press.
4. Satyanarayana U. (2008). Biotechnology, Books and Allied (P) Ltd., Kolkata.
5. Purohit S. S. (2003). Biotechnology Fundamentals and applications, student Edition, Jodhpur.
6. Channarayappa. (2006). Molecular Biotechnology- Principles and practices, University press (India) Private Limited.
7. Hartwell, L. H., L. Hood, M. L. Goldberg, A. E. Reynolds, L. M. Silver and R. G. Veres. (2004). Genetics from Genes to Genomes. McGraw Hill.
8. Lewin B. Genes VIII. (2003). Oxford University Press. Oxford,
9. Watson, J. D., T. A. Baker S. P. Bell, A Cann, M. Levine and R. Losick. (2004). Molecular Biology of Gene V Edition, Pearson Education RH Ltd. India.
10. Brown T. A. (2007). Genomes 3. Garland Science Publishing, New York.

PRACTICALS
1. DNA isolation from microbial source. 2. RNA isolation from microbial source. 3. Plasmid isolation from microbial source. 4. Restriction digestion 5. DNA ligation 6. Bacterial transformation

REFERENCES

1. Hugo, WB and Russell, AD. (2003). Pharmaceutical Microbiology. Blackwell Science, Oxford, UK.
2. Aneja, K.R. (2014). Laboratory Manual of Microbiology and Biotechnology. Medtec
3. Atlas R.M. (1998). Microbiology- Fundamentals and applications, Macmillan Publishing Company, New York.
4. Cappuccino, J.G., and Sherman, N. (1999). Microbiology - A Laboratory Manual. Fourth Edition.
5. Addison Wesley Longman, Inc England.
6. Pelczar, M. J., Chan E.C.S. and Krieg N.R. (1993). Microbiology. McGraw Hill Book Company, New York.
7. Prescott, L.M., Harley, J.P. and Klein, D.A. (2011). Microbiology. WCB McGraw-Hill, NY.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BS3501**					
TITLE OF THE COURSE	**BIOETHICS AND IPR**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	**Sem/Year**	**Course Code**	**Title of the Course**
-	**-**	**-**	**-**

COURSE OBJECTIVES:

- To recognize, compare, and contrast the general "ways of thinking" of science (biology) and of philosophy (ethics).
- To recognize, compare, and contrast the general "ways of thinking" of science (biology) and of philosophy (ethics).
- To give elementary essential concepts of Bioethics, IPR and patent laws.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Student should develop basic understanding of the concepts of Bioethics, IPR and Patent Laws	L2
CO2	This course should generate interest for avenues for pursuing higher studies and careers in these areas	L2
CO3	General knowledge should create awareness necessary for higher studies in biotechnological fields	L2

COURSE CONTENTS

MODULE I – BIOETHICS	15 Hrs
Bioethics- The environmental, legal and socioeconomic impacts of biotechnology; Ethical concerns of biotechnology in research and innovation-The GM crop debate – safety, ethics, perception and acceptance of GM crops; Bioethics of Genetically modified organism;Bioethics of CRISPR technique- for editing human embryos; Bioethics of Gene therapy; Bioethics of Stem cell research;Reproductive medicine and ethics;Use of Animals in Research and Testing, and Alternatives for Animals in Research,Animal Cloning, Human Cloning, and their Ethical Aspects; Public education of theprocess of biotechnology involved in generating new forms of life for informed decision-making.	
MODULE II – INTELLECTUAL PROPERTY RIGHTS AND REGULATIONS	**15 Hrs**
Introduction to Intellectual Property and History. Patents, Trademarks, Copyright, Trade secrets, Industrial Design and Rights, Traditional Knowledge, Geographical Indications - importance of IPR – patentable and non-patentable – patenting life – legal protection of biotechnological inventions – WorldIntellectual Property Rights Organization (WIPO), Pros and Cons of IP protection. Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner. Agreements and Treaties: GATT, TRIPS Agreements; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV &Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.	

REFERENCES

1. Beier, F.K., Crespi, R.S. and Straus, T. (1985). Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.
2. Ganguli Prabuddha. (1998). Gearing up for Patents. The Indian Scenario , Universities Press.
3. H S Chawla. (2011). Introduction to Plant Biotechnology.
4. M K Sateesh. Bioethics and Biosafety. Kindle Edition
5. Shomini Parashar, Deepa Goel. (2013). IPR, Biosafety and Bioethics Pearson, India.
6. F. H. Erbisch and K. M. Maredia. (2003). Intellectual property rights in agricultural Biotechnology, University Press.
7. SivamiahShantharam, Jane F. (1999). Montegomery. Biotechnology, Biosafety and Biodiversity, Oxford & IBHPubl. New Delhi.
8. Jecker Nany S, Jones &Barlet. 1997. Bioethics: An Introduction to the History Methods and Practice, New Delhi.
9. Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan
10. K. Sell. (2000). Cambridge University Press.
11. Essentials of Intellectual Property: Law, Economics, and Strategy By Alexander I.
12. Poltorak; Paul J. Lerner. (2011). Wiley, (2nd edition).
13. Diane O. Fleming, Debra L. (2006). Hunt Biological Safety: Principles and Practices, 4th Edition. ASM.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BS3502**					
TITLE OF THE COURSE	**BIONFORMATICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To get introduced to the basic concepts of Bioinformatics and its significance in biological data analysis.
• To get an overview about biological macromolecular structures and structure prediction methods.

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Will be able to demonstrate mastery of the core concepts of bioinformatics	L1
CO2	The student will be able to apply basic principles of biology, computer science and mathematics to address complex biological problem	L2
CO3	Should be able to plan basic experiments in microbial genetics concerned with clarifying phenotypes and their relationship with the genotype	L3

COURSE CONTENT:	
MODULE 1 BIOLOGICAL DATA TYPES AND SOURCE	**07Hrs**
Introduction to population and sample, Classification and Presentation of Data. Quality of data, private and public data sources. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Specialized Genome databases: (SGD, TIGR, and ACeDB). Microbial genomic database (MBGD), Virus data bank (UICTVdb).	
MODULE 2 SIMILARITY SEARCHING	**10Hrs**
Global and Local sequence alignment, Pair wise comparison of sequences, Multiple Sequence alignment of sequences, scoring matrices. Identification of genes in genomes and Phylogenetic analysis with reference to nucleic acids, Identification of ORFs, Identification of motifs	

MODULE 3 INTERPRETTING the SEQUENCE	07Hrs
Reading DNA from files in FASTA format, reading frames, Regular expressions, restriction maps and restriction enzymes, Genbank libraries, annotation parsing, Annotations indexing, parsing PDB files, parsing BLAST files.	

MODULE 4 SCALING THE HUMAN GENOME	06Hrs
UCSC genome browser, RegulomeDB database, ENCODE-ChIA-PET database, transcription factors binding sites. SNP, EST, STS. Regular Expression (REGEX), Hierarchies and Graphical models (including Markov chain and Bayes algorithm). Genetic variability and connections to clinical data.	

TEXT BOOKS/REFERENCES:

1. Bioinformatics. Keith, J. (2008). Humana Press.
2. R.F. Doolittle. (1996). Computer methods for macromolecular sequence analysis., Academic Press.
3. Bioinformatics. (2004). Sequence and genome analysis. D.W.Mount. Cold Spring Harbor Lab. Press.
4. J. Pevsner. (2003). Bioinformatics and functional genomics. Wiley-Liss.
5. Jorde et al., (2005). Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics, John Wiley and Sons.
6. Baxavanis (2004). Bioinformatics.
7. Fry, J.C. (1993). Biological Data Analysis. A practical Approach. IRL Press, Oxford.
8. Rosenbloom KR. (2015). The UCSC Genome Browser database: update. Nucleic Acids Res.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22MY3601**					
TITLE OF THE COURSE	**INDUSTRIAL MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**		**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To equip the students about the importance of microorganisms in our global society.
- To relate microbes in interdisciplinary connections with other sciences, in particular to productions, food sciences.
- To exhibit depth of knowledge by demonstrating microbial sciences in the field of applied fields industrial microbiology.

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Students will be acquainted with depth of understanding on fermentation technology, modern microbial techniques and analysis relating to industrial microbiology.	L1
CO2	Enable the students to understand the diversity of microbial, structure, function and their environment	L2
CO3	Students will be able to demonstrate a knowledge and understanding of: Concept of Industrial waste management system.	L3
CO4	It will develop problem solving capabilities in practical working in teams in laboratory/industries based on virtual experiments to gather and evaluate microbial data using a range of current analysis techniques relating to microbial productions in industries.	L4

COURSE CONTENT:

MODULE I:	**15 Hrs**

INTRODUCTION TO INDUSTRIAL MICROBIOLOGY: Concepts and scope of microbes in industry. Screening, isolation of industrially important microbes. Strain improvement- mutation, recombination- gene regulation and genetic manipulation. Preservation of industrially important microbes. Culture collection centres. Basic components and design of typical fermenter. Types of fermenter - Laboratory, pilot- scale and production fermenters; constantly stirred tank fermenter, tower fermenter, fixed bed, fluidized bed bioreactors and air-lift fermenter. Types of fermentation - Batch, chemostat, submerged and solid-state fermentation. Different parameters affecting fermentation.

MODULE 2:	15 Hrs
UPSTREAM PROCESSING: Nutrients: growth factors, carbon, nitrogen, mineral sources, buffers, inhibitors, precursors, inducers, oxygen requirements, antifoam agents, hops, malt, malt adjuncts etc. Methods of media and air sterilization. Culturing techniques of microbial strains; inoculum preparation and inoculum development.	
MODULE 3:	**15 Hrs**
DOWNSTREAM PROCESSING: Solid matter, Foam separation, Precipitation, Filtration, Centrifugation, Cell disruption, Liquid extraction, Solvent recovery, chromatography, Membrane processes, Drying, Crystallization, Whole broth processing. Production economics and IPR: Concept of Patenting law, Copyrights, and Trademarks. Patent regulations and filing, processes, products and microorganisms.	
MODULE 4:	**15 Hrs**
MICROBIAL PRODUCTIONS AND APPLICATIONS: Alcohol production, organic acids (citric acid), enzymes: amylases-(Fungal and Bacterial). Amino acid - L-Glutamic acid. Vaccines (Hepatitis B), hormones (human insulin), antibiotic (Penicillin). Mushroom production. Applications of genetic engineering in industrial bioprocessing.	

TEXT BOOKS/REFERNCES:

1. Casida L.E.J.R (2015) Industrial Microbiology, New Age International, New Delhi. 37
2. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.
3. Michael J. Waites, Neil Morgan, John S. Rockey, Gray A. Higton. (2001). Industrial Microbiology: An Introduction, Blackwell Science.
4. Robert H. (2006). Microbiology and Technology of Fermented Foods. Blackwell Publishers.
5. Matthew Rimmer. (2008). Intellectual Property and Biotechnology: Biological Inventions Edward Elgar. Betty C. Hobbs, Food Microbiology, Arnold-Heinemann Publishing Private Limited, New Delhi.
6. James M.J. (2005). Modern Food Microbiology. CBS Publishers and Distributers, Delhi.
7. Bibek R. (2001). Fundamentals of Food Microbiology. Bibek Ray. 2nd Edition. CRC press.
8. Adams M.R. and Moss M.O. (2000). Food Microbiology. Royal Publishing Corporation.
9. John G. (1997). Essentials of Food Microbiology. Arnold International Students Edition.
10. Wulf Crueger. (2016). A Textbook of Industrial Microbiology First CBS Publishers and Distributors Edition.
11. Robert Mellor. (2009). Entrepreneurship for Everyone: A student Textbook. SAGE Publication.

PRACTICALS
1. Isolation of microorganisms from vegetables and fruits. **(2 UNITS)**
2. Study of different types of fermenters (Models/ Charts)
3. Production of wine.
4. Production of alcohol from different sources and estimation by specific gravity method.
5. Production and estimation of amylase from microbial sources
6. Detection and quantification siderophore produced by Pseudomonas spp.

REFERNCES:

1. K. R. Aneja. 2008.Textbook of Basic and Applied Microbiology. New Age International,
2. Michael J. Waites, Neil Morgan, John S. Rockey, Gray A. Higton. (2001) Industrial Microbiology: An Introduction" Practical Manual Author: Blackwell Science.
3. Michael J. Waites, Richard E. Heal, Ann-Mari Mountfort. "Industrial Microbiology: A Laboratory Manual" Bioprocess Technology Consultants Ltd.
4. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.
5. Michael J. Waites, Neil Morgan, John S. Rockey, Gray A. Higton. 2001. Industrial Microbiology: An Introduction, Blackwell Science.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22MY3602**					
TITLE OF THE COURSE	**NANO MICROBIOLOGY AND EXTREMOPHILES**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To introduce concepts of nanotechnology and its applications
• The course will provide the conceptual basis of ubiquity of microbes in extreme environment
• To enable the students to understand the commercial relevance of extremophiles

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Students will acquire and demonstrate competency in nano science by learning synthesis of nano particles and its characterization	L3
CO2	Enable the students to describe the primitive life form and adaptation of microbes to it	L2
CO3	The course will help the students to describe distribution, classification of Extremophiles	L1
CO4	Students will be able to use the application of Extremophiles	L4

COURSE CONTENT:

MODULE 1	**15Hrs**

INTRODUCTION TO NANOTECHNOLOGY: Introduction and Classification: What is nanotechnology? Classification of Nanostructures as 1D, 2D and 3D nanomaterials. Nanoscale Architecture.

Characterization of nanoparticles UV-Vis spectroscopy, Electron Microscopy – HRTEM, SEM, AFM, EDS, XRD.

Classification of NPs: Organic, inorganic and biological sources.

Nano-materials in biological systems: Proteins, Lipids, RNA and DNAProtein Targeting - Small Molecule/Nanomaterial - Protein Interactions Nanomaterial-Cell Interactions-Manifestations of Surface Modification (Polyvalency).

MODULE 2	**15Hrs**

MICROBIAL NANOTECHNOLOGY: Different sources of microbes as NPs. Microbial synthesis of Nanoparticles. Synthesis of nanodrugs –Nanoparticles as drug systems. Diagnostic applications of nanotechnology. Biomedical nanotechnology (diagnostics, delivery and therapeutics), nano toxicology: Cyto-toxicity, Geno-toxicity In vivo tests/assays etc. Applications of microbial NPs in agriculture, food, environmental and other sectors.	
MODULE 3	**15Hrs**
EXTREMOPHILES: Extreme Habitats. Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, radiation, oxygen concentration and low nutrient levels. Life on other planets. Extremophiles - bacteria, archaea and eukaryotes. Classification and salient features of archaea. Genetic and Metabolic diversity.	
MODULE 4	**15Hrs**
ADAPTATIONS AND COMMERCIAL USE OF EXTREMOPHILES: Habitat, mechanism of survival and applications of extremophiles – temperature (thermophiles, psychrophiles), pH (acidophiles, alkalophiles), pressure (peizophiles, barophiles), xerophiles, radiations, methanogens.	

TEXT BOOKS:

1. Mick Wilson, Kamali Kannagara, Geoff Smith, Michelle Simmons, Burkhard Raguse, (2005). NANOTECHNOLOGY: Basic science and emerging technologies, Overseas Press, First Indian Edition.
2. Pradeep T. (2012). Textbook of Nanoscience and Nanotechnology. McGraw Hill Education (India) Private Limited.
3. Murty B.S., Shankar P., Baldev Raj, Rath B. B., James Murday. (2013). Textbook of Nanoscience and Nanotechnology. Springer, Berlin, Heidelberg.
4. Horikoshi, K., Antranikian, G., Bull, A. T., Robb, F.T.., Stetter, K.O. (2011) Extremophiles Handbook, Springer Publications
5. Horikoshi, K., Grant W. (1998). Extremophiles: Microbial Life in Extreme Environments. Wiley Publications.
6. Ramplelotto, Paulo H. (2016). Biotechnology of Extremophiles: Advances ad Challenges. Springer Publications.

PRACTICALS
1. Synthesis of Au/Ag metal nanoparticles by chemical route.
2. Optical properties of Au/Ag nanoparticles by using UV-Vis spectroscopy.
3. Determination of antimicrobial properties of silver nanoparticles.
4. Studies on halophiles isolated from high salt habitat. (Study its pigmentation and salt tolerance phenomenon).
5. Studies on alkalophiles and its enzymes (any one) isolated form extreme alkaline environment.

REFRENCES:

1. Raveendran, P., & Fu, J. (2017). "Microorganisms and Nanotechnology: A Powerful Combination." Journal of Nanomaterials, 2017, 8252804.
2. Mukherjee, P., Roy, M., Mandal, B. P., Dey, G. K., Mukherjee, P. K., Ghatak, J., & Tyagi, A. K. (2008). "Green synthesis of highly stabilized nanocrystalline silver particles by a non-pathogenic and agriculturally important fungus T. asperellum." Nanotechnology, 19(7),

075103.
3. Bhushan, B., & Hoque, M. E. (2019). "Microbial Nanotechnology: Recent Advances and Emerging Applications." Springer.
4. Prasad, R., & Patra, J. K. (2018). "Nanobiotechnology: Microbial Biotechnology." CRC Press.

SEMESTER	VI					
YEAR	III					
COURSE CODE	22BS3601					
TITLE OF THE COURSE	**PRINCIPLES OF 'MULTI-OMICS'**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To acquaint students with various aspects of biotechnology and bio-engineering using omics technologies
• To provide key insights into omics approaches in personalized and precision medicine

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will have knowledge in specific methods used in genomics, proteomics and metabolomics used in analytical processes.	L1
CO2	Students will be able to perform statistical analysis crucial for interpretation of experimental results	L2
CO3	Students will be able to apply specialized research methods necessary for the analysis of proteins, genes and metabolites	L3

COURSE CONTENT:	
MODULE 1 Genome & Genomics	**07Hrs**
Genome mapping: Physical and Genetic Map, Genome Sequencing, Next generation sequencing methods ,Genome Annotation, Functional Genomics	
MODULE 2 Transcriptomics	**07Hrs**
Search for transcription factor binding sites, RNA-Seq, Microarrays, Regulatory RNAs: small or large, Computational prediction of miRNA target genes, RNA Darkmatter	

MODULE 3 Proteomics and Metabolomics	10Hrs
Basic concepts , Tools of proteomics- SDS PAGE, 2D PAGE , Liquid chromatography , Mass Spectrometry (ESI and MALDI) ,Protein identification by peptide mass fingerprinting ,Applications of proteomics. Fundamental concept, Tools of metabolomics- Capillary electrophoresis, Gas chromatography, Electrochemical detectors, Case studies	
MODULE 4 'OMICS': applications and future perspectives	**06Hrs**
Multi-omics in disease prediction and health. Multi-omics technologies for crop improvement and sustainable agriculture. Applications in Biomedical and Environmental sciences	

TEXT BOOKS/REFERANCES:

1. Keith, J. (2008). Bioinformatics. Humana Press.
2. R.F.Doolittle. (1996). Computer methods for macromolecular sequence analysis. Academic Press.
3. Daniel C. Liebler. (2002). Introduction to Proteomics -Tools for the New Biology. Humana Press.
4. J. Pevsner. (2003). Bioinformatics and functional genomics. Wiley-Liss.
5. Jorde et al., (eds.). (2005). Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics John Wiley and Sons.
6. Metabolomics- Methods and Protocols by Wolfram Weckwerth, Humana Press.
7. Fry, J.C. (1993). Biological Data Analysis. A practical Approach. IRL Press, Oxford.
8. Virendra Gomase, Somnath Tagore. (2009). Transcriptomics: Expression Pattern Analysis,; VDM Publishing.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22BS3602**					
TITLE OF THE COURSE	**TOXICOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
1. To learn various toxicants present and their exposure level on day-to-day basis.
2. To study the effects of toxins on the physiologic, metabolic, reproductive, and developmental processes.

COURSE OUTCOMES

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will learn and understand all substances can be toxic depending on the means and level of exposure	L1
CO2	Students will learn the basic concepts of cellular toxicity and chemical actions on cells and body organs	L2
CO3	Students will learn the importance and diversity of drug interactions with various organs	L3

COURSE CONTENT:	
MODULE 1	**10 Hrs**
INTRODUCTION OF TOXICOLOGY: Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins. Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms. Toxicant proceeding *in vivo*: Absorption, Distribution, Excretion an Metabolism of foreign/toxic compounds.	
MODULE II	**5 Hrs**
ENVIRONMENTAL TOXICOLOGY: Environmental pollution- Sources and types of pollution, Important pollution events, Priority pollutants. Air pollution- Classification and properties of air pollutants, Behaviour and fate of air pollutants, Photochemical smog, Acid Rain, health effects of air pollution. Water pollution- origin of Wastewater, Domestic Water Pollution, Industrial water pollution, Agricultural water pollution, Toxic water pollutants and their health effects, Groundwater pollution, marine pollution	

MODULE III	5 Hrs
INDUSTRIAL TOXICOLOGY: Industrial Chemicals: Government Regulation of Chemicals, Ways of exposure, Toxic effects, Long-term consequences and developmental toxicity. Food Additives and Contaminants types of food additives, Preservatives, Saccharin. Toxicity of trace elements- Iodine, iron, zinc, copper, manganese, selenium, molybdenum, and cobalt Cyto-toxicity of heavy metals- Cadmium, mercury, arsenic, chromium and lead. Brief introduction to toxicity of pesticides and inseciticides.	
MODULE IV	**10 Hrs**
ORGAN TOXICOLOGY: Basics of organ toxicity- Target organs, Organ selectivity and specificity, gender specific diversity of toxins. Hepatotoxicity - Actions of toxins on the liver, Chronic liver injury; Cardiotoxicity - pathology of cardiac toxicity, mechanisms of cardiotoxicity; Respiratory Toxicity - Systematic lung toxins, Lung pathology; Reproductive System – Teratogenicity; Neurotoxicity- Effect of toxic agents on neurons, Ion channel neurotoxins and Nephrotoxicity- susceptibility of kidney to toxic insult, chemically induced renal injury.	

REFERENCES:

1. Whalen, Finkel, and Panavelil. (2015). Pharmacology, 6th ed. (Lippincott Williams & Wilkins).
2. Lieberman and Peet. (2018). Mark’s Basic Medical Biochemistry: A Clinical Approach, 5th ed. (Wolters Kluwer).
3. Hodgson, A. (2010). Textbook of Modern Toxicology, 4th ed. J Wiley & Sons.
4. Smart and Hodgson. (2008). Molecular and Biochemical Toxicology, 4th ed., eds. J Wiley & Sons.
5. Frank and Ottoboni. (2011). The Dose makes the Poison: A Plain-language Guide to Toxicology, 3rd ed. eBook, (J Wiley & Sons).
6. Ottoboni. (1997). The Dose makes the Poison: A Plain-language Guide to Toxicology, 2nd ed., (J Wiley & Sons).
7. A-Z Guide to Drug-Herb-Vitamin Interactions, 2nd ed., Gaby, Batz, Chester and Constantine, eds. (Three Rivers Press: 2006).
8. Gilbert. (2004). A Small Dose of Toxicology: The health effects of common chemicals, (CRC Press.
9. Gibson. (2000). Multiple Chemical Sensitivities: A survival guide, (New Harbinger Publications).
10. Cupp and Karch. (2000). Toxicology and Clinical Pharmacology of Herbal Products, eds. (Springer-Verlag).
11. Lawson. (2000). Staying Well in a Toxic World, (Lynwood Press).

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22MY4701**					
TITLE OF THE COURSE	**FOOD AND DIARY MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To equip the students about the importance of microorganisms in our global society.
- To relate microbes in interdisciplinary connections with other sciences, in particular to productions, food sciences and dairy products
- To exhibit depth of knowledge by demonstrating microbial sciences in the field of applied fields of food and dairy microbiology.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will be acquainted with depth of understanding on fermentation technology, modern microbial techniques and analysis relating to food and dairy microbiology.	L1
CO2	Enable the students to understand the diversity of microbial, structure, function and their environment	L2
CO3	Students will be equipped with fundamental knowledge of microbial growth patterns and kinetic studies enabling them to apply the same in various allied fields.	L3
CO4	It will develop problem solving capabilities in practical working in teams in laboratory/industries based on virtual experiments to gather and evaluate microbial data using a range of current analysis techniques relating to productions, food sciences and dairy products and their waste management.	L4

COURSE CONTENT:

MODULE 1: **15 Hrs**

BASICS OF FOOD MICROBIOLOGY: Scope and Development of Food Microbiology, Food as a substrate for microorganisms. Principles and methods of food preservation by Physical, Chemical and food Additives, Bio-preservation. Microbial spoilage of food: Causes and sources of food spoilage. Food borne Infections and Intoxications. Bacteria – Clostridium. Virus-

HepatitisA, Sea toxicants; Mycotoxins (Aflatoxins, Ochratoxins, and others).

MODULE 2:	15 Hrs

FERMENTED FOODS: Fermented Vegetables, Meat Sausages, Beverages, Bread and Idli. Nutritional and therapeutic importance of Edible mushrooms, Single cell Protein, Probiotics and Symbiotics; Nutraceuticals, Quorn and their industrial production.
Food control Agencies: HACCP, Employees Health standards, GMP. Industrial effluents treatment, Criteria of microbiological quality control.

MODULE 3:	15 Hrs

BASIC OF DAIRY MICROBIOLOGY: Nutritional level and microbial flora of milk. Sterilization of milk; predominant types of microorganisms in chilled and refrigerated milk and their importance; heat resistant bacteria and their role in milk spoilage; principles of quality control tests for milk; bacteriological grading, antimicrobial properties in milk, Microbiology of fermented milk - Starter lactic cultures.

MODULE 4:	15 Hrs

MICROBIOLOGY OF DAIRY PRODUCTS: Production and role of microbes in lactic acid, Cream, butter, ice-cream and indigenous dairy products such as yogurt, acidophilus milk, dahi, kefir, koumiss, Shrikhand, cultured butter milk, cheese, and acidophilus milk. Biosensors in Food Industry: Principle, types and applications; Genetically modified foods; Food fortification.

TEXT BOOKS/REFERNCES:

1. Robert H. (2006). Microbiology and Technology of Fermented Foods. Blackwell Publishers.
2. Matthew Rimmer. (2008). Intellectual Property and Biotechnology: Biological Inventions Edward Elgar. Betty C. Hobbs. Food Microbiology, Arnold-Heinemann Publishing Private Limited, New Delhi.
3. Frazier and Wasthoff. (2008). Food Microbiology, Tata McGraw-Hill Publishing Company Limited, New Delh Frazier, C.W. and Westhoff, C.W. Food Microbiology. 4th Edition, Tata McGraw Hill Education Private Limited, New Delhi.
4. Mary E.T and Richard E. I. (2003). Microbial Food Safety Animal Agriculture: Current Topics, Iowa state University Press.
5. Bibek R. (2001). Fundamentals of Food Microbiology. Bibek Ray. 2nd Edition. CRC press.
6. Adams M.R. and Moss M.O. (2000). Food Microbiology. Royal Publishing Corporation.
7. John G. (1997). Essentials of Food Microbiology. Arnold International Students Edition.
8. Stanbury PF, Whitakar A and Hall SJ. (2013). Principles of Fermentation Technology, 2nd Edition Aditya Books (P) Ltd, New Delhi.
9. Robert Mellor. (2009). Entrepreneurship for Everyone: A student Textbook. SAGE Publication.
10. M.P. Dayle et al. (2001). Food Microbiology: Fundamentals & Frontiers, 2nd edition, ASM press. 8
11. Adams, M.R. and Moss M.O. (1995). Food Microbiology, Royal Society of Chemistry Publication, Cambridge.

12. James M. Jay, Martin J. Loessner, David A. Golden, David Allen Golden (2005). Modern Food Microbiology. Springer.
13. Casida L.E.J.R (2015). Industrial Microbiology, New Age International, New Delhi.

PRACTICALS

1. Production and estimation of lactic acid from microbes.
2. Production and estimation of citric acid from microbes.
3. Determination of quality of raw milk by methylene blue reduction test and SPC method.
4. Immobilization technique: whole cell or enzyme- sodium alginate gel method
5. Isolation and characterization of yeast from food samples.

REFERNCES:

1. K. R. Aneja. (2008). Textbook of Basic and Applied Microbiology. New Age International.
2. Casida L.E.J.R. (2015). Industrial Microbiology, New Age International, New Delhi.
3. Prescott S.C and Dunn C.C. (2005). Industrial Microbiology, 4th Edition CBS Publishers and Distributors, New Delhi.
4. Stanbury PF, Whitakar A and Hall SJ (2013). Principles of Fermentation Technology, 2nd Edition Aditya Books (P) Ltd, New Delhi.
5. McNeil B and Harvey LM. (2008). Fermentation. A Practical Approach, IRL press, New York.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22MY4702**					
TITLE OF THE COURSE	**ENVIRONMENTAL MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	-	-	-	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:

- To equip the students about the importance of microorganisms in our global society.
- To create in-depth knowledge of the distribution of microorganisms in nature, their habitat and interaction with other organisms.
- Helps enable the students to understand the importance of microorganisms in the environment, their role in the biogeochemical cycles and also their applications. The beneficial and harmful microorganisms are studied which helps them to know the impact of microbes in the environment.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students will have fundamental understanding of the distribution and habitat of microorganisms in nature. They can apply the knowledge in studying microbial diversity in various environmental niches.	L1
CO2	Enable the students to understand the diversity of microbial, structure, function and their environment	L2
CO3	Students are aware of the role of microorganisms in the environment. They will have knowledge about both positive and negative aspects of microorganisms and their interaction with other organisms.	L3
CO4	Students can apply knowledge in employing these microbes in various applications like microbial remediation etc. Concept of xenobiotics and their management, Concept of environmental monitoring of air pollution and their management.	L2

COURSE CONTENT:

MODULE 1: SOIL MICROBIOLOGY	**15 Hrs**

Soil morphology; Biotic and abiotic interactions; Habitat and niche; Diversity and distribution (Rhizosphere, Mycorrhizosphere, Actinorhizae); Soil erosion and soil conservation; Microbial interaction in soil; Soil pathogens and soil microflora and human health. Biogeochemical cycles - Carbon cycle, Nitrogen cycle and Sulphur cycle; Hg transformation. Diversity in anoxic eco system.	
MODULE 2: AQUATIC BIOLOGY AND SEWAGE TREATMENT	**15 Hrs**
Aquatic Microbiology: Microbial flora of aquatic environment, Upwelling; Marine microbiology; Hydrothermal vents, Nutrients in aquatic environments; Water pollution and water borne diseases; Eutrophication; Water purification; Water quality assays and public health (SPC, MPN, MFT, ONPG and MUG). Sewage treatment: Primary, Secondary and Tertiary treatment. Solid waste treatment (Landfills and Composting); Biogas production; Methanogens and methylotrophs. Newer approaches to sewage treatment and Enzyme technology for treating Industrial waste water.	
MODULE 3: AEROBIOLOGY	**15 Hrs**
Air microflora in different layers of atmosphere, bioaerosol; Microbiology of indoor and outdoor air; Significance of microorganisms in air; Enumeration of microorganisms in air: Impingement in liquids, Impingement in solids, suction and filtration. Molecular methods of air quality assessment; The Greenhouse effect, Ozone depletion, UV radiation and Acid rain. Aeroallergens and Allergies: Causes and tests for detection of aero allergens.	
MODULE 4: BIOLEACHING AND BIODEGRADATION	**15 Hrs**
Bioleaching: Principles, microorganisms and microbe-mineral interactions. Bioleaching of copper, uranium and gold; Dump, heap and bioreactor operations. Role of acidophilic microorganisms in environmental pollution. Biodegradation: Biodegradation of xenobiotic compounds and Recalcitrant compounds, Mechanism and enzymes involved. Role of plasmids in biodegradation. Biodegradation of cellulose, lignin and plastic. Hazards from xenobiotics. Microbiology of environmental remediation. Bioremediation of soil and water 'in-situ' remediation. Bioremediation of oils, Biosorption; Phytoremediation	

TEXT BOOKS/REFERNCES:

1. Bhatia A.L. (2009). Textbook of Environmental Biology. I.K. International Publishing Housing Ltd. New Delhi.
2. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition, Benjamin/Cummings Science Publishing, USA
3. Francis H Chapelle. (2000). Ground Water Microbiology and Geochemistry. 2nd Edition. ASM press.
4. Barton LL & Northup DE. (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
5. Baker K.H and Herson D.S. (2016). Bioremediation. Mc Graw Hill Inc., New York.
6. Jabir Singh Solid Waste Management. (2010). I. K. International Publishing House Ltd. New Delhi.
7. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
8. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
9. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press.
10. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition,

Springer, New York.
11. Singh A, Kuhad, RC & Ward OP. (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg
12. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.
13. Jogdand. (2006). Environmental Biotechnology, Himalaya Publishing House, 3rd Revised Edition: 9. Robert L Tate, Soil Microbiology,2ndEdition, John Wiley and Sons.
14. Christopher S Cox, Christopher M Wathes. (2020). Bioaerosols Handbook. Lewis Publishers.
15. Grant W.D and Long P.E. (1981). Environmental Microbiology. Kluwer Academic Publisher.
16. Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills. (2007). ASM Press.

PRACTICALS
1. Determination of Total solids and Dissolved Oxygen in water samples.
2. Determination of Biological Oxygen Demand (BOD) in water samples.
3. Determination of Chemical Oxygen Demand (COD) in water samples.
4. MPN test for potability of water.
5. Study of microbial interactions in soil (antagonism).

TEXT BOOKS/REFERNCES:

1. K.R. Aneja (2007). Experiments in Microbiology, Plant Pathology and Biotechnology
2. R.C Dubey, D.K Maheshwari (2002), Practical Microbiology. S Chand and Company, New Delhi.
3. James G. Cappuccino, Natalie Sherman. 2014, Microbiology: a laboratory manual. Pearson Education, Boston [Massachusetts]
4. Pepper, I., Gerba, C. P., Gentry, T., & Maier, R. M. (Eds.). (2011). *Environmental microbiology*. Academic press.
5. Cindy H. Nakatsu, Richard L. Cerniglia, and Ian L. (1962). Manual of Environmental Microbiology by Pepper: A practical guide that provides detailed protocols and methods for studying microorganisms in various environmental samples, including soil, water, and air.
6. Bitton, G. (2014). *Microbiology of drinking water: production and distribution*. John Wiley & Sons.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22MY4703**					
TITLE OF THE COURSE	**MICROBIAL PLANT INTERACTIONS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :
1. The course aims to impart knowledge about the interaction of microorganisms with plants, mainly crop plants. The beneficiary aspects of the microbes by helping the plant growth and also increasing the plant health by avoiding diseases and disorders are studied.
2. The course also deals with the plant diseases caused by microorganisms, where microorganisms play a major role in plant health and yield. Collectively, the course helps students to gain fundamental knowledge of role of microorganisms in agriculture.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	The students will be equipped with knowledge about the importance of microorganisms in agricultural field.	L3
CO2	They can understand how to employ microorganisms to enhance agricultural productivity.	L4
CO3	The knowledge of plant pathology will help students to understand microbial diseases in plants, so they understand disease predictions and the prevention measures.	L2
CO4	They will have knowledge about both positive and negative aspects of microorganisms and their interaction with other organisms.	L1
CO5	The course helps them to apply knowledge in employing microbes in various fields.	L4

COURSE CONTENT:	
MODULE I: PLANT-MICROBE INTERACTIONS	**15 Hrs**
Distribution of microorganisms in soil, soil fertility evaluation and improvement. Role of microorganisms in soil fertility. Decomposition of organic matter by microorganisms: cellulose, hemicellulose, lignin, xylan and pectin. Biological nitrogen fixation: Symbiotic nitrogen fixation, (*Rhizobium, Frankia*), non-symbiotic nitrogen fixation *Azotobacter*, *Azospirillum*). Concepts of siderophores and VAM with suitable examples. Application of nitrogen fixing genes in rDNA technology in agriculture research.	
MODULE II: HOST PATHOGEN INTERACTION AND DEFENSE MECHANISM	**15Hrs**
Host Pathogen Interaction: Infectious diseases, non-infectious diseases, Koch's postulates. Parasitism and pathogenicity, Host range of pathogens, Disease triangle, Diseases cycle/Infection cycle, Relationship between disease cycles and epidemics; Mode of entry into the host plant-mechanical forces, microbial enzymes, toxins and growth regulators.**Defense Mechanisms:** Plant Disease Pre-existing structural and chemical defenses. Induced structural (histological-cork layer, abscission layer, tyloses, gums) and biochemical defenses (hypersensitive response), systemic acquired resistance phytoalexins, pathogenesis related (PR) proteins, PGPR and plantibodies.	
MODULE III: PLANT DISEASES AND THEIR MANAGEMENT	**15Hrs**
Plant diseases- Red rust of tea (Algae), Grain and head smut of Sorghum (Fungi), Root knot of mulberry (Nematode). Papaya ring spot (Virus), Sandal Spike Disease (Mycoplasma), Citrus canker (Bacteria). **Plant disease control:** Classification of plant diseases and plant diseases control. Principles and methods in disease control – Legislative methods (quarantine, crop certification), cultural methods (host eradication, crop rotation, and sanitation), soil and sand treatment (Controlling water flow, adding fertilisers, filtering water.), biological control (Suppressive soil and microbial antagonism) and chemical control (fungicides) Control through resistant varieties andquarantine. Plant disease epidemics and forecasting, plant clinic and plant doctor concept. Diagnosis of plant diseases, regulatory, farming education and awareness.	
MODULE IV: BIOINOCULANTS AND PRODUCTION	**15Hrs**
Biofertilizer - types, production and quality control. Cultivation and mass production of bioinoculants- *Rhizobium, Azotobacter.* Phosphate solubilizing microorganisms. Carrier-based inoculants–production, applications and limitations. Nano formulations. **Biopesticides**: Types and mechanism of application of different varieties. *Pseudomonas fluroscence, Bacillus thuringiensis, Trichoderma harzianum,* Nuclear Polyhedrosis Virus. Production, applications and limitations. Nano formulations.	

REFERENCES

1. Alexander M. (1977). Introduction to Soil Microbiology. Wiley Eastern Limited,New Delhi.

2. Alexopoulas C.J and Mims C.W. (1979). Introductory Mycology. New Age International, New Delhi.
3. Aneja K.R. (2007). Experiments in Microbiology, Plant Pathology, Tissue Cultureand Mushroom Cultivation, New Age International, New Delhi.
4. Agrios, G. (2005). Plant Pathology, Fifth Edition, Elsevier Academic Press.
5. Mehrotra R.S. (2003). Plant Pathology, Tata McGraw Hill Publications Limited,New Delhi.
6. Subbaroa N.S. (2017). Soil Microorganisms and Plant Growth, Oxford and IBHPublishing Company, New Delhi.
7. Bhatia A.L. (2009). Textbook of Environmental Biology. I.K. International Publishing Housing Ltd. New Delhi.
8. Atlas R.M. (2000). Handbook of media for environmental microbiology. CRCpress.
9. Francis H Chapelle. (2000). Ground Water Microbiolgy and Geochemistry. 2ndEdition. ASM press.
10. Baker K.H and Herson D.S. (1994). Bioremediation. McGraw Hill Inc., New York.
11. Indu Shekhar Thakur. (2011). Environmental Microbiology: Basic Concepts andApplications. JNU, New Delhi
12. Singh A and Ward O.P. (2004). Applied Bioremediation, Springer.
13. Singh A, Kuhad R.C. Ward O.P. (2009). Advances in Applied Bioremediation.Springer.
14. K.R. Aneja. (2007). Experiments in Microbiology, Plant Pathology and Biotechnology.
15. R.C Dubey, D.K Maheshwari, S Chand. (2012). Practical Microbiology. New Delhi.
16. Microbiology Laboratory Manual – Cappuccino, Sherman, Pearson Education.
17. Manual of Microbiology Kanika Sharma Ane Books Pvt. Ltd.

PRACTICALS

1. Isolation of symbiotic and non-symbiotic nitrogen fixing microorganisms.
2. Effect of seed borne fungi on seed germination and seed vigor.
3. Estimation of total phenols in diseased and healthy plant tissues.
4. solation of phosphate solubilizing bacteria.
5. Study of microbial interactions in soil (antagonism).

REFERENCES:

1. Nicholl DST. (2002). An Introduction to Genetic Engineering. Cambridge UniversityPress.
2. Sandhya M. (2008). Genetic Engineering: Principles and Practice. MacMillan India.2008.
3. Primrose SB and RM Twyman. (2006). Principles of Gene Manipulation and Genomics,Blackwell Publishing MA. USA.
4. K.R. Aneja. (2007). Experiments in Microbiology, Plant Pathology and Biotechnology
5. R.C Dubey, D.K Maheshwari, S Chand. (2012). Practical Microbiology. New Delhi.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	22BS4701					
TITLE OF THE COURSE	RESEARCH METHODOLOGY					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	45	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
To provide an overview of essential research steps to be followed when conducting research / project work.
To understand chief ingredients to be incorporated in conduct as well as writing of scientific reports/dissertation/thesis
To know the implication professional research ethics and common misconduct details of researcher and research work

COURSE OUTCOME		
CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Show and explain the concepts of meaning ofresearch, scope of research including different types of research, scientific research process and research methodology steps	L1
CO2	Perform review of literature using electronic media, selecting research problem formulate research problem statement, writing hypothesis, explain criteria of forming objectives, materials and methods, results and discussion	L2
CO3	Identify and explain experimental research designs for bothqualitative and quantitative research	L2
CO4	Explain different sampling methods and sampling design, basic statistical methods for treatment of data and observations	L2

CO5	Demonstrate ingredients and components of a research report, dissertation and thesis and explain integral components of research article and research proposal	L2
CO6	Explain professional research ethics and elaborate on misconduct in research	L2

COURSE CONTENT:	
MODULE 1:	**12 hrs**
INTRODUCTION TO RESEARCH: Meaning, Objectives and Characteristics of research – Scientific Method Types of research - Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical - Research process - Criteria of good research **PROBLEM STATEMENT:** Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem; **LITERATURE SURVEY:** Importance of literature review in defining a problem **- S**urvey of literature - Primary and secondary sources - web as a source - searching the web - Identifying gap areas from literature review. **HYPOTHESIS:** Definition of hypothesis**,** Basic concepts, variables-Dependent and independent variables, Development of working hypothesis; Ingredients of Research Objectives, deriving objectives of research.	
MODULE 2:	**12 hrs**
Sampling, Material and Methods: Sample- Sampling - Types of sampling; Material - Experiments, Data – Basics of Analysis; Writing materials and method chapter of a research report **Results and Discussion**: Representation of results; Tables, graphs; Discussion, Purpose and Function of Discussion **Research Designs:** Research design; Need of research design - Basic Principles; Features of good design – Important concepts relating to research design; Max-min-con principle, **Common Research Designs**: Cross-sectional, Case-control, Longitudinal and Cohort research designs, advantages and disadvantages of each of research designs **Summary and Conclusion:** Writing of Summary, conclusions of research findings, Acknowledgement section of a research report and an article.	
MODULE 3:	**10Hrs**
Research Ethics: Values, Ethics and Morals**,** Research Professionalism**,** Tenets of Ethics; Conducting and reporting of science/engineering; Relationship in research groups; Hazards to good scientific practice; Scientific misconduct: Fabrication, Falsification and Plagiarism. **Report and Article Writing:** Structure and components of scientific reports; Abstract-Key words**;** Types of reports; Significance of reporting; Different steps in the preparation of reports; Layout, structure and Language of typical reports; References; Citation styles- APA and MLA styles of citation, intext and end text citations. **Oral Presentation:** Importance of effective communication. Planning; Preparation; Practice; Making presentation; Use of visual aids.	
MODULE 4:	**11Hrs**

Scientific Article Writing: Title preparation – Importance of title; need for specific titles; List of authors and addresses – order of names; defining the order with example; types of abstracts; economy of words; How to write introduction- Rules; exceptions; citations and abbreviations Materials and methods: Purpose; materials; methods; tables and figures; form and grammar; Result and Discussion writing: content of results; handling numbers; clarity; avoiding redundancy; Discussion writing: Components of discussion; factual relationships; strengths and limitations; significance of paper; Stating Acknowledgements: Ingredients of the acknowledgements; courtesy; Citation of the References: Rules; electronics aid; in-text citation;styles of referencing
Research Proposal Fundamentals: What is a grant proposal? Why proposals fail?; Developingand writing of grant proposals; overview of steps to develop grant proposals; Proposal Development Process: Standard Proposal Parts; writing Budget section.
Intellectual Property Rights: IPRs- Invention and Creativity- Intellectual Property-Importanceand Protection of Intellectual Property Rights (IPRs); A brief summary of: Patents, Copyrights,Trademarks

REFERENCES:

1. Bruce Tuckman, Brian E Harper. (2016). Conducting Educational Research, 6th Edition, 2012 by Rowman & Littlefield Publishers, Inc. ISBN 978-1-4422-0965-7 (electronic)
2. Kothari, C.R. (1990). Research Methodology: Methods and Techniques. New Age International. 418p.
3. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K. (2002). An introduction to Research Methodology, RBSA Publishers.
4. Anderson, T. W. (2003). An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., New Delhi
5. Sinha, S.C. and Dhiman, A.K. (2002). Research Methodology, EssEss Publications.2 volumes.
6. Trochim, W.M.K. (2005). Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
7. Day, R.A. (1992). How to Write and Publish a Scientific Paper, Cambridge University Press.
8. Fink, A. (2009). Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
9. Coley, S.M. and Scheinberg, C. A. (1990). Proposal Writing. Sage Publications.

MINOR COURSES OFFERED

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22MY2404**					
TITLE OF THE COURSE	**MICROBIAL FERMENTATION**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To equip the students about the importance of microorganisms in our global society.
• To exhibit depth of knowledge by demonstrating microbial sciences in the field of applied fields of industrial, food and dairy microbiology.
• To relate microbes in interdisciplinary connections with other sciences, in particular to industrial productions, food sciences and dairy products.

COURSE OUTCOMES:

CO No.	OUTCOMES	BLOOM'S TAXONOMY LEVEL
CO1	Students will be acquainted with fundamental aspects of basic fermentation microbiology and techniques	L1
CO2	Enable the students to understand the diversity of microbes to be used in various applications	L2
CO3	Students will be able to understand the importance of microorganisms	L3
CO4	Students will be equipped with fundamental knowledge of microbial fermentation with parameters, productions, applications enabling them to apply in various fields.	L2
CO5	The course will enable the student to apply the knowledge in various aspects of fermentation or industrial microbiology	L2

COURSE CONTENT:

MODULE 1: INTRODUCTION TO INDUSTRIAL MICROBIOLOGY	15Hrs

Screening, isolation of industrially important microbes. Strain improvement- mutation, recombination-gene regulation and genetic manipulation. Preservation of industrially important microbes. Culture collection centers. Basic components and design of typical fermenter. Types of fermenter-Laboratory, pilot- scale and production fermenters; tower fermenter, fluidized bed bioreactors and air-lift fermenter. Types of fermentation - Batch, chemostat, submerged and solid-state fermentation. Different parameters affecting fermentation.

MODULE 2: INDUSTRIAL BIOPROCESSING	15Hrs

Upstream Processing: Nutrients: growth factors, carbon, nitrogen, mineral sources, buffers, inhibitors, precursors, inducers, oxygen requirements, antifoam agents and others. Methods of sterilization; inoculum preparation. Downstream processing: Solid matter, Foam separation, Precipitation, Filtration, Centrifugation, Cell disruption, Liquid extraction, Solvent recovery, chromatography, Membrane processes, Drying, Crystallization. Productions and Applications: Alcohol production, organic acids (citric acid). Vaccines (Hepatitis B), hormones (human insulin), antibiotic (Penicillin). Applications of genetic engineering in industrial bioprocessing.

MODULE 3: FOOD MICROBIOLOGY AND FOOD PRESERVATION	15Hrs

Food as a substrate for microorganisms; Principles and methods of food preservation by Physical, Chemical and food Additives, Bio-preservation. Microbial spoilage of food: Causes and sources of food spoilage. Food borne Infections (E. coli) and Intoxications. Bacteria – Clostridium botulinum. Virus-Hepatitis A, Mycotoxins (Aflatoxins). Fermented foods: Sauerkraut, Beverages, Bread and Idli. Nutritional and therapeutic importance: Single cell Protein, Prebiotics, Probiotics and Synbiotics; Nutraceuticals. Food control Agencies: HACCP, GMP. Industrial effluents treatment (Biological treatment).

MODULE 4: DAIRY MICROBIOLOGY	15Hrs

Nutritional level and microbial flora of milk. Sterilization of milk; predominant types of microorganisms in chilled and refrigerated milk and their importance; heat resistant bacteria and their role in milk spoilage; principles of quality control tests for milk; bacteriological grading. Microbiology of dairy products: yogurt, acidophilus milk, curd, kefir, koumiss, cheese. Biosensors in Food Industry; Food fortification.

TEXT BOOKS/REFERNCES:

1. Casida L.E.J.R. (2015). Industrial Microbiology, New Age International, New Delhi. 37
2. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.
3. Michael J. Waites, Neil Morgan, John S. Rockey, Gray A. Higton. (2001). Industrial Microbiology: An Introduction, Blackwell Science.
4. Robert H. (2006). Microbiology and Technology of Fermented Foods. Blackwell Publishers.
5. Matthew Rimmer. (2008). Intellectual Property and Biotechnology: Biological Inventions Edward Elgar. Betty C. Hobbs, Food Microbiology, Arnold-Heinemann Publishing Private Limited, New Delhi.
6. James M.J. (2005). Modern Food Microbiology. CBS Publishers and Distributers, Delhi.
7. Bibek R. (2001). Fundamentals of Food Microbiology. Bibek Ray. 2nd Edition. CRC press.
8. Adams M.R. and Moss M.O. (2000). Food Microbiology. Royal Publishing Corporation.
9. John G. (1997). Essentials of Food Microbiology. Arnold International Students Edition.

10. Wulf Crueger. (2016). A Textbook of Industrial Microbiology First CBS Publishers and Distributors Edition.
11. Robert Mellor. (2009). Entrepreneurship for Everyone: A student Textbook. SAGE Publication.
12. Frazier and Wasthoff. (2008). Food Microbiology, Tata McGraw-Hill Publishing Company Limited, New Delh Frazier, C.W. and Westhoff, C.W. Food Microbiology. 4th Edition, Tata McGraw Hill Education Private Limited, New Delhi.
13. Mary E.T and Richard E. I. (2003). Microbial Food Safety Animal Agriculture: Current Topics, Iowa state University Press.
14. Bibek R. (2001). Fundamentals of Food Microbiology. Bibek Ray. 2nd Edition. CRC press.
15. Robert Mellor. (2009). Entrepreneurship for Everyone: A student Textbook. SAGE Publication.
16. M.P. Dayle et al. (2001). Food Microbiology: Fundamentals & Frontiers, 2nd edition, ASM press. 8
17. Casida L.E.J.R. (2015). Industrial Microbiology, New Age International, New Delhi.

PRACTICALS

1. Isolation of microorganisms from fruits or vegetables.
2. Production and determination of amylase activity.
3. Preparation of wine.
4. Study of different types of fermenters (Models/ Charts).
5. Cell immobilization techniques (yeast cells).
6. Determination of quality of raw milk by methylene blue reduction test.
7. Estimation of lactic acid from different diary product.
8. Estimation of alcohol by specific gravity method.

REFERNCES:

1. K. R. Aneja. (2008). Textbook of Basic and Applied Microbiology. New Age International.
2. Casida L.E.J.R. (2015). Industrial Microbiology, New Age International, New Delhi.
3. Prescott S.C and Dunn C.C. (2005). Industrial Microbiology, 4th Edition CBS Publishers and Distributors, New Delhi.
4. Stanbury PF, Whitaker A and Hall SJ. (2013). Principles of Fermentation Technology, 2nd Edition Aditya Books (P) Ltd, New Delhi.
5. McNeil B and Harvey LM. (2022). Fermentation. A Practical Approach, IRL press, New York.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22MY3503**					
TITLE OF THE COURSE	**MEDICAL MICROBIOLOGY AND DIAGNOSTICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**		**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
This course provides an overview on the role of microbiome in human health and disease
To introduce basic principles and application relevance of clinical disease for students
The course will provide the conceptual basis for understanding pathogenic microorganisms and particularly address the fundamental mechanisms of their pathogenicity
It will also provide opportunities for a student to develop diagnostic skills in microbiology, including the practical application and interpretation of laboratory tests for the diagnosis of infectious diseases

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Enable the students to understand the normal microbiome and its relevance to human health.	L2
CO2	The course will provide the conceptual basis for understanding pathogenic microorganisms and particularly address the fundamental mechanisms of their pathogenicity.	L3

CO3	Students will acquire and demonstrate competency in laboratory safety and in routine and specialized microbiological laboratory skills applicable to microbiological research or clinical methods, including accurately reporting observations and analysis.	L3

COURSE CONTENT:	
MODULE 1: NORMAL MICROBIAL FLORA	**15Hrs**
Factors determining the nature of the normal flora. Normal flora of skin, respiratory system, nervous system, digestive system and urinary and reproductive systems. Beneficial effects of the normal flora. Attributes of microbial pathogenicity: Pathogenicity, Virulence factors, invasion. Toxins: Exotoxins, Enterotoxins and Endotoxins. Types of infections (non communicable and communicable infections. Nosocomial infection, zoonotic diseases, opportunistic pathogens). Routes of transfer. Factors affecting host susceptibility to disease. Immune response to infection.	
MODULE 2: ANTIBIOTICS AND VACCINES	**15Hrs**
Mode of antimicrobial action – antibacterial, antimycobacterial, antifungal, antiviral, antiprotozoal, anthelminthic. Microbial resistance to antibiotics. Molecular principles of drug targeting; Drug delivery system in gene therapy. Vaccine: Inactivated Attenuated, Conjugated, Recombinant vaccines - synthetic peptide vaccines, Multivalent subunit vaccines, DNA vaccines. Immunization schedule and its significance. Secondary metabolites from microorganisms.	
MODULE 3: IMMUNOLOGICAL TECHNIQUES	**15Hrs**
Production and application of Monoclonal antibodies. Types and Principles of Ag-Ab reactions - Precipitation, Agglutination, Complement fixation and its applications. Immunodiffusion, Immunoelectrophoresis, ELISA, RIA, Immunofluorescence, Western Blotting (Immunoblotting), Flow cytometry and Immunoelectron microscopy.	
MODULE 4: DIAGNOSTICS AND BIOMEDICAL MANAGEMENT	**15Hrs**
Diagnostic Microbiology: Collection, transport and storage guidelines; biosafety in diagnostic laboratory and regulations, specific procedures for collection of specimens, processing of specimens. RT-PCR, RAT (Rapid Antigen Test), TrueNat (TB and Covid-19). Biomedical waste segregation, treatment and management.	

TEXT BOOKS/REFERNCES:

1. Anathnarayana and Panikar. (2013). Text Book of Microbiology, 9th Edition. University press.
2. Richard A, Goldsby, Thomas J, Kindt, Barbara A and Osborne. (2000). Kuby Immunology. 4th Edition. W.H. Freeman and Company, New York.
3. Kuby J. (2006). Immunology 6th Edition. W.H. Freeman and company, New York.
4. Warren Levinson. (2000). Medical Microbiology and Immunology, Examination and Board Review. 8th Edition. McGraw Hill. 5. Tortora, Funke, Case. (2009). Microbiology, 9th Edition. Benjamin Cummings.
5. Connie R Mahon. (2010). Text book of diagnostic Microbiology. 3rd edition, Pearson.
6. Fritz H Kayser. (2005). Medical microbiology. ThiemeVerlag. 8. Mackie and McCarthey Medical Microbiology vol 1, Microbial infection, vol 2, Practical Medical Microbiology,

Churchil Livingstone.
7. Frank and Steven A. (2002). Immunology and evolution of Infectious Diseases. Princeton University Press.
8. Wadher and Bhoosreddy. (2005). Manual of Diagnostic Microbiology. Himalaya Publisher.
9. Kufe. (2003). Cancer Medicine. BC Decker Inc.
10. Leslic Collier, John Oxford. (2000). Human virology a text book for students of medicine, dentistry and microbiology. 2nd edition. Oxford university press.
11. Credric, A Mims. (2004). Medical Microbiology, 3rd Edition. Mohshy Inc.
12. Nester Roberts Pearsall Anderson. (2004). Microbiology- a human perspective, 2nd Edition, McGraw-Hill.

PRACTICALS

1. Isolation and identification of normal microflora on simple, selective and enrichment media (throat, skin and nasal sample). (**3 units)**
2. Dental caries susceptibility assay by Snyder's agar test
3. Determination of effectiveness of antiseptics by thumb impression method.
4. Serological reactions: **(3 UNITS)**
   a) Agglutination - Blood grouping and Rh typing
   b) Precipitation reactions: Radial ImmunoDiffusion,
   (c) Ouchtlerlony Double Diffusion

REFERNCES:

1. Funke, B. R., Tortora, G. J., Case, C. L. (2013). Microbiology: An Introduction. United Kingdom: Pearson.
2. Mackie and McCarthey. (1996). Medical Microbiology vol 1, Microbial infection, vol 2, Practical Medical Microbiology, Churchil Livingstone.
3. Frank and Steven A. (2002). Immunology and evolution of Infectious Diseases. Princeton University Press.
4. Wadher and Bhoosreddy. (2005). Manual of Diagnostic Microbiology. Himalaya Publisher.
5. Credric, A Mims. (2004). Medical Microbiology, 3rd Edition. Mohshy Inc.
6. James G. Cappuccino, Natalie Sherman (2014) Microbiology: A Laboratory Manual. Pearson.
7. Leslic Collier, John Oxford. (2000). Human virology a text book for students of medicine, dentistry and microbiology. 2nd Edition. Oxford university press.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22MY3603**					
TITLE OF THE COURSE	**MICROBIOME AND EXTREMOPHILES**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To To equip the students with the basics of Metagenomics.
• The course will provide the conceptual basis of ubiquity of microbes in extreme environment
• To enable the students to understand the commercial relevance of extremophiles

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Enable the students to describe the primitive life form and adaptation of microbes to it	L2
CO2	The course will help the students to describe distribution, classification of Extremophiles	L3
CO3	Techniques and approaches in the exploration of uncultured microbial majority and Microbiome Biology	L1
CO4	Applications can be variedly used by students in different fields.	L2

COURSE CONTENT:	
MODULE 1: MICROBIOME AND ITS APPROACHES	**15 Hrs**

Microbiome: History of microbiome perspective, environmental genomics-microbiomes of oceans and terrestrial ecosystems, Microbiome ecology, Microbiome evolution. Earth Microbiome project. Approaches in Micobiome analysis, Metagenomics (open and closed formats), Meta-transcriptomics, Pan-genomics, Epigenomics, Microfluidics technology in human microbiome, single cell genomics. Metagenomics of archealogical samples, Sargasso Sea project. Advance culturing techniques to study microbiomes.	
MODULE 2: HUMAN MICROBIOME AND DISEASE BIOLOGY	**15 Hrs**
Human microbiome: biodiversity and major genera of human-microbiome, human- microbiome system as a "holobiont" or "superorganism. Microbiome distributions in healthy individuals; composition of specific body sites ‘microbiome: nose, skin, oral, urogenital, etc. Fecal transplants. Designer probiotics, Symbiosis- Dysbiosis -Rebiosis. Personnel microbiome concepts. Microbiome and disease biology: gut-brain conversation, obesity and gut microbiome, infectious diseases and gut microbiome, non-infectious diseases and gut microbiome, microbiome’s role in diseases -Inflammatory bowel disease (IBD), obesity. Effects of diet on microbiome.	
MODULE 3: EXTREMOPHILES	**15 Hrs**
Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, radiation & low nutrient levels; life on other planets. Difference between bacteria, archaea and eukaryotes. Classification and salient features of each Archaean group. Genetic and Metabolic diversity of extremophiles.	
MODULE 4: ADAPTATIONS AND APPLICATIONS OF EXTREMOPHILES	**15 Hrs**
Microbial diversity and its application in modern science. THERMOPHILES and PSYCHROPHILES: Basic concept, classification, adaptations and significance. ALKALIPHILES and ACIDOPHILES: Basic concept, classification, adaptations and significance. PIEZOPHILES/ BAROPHILES: Basic concept, classification, adaptations and significance. XEROPHILES AND RADIATION resistant microbes and applications.	

TEXTBOOKS/ REFERNCES:

1. David N. Fredricks and David A. Relman (2012). "The Human Microbiota: How Microbial Communities Affect Health and Disease" Wiley-Blackwell
2. Lesley Hoyles, Harry J. Flint, and Elaine E. Vaughan (2018). "The Gut Microbiome: An Introduction" John Wiley & Sons
3. Lisa A. Murdock and Nicholas P. Money. (2017). The Microbiome Handbook: Current Research and Applications. CRC Press.
4. Robynne Chutkan. (2015). The Microbiome Solution: A Radical New Way to Heal Your Body from the Inside Out. Avery.
5. Rob DeSalle and Susan L. Perkins. (2015). Welcome to the microbiome. getting to know the trillions of bacteria and other microbes in, on, and around you. Yale University Press.
6. Horikoshi, K., Antranikian, G., Bull, A. T., Robb, F.T.., Stetter, K.O. (2011). Extremophiles Handbook, Springer Publications.
7. Horikoshi, K., Grant W. (1998). Extremophiles: Microbial Life in Extreme Environments. Wiley Publications.
8. Ramplelotto, Paulo H. (2016). Biotechnology of Extremophiles: Advances ad Challenges. Springer Publicationns.

9. Angela E. Douglas (2018). Fundamentals of Microbiome Science – how microbes shape animal biology, Princeton University Press, New Jersey, United States.

PRACTICALS

1. Retrieval of Metagenome data such as ribosomal RNA and whole genome shotgun from biological databases.
2. Bioinformatics tools and softwares used in the analysis of metagenomic data.
3. Taxonomic and Functional annotation of metagenomic data.
4. Studies on halophiles isolated from high salt habitat. (Study its pigmentation and salt tolerance phenomenon).
5. Studies on alkalophiles and its enzymes (any one) isolated form extreme alkaline environment.

REFERENCES:

1. Catherine A. Lozupone and Dan Knights. (2010). Introduction to the Human Microbiome Publisher Name: Wiley-Blackwell.
2. Jacques Ravel and Zamin Iqbal. (2017). Microbiome Analysis: Methods and Protocols Publisher Name: Humana Press.
3. Rob Knight, Jeffrey I. Gordon, and Jeffrey I. Gordon (2011). Microbes and Health Sackler Colloquium: The Human Microbiomes. National Academies Press
4. Camilla L. Nesbø, Roy M. Daniel, and Karl O. Stetter. (2008). "Methods in Microbiology, Volume 37: Extremophiles" Academic Press.
5. Aharon Oren and Friedhelm Meinhardt. (2012). "Methods in Microbiology, Volume 41: Extremophiles Handbook" Academic Press.
6. Yanhe Ma, R. Thane Papke, and Qiang He. (2020). "Methods in Microbiology, Volume 47: Extremophiles" Academic Press.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22CY2401**					
TITLE OF THE COURSE	**INORGANIC CHEMISTRY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

COURSE OBJECTIVES:
• To introduce the specialized subject of the chemistry of polymers
• To understand in detail the mechanisms of the reactions that lead to the formation of polymers.
• To familiarize the students with the types of polymers, the significance of their molecular mass.

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Will be able to demonstrate the composition and structure of polymers	L1
CO2	Should be able to correlate the structure of polymers to their properties and application	L2
CO3	Should be able to demonstrate the significance of polymer molecular mass.	L3

COURSE CONTENT:

MODULE 1	**15 Hrs**

Noble gases
Introduction, isolation of Helium from Natural gas, applications of Noble gases. Preparation properties and structures of fluorides and oxides of Xenon (XeF2, XeF4, XeF6, XeO3, XeO4).

Transition elements: electronic configuration, atomic and ionic radii, ionisation energy, oxidation states, redox potentials, spectral and magnetic properties, catalytic activity, interstitial compound formation.
Lanthanoids and Actinoids

Electronic Configuration, Oxidation States, Spectral and Magnetic Properties, Lanthanide Contraction, Separation of Lanthanides

MODULE 2	**15 Hrs**

Compounds of some Nonmetals.
i) Boron and its compounds: Synthesis, structure and applications of Diborane, Borazole and Boron trifluride.
ii) Halogens and its Compounds: Bleaching powder: manufacture and its applications.

Silicates : Structure of SiO4 4- , Classification of silicates based on the structure. Zeolites: their structure and applications.

Inorganic Polymers: Types of Inorganic Polymers, Comparison with Organic Polymers Synthesis Structural Aspects of Silicones and Siloxanes Applications of Silicones and Siloxanes, Borazines, Silicates, Polysulphates and Phosphazenes

MODULE 3	**15 Hrs**

Bioinorganic Chemistry: Metal Ions Present in Biological Systems, Geochemical Effect on the Distribution of Metals Sodium / K-Pump, Carbonic Anhydrase and Carboxypeptidase, Excess and Deficiency of Some Trace Metals, Toxicity of Metal Ions, Use of Chelating Agents in Medicine, Iron and Its Application in Bio-Systems, Haemoglobin, Storage and Transfer of Iron Chemical Toxicology: Toxic chemicals in the environment – effects of toxic chemicals – cyanide and its toxic effects – pesticides and its biochemical effects – toxicity of lead, mercury, arsenic and cadmium.	
MODULE 4	**15 Hrs**
Hard and soft acid and base (HSAB): Introduction, Classification of acids and bases as hard and soft, Pearson's HSAB concept: acid base strength, hardness and softness, Symbiosis, Theoretical basis of hardness and softness Organometallic compounds: Preparation and synthetic applications of Grignard reagents, Organolithium compounds and lithium dialkylcuprates. Fertilizers: Introduction (need of fertilizers), functions of essential plant nutrients (N,P,K), Classification of fertilizers with examples. Nitrogeneous, Phosphatic and mixed fertilizers with suitable examples. Manufacture of urea and Super phosphate of lime, and their uses. Fertilizer industries in India.	
TEXT BOOKS/REFERANCES: 1. A New Concise Inorganic Chemistry", J. D. Lee, 5th Ed, Chapman & Hall, London (1996). 2. Principles of Inorganic Chemistry B. R. Puri and L. R. Sharma, Jauhar S. P-S. N. Chand & Co., 1998 3. Inorganic Chemistry, ELBS 2nd Edition D. F. Shriver, P. W. Atkins and C. H. Langford, Oxford Univ. Press 2002. 4. Inorganic Chemistry, 4th Edition J. E. Huhee, E. A. Keiter and R. I. Keiter, Pearson Education Asia, 2000 5. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition,1993 prentice Hall, Inc. New Delhi.	

EXPERIMENT
1. Systematic semi-micro qualitative analysis of a mixture of two simple salts (At least seven mixtures of salts with no interfering radicals).
2. Separation of metal ions (Cu 2+, Co2+, Ni 2+, Fe 2+) using paper chromatography andcalculation of Rf values.
3. Separation of Mg (II) and Fe (II) by solvent extraction technique.
TEXT BOOKS/REFERANCES: 1. Vogel's Text Book of Practical Organic Chemistry, 5 th Edition, A.J. Hannford, A.R. Tatchell, B.S. Hurnis, P.W.G. Smith, Pearson Publication. 2. Chemistry Practical Inorganic Qualitaive Analysis For Under Graduate Students, M.J. Mamtora, S.C. Karad, J.S. Makasana, Lap Lambert Academic Publishing. 3. Enhancing undergraduate chemistry laboratories, J. Carndoff, N. Reid, RS. C. Publication.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**22CY2402**					
TITLE OF THE COURSE	**PHYSICAL CHEMISTRY - I**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4		**4**		**60**	**5**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Students should gain a deep understanding of the basic concepts of thermodynamics, including the laws of thermodynamics, internal energy, heat, work, entropy, and the different thermodynamic functions.
• Through a variety of exercises and real-world examples, students should develop strong problem-solving skills related to thermodynamics in chemistry, enabling them to tackle complex thermodynamic problems.
• Students should be able to apply kinetic theories and concepts to analyse and predict the behaviour of chemical reactions, including reaction mechanisms, reaction order, and the effects of temperature, concentration, and catalysts on reaction rates.
• Students should be able to identify and understand the relevance of chemical kinetics in various real-world applications, such as industrial processes, environmental chemistry, and pharmaceutical research.
• Students should be able to understanding of ionic equilibria in aqueous solutions and their role in chemical reactions.
• To make students understand the principles of surface chemistry and its relevance in various chemical and material systems.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students should be able to articulate and explain the laws of thermodynamics, including the first, second, and third laws, and understand their significance in the context of energy and chemical systems.	L1
CO2	Students should be proficient in performing calculations involving thermodynamic quantities, such as heat transfer, work done, changes in internal energy, entropy changes, and Gibbs free energy changes.	L2
CO3	Students should be able to apply kinetic theories and concepts to analyze and predict the behavior of chemical reactions, including reaction mechanisms, reaction order, and the effects of temperature, concentration, and catalysts on reaction rates.	L3

CO4	Students should be able to identify and understand the relevance of chemical kinetics in various real-world applications, such as industrial processes, environmental chemistry, and pharmaceutical research.	L2
CO5	Students should be able to apply the principles of ionic equilibria to predict the behavior of weak acids and bases in aqueous solutions, including calculating pH, determining the relative strengths of acids and bases, and identifying the dominant species present at different pHlevels. They should be able to predict the direction of these equilibria and calculate equilibrium constants under different conditions.	L1
CO6	Students should be able to explain the fundamental principles underlying surface chemistry, including surface tension, adsorption, catalysis, and the behavior of colloids. They should be able to apply these principles to analyze and interpret surface-related phenomena in different chemical and material systems.	L2

COURSE CONTENT:	
MODULE 1	**15Hrs**
Thermodynamics I Exact and inexact differentials. Review of terms, I law of Thermodynamics. Work done (derivation with problems) in isothermal and adiabatic expansion and compression of an ideal gas (IUPAC sign conventions to be used). Heat capacity of a gas at constant pressure and constant volume: relation between P, V and T in an adiabatic process to be derived. Derivation of Kirchoff's equation. Numerical problems. Spontaneous and non-spontaneous processes. *Second law of thermodynamics*: Limitations of I law of thermodynamics with illustrations. Need forII law of thermodynamics, different ways of stating II law with respect to heat and spontaneity. Other forms of II law of thermodynamics. Concept of entropy and its physical significance-illustrations with order, disorder, physical and chemical processes and probability.	
MODULE 2	**15Hrs**
Thermodynamics II *Heat engine*-Carnot's cycle and derivation of the expression for its efficiency. Problems based on efficiency equation. II law in terms of efficiency (η). Change in entropy in reversible and irreversible processes (derivations required) . Calculation of entropy changes in reversible isothermal and reversible adiabatic processes. Phase transitions in terms of Entropy (Fusion, vaporization, sublimation and polymorphic changes) in terms of entropy. Limitations of the entropy concept of spontaneity. Problem on Phase transitions **Gibb's free energy:** Work function, chemical potential. Definition and relationship between free energy and work function. Criteria for equilibrium and spontaneous processes. Gibb's-Helmholtz equation-Derivation. Change of free energy with respect to temperature and pressure. Mention of temperature coefficient, van't Hoff isotherm (derivations included), $\Delta G° = -RT\ lnK_p$. Problems. Derivation of van't Hoff reaction isochore and Clausius-Clapeyron equation. Its applications to ΔT_b and ΔT_f determination (thermodynamic derivation not required). Qualitative treatment of Nernst heat theorem and III law of thermodynamics-statement only. Elementary concept of residual entropy.	
MODULE 3	**15Hrs**
Chemical Kinetics Review of terms –Rate, Order and Molecularity, Derivation of expression for the rate constant of a second order reaction with $a = b$ and $a \neq b$. Expression for half-life of a second order reaction. Mean life for first order reaction to be mentioned. Problems on rate constant, half-life period, mean life period and order of reaction.	

Determination of order of reaction: differential method, method of integration, method of halflife period and isolation method. **Theories of reaction rates:** Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Problems. Simple collisions theory based on hard sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects. Steady state approximation and Lindemann's hypothesis. Experimental determination of kinetics of: (i) inversion of cane sugar by polarimetric method, (ii) spectrophotometric method for the reaction between potassium persulphate and potassium iodide.	
MODULE 4	**15Hrs**
Ionic equilibria Hydrolysis of salts of weak acids and weak bases.Ionic product of water. Relationship between K_h, K_w, K_a and K_b. Degree of hydrolysis and its relationship with K_h. Effect of temperature and dilution on degree of hydrolysis. pH of salt solutions. Problems. Common-ion effect, buffers, buffer action and buffer capacity. pH of buffers. Henderson's equation and its derivation. Solubility product and ionic product in precipitation and in qualitative analysis. Analytical and biological applications of buffers. Theories of indicators. **Surface chemistry** *Review of surface phenomena*. Theories of adsorption . Adsorption isotherms and BET equation (derivation included), Adsorption indicators. Surface film on liquids. Catalysis –Types and theories ((intermediate compound theory and adsorption theory). Heterogeneous catalysis: surface reactions, unimolecular, bi-molecular surface reactions. pH dependence of rate constant of catalysed reactions. Autocatalysis.	

TEXT BOOKS/REFERANCES:

1. Physical Chemistry, 7th Edition P. W. Atkins and Julio de Paula, Oxford Univ. Press, 2002.
2. The Elements of Physical Chemistry, 3rd Edition Peter Atkins, Oxford Univ. Press, 2000.
3. Physical Chemistry – A molecular Approach Donal A. Mcquarrie and John D. Simon, Viva Low-priced Student Edition, 2001.
4. Introduction to Physical Chemistry, 3rd Edition Mark Ladd, Cambridge Low-Priced Edition, 1999.
5. Text Book of Physical Chemistry S. Glasstone, MacMillan India Ltd., 1998.
6. Principles of Physical Chemistry, 4th Edition B. R. Puri and L. R. Sharma and M. S. Pathania, S. L. N. Chand & Co., 1987
7. Text Book of Physical Chemistry P. L. Soni., S. Chand & Co., 1993.
8. Physical Chemistry Alberty R. A. and Silbey R. J. John Wiley & Sons, 1992.
9. Physical Chemistry G. M. Barrow, McGraw Hill, 1986.
10. Physical Chemistry, 3rd Edition Gibert W. Castellan, Narora Publishing House, 1985.

EXPERIMENTS
1. Determination of velocity constant for acid catalysed hydrolysis of methyl acetate and determination of energy of activation.
2. To determine the heat capacity of a solid and to study heat exchange in chemical reactions.
3. The study of kinetics of potassium persulphate and potassium iodide.
4. To determine the enthalpy change when a solute dissolved in a solvent.
5. Determination of pKa of a weak acid by pH metric method.
6. Effect of surfactants on the surface tension of water (Stock solution to be given).

TEXT BOOKS/ REFERENCES

1. Vogel's Text Book of Practical Organic Chemistry, 5th Edition, A.J. Hannford, A.R.Tatchell, B.S. Hurnis, P.W.G. Smith, Pearson Publication.
2. Enhancing undergraduate chemistry laboratories, J. Carndoff, N. Reid, RS. C.Publication.
3. Advanced Practical Chemistry, K. Chelladurai, K. Subbian, Lap Lambert Academic Publishing.
4. Experiments in Physical Chemistry 8th edition, Carl W. Garland, Joseph W. Nibler, and David P. Shoemaker, McGraw-Hill Education.

SEMESTER			**IV**			
YEAR			**II**			
COURSE CODE			**22CY2403**			
TITLE OF THE COURSE			**PHARMACEUTICAL CHEMISTRY**			
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Understand the fundamental principles of medicinal chemistry and drug design.
• Explore the mechanisms of drug action and interaction with biological targets.
• Examine the pharmaceutical development process, including formulation and quality assurance.
• Discuss the regulatory aspects and ethical considerations in pharmaceutical research and development.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students should be able to explain how the chemical structure of a drug affects its biological activity, selectivity, and pharmacokinetic properties.	L1
CO2	Students should be able to describe the molecular mechanisms by which drugs interact with receptors, enzymes, ion channels, and other biological targets. They should be able to explain the concepts of agonists, antagonists, and allosteric modulators in the context of drug action.	L2
CO3	Students should be familiar with the principles of pharmaceutical dosage form design, including factors that influence drug solubility, stability, and bioavailability. They should be able to discuss the various types of dosage forms and the rationale behind their selection.	L3
CO4	Students should have an understanding of the regulatory requirements for drug development, including preclinical testing, clinical trials, and post-marketing surveillance. They should be aware of the ethical considerations involved in conducting pharmaceutical research, including patient safety, informed consent, and compliance with regulatory guidelines.	L2

COURSE CONTENT:	
MODULE 1	**10Hrs**
Introduction to historical development of pharmaceutical chemistry, Common diseases Infective diseases - insect-borne, air-borne and water-borne – hereditary diseases. Terminology Drug, pharmacology, pharmacognosy, pharmacodynamics, pharmacokinetics, anti-metabolites. Absorption of drugs - routes of administration of drugs, factors affecting absorption.	
MODULE 2	**10Hrs**
Designation of drugs based on physiological action; Definition and two examples with structure each of: Anesthetics-General and local. Analgesics - Narcotic and synthetic. Antipyretics and anti-inflammatory agents. Antibiotics - penicillin, streptomycin, chloramphenicol, tetracyclins. Antivirals. AIDS - symptoms, prevention, treatment. Cancer and neoplastic agents.	
MODULE 3	**10Hrs**
Health promotingmedicines-I: Nutracenticals-Vitamins A B C D E and K (structure expected) micronutrients such as Na K Ca Cu Zn I -Medicinally important inorganic compounds of Al, P, As, Hg, Fe – Organic Pharmaceutical acids. Health promoting medicines-II: Agents for kidney function (Aminohippuric acid); Agents for liver function (Sulfobromophthalein); Agents for pituitary function (metyrapone)	

TEXT BOOKS/REFERENCE BOOKS

1. Jayashree Ghosh, Pharmaceutical chemistry, S.Chand and Company Ltd., 2006, New Delhi.
2. Lakshmi S., Pharmaceutical chemistry, S. Chand & Sons, 1995, New Delhi.
3. Ashutosh Kar, Medicinal chemistry, Wiley Eastern Ltd., 1993, New Delhi.
4. David William & Thomas Lemke, Foyes principles of medicinal chemistry, 5th editon 2005, BI Publishers.

SEMESTER	**IV**
YEAR	**II**
COURSE CODE	**22BS2401**
TITLE OF THE COURSE	**BIOSAFETY AND GOOD LABORATORY PRACTICE**

SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	**Sem/Year**	**Course Code**	**Title of the Course**
-	-	-	-

COURSE OBJECTIVES:

- To introduce the students to the concepts of biosafety regulatory frameworks concerning genetically modified organisms at national and international levels.
- To impart knowledge of the principles of GLP and their practical applications.

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Gain knowledge of the various safety procedures to be followed in laboratory.	L2
CO2	Gain the skills and knowledge necessary to understand and work in GLP compliant environment.	L2
CO3	This course should generate interest for avenues for pursuing higher studies and careers in these areas	L2

MODULE I – BIOSAFETY	**18 Hrs**

Introduction, Historical Background; risk assessment and lab acquired infections, Introduction to Biological Safety Cabinets& their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms. Recommended Biosafety Levels for Infectious Agents and Infected Animals. Biosafety Guidelines: Biosafety guidelines and regulations (National and International); Definition of GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture;Recombinant DNA Guidelines (1990); Rules forthe manufacture, use/import/export and storage of hazardous microorganisms/ genetically engineeredorganisms or cells (Ministry of Environment and Forests Notification,1989); Environmental release of GMOs; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.

MODULE II – GOOD LABORATORY PRACTICE	**12 Hrs**

Introduction to GLP, WHO guidelines on GLP, History, Scope (Resources Characterization, Rules, Results, Quality assurance);Levels of Laboratories; General Rules/Protocols for Lab Safety measures; Precaution and Safety in handling of chemicals, Laboratory tools, glasswares and instruments;Sample

storage and disposal; Log Book maintenance, Basic SOPs for instrument handling and Maintenance. Keeping data records, its analysis by using statistical and mathematical tools. Result analysis and its interpretation.GLP as given by OECD, FDA etc (International perspective); Internal and External Audits.

REFERENCES:

- Handbook Good Laboratory Practices-World health organization(WHO)
- Life science protocol manual (2018)-DBT star college scheme
- Guidelines for good laboratory practices-Indian council of medical research, NewDelhi (2008).
- Handbook: Good Laboratory Practices (GLP): quality practices for regulated non-clinical research and development-2nd ed.

SEMESTER			**V**			
YEAR			**III**			
COURSE CODE			**22CY3501**			
TITLE OF THE COURSE			**ORGANIC CHEMISTRY - I**			
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4		**4**	-	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Master the fundamental principles of organic reaction mechanisms.
• Understand the relationship between molecular structure and reactivity in organic compounds.
• Explore the application of organic chemistry concepts in real-world contexts.
• Develop problem-solving skills and laboratory techniques in organic chemistry.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students should be able to explain the mechanisms of various organic reactions, understand electron flow in chemical reactions (e.g., nucleophilic and electrophilic reactions), and predict the products of typical organic transformations. They should be familiar with key reaction intermediates and reaction pathways.	L1
CO2	Students should be able to relate the structure of organic compounds to their chemical reactivity, acidity, basicity, and physical properties such as solubility and boiling points. They should be able to identify factors that influence the reactivity of organic molecules.	L2
CO3	Students should understand the role of organic chemistry in various fields, including pharmaceuticals, agrochemicals, materials science, biochemistry, and environmental chemistry. They should be able to appreciate how organic chemistry impacts everyday life.	L3
CO4	Students should be proficient in solving a range of organic chemistry problems, including synthesis challenges, retrosynthetic analysis, and spectroscopic identification of organic compounds. They should also be comfortable with common laboratory techniques used in organic chemistry, including synthesis, purification, and analysis of organic molecules.	L2

COURSE CONTENT:	
MODULE 1	**15Hrs**

Aliphatic Hydrocarbons

Alkanes: Sources, Nomenclature of branched chain alkanes, preparation of symmetrical and unsymmetrical alkanes- Corey- House reaction and Wurtz reaction - their merits and demerits. Conformational analysis of n-butane - Sawhorse and Newman projection formulae to be used- Energy profile diagram.

Cycloalkanes: Nomenclature. Method of formation. Explanation for stability based on heat of hydrogenation data, Baeyer's strain theory and its limitation, Sachse - Mohr theory of strain-less rings; cyclopropane ring - banana bonds.

Alkenes: Preparation of alkenes by Wittig reaction-stereoselectivity. Addition of HX to unsymmetrical alkene - Markownikov's rule and Antimarkownikov's rule with mechanism. Reactions: Hydroboration- oxidation, reduction, oxymercuration - demercuration, epoxidation. Mechanism of oxidation with $KMnO_4$ and OsO_4.Ozonolysis- mechanism and importance.

Dienes: Classification- isolated, conjugated, cumulated. Structure of allene and butadiene.1,2addition and 1,4 addition reactions. Diels Alder reaction-1,3-butadiene with maleic anhydride.

Alkynes: Methods of preparation - Dehydrohalogenation of vicinal and geminal dihalides; and higher alkynes from terminal alkynes. Reactions - metal ammonia reduction–significance. Oxidationwith $KMnO_4$, acidic nature of terminal alkynes.

MODULE 2	**15Hrs**

Organic halogen compounds

Aromatic nucleophilic substitution *via* benzyne intermediate, mechanism with evidences for the formation of benzyne by trapping with anthracene, Birch reduction.Side chain oxidation of tolueneto benzaldehyde and benzoic acid. Oxidation of naphthalene, anthracene and phenanthrene. Diels- Alder reaction of anthracene with 1,2-dichloroethene. Alkenyl benzenes: Styrene, *cis*- and *trans*- stilbenes and their preparations. Biphenyl: Preparation-Ullmann reaction.

Alkyl halides: Nomenclature. Nucleophilic substitution reactions - S_N1 andS_N2 mechanisms with energy profile diagrams. Effect of (i) nature of alkyl groups,(ii) nature of leaving groups, (iii) nucleophiles and (iv) solvents on S_N1 and S_N2 mechanisms. Elimination reactions - E1 and E2 mechanisms; Hofmann and Saytzeff eliminations with mechanism. Aryl halides: Preparation by halogenation. Relative reactivity of alkyl, allyl, vinyl, aryl and aralkyl halides towards nucleophilic substitution.

MODULE 3	**15Hrs**

Alcohols and Thiols

Alcohols: Introduction and classification. Methods of preparation - (i) From carbonyl compounds - reduction of aldehydes and ketones (by Meerwein-Pondorff-Verley reaction); (ii) from acids and esters (by reduction with $LiAlH_4$); (iii) From alkenes (by hydroborationoxidation
with alkaline peroxide); (iv) hydration of alkenes. Reactions of alcohols: Acidic nature, esterification, oxidation of alcohols with $KMnO_4$. Comparison of the reactivity of 1°, 2° and 3° alcohols- Lucas test, oxidation with $K_2Cr_2O_7$.

Glycols: Preparation from alkenes using OsO_4, $KMnO_4$ and from epoxides. Oxidation of glycols by periodic acid and lead tetraacetate with mechanisms. Pinacol-pinacolone rearrangement.

Glycerol: Preparation from propene and from oils/fats. Uses. Reactions of glycerol: (i) nitration, (ii) action of concentrated H_2SO_4 and (iii) oxidation by periodic acid.

Thiols: Nomenclature. Methods of formation and chemical reactions (with sodium, NaOH, metal oxides, formation of thioesters and oxidation with mild and strong oxidizing agents). Uses of dithianes. Introduction of umpolung character (reversal of polarity) in carbonyl compounds.

MODULE 4	15Hrs

Phenols, Ethers, Epoxides and Organometallic compounds

Classification. Acidic nature - Comparison of acidic strength of phenol with alcohols and monocarboxylic acids. Effect of electron withdrawing –NO_2 group and electron donating –CH_3 group on acidity of phenols at *o*-,*m*-,*p*- positions. Pechmann reaction, Mechanisms of Reimer- Tiemann and Kolbe-Schmidt reactions. Industrial applications of phenols: Conversion of phenol to
(i) aspirin, (ii) methyl salicylate, (iii) salol, (iv) salicyl salicylic acid.

Ethers: Methods of preparation – (i) dehydration of alcohols, (ii) Williamson's ether synthesis. Reactions – Ethers as Lewis bases (complexation with metal ions), cleavage and auto-oxidation. Ziesel's method.

Epoxides: Preparation using per acids, Darzen's reaction. Reactions of mono and 1,2- disubstituted epoxides with (i) carbon nucleophiles, (ii) nitrogen nucleophiles, (iii) reduction with $LiAlH_4$. Preparation and synthetic applications of Grignard reagents, Organolithium compounds and lithium dialkylcuprates.

List of Laboratory/Practical Experiments to be conducted:
1. Recrystallisation and determination of melting point of solids (mixed melting point determination and its importance may be mentioned).
2. Simple distillation and determination of boiling point of liquids.
3. Purification of solids by sublimation.
4. Preparation of aspirin from salicylic acid.
5. Preparation of dibenzalacetone from benzaldehyde (using acetone-alcoholic sodium 6. hydroxide).
7. Preparation of paracetamol from p-aminophenol.

TEXT BOOKS/REFERENCE BOOKS

1. Vogels Textbook Of Practical Organic Chemistry 5Th Edition, FURNISS and BRIAN S and HANNAFORD and ANTONY J, PEARSON INDIA.
2. Microscale Organic Laboratory: With Multistep and Multiscale Syntheses" by Dana W. Mayo, Ronald M. Pike, and David C. Forbes, J. Wiley & Sons.
3. Experimental Organic Chemistry: A Miniscale and Microscale Approach" by John C. Gilbert and Stephen F. Martin, Cengage Learning Publisher.
4. A Small Scale Approach to Organic Laboratory Techniques" 3rd edition, Donald L. Pavia, George S. Kriz, and Gary M. Lampman, Cengage Learning Publisher.

SEMESTER			**V**			
YEAR			**III**			
COURSE CODE			**22CY3502**			
TITLE OF THE COURSE			**PHYSICAL CHEMISTRY - II**			
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	4	-	**4**	-	**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Understand the fundamental principles of electrochemistry and its applications in chemical systems. Learn the principles of electrode processes and kinetics.
• Develop practical and problem-solving skills in electrochemical measurements and data analysis.
• Develop a deep understanding of the principles and applications of phase equilibria in chemical systems.
• Develop a comprehensive understanding of the structure, properties, and behavior of solid materials.
• Develop a thorough understanding of the principles of nuclear chemistry and its applications in various scientific and industrial contexts.
• Develop a comprehensive understanding of the properties, behavior, and applications of colloidal systems in chemistry.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students should be able to describe the components of electrochemical cells, understand the role of electrodes and electrolytes, and explain how redox reactions occur at the electrode surfaces.	L1
CO2	Students should be proficient in conducting electrochemical measurements, such as cyclic voltammetry, potentiostatic/galvanostatic experiments, and impedance spectroscopy. They should be able to analyze experimental data and interpret electrochemical results.	L2
CO3	Students should be proficient in applying the principles of phase equilibria to analyze and predict the behavior of multiple-phase systems, including vapor-liquid, liquid-liquid, and solid-liquid equilibria. They should be able to explain the factors that influence phase transitions, such as temperature, pressure, and composition.	L3

CO4	Students should be proficient in analyzing crystal structures of various solid materials, including simple and complex crystal lattices, and understand the relationship between crystal structures and material properties.	L2
CO5	Students should be proficient in understanding and analyzing nuclear reactions, including radioactive decay, nuclear stability, nuclear fission, and nuclear fusion, as well as the concepts of half-life, decay constant, and radioactivity.	L3
CO6	Students should be proficient in understanding the unique properties and behavior of colloids, including stability, surface phenomena, Brownian motion, Tyndall effect, and coagulation/precipitation processes.	L1

COURSE CONTENT:	
MODULE 1	**15Hrs**
Electrochemistry I Review of electrolytes and Conductance related terms, Methods of determination of molar conductance. Conductometric titrations (only acid-base type). Transport numbers: definition – determination by moving boundary method. Causes of abnormal transport numbers observed in certain systems. Ionic mobility. Problems on transport numbers. Conductivity of water. Kohlrausch's law and its applications: (i) evaluation of Λ_∞ from Λ_+ and Λ_-(ii) evaluation of degree of dissociation of a weak electrolyte (iii) evaluation of $\Lambda_\infty$of a weak electrolyte (iv) determination ofsolubility from conductance of saturated solutions of sparingly soluble salts (AgCl and $BaSO_4$). Problems based on these. Limitations of Arrhenius theory: qualitative account of Debye-Huckel theory, Debye-Huckel-Onsagar equation for aqueous solutions of 1:1 electrolytes. Verification of DHO equation. Galavanic cell: conventions of representing galvanic cells-reversible and irreversible cells, derivation of Nernst equation for single electrode potential (free energy concept).	
MODULE 2	**15Hrs**
Electrochemistry II Weston-cadmium cell:Determination of emf of a cell by compensation method. Determination of E° of Zn/Zn^{2+} and Cu/Cu^{2+}electrodes.Liquid junction potentials, elimination of liquid junction potential. Types of electrodes: Metal and gas electrodes (chlorine), metal/metal insoluble salt electrodes, redox electrodes. Reference electrodes-standard hydrogen electrode, calomel electrode, quinhydrone electrode and glass electrode. Determination of pH using these electrodes.Numerical problems. Concentration cells: (i) emf of concentration cells (ii) determination of solubility of sparingly soluble salts and numerical problems. Redox electrodes, emf of redox electrodes. Potentiometric titration involving only redox systems. **Photochemistry** Laws of photochemistry. Grotthus-Draper law, Stark-Einstein law, differences between photophysical and photochemical processes with examples. Comparison of photochemical and thermal reactions. Quantum yield of photochemical combination of (i) H_2 and Cl_2 (ii) H_2 and Br_2 (iii) dissociation of HI (iv) dimerisation of anthracene. Photosensitization, photostationary equilibrium. Singlet and triplet states. Fluorescence, phosphorescence, luminescence, bioluminescence and chemical sensors. Beer-Lambert's law and its applications. Numerical problems on absorption coefficient and molar extinction coefficient.	

MODULE 3	15Hrs

Phase Equilibria

Statement and explanation of the terms with examples for phase (P), component (C) and degree of freedom (F), Definition and significance of phase rule. Derivation of phase rule. Application of phase rule to one component systems-water and sulphur, -modified form of phase rule to two component systems. Water–potassium iodide and lead-silver systems. Eutectic mixtures and their applications (examples: freezing mixtures, desilverisation of lead by Patterson's method).

Solid state

Crystalline state, Laws of crystallography. Symmetry elements in crystals, crystal systems.Weiss and Miller indices. X-ray diffraction of crystals-derivation of Bragg's equation, Problems Liquid crycstals-Types with examples. Applications Superconducting Solids-High temperature superconductors. Applications.

MODULE 4	15Hrs

Nuclear and Radiochemistry

Nucleus: Structure and stability, binding energy calculations. Instability of the nuclei, radioactive decay law, half life: numerical problems. Radioactive equilibrium, radioactive series. Artificial radioactivity: Nuclear reactions induced by γ-radiation,α,n,p,and d particles. Nuclear fission and fusion. Nuclear reactors, Breeder reactors, Isotopes- separation of isotopes, use of radio isotopes in tracer technique, agriculture, medicine, food preservation and Carbon dating-Numerical problems.

Colloids

Introduction, Classification of colloids, Methods of Preparation of Colloidal Solutions, Purification of Colloidal Solution, Precipitation of colloids by electrolytes, Stabilization of colloidal state, Emulsions, Gels, Application of colloids.

TEXT BOOKS/REFERANCES:

1. Physical Chemistry, 7th Edition P. W. Atkins and Julio de Paula, Oxford Univ. Press, 2002.
2. The Elements of Physical Chemistry, 3rd Edition Peter Atkins, Oxford Univ. Press, 2000.
3. Physical Chemistry – A molecular Approach Donal A. Mcquarrie and John D. Simon, Viva Low-priced Student Edition, 2001.
4. Introduction to Physical Chemistry, 3rd Edition Mark Ladd, Cambridge Low-Priced Edition, 1999.
5. Text Book of Physical Chemistry S. Glasstone, MacMillan India Ltd., 1998.
6. Principles of Physical Chemistry, 4th Edition B. R. Puri and L. R. Sharma and M. S. Pathania, S. L. N. Chand & Co., 1987
7. Text Book of Physical Chemistry P. L. Soni., S. Chand & Co., 1993.
8. Physical Chemistry Alberty R. A. and Silbey R. J. John Wiley & Sons, 1992.
9. Physical Chemistry G. M. Barrow, McGraw Hill, 1986.
10. Physical Chemistry, 3rd Edition Gibert W. Castellan, Narora Publishing House, 1985.

List of Laboratory/Practical Experiments to be conducted:
1. Conductometric titration of hydrochloric acid with sodium hydroxide.
2. Potentiometric titration of potassium dichromate with ferrous ammonium sulphate.
3. Determination of equivalent conductivity of 0.1 N sodium chloride and verification of DHO equation.
4. To construct the phase diagram of two component system (Ex. diphenylaminebenzophenone) by cooling curve method.
5. Preparation and Characterization of Colloidal Silver Sol.
6. Radiation Detection and Measurement using radiation detectors (e.g., Geiger-Müller counters)

TEXT BOOKS/ REFERENCES

1. Vogel's Text Book of Practical Organic Chemistry, 5th Edition, A.J. Hannford, A.R.Tatchell, B.S. Hurnis, P.W.G. Smith, Pearson Publication.
2. Enhancing undergraduate chemistry laboratories, J. Carndoff, N. Reid, RS. C.Publication.
3. Advanced Practical Chemistry, K. Chelladurai, K. Subbian, Lap Lambert Academic Publishing.
4. Experiments in Physical Chemistry 8th edition, Carl W. Garland, Joseph W. Nibler, and David P. Shoemaker, McGraw-Hill Education.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BS3501**					
TITLE OF THE COURSE	**BIOETHICS AND IPR**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Pre-requisite Courses (if any)			
#	**Sem/Year**	**Course Code**	**Title of the Course**
-	**-**	**-**	**-**

COURSE OBJECTIVES:

- To recognize, compare, and contrast the general "ways of thinking" of science (biology) and of philosophy (ethics).
- To recognize, compare, and contrast the general "ways of thinking" of science (biology) and of philosophy (ethics).
- To give elementary essential concepts of Bioethics, IPR and patent laws.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Student should develop basic understanding of the concepts of Bioethics, IPR and Patent Laws	L2
CO2	This course should generate interest for avenues for pursuing higher studies and careers in these areas	L2
CO3	General knowledge should create awareness necessary for higher studies in biotechnological fields	L2

COURSE CONTENTS	
MODULE I – BIOETHICS	**15 Hrs**
Bioethics- The environmental, legal and socioeconomic impacts of biotechnology; Ethical concerns of biotechnology in research and innovation-The GM crop debate – safety, ethics, perception and acceptance of GM crops; Bioethics of Genetically modified organism;Bioethics of CRISPR technique- for editing human embryos; Bioethics of Gene therapy; Bioethics of Stem cell research;Reproductive medicine and ethics;Use of Animals in Research and Testing, and Alternatives for Animals in Research,Animal Cloning, Human Cloning, and their Ethical Aspects; Public education of theprocess of biotechnology involved in generating new forms of life for informed decision-making.	

MODULE II – INTELLECTUAL PROPERTY RIGHTS AND REGULATIONS	15 Hrs
Introduction to Intellectual Property and History. Patents, Trademarks, Copyright, Trade secrets, Industrial Design and Rights, Traditional Knowledge, Geographical Indications - importance of IPR – patentable and non-patentable – patenting life – legal protection of biotechnological inventions – WorldIntellectual Property Rights Organization (WIPO), Pros and Cons of IP protection. Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner. Agreements and Treaties: GATT, TRIPS Agreements; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV &Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.	

REFERENCES:

1. Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBHPublishingCo. New Delhi.
2. Ganguli Prabuddha Gearing up for Patents. The Indian Scenario" , Universities Press (1998)
3. Introduction to Plant Biotechnology, H S Chawla
4. M K Sateesh. Bioethics and Biosafety. Kindle Edition
5. Shomini Parashar, Deepa Goel IPR, Biosafety and Bioethics Pearson India 2013
6. F. H. Erbisch and K. M. Maredia. Intellectual property rights in agricultural Biotechnology, UniversityPress.
7. SivamiahShantharam, Jane F. Montegomery. Biotechnology, Biosafety and Biodiversity, Oxford &IBHPubl. New Delhi.
8. Jecker Nany S, Jones &Barlet Bioethics: An Introduction to the History Methods and Practice, NewDelhi.
9. Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan
10. K. Sell Cambridge University Press, 2000.
11. Essentials of Intellectual Property: Law, Economics, and Strategy By Alexander I.
12. Poltorak; Paul J. Lerner Wiley, 2011 (2nd edition).
13. Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4th Edition. ASM 2006.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**22BS3502**					
TITLE OF THE COURSE	**BIONFORMATICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To get introduced to the basic concepts of Bioinformatics and its significance in biological data analysis.
• To get an overview about biological macromolecular structures and structure prediction methods.

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Will be able to demonstrate mastery of the core concepts of bioinformatics	L1
CO2	The student will be able to apply basic principles of biology, computer science and mathematics to address complex biological problem	L2
CO3	Should be able to plan basic experiments in microbial genetics concerned with clarifying phenotypes and their relationship with the genotype	L3

COURSE CONTENT:	
MODULE 1 BIOLOGICAL DATA TYPES AND SOURCE	**07Hrs**
Introduction to population and sample, Classification and Presentation of Data. Quality of data, private and public data sources. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Specialized Genome databases: (SGD, TIGR, and ACeDB). Microbial genomic database (MBGD), Virus data bank (UICTVdb).	
MODULE 2 SIMILARITY SEARCHING	**10Hrs**
Global and Local sequence alignment, Pair wise comparison of sequences, Multiple Sequence alignment of sequences, scoring matrices. Identification of genes in genomes and Phylogenetic analysis with reference to nucleic acids, Identification of ORFs, Identification of motifs	

MODULE 3 INTERPRETTING the SEQUENCE	07Hrs
Reading DNA from files in FASTA format, reading frames, Regular expressions, restriction maps and restriction enzymes, Genbank libraries, annotation parsing, Annotations indexing, parsing PDB files, parsing BLAST files.	
MODULE 4 SCALING THE HUMAN GENOME	**06Hrs**
UCSC genome browser, RegulomeDB database, ENCODE-ChIA-PET database, transcription factors binding sites. SNP, EST, STS. Regular Expression (REGEX), Hierarchies and Graphical models (including Markov chain and Bayes algorithm). Genetic variability and connections to clinical data.	

TEXT BOOKS/REFERENCES:

1. Bioinformatics. Keith, J. Humana Press, 2008.
2. Computer methods for macromolecular sequence analysis. R.F.Doolittle, Academic Press, 2096.
3. Bioinformatics. Sequence and genome analysis. D.W.Mount. Cold Spring Harbor Lab. press. 2004.
4. Bioinformatics and functional genomics. J. Pevsner. Wiley-Liss, 2003.
1. 5. Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics, Jorde et al., (eds.) John Wiley and Sons, 2005.
5. Baxavanis (2098). Bioinformatics.
6. Fry, J.C. (2093). Biological Data Analysis. A practical Approach. IRL Press, Oxford.
2. 8. Rosenbloom KR et al, The UCSC Genome Browser database: 2015 update. Nucleic Acids Res. 2015 Jan 28; 43(Database issue): D670-81

SEMESTER			**VI**			
YEAR			**III**			
COURSE CODE			**22CY3601**			
TITLE OF THE COURSE			**ORGANIC CHEMISTRY - II**			
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4		**4**		**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Understand the structure, reactivity, and synthesis of aldehydes and ketones, and their significance in organic chemistry.
• Explore the properties, reactions, and applications of carboxylic acids and their derivatives.
• Analyze the structure, generation, stability, reactivity, and significance of heterocyclic compounds.
• Master the principles of stereochemistry and their role in organic reactions.
• Examine the properties, reactions, and significance of amines in organic chemistry.

COURSE OUTCOMES:

CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students should be proficient in explaining the mechanisms of reactions involving aldehydes and ketones, including nucleophilic addition, oxidation, reduction, and condensation reactions. They should understand the importance of these compounds in both synthetic organic chemistry.	L1
CO2	Students should be able to explain the structure and reactivity of carboxylic acids, as well as their derivatives (esters, amides, acid chlorides, etc.), including hydrolysis, esterification, and acylation reactions.	L2
CO3	Students should be proficient in identifying common heterocyclic rings, such as furans, pyrroles, and pyridines, and explaining their reactivity, aromaticity, and significance in pharmaceuticals, bioactive molecules, and materials science.	L3
CO4	Students should be proficient in explaining stereochemistry, including chiral molecules, enantiomers, diastereomers, and the basics of optical activity. They should be able to apply these concepts to predict stereochemical outcomes in organic reactions and to analyze the three-dimensional arrangement of molecules.	L2
CO5	Students should be able to explain the structure, reactivity, and synthesis of amines, including nucleophilic substitution, amidation, and reactions of aromatic amines. They should understand the role of amines in biological systems, drug design, and synthetic methodologies.	L3

COURSE CONTENT:	
MODULE 1	**15Hrs**
Aldehydes and Ketones Nomenclature. Preparation of aldehydes: from acid chlorides (Rosenmund reaction), Gattermann-Koch aldehyde synthesis. Preparation of Ketones: From nitriles, from carboxylic acids with alkyl lithium, from acid chlorides with metal alkyls. Mechanisms of: Aldol condensation, Perkin condensation, Knoevenagel condensation, Benzoin condensation and Acetal formation. General mechanism of condensation with ammonia and its derivatives (NH_2-R; R = $-NH_2$, $-OH$, $-NH-CO-NH_2$). Reduction: Reduction by LiAlH4 and $NaBH_4$. Mannich reaction. Mechanisms of Clemmensen and Wolff-Kishner reductions. **Tautomerism and Enolates** Tautomerism in carbonyl compounds – Keto-Enol tautomerism. Acidity of α-hydrogen atoms in aldehydes, ketones and active methylene compounds (example diethyl malonate, ethyl acetoacetate and acetyl acetone). Preparation of (from acetic acid) and synthetic applications of diethyl malonate (preparation of monocarboxylic acids - butanoic acid, dicarboxylic acid - Adipic acid, unsaturated acids - cinnamic acid, ketones - butanone, cyclic compounds - barbituric acid) Preparation of ethyl acetoacetate (from ethyl acetate). Synthetic applications of ethyl acetoacetate (preparation of monocarboxylic acids - butanoic acid, dicarboxylic acid –succinic acid, unsaturated acids- crotonic acid, ketones - butanone).	
MODULE 2	**15Hrs**
Carboxylic acids and their derivatives. Nomenclature. Preparation: Acid hydrolysis of nitriles with mechanism. Acidic strength (pKa values) - Effect of substituents on the strength of aliphatic and aromatic carboxylic acids. (comparison of acidic strength of formic and acetic acids; acetic acid and monochloro, dichloro, trichloro acetic acids ; benzoic and p-nitrobenzoic acid; benzoic acid and p-aminobenzoic acid) Reactions: Formation of esters, acid chlorides, amides and anhydrides. Hell-Vollhardt-Zelinski reaction, Decarboxylation and reduction (using LiAlH4). (already included under preparation of alcohols from acid) Di and tri carboxylic acids: Action of heat on dicarboxylic acids (Oxalic to Adipic acids) Reactions of tartaric acid and citric acid. (action of heat, reduction with HI). Reactionsof acid chlorides (hydrolysis, reaction with alcohol, ammonia and lithium dialkylcuprates). Acid anhydrides (hydrolysis, reaction with alcohol, ammonia). Esters (alkaline hydrolysis, ammonolysis and alcoholysis). Amides (hydrolysis, reduction, Hoffmann rearrangement). Mechanism of ester hydrolysis - acid and base catalysed (acyl O-cleavage: BAC2, AAC2; alkyl O-cleavage: AAL1 mechanisms).	
MODULE 3	**15Hrs**
Stereochemistry Elements of symmetry in chiral and achiral molecules, chirality, stereogenic centre. Fischer projection formulae. *Enantiomers*: Optical activity; use of +/–, *d/l* and D/L notations. Properties of enantiomers, chiral and achiral molecules with two stereogenic centers. Meso compounds. Cahn-Ingold-Prelog sequencerules: R, S system of nomenclature. *Diastereomers:* Threo and Erythro isomers. Racemisation and resolution. Relative and absolute configuration. *Optical isomerism due to* restricted rotation about single bonds- diphenyl systems. *Geometric isomerism*: Determination of configuration of geometric isomers. Cis & trans, E, Z system of nomenclature. Geometric isomerism in oximes. *Alicyclic compounds*: Conformations of four to eight membered cycloalkanes and disubstituted cyclohexanes. *Bicylic systems*: Nomenclature and conformations of decalins and norbornane.	

MODULE 4	15Hrs

Amines

Classification. Preparation of alkyl and aryl amines-reductive amination of carbonyl compounds, Gabriel phthalimde synthesis. Basicity of amines in aqueous solution: Inductive, resonance, steric and solvation effects on the basicity of amines. Reaction of amines as nucleophiles – Methylation, quarternary salts, Hoffmann elimination with mechanism. Distinguishing reactions of 1°, 2° and 3° amines. Diazotization and synthetic applications of diazonium salts.Sandmeyer's reaction. (conversion to chlorobenzene, bromobenzene and benzonitrile), hydrolysis, reduction (to phenyl hydrazine and aniline), coupling reactions to give azo dyes (*p*-hydroxyazobenzene and 1-phenylazo-2-naphthol).

Heterocyclic compounds

Introduction, classification, structures, resonance and aromatic character of furan, pyrrole, thiophene and pyridine. Methods of preparation and reactions of pyrrole, furan, thiophene, pyridine.
Mechanism of electrophilic substitution reactions. Comparison of basicity of pyrrole, pyridine and piperidine. Preparation and reactions of indole, quinoline and isoquinoline.

List of Laboratory/Practical Experiments to be conducted:
1. Organic qualitative analysis of mono functional organic compounds through functional group analysis. (At least 5 organic functional groups)
2. Isolation of lycopene from tomatoes.
3. Isolation of caffeine from tea leaves.

TEXT BOOKS/REFERENCE BOOKS

1. Vogels Textbook Of Practical Organic Chemistry 5Th Edition, FURNISS and BRIAN S and HANNAFORD and ANTONY J, PEARSON INDIA.
2. Microscale Organic Laboratory: With Multistep and Multiscale Syntheses" by Dana W. Mayo, Ronald M. Pike, and David C. Forbes, J. Wiley & Sons.
3. Experimental Organic Chemistry: A Miniscale and Microscale Approach" by John C. Gilbert and Stephen F. Martin, Cengage Learning Publisher.
4. A Small Scale Approach to Organic Laboratory Techniques" 3rd edition, Donald L. Pavia, George S. Kriz, and Gary M. Lampman, Cengage Learning Publisher.

SEMESTER			**VI**			
YEAR			**III**			
COURSE CODE			**22CY3602**			
TITLE OF THE COURSE			**SPECTROSCOPY**			
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4		**4**		**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Understand the principles of spectroscopic techniques used in chemical analysis.
• Understand the theoretical background and limitations of spectroscopy.
• Analyze spectroscopic data and interpret spectra.
• Explore the applications of spectroscopy in chemical research and industry.
• Develop practical skills in spectroscopy and experimental design.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students should understand the underlying principles of various spectroscopic techniques, such as UV spectroscopy, Raman spectroscopy, nuclear magnetic resonance (NMR), and infrared spectroscopy (IR). They should be able to describe how these techniques provide information about molecular structure and behavior.	L1
CO2	Students should understand the theoretical foundations of spectroscopy, including the interaction of radiation with matter, selection rules, and the factors that affect spectral features. They should also be aware of the limitations and potential sources of error in spectroscopic measurements.	L2
CO3	Students should be proficient in analyzing spectroscopic data, including understanding peak positions, intensities, shapes, and patterns in spectra. They should be able to extract meaningful information from spectra, such as identifying functional groups, determining molecular structures, and analyzing chemical environments.	L3
CO4	Students should be able to identify and explain the various applications of spectroscopic techniques in chemistry, including materials analysis, pharmaceutical research, environmental monitoring, forensic science, and process control in industry. They should understand the role of spectroscopy in advancing scientific knowledge and solving practical problems.	L2
CO5	Students should be proficient in using spectroscopic instruments, setting up experiments, collecting data, and analyzing results. They should be able to design experiments to answer specific research questions or solve analytical challenges using spectroscopic techniques.	L3

COURSE CONTENT:	
MODULE 1	**15Hrs**
Fundamentals of Spectroscopy and Ultra-Violet and Visible Spectroscopy Fundamentals of Spectroscopy: Electromagnetic radiation, interaction of electromagnetic radiation radiation with matter. Regions of electromagnetic spectrum and associated spectroscopic techniques. Ultra-Violet and Visible Spectroscopy: The Absorption Laws, Measurement of Absorption Intensity, Instrumentation, Formation of Absorption Bands, Theory of Electronic Spectroscopy,Types of Electronic Transitions,Transition Probability, The Chromophore Concept, Auxochrome, Absorption and Intensity shifts, Types of Absorption bands, Solvent Effects, Effect of Temperature and Solvent on the Fineness of Absorption Band, Conjugated dienes, Woodward-fieser Rules for Calculating Absorption Maximum in Dienes, Distortion of the Chromophore, Poly-enes and Poly-ynes, Ultra-violet Absorption in α, β-unsaturated Carbonyl Compounds, Woodward-fieser rules for Calculating Absorption Maximum in, α, β-unsaturated carbonyl compounds, Compounds with N to O Bonds, Benzene and its Derivatives, Applications of ultra-violet Spectroscopy.	
MODULE 2	**15Hrs**
Infra-Red Spectroscopy Principle of infra-red spectroscopy, Theory—Molecular Vibrations, Vibrational Frequency, Number of Fundamental Vibrations, Selection Rules (Active and Forbidden Vibrations), Factors Influencing Vibrational Frequencies, Scanning of Infra-red Spectrum (Instrumentation), Sampling Techniques, Finger Print Region, Spectral Features of Some classes of organic, Important Features in Infra-red Spectroscopy, Applications of infra-red spectroscopy.	
MODULE 3	**15Hrs**
Raman Spectroscopy Introduction, Quantum theory of Raman Effect, Theory of Raman spectra-Stoke's and anti-stoke's lines, Instrumentation, Conditions for Raman spectroscopy, Equivalence of Beer Lambert law of, absorption in Raman Scattering, Characteristic Parameters of Raman lines, Raman spectra of diatomic molecules, Rotational-Vibrational Raman Spectra, Vibrational Raman Spectra of Polyatomic, Molecules, Rule of Mutual Exclusion Principle, Moment of Inertia of diatomic molecules, and Raman Spectroscopy, Infra-red and Raman Spectra are, Complementary, Structure elucidation of Raman Spectroscopy, Importance of Raman Spectra, Applications of Raman Spectroscopy.	
MODULE 4	**15Hrs**
Nuclear Magnetic Resonance (NMR) Spectroscopy Introduction, Theory Instrumentation, Positions of Signals (Chemical Shift), Internal Standards, Shielding and Deshielding Effects, Factors Influencing Chemical Shift, Solvents Used, Peak area and Proton Counting, Splitting of the Signals, Spin-spin Coupling, NMR Absorption by other Nuclei, Calculating the Ratio in the Heights of the Signals, Coupling Constant (J), Some Important Nmr Spectra, C13–NMR Spectroscopy, Applications of NMR Spectroscopy, Important Features inNuclear Magnetic Resonance Spectroscopy, Simple Problems on Nuclear Magnetic.	

TEXT BOOKS/REFERENCE BOOKS

1. Elementary Organic Spectroscopy Principle and Principle and Chemical Applications 5th Edition, YR Sharma, S. Chand Publication
2. Introduction to Spectroscopy5th edition, Donald L. Pavia, Cengage India Private Limited.
3. Spectrometric Identification of Organic Compounds8th edition, David J. Kiemle, David L.Bryce, Francis X. Webster, Robert M. Silverstein, John Wiley & Sons Inc.
4. Organic Spectroscopy V. R. Dani, Tata McGraw Hill, 1998.
5. Organic Spectroscopy W. Kemp, ELBS IV Edition, 1998

EXPERIMENTS
1. Measurement of Iron in Egg Yolk: An UV Instrumental Analysis Experiment Using Biochemical Principles
2. Determination of log Kow Values for Four Drugs
3. Determination of Phosphorus in Cola Drinks
4. Analysis of Aspirin Tablets
5. Measuring Breath Alcohol Concentrations with an FTIR Spectrometer

TEXT BOOKS/REFERENCES
1. Vogels Textbook Of Practical Organic Chemistry 5Th Edition, FURNISS and BRIAN S and HANNAFORD and ANTONY J, PEARSON INDIA.
2. Maloney, Kevin & Quiazon, Emmanuel & Indralingam, Ramee. (2008). Measurement of Iron in Egg Yolk: An Instrumental Analysis Experiment Using Biochemical Principles. Journal of Chemical Education - J CHEM EDUC. 85. 10.1021/ed085p399.
3. Harris, Mark & Logan, Jennifer. (2014). Determination of log Kow Values for Four Drugs. Journal of Chemical Education. 91. 915–918. 10.1021/ed400655b.
4. ozano-Calero, Diego & Martìn-Palomeque, Pilar & Madueño-Lorguillo, Silvia. (1996). Determination of Phosphorus in Cola Drinks. Journal of Chemical Education - J CHEM EDUC. 73. 10.1021/ed073p1173.
5. Method development for analysis of aspirin tablets, Kenneth W. Street Journal of Chemical Education 1988 65 (10), 914
6. Kniesel, A. & Bellamy, M.K. (2003). Measuring breath alcohol concentrations with an FTIR spectrometer. Journal of Chemical Education. 80. 1448-1450.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22BS3601**					
TITLE OF THE COURSE	**PRINCIPLES OF ‘MULTI-OMICS’**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• To acquaint students with various aspects of biotechnology and bio-engineering using omics technologies
• To provide key insights into omics approaches in personalized and precision medicine

CO No.	**OUTCOMES**	**Bloom’s Taxonomy Level**
CO1	Students will have knowledge in specific methods used in genomics, proteomics and metabolomics used in analytical processes.	L1
CO2	Students will be able to perform statistical analysis crucial for interpretation of experimental results	L2
CO3	Students will be able to apply specialized research methods necessary for the analysis of proteins, genes and metabolites	L3

COURSE CONTENT:	
MODULE 1 Genome & Genomics	**07Hrs**
Genome mapping: Physical and Genetic Map, Genome Sequencing, Next generation sequencing methods ,Genome Annotation, Functional Genomics	
MODULE 2 Transcriptomics	**07Hrs**
Search for transcription factor binding sites, RNA-Seq, Microarrays, Regulatory RNAs: small or large, Computational prediction of miRNA target genes, RNA Darkmatter	

MODULE 3 Proteomics and Metabolomics	10Hrs
Basic concepts , Tools of proteomics- SDS PAGE, 2D PAGE , Liquid chromatography , Mass Spectrometry (ESI and MALDI) ,Protein identification by peptide mass fingerprinting, Applications of proteomics. Fundamental concept, Tools of metabolomics- Capillary electrophoresis, Gas chromatography, Electrochemical detectors, Case studies	
MODULE 4 'OMICS': applications and future perspectives	**06Hrs**
Multi-omics in disease prediction and health. Multi-omics technologies for crop improvement and sustainable agriculture. Applications in Biomedical and Environmental sciences	

TEXT BOOKS/REFERANCES:

1. Bioinformatics. Keith, J. Humana Press, 2008.
2. Computer methods for macromolecular sequence analysis. R.F.Doolittle, Academic Press, 2096.
3. Introduction to Proteomics -Tools for the New Biology by Daniel C. Liebler, Humana Press..
4. Bioinformatics and functional genomics. J. Pevsner. Wiley-Liss, 2003.
5. Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics, Jorde et al., (eds.) John Wiley and Sons, 2005.
6. Metabolomics- Methods and Protocols by Wolfram Weckwerth, Humana Press.
7. Fry, J.C. (2093). Biological Data Analysis. A practical Approach. IRL Press, Oxford.
8. Transcriptomics: Expression Pattern Analysis, Virendra Gomase, Somnath Tagore; VDM Publishing, 2009 – Science

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**22BS3602**					
TITLE OF THE COURSE	**TOXICOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**30**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
1. To learn various toxicants present and their exposure level on day-to-day basis.
2. To study the effects of toxins on the physiologic, metabolic, reproductive, and developmental processes.

COURSE OUTCOMES

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Students will learn and understand all substances can be toxic depending on the means and level of exposure	L1
CO2	Students will learn the basic concepts of cellular toxicity and chemical actions on cells and body organs	L2
CO3	Students will learn the importance and diversity of drug interactions with various organs	L3

COURSE CONTENT:	
MODULE 1	**10 Hrs**
INTRODUCTION OF TOXICOLOGY: Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins. Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms. Toxicant proceeding *in vivo*: Absorption, Distribution, Excretion an Metabolism of foreign/toxic compounds.	
MODULE II	**5 Hrs**
ENVIRONMENTAL TOXICOLOGY: Environmental pollution- Sources and types of pollution, Important pollution events, Priority pollutants. Air pollution- Classification and properties of air pollutants, Behaviour and fate of air pollutants, Photochemical smog, Acid Rain, health effects of air pollution. Water pollution- origin of Wastewater, Domestic Water Pollution, Industrial water pollution, Agricultural water pollution, Toxic water pollutants and their health effects, Groundwater pollution, marine pollution	

MODULE III	5 Hrs
INDUSTRIAL TOXICOLOGY: Industrial Chemicals: Government Regulation of Chemicals, Ways of exposure, Toxic effects, Long-term consequences and developmental toxicity. Food Additives and Contaminants types of food additives, Preservatives, Saccharin. Toxicity of trace elements- Iodine, iron, zinc, copper, manganese, selenium, molybdenum, and cobalt Cyto-toxicity of heavy metals- Cadmium, mercury, arsenic, chromium and lead. Brief introduction to toxicity of pesticides and inseciticides.	
MODULE IV	**10 Hrs**
ORGAN TOXICOLOGY: Basics of organ toxicity- Target organs, Organ selectivity and specificity, gender specific diversity of toxins. Hepatotoxicity - Actions of toxins on the liver, Chronic liver injury; Cardiotoxicity - pathology of cardiac toxicity, mechanisms of cardiotoxicity; Respiratory Toxicity - Systematic lung toxins, Lung pathology; Reproductive System – Teratogenicity; Neurotoxicity- Effect of toxic agents on neurons, Ion channel neurotoxins and Nephrotoxicity- susceptibility of kidney to toxic insult, chemically induced renal injury.	

REFERENCE BOOKS:

1. Whalen, Finkel, and Panavelil, Pharmacology, 6th ed. (Lippincott Williams & Wilkins: 2015).
2. Lieberman and Peet, Mark's Basic Medical Biochemistry: A Clinical Approach, 5th ed. (Wolters Kluwer: 2018).
3. Hodgson, A Textbook of Modern Toxicology, 4th ed. (J Wiley & Sons: 2010).
4. Molecular and Biochemical Toxicology, 4th ed., Smart and Hodgson, eds. (J Wiley & Sons: 2008).
5. Frank and Ottoboni, The Dose makes the Poison: A Plain-language Guide to Toxicology, 3rd ed. eBook, (J Wiley & Sons: 2011).
6. Ottoboni, The Dose makes the Poison: A Plain-language Guide to Toxicology, 2nd ed., (J Wiley & Sons: 1997).
7. A-Z Guide to Drug-Herb-Vitamin Interactions, 2nd ed., Gaby, Batz, Chester and Constantine, eds. (Three Rivers Press: 2006).
8. Gilbert, A Small Dose of Toxicology: The health effects of common chemicals, (CRC Press: 2004).
9. Gibson, Multiple Chemical Sensitivities: A survival guide, (New Harbinger Publications: 2000).
10. Toxicology and Clinical Pharmacology of Herbal Products, Cupp and Karch, eds. (Springer-Verlag: 2000).
11. Lawson, Staying Well in a Toxic World, (Lynwood Press: 2000).

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22CY4701**					
TITLE OF THE COURSE	**POLYMER CHEMISTRY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

COURSE OBJECTIVES:
• To introduce the specialized subject of the chemistry of polymers
• To understand in detail the mechanisms of the reactions that lead to the formation of polymers.
• To familiarize the students with the types of polymers, the significance of their molecular mass.

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Will be able to demonstrate the composition and structure of polymers	L1
CO2	Should be able to correlate the structure of polymers to their properties and application	L2
CO3	Should be able to demonstrate the significance of polymer molecular mass.	L3

COURSE CONTENT:

MODULE 1	**12Hrs**

Basic principles of polymer chemistry

Historical development of polymer chemistry. Monomers, polymers, repeating units, functionality. Nomenclature of polymers. Importance and applications of polymers –acrylic, vinyl, cellulose, fluorinated, poly ethylene, & SAN copolymer. Classification of polymers. Ladder and spiral polymers. Cis- trans configuration. DL isomers and tacticity. Inorganic polymers- importance, advantages and applications- structure, preparation and properties of silicones and polyphosphazenes. Comparison with organic polymers.

MODULE 2	**12Hrs**

Free radical addition polymerization

Chain growth polymerization. Mechanism of chain growth polymerization. Initiation, propagation and termination. Types of free radical initiators (peroxo, azo and redox initiators).Initiator efficiency. Inhibitors and retarders – functions and examples. Chain transfer reactions. Kinetics of chain growth polymerization. Kinetic chain length. Auto acceleration, thermal &electrochemical polymerization.

MODULE 3	12Hrs
Ionic & stereoregular polymerization Ionic polymerization – anionic and cationic catalysts, Solvent effects in ionic polymerizations. Mechanism and kinetics of anionic and cationic polymerizations. Counter ions. Termination modes. Living polymers. Coordination polymerization: stereo regularity, Ziegler-Natta catalysts. Metallocene catalysts. Bimetallic and monometallic mechanisms.	
MODULE 4	**12Hrs**
Condensation or step growth polymerization Step growth polymerization,-Average functionality, basic characteristics, extent of reaction, degree of polymerization, Carother's equation. Gel and gel point. Mechanism of self-catalysed and non-catalysed esterification. Ring-opening & interfacial polymerization, Copolymerization: random, alternate, block and graft. Copolymerization involving two monomers(free radical mechanism). Reactivity ratio, its determination. Q-e scheme. Polymerisation techniques (bulk, solution, suspension and emulsion). Melt, solution and interfacial condensation.	
MODULE 5	**12Hrs**
Molecular mass and size of polymers Degree of polymerization and molecular weight. Practical significance of molecular weight. Threshold molecular weight. Concept of average molecular mass and molecular mass distribution. Number average, weight average and z average molecular mass and their calculation. Viscosity average molecular mass. Molecular mass distribution curve. Polydispersity and polydispersity index of polymers. Examples of monodispersed and polydispersed polymers. Molecular mass & mechanical properties. Size of polymer molecules.	

TEXT BOOKS/REFERANCES:

1. Malcon P. Steves, Polymer chemistry-An introduction, 3rd edition, Oxford University Press.
2. F. W. Billmayer, Text book of Polymer Science, 3rd edition, John Wiley &Sons
3. V. R. Gowariker, N. V. Viswanathan&J. Sreedhar, Polymer Science, New Age International Publishers.
4. P. Bahadur&N. V. Sastry, Principles of Polymer Science, Narrora Publishing House, 2nd Edition, New Delhi.
5. PremamoyGhosh, Polymer Science & Technology, 3rd edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi.
6. G. Odian, Principles of polymerization, 3 rd edition, John Wiley &Sons.
7. G. S. Misra, Introductory Polymer Chemistry New age International Publishers & Distributors, New Delhi
8. V. K. Ahluwalia& A. Misra, Polymer Science-A Text Book, AneBooks, India, New Delhi.
9. J. R. Fried, Polymer Science & Technology, Prentice Hall of India Pvt. Ltd, New Delhi.

EXPERIMENTS
1. Determination of molecular weight of polymer by Viscosity.
2. Synthesis of Nylon.
3. Free Radical Polymerization of Styrene.
4. Preparation of Polyvinyl Chloride
5. Synthesis of polyurethane foam.
6. Synthesis of Polymer Nanoparticles.

TEXT BOOKS/REFERANCES:

1. Malcon P. Steves, Polymer chemistry-An introduction, 3rd edition, Oxford University Press.
2. F. W. Billmayer, Text book of Polymer Science, 3rd edition, John Wiley &Sons
3. V. R. Gowariker, N. V. Viswanathan&J. Sreedhar, Polymer Science, New Age International Publishers.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22CY4702**					
TITLE OF THE COURSE	**INORGANIC CHEMISTRY- II**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

COURSE OBJECTIVES:
• To make students understand about co-ordination compounds their synthesis, reactions and applications
• To impart knowledge about organometallic compounds.

CO No.	**OUTCOMES**	**Bloom's Taxonomy Level**
CO1	Will understand the mechanism of reaction of transition metal complexes.	L1
CO2	Should be able to correlate the structure of Transition Metal complexes with their magnetic properties.	L2
CO3	Will be able to gain knowledge organo-metallic compounds and its significance as a catalyst.	L3

COURSE CONTENT:

MODULE 1 — **15 Hrs**

CO-ORDINATION COMPOUNDS

Coordination compounds, terminologies, ligands and their classification (mono, bi, tri, tetra,penta and hexa dentate ligands) and ambidentate ligands, coordination number, nomenclature of coordination compounds. Theories of structure and bonding (Explanation for the formation of complexes by Werner's Theory taking cobalt amine complexes). EAN rule, Valence bond theory-postulates, low spin and high spin complexes with examples (cobalt and nickel-based complexes), limitations of VBT. Crystal field theory (octahedral, tetrahedral and squareplanar complexes). Magnetic properties of [CoF6]3-, [Fe(CN)6]4Spectral properties of [Ti(H2O)6]3+, [Co(H2O)6]3+Isomerism-Structural: ionization, linkage, hydrate and coordination isomerism with examples. Stereoisomerism : geometrical and optical isomerism in cobalt amine complexes.

MODULE 2 — **15 Hrs**

REACTION MECHANISM IN TRANSITION METAL COMPLEXES

Energy profile of a reaction inert and labile complexes, kinetics of octahedral substitution and mechanistic aspects. Acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism and evidence in its favour. Substitution reactions of square planar complexes - Trans effect and applications of trans effect, substitution reactions of tetrahedral complexes, isomerization and racemisation reactions of coordination compounds. Electron transfer reaction- inner sphere and outer sphere reactions, complementary and noncomplementary reactions.

MODULE 3	15 Hrs

MAGNETIC PROPERTIES OF TRANSITION METAL COMPLEXES

Types of magnetic behaviour, orbital contributions, spin orbital coupling, spin cross over system, methods of determining magnetic susceptibility, diamagnetic corrections, ferro and antiferro magnetic coupling, super paramagnetisam. spin-only formula. Electron Spectra of Transition Metal Complexes Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series. Orgel-energy level diagram for d1 and d9 states, discussion of the electronic spectrum of [Ti(H2O)6]3+ complex ion.

MODULE 4	15 Hrs

ORGANOMETALLIC COMPOUNDS

Ligands, classification (hapticity). Synthesis and structure of K[PtCl3(η2-C2H4)] Metal carbonyls – Cr(CO)6, Mn2(CO)10; eighteen electron rule and its deviations with examples.Applications of coordination/organometallic compounds: cis-platin in cancer therapy,Na2Ca, EDTA in the treatment of heavy metals (Pb, Hg) poisoning, Wilkinson's Catalyst in alkene, hydrogenation, decarbonylation reaction, Rh-catalyst reaction, Zigler natta reaction,Hack reaction and Suzuki coupling reaction.

TEXT BOOKS/REFERANCES:

1. A New Concise Inorganic Chemistry", J. D. Lee, 5th Ed, Chapman & Hall, London (1996).
2. Principles of Inorganic Chemistry B. R. Puri and L. R. Sharma, Jauhar S. P-S. N. Chand & Co., 1998
3. Inorganic Chemistry, ELBS 2nd Edition D. F. Shriver, P. W. Atkins and C. H. Langford, Oxford Univ. Press 2002.
4. Inorganic Chemistry, 4th Edition J. E. Huhee, E. A. Keiter and R. I. Keiter, Pearson Education Asia, 2000
5. Modern Inorganic Chemistry W. L. Jolly, McGraw Hill Co.
6. Inorganic Chemistry, 3rd Edition (ISE) A G Sharpe, Addison Wesley, 1989.

EXPERIMENTS
1. Estimation of percentage of iron in haematite using barium diphenylamine sulphonate as an internal indicator.
2. Estimation of calcium in lime stone.
3. Estimation of nickel using EDTA and standard zinc sulphate.
4. Preparation of sodium trioxalatoferrate (III) and estimation of iron.
5. Estimation of zinc using EDTA.

TEXT BOOKS/REFERANCES:

1. Vogel's Text Book of Practical Organic Chemistry, 5 th Edition, A.J. Hannford, A.R. Tatchell, B.S. Hurnis, P.W.G. Smith, Pearson Publication.
2. Chemistry Practical Inorganic Qualitaive Analysis For Under Graduate Students, M.J. Mamtora, S.C. Karad, J.S. Makasana, Lap Lambert Academic Publishing.
3. Enhancing undergraduate chemistry laboratories, J. Carndoff, N. Reid, RS. C. Publication.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22CY4703**					
TITLE OF THE COURSE	**NANOSCIENCE AND MATERIAL CHEMISTRY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

COURSE OBJECTIVES:
• To make students understand about co-ordination compounds their synthesis, reactions and applications
• To impart knowledge about organometallic compounds.

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Will understand the mechanism of reaction of transition metal complexes.	L1
CO2	Should be able to correlate the structure of Transition Metal complexes with their magnetic properties.	L2
CO3	Will be able to gain knowledge organo-metallic compounds and its significance as a catalyst.	L3

COURSE CONTENT:

MODULE 1 | **15 Hrs**

INTRODUCTION OF NANOMATERIALS

Background to Nanoscience: Definition of Nano, Scientific revolution-Atomic Structure and atomic size, emergence and challenges of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of Nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties.

Types of nanostructure and properties of nanomaterials: One dimensional, Two dimensional and Three-dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties.

MODULE 2 | **15 Hrs**

SYNTHESIS OF NANOMATERIALS

Colloids :- Introduction to Colloids and Colloids in Solutions, Effect of Charges on Colloids, Stearic Repulsion, Synthesis of Colloids, Nucleation and Growth of Nanoparticles.

Different methods of production: Top down and bottom-up approach with examples.

Physical Methods; Inert gas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ball Milling, Molecular beam epitaxy, Chemical Vapour deposition (CVD), ALD method and other variants, electrodeposition.

Chemical Methods: Sol-gel, hydrothermal, solvothermal, combustion method, microwave method, coprecipitation method, Photochemical synthesis, Electrochemical synthesis.

Biological Methods:- Synthesis Using Microorganisms, Synthesis Using Plant Extracts Use of Proteins

MODULE 3	15 Hrs
Characterization: Basic principle and application of X-ray diffraction, SEM, FESEM, TEM, EDS analysis, AFM, XPS, UV-Visible Spectrophotometers with respect to CNT, graphite, graphene, metal dichalcogenides, Quantum dots, core-shell nanoparticles.	
MODULE 4	**15 Hrs**

APPLICATION OF NANOMATERIALS

Environmental Nano-Remediation Technology

Nanofiltration for treatment of wastes – Removal of Organics, Inorganics and Pathogens – Nanotechnology for water purification –Treatment of industrial waste water using Nanomaterials – Environmental benefits of Nanomaterials.

Class of Materials Used in Medicine

Introduction, Properties of Materials, Type of Materials in Medicine – Metals, Polymers, Hydrogels, Ceramics, Glasses and Glass Ceramics, Composites, Thin films, Grafts and Coatings.

TEXT BOOKS/REFERANCES:

1. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge UK 2005.
2. Chemistry of Nanomaterials: Synthesis, properties and applications by CNR Rao et.al., Royal Society of Chemistry, Cambridge UK 2006.
3. Nanocharacterization Techniques, Allessandra L. Da Roz, M. Ferreira, F. L. Leite, O. N. Oliviera, 2017, Elsevier, Cambridge, USA, ISBN: 978-0-323-49788-7
4. Fundamental Properties of Nanostructured Materials, Ed. D. Fiorani (World Scientific, Singapore, 1994.
5. Hand Book of Nanotechnology, by Bharat Bhushan, 2007, Springer Science + Business Media, Inc, NY, USA.
6. Biomaterials Science, An Introduction to Materials in Medicine, Edited by Buddy D.Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Academic Press, A
7. Wiesner, M.R., and Bottero, J.Y. (Ed.) ―‖ Environmental Nanotechnology: Applications and Impacts of Nanomaterials‖ McGraw-Hill, New York, 2007.

EXPERIMENTS
1. Synthesis of metal oxide nanoparticles by solution sol-gel methods.
2. Synthesis of metal oxide nanoparticles by solution combustion methods
3. Synthesis of multi-ferrite nano-particles by chemical co-precipitation method.
4. Synthesis of silver nanoparticles, and its spectral analysis.
5. Preparation of cadmium sulphide nanoclusters and its spectral studies
TEXT BOOKS/REFERANCES: 1. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004. 2. Nanofabrication Principles, Capabilities and Limits, Zheng Cui, Springer, New York, 2008. 3. Enhancing undergraduate chemistry laboratories, J. Carndoff, N. Reid, R.S.C. Publication.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22BS4701**					
TITLE OF THE COURSE	**RESEARCH METHODOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**45**	**3**

Perquisite Courses (if any)

#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
To provide an overview of essential research steps to be followed when conducting research / project work.
To understand chief ingredients to be incorporated in conduct as well as writing of scientific reports/dissertation/thesis
To know the implication professional research ethics and common misconduct details of researcher and research work

COURSE OUTCOME

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Show and explain the concepts of meaning ofresearch, scope of research including different types of research, scientific research process and research methodology steps	L1
CO2	Perform review of literature using electronic media, selecting research problem formulate research problem statement, writing hypothesis, explain criteria of forming objectives, materials and methods, results and discussion	L2
CO3	Identify and explain experimental research designs for both qualitative and quantitative research	L2
CO4	Explain different sampling methods and sampling design, basic statistical methods for treatment of data and observations	L2
CO5	Demonstrate ingredients and components of a research report, dissertation and thesis and explain integral components of research article and research proposal	L2
CO6	Explain professional research ethics and elaborate on misconduct in research	L2

COURSE CONTENT:	
MODULE 1:	**12 hrs**
INTRODUCTION TO RESEARCH: Meaning, Objectives and Characteristics of research – Scientific Method Types of research - Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical - Research process - Criteria of good research **PROBLEM STATEMENT:** Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem; **LITERATURE SURVEY:** Importance of literature review in defining a problem **- S**urvey of literature - Primary and secondary sources - web as a source - searching the web - Identifying gap areas from literature review. **HYPOTHESIS:** Definition of hypothesis**,** Basic concepts, variables-Dependent and independent variables, Development of working hypothesis; Ingredients of Research Objectives, deriving objectives of research.	
MODULE 2:	**12 hrs**
Sampling, Material and Methods: Sample- Sampling - Types of sampling; Material - Experiments, Data – Basics of Analysis; Writing materials and method chapter of a research report **Results and Discussion**: Representation of results; Tables, graphs; Discussion, Purpose and Function of Discussion **Research Designs:** Research design; Need of research design - Basic Principles; Features of good design – Important concepts relating to research design; Max-min-con principle, **Common Research Designs**: Cross-sectional, Case-control, Longitudinal and Cohort research designs, advantages and disadvantages of each of research designs **Summary and Conclusion:** Writing of Summary, conclusions of research findings, Acknowledgement section of a research report and an article.	
MODULE 3:	**10Hrs**
Research Ethics: Values, Ethics and Morals**,** Research Professionalism**,** Tenets of Ethics; Conducting and reporting of science/engineering; Relationship in research groups; Hazards to good scientific practice; Scientific misconduct: Fabrication, Falsification and Plagiarism. **Report and Article Writing:** Structure and components of scientific reports; Abstract-Key words**;** Types of reports; Significance of reporting; Different steps in the preparation of reports; Layout, structure and Language of typical reports; References; Citation styles- APA and MLA styles of citation, intext and end text citations. **Oral Presentation:** Importance of effective communication. Planning; Preparation; Practice; Making presentation; Use of visual aids.	
MODULE 4:	**11Hrs**
Scientific Article Writing: Title preparation – Importance of title; need for specific titles; List of authors and addresses – order of names; defining the order with example; types of abstracts; economy of words; How to write introduction- Rules; exceptions; citations and abbreviations Materials and methods: Purpose; materials; methods; tables and figures; form and grammar; Result and Discussion writing: content of results; handling numbers; clarity; avoiding redundancy; Discussion writing: Components of discussion; factual relationships; strengths and limitations; significance of paper; Stating Acknowledgements: Ingredients of the acknowledgements; courtesy; Citation of the References: Rules; electronics aid; in-textcitation; styles of referencing **Research Proposal Fundamentals:** What is a grant proposal? Why proposals fail?; Developing and writing of grant proposals; overview of steps to develop grant proposals; Proposal Development Process:Standard Proposal Parts; writing Budget section. **Intellectual Property Rights:** IPRs- Invention and Creativity- Intellectual Property-Importance and Protection of Intellectual Property Rights (IPRs); A brief summary of: Patents, Copyrights, Trademarks.	

REFERENCES:

1. Bruce Tuckman, Brian E Harper, Conducting Educational Research, 6th Edition, 2012 byRowman & Littlefield Publishers, Inc. ISBN 978-1-4422-0965-7 (electronic)

2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International.418p.

3. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to ResearchMethodology, RBSA Publishers.

4. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd.,New Delhi

5. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications.2 volumes.

6. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic DogPublishing. 270p.

7. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.

8. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. SagePublications

9. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**22CY2404**					
TITLE OF THE COURSE	**COORDINATION COMPOUNDS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4	**-**	**4**	**-**	**60**	**6**

COURSE OBJECTIVES:

- To make students understand about co-ordination compounds their synthesis, reactions and applications
- To impart knowledge about organometallic compounds.

CO No.	OUTCOMES	Bloom's Taxonomy Level
CO1	Will understand the mechanism of reaction of transition metal complexes.	L1
CO2	Should be able to correlate the structure of Transition Metal complexes with their magnetic properties.	L2
CO3	Will be able to gain knowledge organo-metallic compounds and its significance as a catalyst.	L3

COURSE CONTENT:

MODULE 1	**15 Hrs**

CO-ORDINATION COMPOUNDS

Coordination compounds, terminologies, ligands and their classification (mono, bi, tri, tetra,penta and hexa dentate ligands) and ambidentate ligands, coordination number, nomenclature of coordination compounds. Theories of structure and bonding (Explanation for the formation of complexes by Werner's Theory taking cobalt amine complexes). EAN rule, Valence bond theory-postulates, low spin and high spin complexes with examples (cobalt and nickel-based complexes), limitations of VBT. Crystal field theory (octahedral, tetrahedral and squareplanar complexes). Magnetic properties of [CoF6]3-, [Fe(CN)6]4Spectral properties of [Ti(H2O)6]3+, [Co(H2O)6]3+Isomerism-Structural: ionization, linkage, hydrate and coordination isomerism with examples. Stereoisomerism : geometrical and optical isomerism in cobalt amine complexes.

MODULE 2	**15 Hrs**

REACTION MECHANISM IN TRANSITION METAL COMPLEXES

Energy profile of a reaction inert and labile complexes, kinetics of octahedral substitution and mechanistic aspects. Acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism and evidence in its favour. Substitution reactions of square planar complexes - Trans effect and applications of trans effect, substitution reactions of tetrahedral complexes, isomerization and racemisation reactions of coordination compounds. Electron transfer reaction- inner sphere and outer sphere reactions, complementary and noncomplementary reactions.

MODULE 3	15 Hrs

MAGNETIC PROPERTIES OF TRANSITION METAL COMPLEXES

Types of magnetic behaviour, orbital contributions, spin orbital coupling, spin cross over system, methods of determining magnetic susceptibility, diamagnetic corrections, ferro and antiferro magnetic coupling, super paramagnetisam. Spin-only formula. Electron Spectra of Transition Metal Complexes Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series. Orgel-energy level diagram for d1 and d9 states, discussion of the electronic spectrum of [Ti(H2O)6]3+ complex ion.

MODULE 4	15 Hrs

ORGANOMETALLIC COMPOUNDS

Ligands, classification (hapticity). Synthesis and structure of K[PtCl3(η2-C2H4)] Metal carbonyls – Cr(CO)6, Mn2(CO)10; eighteen electron rule and its deviations with examples.Applications of coordination/organometallic compounds: cis-platin in cancer therapy,Na2Ca, EDTA in the treatment of heavy metals (Pb, Hg) poisoning, Wilkinson's Catalyst in alkene, hydrogenation, decarbonylation reaction, Rh-catalyst reaction, Zigler natta reaction,Hack reaction and Suzuki coupling reaction.

TEXT BOOKS/REFERANCES:

1. A New Concise Inorganic Chemistry", J. D. Lee, 5th Ed, Chapman & Hall, London (1996).
2. Principles of Inorganic Chemistry B. R. Puri and L. R. Sharma, Jauhar S. P-S. N. Chand & Co., 1998
3. Inorganic Chemistry, ELBS 2nd Edition D. F. Shriver, P. W. Atkins and C. H. Langford, Oxford Univ. Press 2002.
4. Inorganic Chemistry, 4th Edition J. E. Huhee, E. A. Keiter and R. I. Keiter, Pearson Education Asia, 2000
5. Modern Inorganic Chemistry W. L. Jolly, McGraw Hill Co.
6. Inorganic Chemistry, 3rd Edition (ISE) A G Sharpe, Addison Wesley, 1989.

EXPERIMENT
1. Estimation of percentage of iron in haematite using barium diphenylamine sulphonate as an internal indicator.
2. Estimation of calcium in lime stone.
3. Estimation of nickel using EDTA and standard zinc sulphate.
4. Preparation of sodium trioxalatoferrate (III) and estimation of iron.
5. Estimation of zinc using EDTA.

TEXT BOOKS/REFERANCES:

1. Vogel's Text Book of Practical Organic Chemistry, 5 th Edition, A.J. Hannford, A.R. Tatchell, B.S. Hurnis, P.W.G. Smith, Pearson Publication.
2. Chemistry Practical Inorganic Qualitaive Analysis For Under Graduate Students, M.J. Mamtora, S.C. Karad, J.S. Makasana, Lap Lambert Academic Publishing.
3. Enhancing undergraduate chemistry laboratories, J. Carndoff, N. Reid, RS. C. Publication.

SEMESTER			**V**			
YEAR			**III**			
COURSE CODE			**22CY3503**			
TITLE OF THE COURSE			**PHYSICAL CHEMISTRY FOR BIOLOGICAL SCIENCES**			
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4		**4**		**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Students should gain a deep understanding of the basic concepts of thermodynamics, including the laws of thermodynamics, internal energy, heat, work, entropy, and the different thermodynamic functions.
• Through a variety of exercises and real-world examples, students should develop strong problem-solving skills related to thermodynamics in chemistry, enabling them to tackle complex thermodynamic problems.
• Students should be able to apply kinetic theories and concepts to analyse and predict the behaviour of chemical reactions, including reaction mechanisms, reaction order, and the effects of temperature, concentration, and catalysts on reaction rates.
• Students should be able to identify and understand the relevance of chemical kinetics in various real-world applications, such as industrial processes, environmental chemistry, and pharmaceutical research.
• Develop a comprehensive understanding of the structure, properties, and behavior of solid materials.
• Develop a thorough understanding of the principles of nuclear chemistry and its applications in various scientific and industrial contexts.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students should be able to articulate and explain the laws of thermodynamics, including the first, second, and third laws, and understand their significance in the context of energy and chemical systems.	L1
CO2	Students should be proficient in performing calculations involving thermodynamic quantities, such as heat transfer, work done, changes in internal energy, entropy changes, and Gibbs free energy changes.	L2

CO3	Students should be able to apply kinetic theories and concepts to analyze and predict the behavior of chemical reactions, including reaction mechanisms, reaction order, and the effects of temperature, concentration, and catalysts on reaction rates.	L3
CO4	Students should be able to identify and understand the relevance of chemical kinetics in various real-world applications, such as industrial processes, environmental chemistry, and pharmaceutical research.	L2
CO5	Students should be proficient in analyzing crystal structures of various solid materials, including simple and complex crystal lattices, and understand the relationship between crystal structures and material properties.	L1
CO6	Students should be proficient in understanding and analyzing nuclear reactions, including radioactive decay, nuclear stability, nuclear fission, and nuclear fusion, as well as the concepts of half-life, decay constant, and radioactivity.	L2

COURSE CONTENT:

MODULE 1	**15Hrs**

Thermodynamics

Exact and inexact differentials. Review of terms, I law of Thermodynamics. Work done (derivation with problems) in isothermal and adiabatic expansion and compression of an ideal gas (IUPAC sign conventions to be used). Heat capacity of a gas at constant pressure and constant volume: relation between P, V and T in an adiabatic process to be derived. Derivation of Kirchoff's equation. Numerical problems. Spontaneous and non-spontaneous processes.

Second law of thermodynamics: Limitations of I law of thermodynamics with illustrations. Need forII law of thermodynamics, different ways of stating II law with respect to heat and spontaneity. Other forms of II law of thermodynamics. Concept of entropy and its physical significance-illustrations with order, disorder, physical and chemical processes and probability.

Heat engine-Carnot's cycle and derivation of the expression for its efficiency. Problems based on efficiency equation. II law in terms of efficiency (η). Change in entropy in reversible and irreversible processes (derivations required) . Calculation of entropy changes in reversible isothermal and reversible adiabatic processes. Phase transitions in terms of Entropy (Fusion, vaporization, sublimation and polymorphic changes) in terms of entropy. Limitations of the entropy concept of spontaneity. Problem on Phase transitions. III law of thermodynamics-statement only. Elementary concept of residual entropy.

MODULE 2	**15Hrs**

Chemical Kinetics

Review of terms –Rate, Order and Molecularity, Derivation of expression for the rate constant of a second order reaction with $a = b$ and $a \neq b$. Expression for half-life of a second order reaction. Mean life for first order reaction to be mentioned. Problems on rate constant, half-life period, mean life period and order of reaction.

Determination of order of reaction: differential method, method of integration, method of halflife period and isolation method.

Theories of reaction rates: Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Problems. Simple collisions theory based on hard sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects. Steady state approximation and Lindemann's hypothesis. Experimental determination of kinetics of: (i) inversion of cane sugar by polarimetric method, (ii) spectrophotometric method for the reaction between potassium persulphate and potassium iodide.

MODULE 3	**15Hrs**

Electrochemistry

Conductance related terms, Methods of determination of molar conductance. Conductometric titrations (only acid-base type). Transport numbers: definition – determination by moving boundary method. Ionic mobility. Problems on transport numbers. Kohlrausch's law and its applications, Problems based on these. Qualitative account of Debye-Huckel theory, Debye-Huckel- Onsagar equation for aqueous solutions of 1:1 electrolytes. Verification of DHO equation. Galavanic cell: conventions of representing galvanic cells, derivation of Nernst equation for single electrodepotential (free energy concept). Determination of emf of a cell by compensation method. Liquid junction potentials, elimination of liquid junction potential. Types of electrodes: Metal and gas electrodes (chlorine), metal/metal insoluble salt electrodes, redox electrodes. Reference electrodes-
standard hydrogen electrode, calomel electrode, quinhydrone electrode and glass electrode. Determination of pH using these electrodes. Numerical problems.

MODULE 4	**15Hrs**

Solid state

Crystalline state, Laws of crystallography. Symmetry elements in crystals, crystal systems.Weiss and Miller indices. X-ray diffraction of crystals-derivation of Bragg's equation, Problems Liquid crycstals-Types with examples. Applications Superconducting Solids-High temperature superconductors. Applications.

Nuclear and Radiochemistry

Nucleus: Structure and stability, binding energy calculations. Instability of the nuclei, radioactive decay law, half life: numerical problems. Radioactive equilibrium, radioactive series. Artificial radioactivity: Nuclear reactions induced by γ-radiation,α,n,p,and d particles. Nuclear fission and fusion. Nuclear reactors, Breeder reactors, Isotopes- separation of isotopes, use of radio isotopes in tracer technique, agriculture, medicine, food preservation and Carbon dating-Numerical problems.

TEXT BOOKS/REFERANCES:

1. Physical Chemistry, 7th Edition P. W. Atkins and Julio de Paula, Oxford Univ. Press, 2002.
2. The Elements of Physical Chemistry, 3rd Edition Peter Atkins, Oxford Univ. Press, 2000.
3. Physical Chemistry – A molecular Approach Donal A. Mcquarrie and John D. Simon, Viva Low-priced Student Edition, 2001.
4. Introduction to Physical Chemistry, 3rd Edition Mark Ladd, Cambridge Low-Priced Edition, 1999.
5. Text Book of Physical Chemistry S. Glasstone, MacMillan India Ltd., 1998.
6. Principles of Physical Chemistry, 4th Edition B. R. Puri and L. R. Sharma and M. S. Pathania, S. L. N. Chand & Co., 1987

7. Text Book of Physical Chemistry P. L. Soni., S. Chand & Co., 1993.
8. Physical Chemistry Alberty R. A. and Silbey R. J. John Wiley & Sons, 1992.
9. Physical Chemistry G. M. Barrow, McGraw Hill, 1986.
10. Physical Chemistry, 3rd Edition Gibert W. Castellan, Narora Publishing House, 1985.

List of Laboratory/Practical Experiments to be conducted:
1. Determination of velocity constant for acid catalysed hydrolysis of methyl acetate and a. determination of energy of activation.
2. To determine the enthalpy change when a solute dissolved in a solvent.
3. The study of kinetics of potassium persulphate and potassium iodide.
4. Conductometric titration of hydrochloric acid with sodium hydroxide.
5. Determination of equivalent conductivity of 0.1 N sodium chloride and verification of 6. DHO equation.
7. Radiation Detection and Measurement using radiation detectors (e.g., Geiger-Müller counters)

TEXT BOOKS/ REFERENCES

1. Vogel's Text Book of Practical Organic Chemistry, 5th Edition, A.J. Hannford, A.R.Tatchell, B.S. Hurnis, P.W.G. Smith, Pearson Publication.
2. Enhancing undergraduate chemistry laboratories, J. Carndoff, N. Reid, RS. C.Publication.
3. Advanced Practical Chemistry, K. Chelladurai, K. Subbian, Lap Lambert Academic Publishing.
4. Experiments in Physical Chemistry 8th edition, Carl W. Garland, Joseph W. Nibler, and David P. Shoemaker, McGraw-Hill Education.

SEMESTER			**VI**			
YEAR			**III**			
COURSE CODE			**22CY3603**			
TITLE OF THE COURSE			**ORGANIC CHEMISTRY FOR BIOLOGICAL SCIENCES**			
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	4		**4**		**60**	**6**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES:
• Understand the structure, reactivity, and synthesis of aldehydes and ketones, and their significance in organic chemistry.
• Explore the properties, reactions, and applications of carboxylic acids and their derivatives.
• Master the principles of stereochemistry and their role in organic reactions.
• Master the fundamental principles of organic reaction mechanisms.
• Understand the principles of spectroscopic techniques used in chemical analysis.

COURSE OUTCOMES:		
CO No.	**OUTCOMES**	**BLOOM'S TAXONOMY LEVEL**
CO1	Students should be proficient in explaining the mechanisms of reactions involving aldehydes and ketones, including nucleophilic addition, oxidation, reduction, and condensation reactions. They should understand the importance of these compounds in both synthetic organic chemistry.	L1
CO2	Students should be able to explain the structure and reactivity of carboxylic acids,as well as their derivatives (esters, amides, acid chlorides, etc.), including hydrolysis, esterification, and acylation reactions.	L2
CO3	Students should be able to explain the mechanisms of various organic reactions, understand electron flow in chemical reactions (e.g., nucleophilic and electrophilic reactions), and predict the products of typical organic transformations. They should be familiar with key reaction intermediates and reaction pathways.	L3
CO4	Students should be proficient in explaining stereochemistry, including chiral molecules, enantiomers, diastereomers, and the basics of optical activity. They should be able to apply these concepts to predict stereochemical outcomes in organic reactions and to analyze the three-dimensional arrangement of molecules.	L2
CO5	Students should understand the underlying principles of various spectroscopic techniques, such as UV spectroscopy, nuclear magnetic resonance (NMR), and infrared spectroscopy (IR). They should be able to describe how these techniques provide information about molecular structure and behavior.	L3

COURSE CONTENT:	
MODULE 1	**15Hrs**
Aliphatic Hydrocarbons and Alcohol Alkanes: Sources, Nomenclature of branched chain alkanes, preparation of symmetrical and unsymmetrical alkanes- Corey- House reaction and Wurtz reaction - their merits and demerits. Conformational analysis of n-butane - Sawhorse and Newman projection formulae to be used-Energy profile diagram. Alkenes: Preparation of alkenes by Wittig reaction-stereoselectivity. Addition of HX to unsymmetrical alkene - Markownikov's rule and Antimarkownikov's rule with mechanism. Reactions: Hydroboration-oxidation, reduction, oxymercuration - demercuration, epoxidation. Alkynes: Methods of preparation - Dehydrohalogenation of vicinal and geminal dihalides; and higher alkynes from terminal alkynes. Reactions - metal ammonia reduction–significance. Oxidation with KMnO4, acidic nature of terminal alkynes. Alcohols: Introduction and classification. Methods of preparation - (i) From carbonyl compounds - reduction of aldehydes and ketones (by Meerwein-Pondorff-Verley reaction); (ii) from acids and esters (by reduction with LiAlH4); (iii) From alkenes (by hydroborationoxidation with alkaline peroxide); (iv) hydration of alkenes. Reactions of alcohols: Acidic nature, esterification, oxidation of alcohols with KMnO4. Comparison of the reactivity of 1°, 2° and 3° alcohols- Lucas test, oxidation with K2Cr2O7	
MODULE 2	**15Hrs**
Phenols, Aldehydes and Ketones Phenols: Classification. Acidic nature - Comparison of acidic strength of phenol with alcohols and monocarboxylic acids. Effect of electron withdrawing –NO2 group and electron donating –CH3 group on acidity of phenols at *o-,m-,p-* positions. Pechmann reaction, Mechanisms of Reimer-Tiemann and Kolbe-Schmidt reactions. Industrial applications of phenols: Conversion of phenol to (i) aspirin, (ii) methyl salicylate, (iii) salol, (iv) salicyl salicylic acid. Aldehydes and Ketones: Nomenclature. Preparation of aldehydes: from acid chlorides (Rosenmund reaction), Gattermann-Koch aldehyde synthesis. Preparation of Ketones: From nitriles, from carboxylic acids with alkyl lithium, from acid chlorides with metal alkyls. Mechanisms of: Aldol condensation, Perkin condensation, Knoevenagel condensation, Benzoin condensation and Acetal formation. General mechanism of condensation with ammonia and its derivatives ($NH_2{-}R$; $R = {-}NH_2$, $-OH$, $-NH{-}CO{-}NH_2$). Reduction: Reduction by LiAlH4 and $NaBH_4$. Mannich reaction. Mechanisms of Clemmensen and Wolff-Kishner reductions.	
MODULE 3	**15Hrs**
Carboxylic acids and Stereochemistry *Carboxylic acids:* Nomenclature. Preparation: Acid hydrolysis of nitriles with mechanism. Acidic strength (pKa values) - Effect of substituents on the strength of aliphatic and aromatic carboxylic acids. (comparison of acidic strength of formic and acetic acids; acetic acid and monochloro, dichloro, trichloro acetic acids ; benzoic and p-nitrobenzoic acid; benzoic acid and p-aminobenzoic acid) Reactions: Formation of esters, acid chlorides, amides and anhydrides. Hell-Vollhardt-Zelinski reaction, Mechanism of ester hydrolysis - acid and base catalysed (acyl O-cleavage: BAC2, AAC2; alkyl O-cleavage: AAL1 mechanisms).	

Stereochemistry: Elements of symmetry in chiral and achiral molecules, chirality, stereogenic centre. Fischer projection formulae.*Enantiomers*: Optical activity; use of +/–, *d/l* and D/L notations. Properties of enantiomers, chiral and achiral molecules with two stereogenic centers. Meso compounds. Cahn-Ingold-Prelog sequence rules: R, S system of nomenclature.*Diastereomers:* Threo and Erythro isomers. Racemisation and resolution. Relative and absolute configuration. *Optical isomerism due to* restricted rotation about single bonds- diphenyl systems.*Geometric isomerism*: Determination of configuration of geometric isomers. Cis & trans, E, Z system of nomenclature. Geometric isomerism in oximes.

MODULE 4	**15Hrs**

Spectroscopy

Fundamentals of Spectroscopy, Electromagnetic radiation.

Ultra-Violet and Visible Spectroscopy: The Absorption Laws, Measurement of Absorption Intensity, Theory of Electronic Spectroscopy,Types of Electronic Transitions, The Chromophore Concept, Auxochrome, Absorption and Intensity shifts, Applications of ultra-violet Spectroscopy.

Infra-Red Spectroscopy: Principle of infra-red spectroscopy, Theory—Molecular Vibrations, Factors Influencing Vibrational Frequencies, Scanning of Infra-red Spectrum (Instrumentation), Sampling Techniques, Finger Print Region, Spectral Features of Some classes of organic Applications of infra-red spectroscopy.

Nuclear Magnetic Resonance (NMR) Spectroscopy: Introduction, Theory, Positions of Signals (Chemical Shift), Internal Standards, Shielding and Deshielding Effects, Factors Influencing Chemical Shift, Solvents Used, Peak area and Proton Counting, Splitting of the Signals, Spin-spin Coupling, Coupling Constant (J), Some Important NMR Spectra, C13–NMR Spectroscopy, Applications of NMR Spectroscopy, Important Features in Nuclear Magnetic Resonance Spectroscopy, Simple Problems on Nuclear Magnetic.

List of Laboratory/Practical Experiments to be conducted:
1. Organic qualitative analysis of mono functional organic compounds through functional group analysis. (At least 5 organic functional groups)
2. Recrystallisation and determination of melting point of solids (mixed melting point determination and its importance may be mentioned).
3. Simple distillation and determination of boiling point of liquids.
4. Purification of solids by sublimation.

TEXT BOOKS/REFERENCE BOOKS

1. Vogels Textbook Of Practical Organic Chemistry 5Th Edition, FURNISS and BRIAN S and HANNAFORD and ANTONY J, PEARSON INDIA.
2. Microscale Organic Laboratory: With Multistep and Multiscale Syntheses" by Dana W. Mayo, Ronald M. Pike, and David C. Forbes, J. Wiley & Sons.
3. Experimental Organic Chemistry: A Miniscale and Microscale Approach" by John C. Gilbert and Stephen F. Martin, Cengage Learning Publisher.
4. A Small Scale Approach to Organic Laboratory Techniques" 3rd edition, Donald L. Pavia, George S. Kriz, and Gary M. Lampman, Cengage Learning Publisher.