M.Sc.,
BIOTECHNOLOGY

ACADEMIC YEAR 2026-2027

M.Sc., BIOTECHNOLOGY

The course of study and scheme of examination

A.University Vision

To provide quality education to reach the un-reached.

B.University Mission

- To conduct research, teaching and outreach programmes to improve conditions of human living.
- To create an academic environment that honours women and men of all races, caste, creed, cultures and an atmosphere that values intellectual curiosity, pursuit of knowledge, academic freedom and integrity.
- To offer a wide variety of off-campus educational and training programs, including the use of information technology, to individuals and groups.
- To develop partnership with industries and government so as to improve the quality of the workplace and to serve as catalyst for economic and cultural development.
- To provide quality/inclusive education, especially for the rural and un-reached segments of economically downtrodden students including women, socially oppressed and differently abled.

C.PREAMBLE

Master of Science (M.Sc.) in Biotechnology, the curricula, and course content were designed to meet the standards of UGC-CSIR (NET) and (SLET) examinations. The choice- based credit system of learning develops a strong base in the core subject and specializes in the disciplines of his / her liking and abilities and develops an in-depth understanding of various aspects of Biotechnology. The students develop experimental skills, design, and implementation of novel synthetic methods, and develop the aptitude for academic and professional skills, by acquiring basic concepts for structural elucidation with hyphenated techniques, and understanding the fundamental biological process and rationale of the computer. The project introduced in the curriculum will motivate the students to pursue research and entrepreneurial skill development**.**

D. PROGRAMME EDUCATIONAL OUTCOMES (PEO)

In alignment with the Vision and Mission of the University, the following have been defined as the PEO for the graduates.

PEO1: Developing strong positive attitude to learn independently the concepts in the field of study

PEO2: Ensuring confidence among the learners to apply the knowledge and skills gained to solve real life issues

PEO3: Habituating ethical values among the learners to succeed in personal and professional life

E. PROGRAMME OUTCOMES (PO)

Programme Outcomes for the Under Graduate Degree Programmes of the University are articulated as under.

After the successful completion of Undergraduate Programme from the University, the learner should be able to

PO1: Comprehend the knowledge acquired and communicate the same to others

PO2: Analyze and compare the factual data / situation to comprehend and to critically evaluate to find solution to the problem ahead

PO3: Apply theories and philosophies learned in solving the problem in scientific manner

PO4: Think reflectively on the earlier activities and attempt for self-directed lifelong learning process

PO5: Understand multicultural existence and identify the means to prolong moral/ethical values in personal and professional life

PO6: Explore through multiple sources and get exposed to the digital literacy and information explosion with latest technology

PO7: Act as a responsible member in the varies teams with facilitating capability and formulate teams as a leader for defined purposes

F. PROGRAMME SPECIFIC OUTCOMES (PSO)

On completion of the programme, graduates will be able to:

PSO1: Disciplinary Knowledge Apply advanced theoretical and practical knowledge of core disciplines—including biochemistry, microbiology, molecular biology, genetics, biostatistics, bioinformatics, and immunology—to support higher studies, cutting-edge research, and innovation.

PSO2: Critical Thinking Analyze complex biological and biotechnological problems critically, evaluating appropriate methodologies, bioethics, regulatory affairs, and safety solutions within academic, industrial, and healthcare contexts.

PSO3: Problem Solving Solve intricate biological, environmental, and health-related challenges using logical reasoning, robust scientific experimental design, and modern computational tools like bioinformatics.

PSO4: Analytical Reasoning Interpret complex experimental data, molecular structures, and metabolic pathways using quantitative and qualitative techniques to address scientific, agricultural, and sustainability-related challenges.

PSO5: Research Skills Demonstrate advanced research aptitude by formulating valid biological hypotheses, conducting rigorous laboratory experiments, analyzing data, and effectively communicating scientific findings through publications and presentations.

PSO6: Self-directed Learning Engage in lifelong learning and independently adapt to rapid

technological advancements in biotechnology, genetic engineering, synthetic biology, and evolving life science domains.

PSO7: Employability and Entrepreneurship Master advanced laboratory techniques and develop business acumen to foster employability, entrepreneurship, and career readiness across the pharmaceutical, food processing, agricultural, and tech-driven bio-sectors.

Each Course has to address a minimum of 4 PSOs

Level of contribution of the Course towards attaining PSOs

0 – No Contribution 1 – Low Level 2 – Medium Level 3 – High Level

F. COURSE OUTCOMES (CO)

Four Course Outcomes (COs) for each course that can be achieved by the learners on completion of that particular course are as follows:

Considering outcomes related to

i. K1 and K2 level of evaluation in all the Units as CO1

ii. K3 level of evaluation in all the Units as CO2

iii. K4 level of evaluation in all the Units as CO3

iv. K5 and K6 level of evaluation in all the Units as CO4.

All the COs proposed in each of the courses should be mapped with POs based on the relevance.

Level of Correlation between COs and POs

0 – No Correlation 1 – Low 2 – Medium 3 – High

G.PROGRAMME DETAILS

Eligibility Criteria

The Candidates who shall be admitted to the M.Sc Biotechnology course, should have passed B.Sc degree with Biotechnology/any life Science subject that may be considered as equivalent by Manonmaniam Sundaranar University.

Medium of Instruction: English

Duration of the Programme: 2 Years

Examination Pattern:

	External marks	**Internals marks**	**Total marks**

Theory	75	25	100
Practical	50	50	100

Time allotted: Theory – 03Hrs & Practical – 03 hrs

Marks allotted for university examination:

Marks distribution for internals:

	Test	**seminars**	**Assignment**	**Total marks**
Theory Internal	15	05	05	25

	Test	**Record**	**Total marks**
Practical Internal	25	25	50

Pattern of question paper (theory)

I. QUESTION PAPER PATTERN

The question paper pattern for all theory papers shall be as follows.

Duration of Exam: 3Hours

Section	Type of questions	Mark
Part-A	Multiple choice question (Two question from each unit compulsory)	15×1=15 Marks
Part-B	Internal Choice questions (One question from each unit: either/or)	5×4=20 marks
Part-C	Internal Choice questions (One question from each unit: either/or)	5×8=40 marks
	Total	**75 Marks**

J. MODEL QUESTION PAPER

Subject: Microbiology

Part A- (15 x 1 = 15 marks)
Answer ALL questions
Choose the correct answer

1. Which kingdom includes bacteria?
   (a) Protista (b) Monera
   (c) Fungi (d) Plantae
2. A scientist wants to observe the internal structure of bacteria at very high magnification. Which microscope should be used?
   (a) Dark field (b) Fluorescent
   (c)Electron (d) Light
3. Which feature helps to distinguish eukaryotic microorganisms from bacteria

(a) Presence of DNA (b) Presence of ribosomes
(c) Presence of membrane bound nucleus (d) Presence of cytoplasm

4. High temperature can kill microorganisms because it
(a) Increases oxygen (b) Denatures proteins and enzymes
(c) Produces vitamins (d) Removes nutrients

5. A bacterium grows using sunlight as energy and CO_2 as carbon source. It is classified as
(a) Chemoheterotroph (b) Photoautotrophs
(c) Chemoautotroph (d) Saprophyte

6. If bacteria are counted by colony formation on agar plates, the method measures:
(a) Total cells (b) Dead cells only
(c) Viable cells (d) Viral particles

7. Arrange the following moist heat sterilization methods in increasing order of temperature used:
1. Pasteurization 2. Boiling 3. Autoclaving
(a) 1 → 2→ 3
(b) 2 → 1→ 3
(c) 3 → 2→ 1
(d) 1 → 3→ 2

8. Match the following in the sequence as: method-purpose-result

Method	Purpose	Result
A .Sterilization	1. Disinfection	P. Antisepsis
B. Disinfection	2.Reduce pathogens	Q. Safer surfaces
C. Antisepsis	3. Prevent infection in tissues	R. Safe living tissues

(a) A-1-P , B-2-Q, C-3-R
(b) A-2-Q, B-1-P, C-3-R
(c) A-3-R, B-2-P, C-1-Q
(d) A-1-Q, B-3-R, C-2-P

9. A hospital uses UV lamps in operation theatres after surgery hours. What is the best justification for using UV radiation?
(a) UV rays deeply penetrate surgical instruments
(b) UV rays damages microbial DNA on exposed surfaces
(c) UV rays increases oxygen concentration
(d) UV rays replaces autoclaving completely

10. Which statement about molecular analysis of bacterial communities is incorrect?
(a) It helps to study microbial diversity
(b) It commonly uses nucleic acid analysis
(c) It avoids the need for microbial cultivation in many cases
(d) It identifies microbes only through staining reactions

11. Assertion (A): ARDRA involves restriction digestion of amplified ribosomal DNA
Reason (R): ARDRA is used to study bacterial diversity and identification

(a) Both A and R are true, and R is the correct explanation of A (b) Both A and R are true, but R is not the correct explanation of A
(c) A is true, but R is false
(d) A is false, but R is true

12. Culture independent methods are especially useful for studying ---------- microorganisms
    (a) Pathogenic only (b) Unculturable
    (c) Photosynthetic only (d) Thermophilic only

13. A microorganism isolated from Soda lake grows best at pH 10. This justifies classifying it as
    (a) Acidophile (b) Halophile
    (c) Alkaliphile (d) Mesophile
14. A milk sample left outside refrigeration develops odour, sour and curdling within hours. Which factor best explain this
    (a) Growth of microorganisms utilizing milk nutrients
    (b) Lack of proteins in milk
    (c) Absence of bacteria in milk
    (d) Radiation sterilization of milk
15. Arrange the sequence involved in pasteurization of milk
    (a) Cooling (b) Heating milk
    (c) Destruction of pathogens (d) Safe storage

    (a) 2 → 3→ 1→4
    (b) 2 → 1→ 3→4
    (c) 3 → 2→ 1→4
    (e) 1 → 3→ 2→4

SECTION B – (5x4 = 20 marks)
Answer ALL questions choosing either (a) or (b).
Each answer should not exceed 250 words

16. (a) Differentiate between prokaryotic and eukaryotic microorganisms

    Or

    (b) Explain how staining improves visibility of microorganisms under a microscope

17. (a) Explain the concept of synchronous culture

    Or

    (b)Explain the composition and function of culture media
18. (a) Compare moist heat sterilization and dry heat sterilization based on principle, temperature and applications

    Or

    (b)Explain the different classes of antibiotics based on their mode of action
19. (a) Assess the advantages of ARDRA in microbial identification

    Or

(b)Analyze the principle of Density gradient gel electrophoresis

20. (a) Analyze the role of microorganisms in food spoilage

Or

(b) Analyze the survival adaptations of extremophiles in harsh environments

SECTION C – (5x8 = 40 marks)
Answer ALL questions choosing either (a) or (b)
Each answer should not exceed 600 words

21. (a) Describe the structure and working principle of a Light Field microscope

Or

(b)Describe the structure and functions of a eukaryotic cell

22. (a) Explain the importance of pure culture techniques in Microbiology

Or

(b)Predict what will happen to microbial growth if essential nutrients are absent in the medium

23. (a) Design a complete protocol for antimicrobial susceptibility testing and interpretation of results

Or

(b)Analyze the various methods of sterilization and disinfection used in Microbiology laboratories

24. (a) Analyze the various methods sued to assess the microbial diversity in natural environments

Or

(b)Evaluate the effectiveness of culture-independent methods over culture-dependent methods in Microbial ecology

25. (a) Discuss the diversity of microorganisms associated with food and milk and their significance

Or

(c) Assess the importance of extremophiles in Biotechnology

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Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum Framework (LOCF) Guideline Based Credits and Hours Distribution System

For all Post – Graduate Courses including Lab Hours

FIRST YEAR – SEMESTER – I

Part	List of Courses	Credits	No. of Hours
	Core – I	4	5
	Core – II	4	5
	Core – III	4	5
	Elective – I	2	4
	Elective – II	2	3
	Practical-I	4	8
		20	**30**

SEMESTER-II

Part	List of Courses	Credits	No. of Hours
	Core – IV	4	5
	Core – V	4	5
	Core – VI	4	5
	Elective –III	4	4
	Elective –IV	2	3
	Practical –II	2	6
	Skill enhancement Course-1	2	2

		22	**30**

SECOND YEAR – SEMESTER – III

Part	List of Courses	Credits	No. of Hours
	Core – VII	4	5
	Core – VIII	4	5
	Core – IX	4	5
	Core (Industry Module) – X	4	5
	Elective – V	2	3
	Practical –III	2	2
	Practical –IV	2	3
	Skill Enhancement Course - II	2	2
	Internship / Industrial Activity/Field visit/Research Updating activity*	2	-
		26	**30**

SEMESTER-IV

Part	List of Courses	Credits	No. of Hours
	Core – XI	4	5
	Core – XII	4	5
	Project with VIVA VOCE	7	10
	Practical-V	2	3
	Elective – VI (Industry Entrepreneurship)	3	4
	Skill Enhancement Course – III / Professional Competency Skill	2	3
	Extension Activity	1	-
		23	**30**

Total 91 Credits for PG Courses

***- Internship / Industrial Activity/Field visit/Research Updating activity-A report should be submitted at the end of IIIrd Semester and evaluated by external examiners**

-Internship students should submit certificate of attendance from the industry along with the report.

FIRST YEAR

Subject Status (Core/Elective)		*Subject Title*	*ins. hrs /week*	*Credits*	*Int. Marks*	*Ext. Marks*	*Total*
SEMESTER I							
Core Course	Core Paper- I	Biochemistry	5	4	25	75	100
	Core Paper - II	Cell and Molecular Biology	5	4	25	75	100
	Core Paper - III	Microbiology	5	4	25	75	100
	Core Practical-I	Lab in Biochemistry, Cell & Molecular Biology & Microbiology	8	4	50	50	100
Elective	Elective- I	A. Genetics B. Virology C. Basic Analytical Methods	4	2	25	75	100
	Elective-II	A. Enzyme technology B. Dairy technology C. Pharmaceutical technology	3	2	25	75	100
			30	**20**			
SEMESTER II							
Core Course	Core Paper -IV	Immunology	5	4	25	75	100
	Core Paper - V	Genetic Engineering	5	4	25	75	100
	Core Paper -VI	Developmental and Stem cell Biology	5	4	25	75	100
	Core Practical-II	Lab in Immunology & GeneticEngineering	6	4	50	50	100
Elective	Elective -III	A. Medical Laboratory Technology B. Food and Nutrition C. Biodiversity	4	2	25	75	100
	Elective - IV	A. Genomics & Proteomics B. Environmental Sciences C. Herbal Biotechnology	3	2	25	75	100
Skill Enhancement Course	SEC - I	A. Mushroom Cultivation and Apiculture B. Vermiculture Technology C. Validation of Medicinal Plants	2	2	25	75	100
			30	**22**			

L. Mapping of Course Outcomes (COs) with Programme Outcomes (POs) and Programme Specific Outcomes (PSOs) can be carried out accordingly, assigning the appropriate level in the grids:

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1														
CO2														
CO3														
CO4														

FIRST YEAR- SEMESTER-I

Course	**CORE PAPER -I**
Title of the Course	**BIOCHEMISTRY**
Credits	**4**
Hours/Week	**5**
Course Objectives	1.To learn the physical and chemical nature of Biomolecules 2.To learn various types of biomolecules 3.To develop knowledge on intermediary metabolism of CHO, Proteins, and Lipids 4.To teach the basics and advance of enzymes and their classifications 5. To develop a piece of knowledge in clinical biochemistry.

Units	**Course Contents**	**Teaching hours**
Unit I	Basic Concepts: Units of measurements of solutes in solution, e.g. Normality, Molality, Molarity. Hyper and hypotonic solution, pH, pK, acids, bases, Types of bonds - ionic bonds, covalent bonds, hydrogen bonds and Vander Waals interactions)	12 hours

Unit-II	Biomolecules: Definitions, nomenclature, classification and structure of carbohydrates, Definitions, nomenclature, classification and structure of amino acids and proteins (hemoglobin, myoglobin, and plasma proteins), lipids and Nucleic acids.	12 hours
Unit-III	Metabolism: Metabolism of Carbohydrates - EMP, TCA, HMP. Glycogen metabolism, Gluconeogenesis. Amino Acids -Transamination, Deamination, Urea cycle. Lipids and Nucleic Acids - Biosynthesis of fatty acids, Metabolism of nucleotides- Salvage pathway, Mechanism of Oxidative Phosphorylation and Photophosphorylation	
Unit-IV	Enzymology: Enzymes: Historical background, Nomenclature and classification, Chemical nature, Factors affecting enzyme activity, Active sites. Iso-enzymes and Enzyme kinetics (MM, LB plot, Km)	12 hours
Unit-V	Clinical biochemistry: Blood sugar level, Factors controlling blood sugar level – hypo, hyperglycemia, Diabetes mellitus, types – GTT. Metabolism of bilirubin- jaundice-types. Differential diagnosis and liver function tests. Renal functional tests and gastric function tests.	12 hours
Unit-VI	**Internal Assessments, Seminars, and Guest lecture**	05 hours
Total Teaching hours		65

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Textbook:

1. J.L. Jain, S. Jain and N. Jain. Fundamentals of Biochemistry. S. Chand & Co, 2016.
2. Ambika Shanmugam. Biochemistry. Published by Wolters Kluwer, 8th Edition, 2016.
3. A.C. Deb. Fundamental of Biochemistry. New Central Book Agency, 2012
4. Biochemistry, 7th Edition, Jermy M. Berg John, L. Tymoczko, Lubertstryer, 2012.W.H, Freeman & company NewYork 2.
5. Molecular Bio methods handbook, 2nd edition R.Rapley & J.M Walker, 2008, Humanapress.
6. Principles of Biochemistry, 5th Edition AL. Lehninger, D.L. Nelson and M.M Cox ., 2008.worth publishers , NewYork.
7. Biochemistry , 4th Edition, G.Zubay,1998. Mc Millan publishing Co.NewYork.
8. Harper‟s Biochemistry,29th Edition-Rober K. Murray, DarylK.Grammer,2012 Mc Graw Hill, lange Medical Books
9. Understanding enzymes -5theditionTrevorpalmer,Prentice Hall/Ellias Horwood1995
10. Text Book Medical Biochemistry M.N. Chatterjee 8th edition Jaypeebrothers Medicalpublishers.2013

Reference Book:

1. D.L. Nelson and M.M. Cox. Lehninger, Principles of Biochemistry, WHFreeman Publishers, 7th Edition, 2017.
2. V.W. Rodwell, D.A. Bender, K.M. Botham, P.J. Kennell and P.A. Weil.Harper's Illustrated Biochemistry, 30th Edition. McGraw Hill, 2015.
3. Wilson and Walker. Principles and Techniques of Practical Biochemsitry, 6th edition, Cambridge University, Press. 2005.
4. Upadhyaya A Upadhyaya K and Nath. Biophysical Chemistry: Principlesand Techniques, 3rd Edition. Himalayan publications, 2009.
5. M.N. Chatterjee and Rana Shinde, Textbook of Medical Biochemistry, 8thEdition. Jaypee Brothers Medical Publishers (P) Ltd., 2012.
6. Biochemistry – 4th edition Donald voet and Judith G.Voet ,VP Publishers2011 steitz and A.M.Weiner ,The Benjamin /CUMMINGS publ.Co.,Inc.,California,2013
7. Genes VI (9th Ed).Benjamin Lewin, oxford universitypress,uk.,2007 10. Molecularbiology of cell (5th edition) brucealberts, alexanderjohnson, Julianlewis, martinraff, keithRoberts, peterwalter, garland sciencepublications.2008
8. Molecular Biology (5th edition).weaver . R.F,McGraw Hillpublications,2011. Cell and molecular biology : concepts and experiments (5th edition).geraldkarp,wiley publications,2013

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites, etc.]

https://nptel.ac.in/courses/104105076,https://oli.cmu.edu/courses/biochemistry-open-free/,
https://onlinecourses.nptel.ac.in/noc20_cy10/preview,
E-Books: https://www.pdfdrive.com/biochemistry-books.html,
E-journals: Process Biochemistry (Elsevier), Journal of Cellular Biochemistry (Wiley)

COURSE OUTCOMES (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Define and explain the core concepts of solution chemistry, the structural classifications of primary biomolecules major metabolic pathways, basic enzyme kinetics, and clinical biomarkers of metabolic disorders.

CO2 (K3 - Apply): Apply principles of molarity and pH to solution preparation, use metabolic pathway mechanisms to calculate energy yields, and utilize enzyme kinetic equations to determine enzymatic activity and inhibition.

CO3 (K4 - Analyze): Analyze and contrast the functional differences between aerobic and anaerobic metabolic pathways, investigate the factors influencing enzyme kinetics, and examine the metabolic interrelationships between different organ functions based on clinical biochemistry profiles.

CO4 (K5 & K6 - Evaluate & Create): Evaluate clinical laboratory data to diagnose metabolic pathologies like Diabetes mellitus and jaundice, and synthesize holistic metabolic frameworks mapping the integration of carbohydrate, lipid, and protein metabolism in healthy versus diseased states.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	**CORE PAPER -II**
Title of the Course	**CELL AND MOLECULAR BIOLOGY**
Credits	**4**
Hours/Week	**5**
Course Objectives	1.To understand the basic concepts of the prokaryotic and eukaryotic cells. 2.To Understand the individual and coordinated functions of various cell organelles. 3.To familiarize the student with various aspects of cell and molecular biology streams including cellular organization and their interactions in DNA replication, protein biosynthesis, and translational regulation 4.To develop a comprehensive understanding of the complete cellular and molecular function of cell organelles in terms of cell-to-cell interaction, gene regulation, cellular signaling 5.To impart the molecular biology knowledge in applications of various human health care

Units	**Course Contents**	**Teaching hours**
UNIT I	Cell Biology: Structure and function of cells in prokaryotes and eukaryotes; Structure and organization of Membrane - Membrane Model, active and passive, transport channels and pumps. Structure& Biogenesis of Mitochondria and Chloroplast. Structure of Endoplasmic reticulum, Golgi complex, lysosomes.	12 hours
UNIT-II	Cell division: Mitosis, Meiosis, regulation of cell cycle; Factors regulating cell cycle. Nucleic acid structure, Genome Organization. DNA replication: Enzymes and mechanisms of DNA replication in prokaryotes and eukaryotes, Telomeres, telomerase and end replication. Role of telomerase in aging and cancer. DNA replication models, DNA damage, Mutations, DNA repair and recombination.	12 hours
UNIT – III	Transcription: Basic mechanism in prokaryotes and eukaryotes. RNA polymerase, Reverse transcriptase and regulation. Post- transcriptional processing: 5'-Cap formation; 3'-end processing and polyadenylation; splicing: RNA editing; Nuclear export of mRNA; mRNA stability. Translation - Prokaryotic and eukaryotic translation, the translation machinery, Mechanisms of initiation, elongation and termination, Regulation of translation, co-and post-translational modifications of proteins and localization.	12 hours
UNIT – IV	Gene regulation: Prokaryotic gene regulation- Operon concept; Lac operon and tryptophan operon. Eukaryotic gene regulation: Chromatin Structure, Regulation at transcriptional Level: DNA binding domains of the regulatory proteins. Transposable genetic elements	12 hours

UNIT-V	Epigenetics: Epigenetic regulation of gene expression, Modifications, Cancer Epigenetics. Cancer Biology: Viral and cellular oncogenes; Tumor suppressor genes - Structure, function and mechanism of action of pRB and p53, p21, BRACA1. Oncogenes as transcriptional activators.	12 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lectures	5 hours
Total Lecture hours 65 hours		65 hours

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text Books

1. Molecular cell Biology, by Darnell, Lodish, Baltimore, Scientific American Books, Inc., 1994.
2. Molecular and cellular Biology, Stephen L. Wolfe, Wadsworth Publishing Company, 1993.
3. Cell and Molecular Biology: Concepts and Experiments 5th Ed, Gerald Karp. Wiley publications, 2013.
4. Cell biology D E Sadava, CBS Publishers & Distributors, 2009

Reference books

1. Molecular and cellular Biology, Stephen L. Wolfe, Wadsworth Publishing Company,1993
2. Molecular Biology LabFax, T.A. Brown (Ed.), Bios Scientific Publishers Ltd., Oxford, 1991
3. Molecular Biology LabFax, T.A. Brown (Ed.), Bios Scientific Publishers Ltd., Oxford, 1991.
4. Molecular Biology of the Gene (4th Edition), J.D.Watson, N.H.Hopkins, J.W.Roberts,
5. J.A. Steitz and A.M.Weiner, The Benjamin/Cummings Publ. Co., Inc., California, 1987.
6. Genes VI (6th Edition) Benjamin Lewin, Oxford University Press, U.K.,1998
7. Molecular biology of cell – Albert Bruce et al.,1994 3rd Ed.
8. Molecular Biology-Weaver. R. F. 3rd ed. Mc Graw Hill publication ,2005
9. The Molecular Biology of Cancer: S. Pelengaris, M. Khan. Blackwell Publication.2002

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites, etc.]

1. Swayam- Molecular biology course by Dr. Nayan K. Jain, Gujarat University
2. Swayam- Cell Biology by Dr K. Sanatombi
3. NPTEL - Molecular Cell Biology by Prof. D. Karunagaran
4. https://www.coursera.org/courses?query=molecular%20biology
5. https://www.cdc.gov/labtraining/training-courses/basic-molecular-biology/index.html

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the structural organization of prokaryotic and eukaryotic cells, cell organelles, and membrane transport systems, while explaining the fundamental mechanisms of genome organization, DNA replication, transcription, translation, operon regulation, and epigenetic modifications.

CO2 (K3 - Apply): Apply knowledge of cellular transport, enzymatic replication/transcription machinery, and translational regulation to solve conceptual and quantitative problems relating to gene expression, mutation frequencies, and protein localization.

CO3 (K4 - Analyze): Analyze the functional differences between prokaryotic and eukaryotic molecular processes, evaluate the multi-tiered regulation of cell cycles, post-transcriptional/translational modifications, and distinguish the distinct regulatory mechanisms of oncogenes versus tumor suppressor genes ($p53$, pRB).

CO4 (K5 & K6 - Evaluate & Create): Evaluate experimental evidence and molecular models concerning DNA repair, transposable elements, and chromatin structure, and synthesize comprehensive conceptual frameworks illustrating how dysregulated cell cycle checkpoints, mutations, and epigenetic variations culminate in aging and cancer.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	CORE PAPER -III
Title of the Course	MICROBIOLOGY
Credits	4
Hours/Week	5
Course Objectives	1. To understand the History of Microbiology. 2. To well understand the Nutritional classification of bacteria, etc. 3. To obtain knowledge about Sterilization and Disinfection. 4. To obtain knowledge of Microbial diversity. 5. To know the basic Microbial community in natural habitats.

Units	Course Contents	Teaching Hours
Unit-I	History of Microbiology - Classification of microorganisms – Kingdom - Protista, Prokaryotic and eukaryotic microorganisms, Five kingdom concept of classification, Archaebacteria, Eubacteria and eukaryotes. Microscope - Light field, Dark field, Fluorescent and Electron microscope, Prokaryotic and Eukaryotic cell structure. Staining techniques – Simple and Differential staining.	12 hours
Unit-II	Nutritional classification of bacteria, Isolation, cultivation, enumeration and preservation of microbes; Culture media and its types - Pure culture technique - Growth curve; Axenic culture, Synchronous culture, Continuous culture; Effect of physical and chemical factors on microbial growth.	12 hours
Unit-III	Sterilization and Disinfection: Moist heat, Dry heat, Radiation, Filtration, Phenols, Halogens, Phenol coefficient method. Antibiotics - Inhibitors of Nucleic acid, protein and cell wall synthesis. Chemotherapeutic agents - Antimicrobial susceptibility test.	12 hours
Unit-IV	Microbial diversity- methods to assess microbial diversity, Culture dependent and culture-independent methods. Molecular analysis of bacterial community; Denaturating Gradient Gel Electrophoresis (DGGE), Terminal Restriction Fragment Length (TRFL) Polymorphism (T- RFLP), Amplified Ribosomal DNA and Restriction Analysis (ARDRA).	12 hours
Unit-V	Microbial communities in natural habitats – air, water, soil, food, and milk. Food and milk-borne diseases, Extremophiles - habitant & Classification, Halophiles, Thermophiles, Alkaliphiles, Acidophiles, Biotechnological applications of Extremophiles.	12 hours

Unit-VI	Internal Assessments, Seminars, and Guest Lectures	05 hours
	Total Teaching hours	65

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text book:

1. Microbiology 3rd Edition by Dave Wessner (Author), Christine Dupont (Author), TrevorCharles (Author), Josh Neufeld (Author) 3rd edition (December 3, 2020)
2. Fundamentals of Microbiology 12th Edition by Jeffrey C. Pommerville (Author) 12th edition (March 29, 2021).
3. Burton's Microbiology for the Health Sciences 11th Edition by Paul G. Engelkirk (Author) 11th edition (October 10, 2018)
4. Brock Biology of Microorganisms plus Pearson Mastering Microbiology with Pearson eText,Global Edition 15th Edition 15th edition (March 27, 2018)
5. Microbiology: An Evolving Science Fifth Edition by Joan L. Slonczewski (Author), John W.Foster (Author), Erik R. Zinser (Author) Fifth edition (July 1, 2020).
6. Microbiology with Diseases by Taxonomy, Loose-Leaf Plus Mastering Microbiology withPearson eText -- Access Card Package (6th Edition) 6th Edition 6th edition (January 14, 2019).

Reference Book:

1. Medical Microbiology: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and Control. With STUDENT CONSULT Online Access (Greenwood, Medical Microbiology) 17th Edition by David Greenwood BSc PhD DSc FRCPath (Author), Richard C. B. Slack MA MB BChir FFPHM MRCPath DRCOG (Author), John F. Peutherer BSc MB ChB MD FRCPath FRCPE (Author), & 1 more Churchill Livingstone; 17th edition (June 6, 2007)
2. Microbiology Experiments: A Health Science Perspective Paperback – International Edition,January 1, 2018MC GRAW HILL; 9th edition (January 1, 2018)
3. Hugo and Russell's Pharmaceutical Microbiology, 8th Edition by Denyer (Author) Wiley-Blackwell; (August 12, 2011)
4. Clinical Bacteriology Hardcover – August 1, 1980 by E Joan Stokes E Arnold; Fifth Edition(August 1, 1980)
5. Review of Medical Microbiology and Immunology (Medical Microbiology & Immunology(Levinson) 9th Edition (March 10, 2006).

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Identify the historical milestones in microbiology, explain the principles of microscopy and staining, describe the nutritional and structural classifications of microorganisms, and outline the concepts of microbial growth, sterilization, and ecological diversity.

CO2 (K3 - Apply): Apply appropriate isolation, cultivation, enumeration, and preservation techniques for microbial cultures, implement sterilization methods and antimicrobial susceptibility tests in laboratory environments, and use mathematics to calculate microbial growth kinetics.

CO3 (K4 - Analyze): Analyze the differences between culture-dependent and culture-independent methods for assessing microbial diversity, contrast the mechanisms of molecular analysis techniques (such as DGGE, T-RFLP, and ARDRA), and examine the physiological adaptations of different types of extremophiles.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the efficacy of physical and chemical disinfectants using metrics like the phenol coefficient, appraise clinical and safety hazards of food- and milk-borne pathogens in natural habitats, and formulate biotechnological frameworks to utilize extremophiles and their enzymes for industrial or environmental solutions.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	CORE PRACTICAL -I
Title of the Course	Lab In Biochemistry, Cell & Molecular Biology and Microbiology
Credits	4
Hours/Week	8

Unit	Course Content	Teaching Hours
UNIT I	**Biochemistry** 1. Determination of Chl.a, Chl.b & total Chl. by Arnon method. 2. Estimation of Carbohydrates 3. Estimation of salivary amylase activity in relation to, substrate/pH/Temperature 4. Estimation of blood glucose &urea 5. Estimation of total serum proteins 6. Estimation of creatinine in urine. 8. Paper / thin layer chromatography	20 hours
UNIT-II	**Cell and Molecular biology** 1. Isolation of Genomic DNA from E.coli 2. Isolation of plasmid DNA from E.coli 3. Elution & quantification of DNA from agarose gel. 4. Preparation of competent cells and transformation 5. PCR 6. Isolation of Total RNA from bacteria	20 hours
UNIT – III	**Microbiology** 1. Sterilization techniques 2. Preparation of culture media (Selective and Enriched media) 3. Staining techniques- Simple, Differential and Motility studies 4. Determination of Bacterial growth curve 5. Enumeration of bacteria from environmental samples- soil and water 6. Pure culture techniques - Streak, pour plate and spread plate. 7. Biochemical tests for identification of bacteria (IMViC, TSI, Catalase, Oxidase) 8. Water quality analysis – MPN method.	25 hours
	Total Lecture hours	**65 hours**

Method of Evaluation: (50 Internal marks + 50 External Marks=100)

Distribution for internals Test (CIA I + CIAII)	End Semester Examination	Total marks
50	50	100

Reference

1. Introduction to Practical Biochemistry, E.F Plummer Mu, Plummer TataMcGraw-Hill Education, 1998.
2. Molecular cloning: a laboratory manual, 4th ed. J.Sambrook, Fritsch and T.Maniatis. cold spring harbor laboratory press, NewYork,2012
3. Essential Cell Biology : a practical approach volume 1: cell structure. JohnDavey, J. Michaellord. Oxford university press, USA, 2003
4. Principles and techniques of biochemistry and molecular biology (7th ed).keithWilson(editor),john walker (editor),Cambridge universitypress,2010.
5. Microbiology- A Laboratory manual P. Gunasekaran . New age publications, Newdelhi,1995.
6. Molecular cloning-A Laboratory manual. Sambrook, J , Fritsch. E.F, and T.Maniatis, 2nd Edition. Cold spring Harbor Laboratory press, New York, 1989.
7. Laboratory exercise of Microbiology, J.P. Harley and L.M. Prescott, 5th Edition, theMcGraw-Hill companies, 2002.
8. Microbiology: A Laboratory Manual, J.G. Cappuccino and N. Sherman, Addison-Wesley, 2002.
9. Laboratory Manual of Experimental Microbiology ,R.M.Atlas, A.E.Brown and L.C.Parks, 1995. Mosby, St.Louis,2002.
10. Laboratory manual in General Microbiology, N.Kannan, Panimapublishers.
11. Bergey‟s Manual of Determinative Bacteriology. Ninth Edition J.G.Holt,R.Krieg.,Lippincott Williams, Wilkin publishers, 2000.

Based on the guidelines and structure provided in your document, here are the four **Course Outcomes (COs)** tailored specifically to this Practical/Laboratory syllabus covering Biochemistry, Cell & Molecular Biology, and Microbiology (Units I to III).
Because this is an experimental, hands-on lab syllabus, the outcomes focus heavily on technical execution, data interpretation, troubleshooting, and experimental design within the required Bloom's Taxonomy evaluation levels ($K1$ to $K6$).

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): State the underlying scientific principles, chemical reactions, and safety protocols for biochemical estimations, chromatography, genomic/plasmid DNA

isolation, PCR amplification, microbiological staining, and bacterial identification tests.

CO2 (K3 - Apply): Demonstrate procedural proficiency in preparing standard solutions and culture media, executing aseptic sterilization techniques, performing transformation assays, operating thermal cyclers, and using streak, pour, and spread plate methods to isolate pure bacterial cultures.

CO3 (K4 - Analyze): Analyze and interpret experimental quantitative data, including calculating chlorophyll concentrations via the Arnon method, generating bacterial growth curves, determining water quality using the Most Probable Number index, and calculating DNA yield/purity from agarose gels.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the diagnostic validity of clinical profiles (glucose, urea, creatinine, serum proteins) and biochemical test matrices to identify unknown bacterial strains, and troubleshoot experimental deviations to optimize molecular and biochemical protocols.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	2
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	2
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	ELECTIVE -1
Title of the Course	(A) GENETICS
Credits	2
Hours/Week	4
Course Objectives	1.To provide the basic knowledge of genetics in higher eukaryotic domains and over all conceptsof Mendelian genetics. 2.To understand about genetic inheritance and linkages 3.To provide the basic concept sex determination 4.To understand about genetic code, mutation and regulations 5.To Enrich the students' knowledge with respect to genetic engineering, transgenesis and ethics

Units	Course Contents	Teaching Hours
UNIT I	Genetics – History, Definition and scope - Pre- Mendelian genetic concepts. Basis of Mendelian Inheritance and Mendelian genetics. Chromosome theory of linkage, crossing over, recombinations and mapping of genes on chromosomes	12 hours
UNIT-II	Blood Groups and their inheritance in Human – Linkage and Crossing Over - Drosophila – Morgans' Experiments – Complete and Incomplete Linkage, Linkage Groups, Crossing Over types, Mechanisms – Cytological Evidence for Crossing Over, Mapping of Chromosomes – Interference and Coincidence.	8 hours
UNIT – III	Sex Linkage in Drosophila and Man, Sex influenced and Sex Limited Genes – Non- Disjunction and Gynandromorphs – Cytoplasmic Inheritance – Maternal effect on Limnaea (Shell Coiling), Male Sterility (Rode's Experiment).	9 hours

UNIT – IV	Nature and Function of Genetic Material – Genetic code – Why the genetic code is comma less, non ambiguous, degenerate triplet code. Fine Structure of the Gene. Gene Regulation – Operon Concept – Lac Operon – Positive and Negative Regulation. Mutation – Molecular Basis of Mutation, Types of Mutation, Mutagens, Mutable and Mutator Genes. Chromosomal Aberrations – Numerical and Structural examples from Human.	8 hours
UNIT-V	Genetic engineering – Objectives, tools, gene cloning and gene isolation. Transgenic plants and animals, Animal Breeding – Heterosis, Inbreeding, Out Breeding, Out Crossing, Hybrid Vigour. Population Genetics- Hardy Weinberg Law – Gene Frequency, Factors Affecting Gene Frequency, Eugenics, Euphenics and Euthenics.	8 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lecturers	5 hours
	Total Lecture hours 65 hours	50 hours

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text Books

1. Gardner et al (1991). Principles of Genetics. John Wiley.
2. Hartl. D.L. A primer of population genetics. III edition, Sinauer associates inc. Sunderland, 2000
3. Human genetics, A. Gardner, R. T. Howell and T. Davies, Published by Vinod Vasishtha for Viva Books private limited, 2008.
4. The science of Genetics by Alan G. Atherly, Jack. R, Girton, Jhon. F, Mc Donald. Sounders college publishers.

Reference Books

1. Strachan and Read (2003).Human Molecular Genetics. Wiley.
2. Pasternak (2005).An Introduction to Molecular Human Genetics. Fritzgarald.
3. Prichard & Korf (2004).Medical Genetics a ta Glance. Blackwell.
4. Manu L Lothari, Lopa A Mehta, sadhana S Roy Choudhury (2009). Essential of Human Genetics(Universities Press India ltd) Publishing.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

https://www.classcentral.com/course/swayam-genetics-and-genomics-17623 2.
https://nptel.ac.in/courses/102/104/102104052/

3. https://www.coursera.org/learn/genetics-evolution

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the history of genetics, Mendelian inheritance laws, chromosome theories of linkage, sex-linked traits, characteristics of the genetic code, types of mutations, and the basic principles of population genetics and genetic engineering.

CO2 (K3 - Apply): Apply genetic principles to solve problems related to human blood group inheritance, construct chromosome gene maps from crossing-over data, calculate genetic/allele frequencies using the Hardy-Weinberg equilibrium equation, and utilize genetic engineering tools for gene cloning workflows.

CO3 (K4 - Analyze): Analyze the mechanisms of chromosomal aberrations, complete and incomplete linkage in *Drosophila*, cytoplasmic inheritance patterns (e.g., shell coiling in *Limnaea*), positive vs. negative operon regulation, and distinguish between different animal breeding strategies like inbreeding, out-crossing, and heterosis.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the impact of mutagens and non-disjunction events on human health and phenotype, appraise the ethical and scientific advancements of transgenic plants, animals, and eugenics/euphenics concepts, and design conceptual frameworks for developing hybrid vigor or targeted gene isolation experiments.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	2
CO2	2	3	3	2	0	1	1	3	3	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	**ELECTIVE -I**
Title of the Course	**(B) VIROLOGY**
Credits	**2**
Hours/Week	**4**
Course Objectives	1. Contrast differences in virus architecture and classification. 2. To understand the viral diagnostic and detection methods. 3. Distinguish characteristics of normal cells and virus-infected cells. 4. Explain and apply methods used in research and diagnosis of viral diseases. 5. Describe cellular and therapeutic antiviral strategies and social stigmas against infected individuals.

Matching Table (Put Yes / No in the appropriate box)

Unit	i. Remembering	ii. Understanding	iii. Applying	iv. Analyzing	v. Evaluating	vi. Creating
1	Yes	Yes	No	No	No	No
2	Yes	Yes	No	No	No	No
3	Yes	Yes	No	No	No	No
4	Yes	Yes	No	No	No	No
5	Yes	Yes	No	No	No	No

Units	**Course Contents**	**Teaching hours**
Unit I	General Virology: Structure of viruses: Enveloped and non-enveloped viruses, Capsid symmetries - icosahedral, polyhedral and helical, structural proteins - matrix proteins and lipoproteins, viral genomic organization and replication - types of nucleic acids, protein-nucleic-acid interactions and genome packaging, Virus related structures – viroids and prions. Cultivation of viruses, Cytopathic effect - pock forming unit.	10 hours
Unit-II	Viral diagnostic and detection methods: Sample processing - enrichment and concentration, Direct methods of detection - light microscopy (inclusion bodies), electron microscopy, Immuno diagnosis, hemagglutination, Complement fixation, neutralization, Western blot, Radioactive Immuno precipitation Assay (RIPA), Flow Cytometry and Immuno histochemistry. Nucleic acid-based diagnosis: Nucleic acid hybridization, PCR, microarray and nucleotide sequencing, LINE probe assay.	08 hours

Unit-III	Bacteriophages and plant viruses: Bacteriophage: Morphology, genome organization, classification - Lifecycle - Lytic and Lysogenic Cycle, Head and tail phages - T4 phage - Phage - Filamentous Bacteriophages – 174 - M13, Phage therapy for control of bacterial poultry diseases. Viral diseases in Plants: Histological, physiological and cytological changes in infected plants, Behavior of viruses in plants, Methods for detection of plant viruses, Transmission of plant viruses through vectors-insects, nematodes and fungi.	13 hours
Unit-IV	Clinical virology: Pathogenesis, clinical symptoms, epidemiology and prophylaxis of DNA Viruses - pox virus, Herpes Virus, Adenovirus, Hepatitis Virus. RNA Viruses - Picorna Virus, Orthomyxo Virus, Rabies Virus, HIV. Oncogenic viruses; Virus-induced cell transformation and oncogenesis, Mechanism of cell transformation by tumor viruses, Retrovirus mediated oncogenesis.	08 hours
Unit-V	Viral vaccines and anti-viral drugs: Viral vaccines, conventional vaccines-killed and attenuated, Modern vaccines - DNA vaccines, recombinant DNA/protein vaccines, subunits vaccines, peptide vaccines, anti-idio type vaccines, edible vaccines, immuno modulators (cytokines), adjuvants to increase immunogenicity of vaccines. Antivirals: Interferons, 21 designing and screening for antivirals, mechanisms of action, anti retrovirals - mechanism of action and drug resistance.	05 hours
Unit-VI	Internal Assessments, Seminars and Guest lecture	5 hours
	Total Teaching hours	50

Method of Evaluation: (25 Internal marks + 75 External Marks = 100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Reference & Text Books:

1. Virology principles and application John Carter and Venetia Saunders (2007) John Wiley andSons publishers.
2. Principles of Virology 4th edition Jane Flint.
3. Real –Time PCR: Current technology and applications 1st edition (2009) edited by Julie Logan *et al*.,
4. Analytical techniques in DNA sequencing edited by Brian K. Nunnally
5. Medical Microbiology: with student consult by Patrick R. Murray Ph.D. (Author), Ken S. Rosenthal PhD Saunders; 7th edition.
6. Antiviral Agents, Vaccines and Immunotherapies. Stephen K. Trying. October 2004. Marcel Dekker.

Course Material:

1. International Congress on Taxonomy of Viruses ;http://WWW.ncbi.nlm.nih.gov/ICTV
2. Knipe David M., Peter M. Howley, Diane E. Griffin, Robert A. Lamb, Malcolm A. Martin, Bernard Roizman, Stephen E.Straus, (2007), Field's Virology, 5th Ed. Lippincott Williams &Wilkins
3. Cann Alan J, (2000),DNA virus Replication, Oxford University press
4. https://www.yourgenome.org/facts/what-is-PCR-polymerase-chain-reaction.

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the structural architecture, capsid symmetries, and genomic organization of enveloped and non-enveloped viruses, sub-viral agents (viroids and prions), and outline the lifecycle steps of bacteriophages, plant viruses, and major human clinical pathogens.

CO2 (K3 - Apply): Apply classical and modern diagnostic methodologies—including immunodiagnostic assays (Western blot, Flow Cytometry), nucleic acid-based testing (PCR, microarrays, LINE probe assays), and virus cultivation/quantification techniques (pock-forming units)—to safely isolate and detect viral loads.

CO3 (K4 - Analyze): Analyze the pathological differences between lytic and lysogenic life cycles, compare the transmission vectors and physiological changes in plant viral infections, and contrast the mechanisms of cell transformation and oncogenesis triggered by DNA and RNA tumor viruses.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the clinical efficacy, epidemiological trends, and preventative strategies (prophylaxis) against severe human viral diseases, and hypothesize/design targeted therapeutic frameworks utilizing modern vaccine platforms (DNA, edible, or recombinant vaccines) and specific antiviral or antiretroviral drug combinations while accounting for potential drug resistance.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	ELECTIVE -1
Title of the Course	(C) BASIC ANALYTICAL METHODS
Credits	2
Hours/Week	4
Course Objectives	1. To learn the principles of the various analytical instrument. 2. To teach the SOP of analytical instruments. 3. To study the different chromatography separation methodologies 4. To study different electrophoresis isolation methodologies 5. To learn advanced microscopic methods in image processing

Units	Course Contents	Teaching hours
Unit I	Electrochemical techniques- basic principles- The pH electrode- Ion-selective, gas- sensing and oxygen electrodes. Elementary details of biosensors. Beer- Lambert's law, light absorption and its transmittance. Basic principles & brief outline of instrumentation of UV- Visible Spectroscopy, Infrared Spectroscopy, NMR, Mass spectrometry. Spectrofluorometric, Flame photometry and Atomic absorption spectrophotometry.	10 hours
Unit-II	Introduction & classification of chromatography. Instrumentation & applications of Column chromatography, TLC, Paper chromatography, GC, HPTLC and HPLC.	08 hours
Unit-III	Centrifugation- basic principles, instrumentation, centrifugation units. Sedimentation velocity, sedimentation equilibrium, cell fractionation methods. Differential, density gradient, isopycnic and equilibrium centrifugation. Preparative and analytical ultracentrifugation techniques. Isoelectric focusing, Blotting methods- Western, Southern and Northern and their applications.	13 hours
Unit-IV	General principles. Factors affecting the migration rate – sample, electric field, buffer and supporting medium. Tiselius moving boundary electrophoresis. PAGE. SDS– PAGE, Pulse-field gel electrophoresis. Cellulose acetate membrane electrophoresis and Agarose gel electrophoresis.	08 hours
Unit-V	Radio isotopic techniques: GM Counter, Scintillation Counter and Autoradiography. Principles of microscopy- Fluorescent, Transmission and Scanning electron microscopy, Confocal microscopy. Microtome analysis and measurement of images	05 hours
Unit-VI	Internal Assessments, Seminars, and Guest lecture	5 hours
Total Teaching hours		50

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Textbook:

1. Keith Wilson, John M Walker. Principles and techniques of Biochemistry and Molecular Biology.Cambridge University Press. 7th edition, 2017.
2. Shawney. Practical Biochemistry. Narosa Publishing, 1995.
3. Upadhyaya A Upadhyaya K and Nath. Biophysical Chemistry: Principles and Techniques, 3rdEdition. Himalayan publications, 2009.
4. D. Frifelder and M. Malacinski. Essentials of Molecular Biology, Jones & Bartlett, 5th Edition,2015.
5. R.D. Braun. Introduction to Instrumental Analysis. Pharma Book Syndicate, 2006.
6. Chatwal and Anand. Instrumental Methods of Analysis. 5th Edition, Himalayan publication,2007.
7. Jag Mohan. Organic Spectroscopy, Principles and Application. Narosa Publishing House, 2ndEdition, 2007.

Reference Book:

1. Principles and Techniques of Practical Biochemistry (Paperback) by KeithWilson(Editor), John Walker (Editor), John M. Walker (Author) Fifth Edition, 2000.
2. Introductory Practical Biochemistry (Hardcover).by S. K. Sawhney; Randhir Singh(Editor) 2005
3. Principles of Physical Biochemistry (2nd Edition) by Kensal E van Holde, CurtisJohnson, andPui Shing Ho (Hardcover – April 16, 2005).
4. Physical Biochemistry: Applications to Biochemistry and Molecular Biology by David M.Freifelder (Paperback – Aug 15,1982).
5. Instrumental Methods of Chemical Analysis by G R Chatwal and S KAnand (Hardcover –Jun1980).

Course Material:

Website links: https://www.edx.org/course/basic-analytical-chemistry,
E-Books: http://shvaiko.ru/wp-content/uploads/2010/02/Analytical-Techniques-Julia-C.-Drees-Alan-H.-B.-Wu.pdf tml, https://www.uvm.edu/~gpetrucc/courses/chem196/Textbooks/Manahan%20-%20Fundamentals%20of%20Environmental%20Chemistry/1491Ch25.pdf,E- journals:

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): State the working principles and structural components of

electrochemical electrodes, spectrophotometers (UV-Vis, IR, NMR, Mass), chromatographic systems, preparative/analytical centrifuges, electrophoretic units, radioisotopic counters, and high-resolution microscopes.

CO2 (K3 - Apply): Apply the Beer-Lambert law to calculate solute concentrations, choose appropriate chromatography matrices (HPLC, GC, TLC) for biomolecule separation, and operate mathematical units of centrifugation and electrical field dynamics to optimize biomolecular migration and sedimentation.

CO3 (K4 - Analyze): Analyze the separation patterns of proteins and nucleic acids across various matrices (SDS-PAGE, Agarose, Isoelectric focusing, Pulse-field gel electrophoresis), contrast the applications of different blotting workflows (Southern, Northern, Western), and differentiate between structural data captured via TEM, SEM, and Confocal microscopy.

CO4 (K5 & K6 - Evaluate & Create): Evaluate experimental data, resolution artifacts, and isotopic decay curves to validate the purity, mass, and structure of biological samples, and compile/design multi-instrumental analytical frameworks integrating cell fractionation, isolation, and downstream structural characterization.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	ELECTIVE -II
Title of the Course	(A) ENZYME TECHNOLOGY
Credits	2
Hours/Week	3
Course Objectives	1. To Learn about the classification and structure properties of enzymes 2. To Understand the kinetics, catalysis and inhibitions activities of enzymes 3. To understand physical properties, downstream process and purification of enzymes. 4. To Expedite how enzymes are used as co-factors. 5. To Enrich the students' knowledge with respect to different applications of Enzymes

Unit	Course Contents	Teaching Hours
UNIT I	Introduction to enzymes: History of enzymes, nomenclature and classification of enzymes. Structural features of Enzymes and Chemical nature of Enzymes. : amino acids- Structure, Protein structure: Primary, secondary, tertiary and quaternary structure. Specificity of Enzymes: Types of specificity, the Koshland's "induced fit" hypothesis, strain or transition- state stabilization hypothesis.	10 hours
UNIT-II	Enzyme Catalysis and Kinetics: Factors affecting the rate of chemical reactions, kinetics of uncatalyzed chemical reactions, kinetics of enzymes catalyzed reaction, methods for investigating the kinetics of enzyme- catalyzed reactions, nature of enzyme catalysis, inhibition of enzyme activity.	8 hours
UNIT – III	Extraction and purification of microbial enzymes: Importance of enzyme purification, different sources of enzymes. Extracellular an intracellular enzymes. Physical and chemical methods used for cell disintegration. Enzyme fractionation by precipitation (using Temperature, salt, solvent, pH, etc.), Liquid-liquid extraction, ion exchange, gel chromatography, affinity chromatography and other special purification methods, Enzyme crystallization techniques. Criteria of purity of enzymes. Pitfalls in working with pure enzymes.	12 hours
UNIT – IV	Enzyme inhibition and Co-factors: Irreversible, reversible, competitive, non-competitive and un-competitive inhibition with suitable examples and their kinetic studies. Allosteric inhibition, types of allosteric inhibition and their significance in metabolic regulation & their kinetic study. Vitamins and their co-enzymes: Structure and functions with suitable examples. Metallo enzymes and Metal ions as co-factors and enzymes activators.	9 hours

UNIT-V	Immobilization of microbial enzymes and Enzyme Engineering: Methods viz. adsorption, covalent bonding, entrapment & membrane confinement and their analytical, therapeutic & industrial applications. Applications of microbial enzymes: Microbial enzymes in textile leather, wood industries and detergents. Enzymes in Clinical diagnostics. Enzyme sensors for clinical processes and environmental analyses. Enzymes as therapeutic agents.	9 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lecturers	5 hours
	Total Lecture hours	50hours

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text Book(s)

1. Introduction to proteins Structure by Branden and Tooze (1998): Garland Publishing Group.
2. Biotechnology. Volume 7 A- Enzymes in Biotechnology. 1983 Edited by H.J. Rehm and G.Reed. Verlag Chemie.
3. Methods of Enzymatic analysis by Hans Ulrich, Bergmeyer, AcademicPress.
4. Methods in Enzymology by W.A.Wood, AcdemicPress.
5. Topics in Enzyme and Fermentation Biotechnology by L.N. Wiseman, John Wiley and Sons.

References Books

1. Enzymes by Palmer (2001): Horwood publishing series.
2. Fundamentals of Enzymology by price and Stevens (2002): Oxford University Press.
3. Enzyme Technology by Helmut Uling (1998): John Wiley.
4. Methods in Enzymology. Volume 22-Enzyme purification and related techniques. Edited by William B.Jakoby. Academic press, New York.
5. Allosteric Enzymes-Kinetic Behaviour. 1982. By B.I .Kurganov, John Wiley and Sons. Inc., NewYork.

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the history, classification, and chemical/structural features of enzymes and proteins, and explain the theoretical models of enzyme specificity, cell disintegration methods, cofactor functions, and principles of enzyme immobilization.

CO2 (K3 - Apply): Apply enzymatic kinetic principles to calculate reaction rates, construct mathematical

graphs to determine values like K_m and V_{max}, choose appropriate downstream purification methods (such as salt precipitation and affinity chromatography), and employ targeted enzyme immobilization methods for specific industrial applications.

CO3 (K4 - Analyze): Analyze and contrast the mechanism and kinetic graphs of reversible (competitive, non-competitive, un-competitive) and irreversible enzyme inhibition, examine the regulatory role of allosteric enzymes in metabolic pathways, and differentiate between the criteria used to verify enzyme purity.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the clinical, therapeutic, and environmental efficacy of microbial enzymes and enzyme sensors, appraise the pitfalls of processing pure enzyme lines, and design scalable bioprocess frameworks or enzyme engineering protocols tailored for industries like textiles, leather, and detergents.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	ELECTIVE- II
Title of the Course	(B) DAIRY TECHNOLOGY
Credits	2
Hours/Week	3
Course Objectives	1. To teach the microbial knowledge in milk 2. To learn the processing of milk microbiological methods 3. To understand how the milk products are in quality make through dairy industry 4. To made knowledge in differentiate the traditional and industrial make dairy products and its processing 5. To aware the students about milk borne diseases

Unit	Course Contents	Teaching Hours
UNIT I	Common microbes in milk and their significance. Sources of microbial contamination of raw milk in influencing the quality of milk during production, collection, transformation and storage. Clean milk production and antimicrobial systems in raw milk. Microbial changes in raw milk during long storage. Microbiological grading ofraw milk.	12 hours
UNIT-II	Microbiological processing techniques: bactofugation, thermization, pasteurization, sterilization, boiling ,UHT, non thermal processes and membrane filtration of milk, Role of psychrophilic, mesophilic, thermophilic and thermoduric bacteria in the spoilage of processed milk, Microbiological standards (BIS/PFA) of heat treated fluid milks.	12 hours
UNIT – III	Microbiological quality of dairy products; fat rich (cream and butter), frozen (ice cream), concentrated (evaporated and condensed milk), dried milks (roller and spray dried), infant dairy foods and legal standards. Factors affecting microbial quality of these products during processing, storage and distribution. Pro biotics and pre biotics (GRAS), Cloning - sanitation, Control of microorganisms in dairy processing.	12 hours
UNIT – IV	Microbiology quality of traditional dairy products; heat desiccated (khoa, burfi, peda, kheer), acid coagulated (paneer, chhana, rasgulla), fermented (lassi, srikhand and frozen kulfi). Sources of microbial contaminants and their role in spoilage. Importance of personnel and environmental hygiene on quality of traditional milk products. Microbiological standards for indigenous dairy foods.	12 hours

UNIT-V	Milk-borne diseases – viral and bacterial, zoonotic infections, Pathogens associated with fluid milks, dairy products and their public health significance, importance of bio flims and their role in transmission of pathogens in dairy products and preventive strategies. Regulatory control of dairy products, Testing of milk and milk products, Treatment of dairy wastes.	12 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lecturers	5 hours
	Total Lecture hours 65 hours	65 hours

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text Books:

1. Adams MR and Moss MO. (1995).food microbiology, the royal Society of Chemistry, Cambridge.
2. Andrews AT, Varley J (1994) biochemistry of milk products. Royal Society of Chemistry.
3. Banwart G J(1989), basic food microbiology, Chapman & hall, New York.
4. Frazier WC and Westh off D C.(1988) food microbiology, TATA McGraw hill publishing company Ltd. New Delhi.

References

1. Hobbs BC and Roberts D. (1993) food poisoning and food hygiene,Edward Arnold (a division of Hodder and Stoughton), London. May JM. (1987) Modern food Microbiology, CBS publishers and distributors, New Delhi.
2. Robinson RK. 1990. The Microbiology of milk. Elsevier applied Science. London
3. Edward Harth, J.T.Steele. Applied Dairy Microbiology .1998. Marcel DeekerInc.
4. Modi, HA (2009) dairy microbiology pointer publishers, India.
5. Marth, E.H and steel J. L (2001) applied Dairy Microbiology, 2nd Edition, Marcel Dekker, Inc.270 MadisonAvenue,new York, New York10016.

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Identify common milk microflora, list the sources of microbial contamination in raw milk, outline legal microbiological standards (BIS/PFA/GRAS), and describe the operational

principles of dairy processing techniques and waste treatment systems.

CO2 (K3 - Apply): Apply appropriate thermal (pasteurization, UHT) and non-thermal (bactofugation, membrane filtration) preservation methods to control spoilage, use standardized microbiological assays to grade raw milk quality, and implement sanitization and hygiene protocols within dairy production plants.

CO3 (K4 - Analyze): Analyze the specific roles of psychrophilic, mesophilic, thermophilic, and thermoduric bacteria in the spoilage of fluid milk and diverse dairy products (fat-rich, concentrated, dried, and traditional indigenous items), and examine how biofilms facilitate pathogen transmission.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the public health significance and epidemiological risks of milk-borne zoonotic diseases, assess dairy products against regulatory safety checklists, and formulate comprehensive, integrated preventive frameworks (from production to distribution) to guarantee clean, safe dairy food lines.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	2
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	2
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	ELECTIVE - II
Title of the Course	(C) PHARMACEUTICAL TECHNOLOGY
Credits	2
Hours	3
Course Objectives	1To learn dru.gs and its involved detoxification through phase 1 & 2 reactions 2 To teach drugmechanism like passive and active phases 3 To learn the drugs manufacture biotechnological pharmaceutical industry 4 To understand the importance of drugs in treating various metabolic disorders 5 To teachvarious applications of drugs in various fields.

Unit	Course Content	Teaching Hours
UNIT I	Objectives of Pharmaceutical Biotechnology – generic and Biogeneric drugs. Stages in drug development, FDA drug approval process. Pharmacokinetics and Pharmacodyanamics – Preclinical trials, Clinical trials, New drug application (NDA), Post clinical trials, Drug marketing, Prodrug concept – Absorption, distribution and metabolism of drugs.	10 hours
UNIT-II	Adverse response to drugs, drug tolerance, drug intolerance, Idio SYNERACY (Pharmacogenesis), drug allergy. Tachyphylaxis, drug abuse and novel drug delivery systems.	08 hours
UNIT – III	Production of recombinant proteins as drugs – Humulin, Humatrope, Factor VIII Kogenate, Epogen, Neulasta, Avonex, Antimicrobial peptides (β – defensinz), vaccines (Pentavac) and Cancer biologics (rituximab).	13 hours
UNIT – IV	Mechanism of action of drugs used in therapy of: respiratory system - cough, bronchial - asthma, pulmonary tuberculosis. GIT – digestants, appetite suppressants. hypolipidemia agents, vomiting, constipation and peptic ulcer. Antimicrobial drugs- sulfonamides, trimethoprim, cotrimoxazole, penicillin and macrolides. Amino glycosides, cephalosporin, Insulin and oral diabetic drugs, anti-fertility and ovulation inducing drugs.	08 hours
UNIT-V	Muti drug resistance, Drug toxicity analysis - Common side effects of drugs and its management, National and International Drug approval agencies. Top National and International Pharmaceutical Industries.	08 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lecturers	5 hours
	Total Lecture hours	**50 hours**

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text Book:

1. The pharmacology Vol I and Vol II– Goodman and Gillman, Mc Graw Hill professional; 12 ed (2010)
2. Basic pharmacology – Foxter cox bulter worth"s1980.
3. Pharmacology and Pharmaco therapeutics – R.S.Satoskar.S.D. Bhandhhakar & S.S. Anilapure popular Prakashar Bombay.

Reference

1. Principles of medical chemistry – William O. Foge. B.I. Waverks Pvt Ltd, NewDelhi.
2. Oxford text books of clinical pharmacology and drug therapy .D.G.Burger's Medical Chemistry & Drug discovery.
3. Principles and practice – Manfred. E. Wolf John Wiley andsons.

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the core objectives of pharmaceutical biotechnology, distinguish between generic and biogeneric drugs, outline the phases of clinical trials and the FDA approval process, and explain basic pharmacokinetics, pharmacodynamics, and mechanisms of drug resistance.

CO2 (K3 - Apply): Apply pharmacological principles to determine how drugs are absorbed, distributed, and metabolized in the body, employ the prodrug concept to improve drug bioavailability, and choose appropriate novel drug delivery systems to mitigate adverse drug responses, tolerances, and allergies.

CO3 (K4 - Analyze): Analyze the molecular mechanisms of action for therapeutic drugs targeting the respiratory system, gastrointestinal tract, and endocrine system (such as insulin and anti-fertility drugs), and contrast the modes of action among different antibiotic classes like sulfonamides, penicillins, and aminoglycosides.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the clinical efficacy, adverse reactions, and toxicity profiles of recombinant biopharmaceuticals (such as Humulin, Factor VIII, and rituximab), appraise global regulatory standards governed by national and international approval agencies, and design management strategies to circumvent multi-drug resistance and side effects in pharmaceutical development.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	2
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	2
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

SEMESTER-II

Course	**CORE PAPER -1V**
Title of the Course	**IMMUNOLOGY**
Credits	**4**
Hours/Week	**5**
Course Objectives	1. To Learn the basic components and principles of defense mechanism against infections 2. To Understand the properties antigens and structure and types of Immunoglobulin 3. To understand principle behind Antigens- Antibody reactions. 4. To Expedite how the immune system recognizes foreign antigen and the significance of self/non-self-discrimination 5. To Enrich the students' knowledge with respect to different applications of Immunotechnology

Units	Course Contents	Teaching Hours
UNIT I	Introduction to the study of Immunology: Historic perspective, Overview and Concepts, Humoral and Cellular- Mediated Immune responses. Components of immunity, Innate and Adaptive immunity. Haematopoiesis and differentiation of immune cells. Cells and Tissues of the immune system: Cells involved in the Immune response: Macrophages, B and T lymphocytes, Dendritic cells, Natural killer and Lymphokine activated killer cells, Eosinophils, Neutrophils and Mast cells. The lymphoid organs: Thymus, Bone marrow, Spleen, lymph nodes and MALT.	12 hours
UNIT-II	Antigens and Immunogenicity. Nature of Antigens and antibodies. Theories of Antibody formation. Antibody – basic structure, Properties of immunoglobulin and subtypes. Complement and its role in Immune responses.	12 hours
UNIT – III	Antigen - Antibody reaction, Strength of antigen and antibody reaction, Cross reactivity, Precipitation and Agglutination reactions, Radioimmunoassay and ELISA.	12 hours
UNIT – IV	Cytokines: structure of Cytokines; Function of Cytokines. Complement fixation. Structure and functions of MHC class I and II molecules - antigen recognition and presentation, HLA typing, Hypersensitivity Reactions - Types of Hypersensitivity, Immune tolerance, Autoimmunity and transplantation.	12 hours

UNIT-V	Hybridoma secreting monoclonal antibodies - Recombinant antibody molecules. Catalytic Antibodies. Modern vaccines - DNA vaccines, Recombinant DNA/protein vaccines, subunits vaccines, peptide vaccines, anti-idiotype vaccines, edible vaccines. Immunological techniques for identification of infectious diseases: Immuno diffusion, immune-electrophoresis, Western blot and Flow cytometry.	12 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lecturers	5 hours
	Total Lecture hours 65 hours	65 hours

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text Book(s)

1. Parham, P. (2014). The Immune System (4th edition). W. W. Norton &Company.
2. Murphy, K., Travers, P., Walport, M., &Janeway, C. (2012).Janeway's Immunobiology. NewYork: Garland Science.
3. Paul, W. E. (1993). Fundamental Immunology. New York: Raven Press. Goding, J. W.(1986). Monoclonal Antibodies: Principles and Practice
3. C.V.Rao. 2002, An Introduction to Immunology, Narosa Publishing House, Chennai.

References Books

1. Immunology (7th ed) J. Kuby ,W.H freeman and company , NewYork. 2013
2. Basic immunology updates ed: functions and disorders of immune system (3rd ed). abulk.abbas, Andrew H.H Lictman, saunders publishers , NewYork,2010
3. Immunology: an introduction (4th) I.R Tizard, Saunders college publishers, NewYork.
4. Essential immunology (11th ed). Peterdelves, seamusmartin, Dennjis burton, Ivan Roitt, Wiley –Blackwell publication, Singapore, 2006
5. Immunology (Lippincotts illustrated reviews series) thaodoan, roger melvold, susanviselli, CarlWaltenbaugh, Lippincott Williams & Wilkins publications2012
6. Fundamental Immunology (7th ed) William e Paul, Lippincott Williams & Wilkins publications, 2012.
7. Essentials of clinical immunology (6th ed) Helen chapel ,Manselhaeney, Siraj misbah, Neil snowden, Wiley-Blackwell publications,2014.
8. Monoclonal antibodies principles and practice (3rd ed) W.Goodings, academic press, 2010
9. Monoclonal antibodies :P methods and protocols (2nd ed) .Vincentossipo, Nicolas fisher, Humanapress, 2014.
10. Essentials of Clinical Immunology (6th ed). Helen chapel, Manselhaeney, Siraj misbah, Neil Snowden, Wiley- Blackwell publications,2014 J Kuby, 2003, Immunology 5th edition, W.H. Freeman and Company, New York.. I.R.Tizard, 1995, Immunology: An Introduction, 4th

edition, Saunders College Publishers, New York.
12. I. Roitt, 1994, Essential Immunology, Blackwell Science, Singapore.
13. A. Bul and K. Abbas, 1994, Cellular and Molecular Immunology.
14. Current Protocols in Immunology 3 Volumes, Wiley Publications1994.
15. Monoclonal Antibodies: Principles and Practice, J. W. Goding, 1983. Academic Press.
16. Hybridoma Technology in the Biosciences and medicine, T.A. Springer, 1985. Plenum Press NY

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1. https://nptel.ac.in/courses/102/105/102105083/
2. https://www.coursera.org/specializations/immunology

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the historical breakthroughs in immunology, identify the cells and lymphoid organs involved in hematopoiesis, and explain the structural features and functions of antigens, immunoglobulins, cytokines, and Major Histocompatibility Complex (MHC) molecules.

CO2 (K3 - Apply): Apply immunochemical principles to perform and interpret classic and modern antigen-antibody interactions, such as precipitation, agglutination, Radioimmunoassay (RIA), $ELISA$, immunoelectrophoresis, and Flow Cytometry for clinical diagnosis.

CO3 (K4 - Analyze): Analyze the multi-tiered mechanisms of innate versus adaptive immunity, contrast the pathways of the complement system, differentiate between the four types of hypersensitivity reactions, and examine the molecular basis of immune tolerance, autoimmunity, and transplant rejection.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the engineering strategies behind hybridoma technology for monoclonal, recombinant, and catalytic antibody production, appraise the efficacy of diverse modern vaccine platforms (DNA, subunit, peptide, and edible vaccines), and formulate targeted immunological frameworks for identifying and managing infectious diseases.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1

CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	**CORE PAPER -V**
Title of the Course	**GENETIC ENGINEERING**
Credits	**4**
Hours/Week	**5**
Course Objectives	1.To understand the basis of Enzyme, Ligases in Genetic Engineering Tools. 2.To well understood the Cloning Vectors. 3.To obtain knowledge about Gene cloning strategies and transformation techniques. 4.To obtain the knowledge of Selection, Screening, and analysis of recombinants. 5.To know the basic Genetic Engineering Techniques- Application of rDNA technology.

Units	**Course Contents**	**Teaching Hours**
Unit-I	Tools of Genetic Engineering: Enzymes - endo & exo nucleases-Restriction endonucleases - types, nomenclature, recognition sequences and mechanism of action. Isochizomers, Iso customers and star activity. Methylation, and modification. Ligases – types (NAD and ATP dependent), mechanism of action. Role of Kinases, phosphatases, polynucleotide phosphorylase, polynucleotide kinases, terminal transferase, Alkaline phosphatase, Reverse transcriptase, Taq polymerase.	12 hours
Unit-II	Cloning vectors: General characteristics of vectors-The promoter, MCS, Ori and Marker genes-lac Z. Construction of pBR 322, pBR325, pBR327, pUC8, pUC 18 & 19 vectors and Expression vectors - Bacteriophage vectors, Lambda phage, Insertion vectors, Replacement vectors, Cosmids, Phagemids, Mini chromosomes, BAC‟s, YAC‟s, Shuttle vectors, Ti plasmids, Vectors for animals-SV40 and Bovine papillomavirus.	12 hours

Unit-III	Gene cloning strategies and transformation techniques: Chimeric DNA Cloning strategies- Partial digestion, End modification, Use of adaptors and linkers, Homopolymer tailing in cDNA cloning, Ligation. Advanced cloning strategies - Cloning from mRNA, synthesis and Cloning of cDNA - Isolation and purification of RNA, Synthesis of cDNA, Isolation of plasmids, Cloning cDNA in plasmid vectors, Cloning cDNA in bacteriophage vectors. PCR amplified DNA. Genomic DNA libraries, cDNA library. Transformation techniques: Preparation of competent cells, Physical methods - Electroporation, Microinjection, Gene gun, chemical methods - PEG, DEAE, $CaCl_2$, calcium phosphate precipitation method, Liposome-mediated method.	12 hours
Unit-IV	Selection, screening and analysis of recombinants: Genetic selection - Insertional inactivation, Antibiotic resistant genes, lac Z genes, Blue white screening, α - Complementation, Colony hybridization, Immunological screening, Plaque hybridization, Blotting techniques, DNA sequencing - chemical and enzymatic methods, PCR and its variants, Preparation of radio labelled and non -radiolabelled probes and its applications.	12 hours
Unit-V	Applications of rDNA technology: Production of vaccines – Hepatitis B, Edible Vaccine, Hormones – Somatotropin, Humulin, Blood clotting factor VIII, Interferons, Diagnostics of inherited disorders and infectious diseases, Gene therapy, ADA - Cystic fibrosis.	12 hours
Unit-VI	Internal Assessments, Seminars, and Guest Lecture	05 hours
	Total Teaching hours	65

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Textbook:

1. Concepts of Genetics (Mastering genetics) 12th Edition by William Klug (Author), Michael Cummings (Author), Charlotte Spencer (Author), Michael Palladino (Author), Darrell Killian (Author).
2. Genetics: A Conceptual Approach Sixth Edition by Benjamin A. Pierce (Author) W. H. Freeman; Sixth edition (December 19, 2016).
3. Genetics: From Genes to Genomes, 5th Edition by Leland H. Hartwell (Author), Michael L. Goldberg (Author), Janice A. Fischer (Author), Leroy Hood (Author), Charles F. Aquadro

(Author)McGraw-Hill Education; 5th edition (September 5, 2014).
4. Genetics: Analysis of Genes and Genomes: Analysis of Genes and Genomes 9th Edition by Daniel L. Hartl (Author), Bruce Cochrane (Author) Jones & Bartlett Learning; 9th edition (December 14, 2017).
5. Principles of Genetics 6th Edition by D. Peter Snustad (Author), Michael J. Simmons (Author) John Wiley and Sons; 6th edition (August 23, 2011).
6. An Introduction to Genetic Engineering 3rd Edition, author: Desmonds S.T. Nicholl, University of Paisley May 2008.
7. Gene Cloning and DNA Analysis: An Introduction 7th Edition by T. A. Brown Wiley-Blackwell; (January 19, 2016).
8. Biotechnology: Applying the Genetic Revolution 1st Edition by David P. Clark BA (honors)Christ's College Cambridge 1973
PhD University of Brsitol (England) 1977 (Author), Nanette Pazdernik Academic Cell;1st edition (September 19, 2008).

Reference Books:

1. An Introduction to Genetic Engineering (Studies in Biology) 2nd Edition by Desmond S. T.Nicholl
2. Genetically Engineered Foods (Volume 6) (Handbook of Food Bioengineering, Volume 6) 1st Edition by Alexandru Mihai Grumezescu (Editor), Alina Maria Holban (Editor) 2017.
3. Genetically Engineered Foods Hardcover – January 1, 2021 by Armando Mills (Author) ED-Tech Press; 1stedition
4. Genetic Engineering: A Christian Perspective Paperback – December 27, 2019 by Michael Scaife.

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Identify the properties of molecular tools (restriction enzymes, ligases, and polymerases), describe the structural components of diverse cloning vectors, and explain the basic mechanisms behind gene library construction, screening methods, and therapeutic applications of recombinant DNA technology.

CO2 (K3 - Apply): Apply appropriate biochemical modifications—such as using linkers, adaptors, and homopolymer tailing—to construct chimeric DNA, utilize physical and chemical transformation methods to deliver genes into host cells, and implement PCR techniques along with specific probes to amplify and detect target sequences.

CO3 (K4 - Analyze): Analyze the choice of vector systems (ranging from plasmids and bacteriophages to high-capacity YACs/BACs and expression vectors) for specific cloning hosts, compare genomic versus cDNA library strategies, and distinguish between genetic selection mechanisms like insertional inactivation, α-complementation, and blue-white screening.

CO4 (K5 & K6 - Evaluate & Create): Evaluate DNA sequencing profiles, blotting data, and genetic screens to validate successful gene expression and recombinant stability, and synthesize integrated genetic engineering pipelines to design bioprocesses for producing recombinant therapeutic agents (such as Humulin, Hepatitis B vaccines, and gene therapy vectors for ADA or Cystic Fibrosis).

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	**CORE PAPER - V1**
Title of the Course	**DEVELOPMENTAL AND STEM CELL BIOLOGY**
Credits	**4**
Hours/Week	**5**
Course Objectives	1. To study the basics of sperm, egg cell cycle and its various stages 2. To teach the developmental concepts of drosophila and chick 3. To teach the concepts of stem cell, embryonic and adult stem cell 4. To study the types of stem cell and stem cell mediated antigen role different stem cell To understand the recent advances and its applications to modern biotechnology.

Units	**Course Contents**	**Teaching Hours**
Unit-I	Introduction to Developmental Biology: Cells and morphogens gradients. Ultrastructure of sperm, egg, pollen and ovule. Production of gametes in animal and plant (Spermatogenesis, Oogenesis). Cell surface molecules in sperm - egg recognition in animals; zygote formation, cleavage, blastula formation, gastrulation and formation of germ layers in animals.	12 hours

Unit-II	Developmental Concepts: Morphogenesis and organogenesis in animals (Drosophila and Chick). Cell fate and cell lineages; genomic equivalence and the cytoplasmic determinants; imprinting. Role of in development. Cellular differentiation and Differential activation. Role of cell death in development. Teratogenesis - Ageing, transgenic.	12 hours
Unit-III	Introduction to Stem cell biology: Introduction to concepts in stem cell biology (renewal and potency) introduction to stem cells, Germ line stem cells and germ line derived pluripotent cell, Epigenetics, nuclear transfer and cloning, introduction to cell, tissues and organ. Introduction to embryonic and adult stem cell.	12 hours
Unit-IV	Basic and types of Stem cell: Stem cell basic: Reprogramming and induced pluripotent cells (iPS cells), chromatin and stem cells, telomeres and stem cells, Stem cell differentiation and characterization: CD antigens and its role in stem cell differentiation. Neuronal stem cell, mesenchymal stem cell, Cardiac stem cells, Hematopoietic stem cells.	12 hours
Unit-V	Technique and application techniques used for stem cell isolation, enumeration and *in vivo* expansion, techniques used for stem cell characterization. Therapeutic applications of stem cell: fundamentals of regenerative medicine, autologous and allogenic stem cell transplantation, HLA typing, Stem cell banking – Cryopreservation techniques, national and International guidelines, Recent advances in Stem cell Biology.	12 hours
Unit-VI	Internal Assessments, Seminars, and Guest Lecture	05 hours
	Total Teaching hours	65

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text Books

1. Essentials of stem cell biology 2009, (Second ed) Robert Lanza, John Gearhart, Brigid Hogan, Douglass Melton, Roger Pedersen, E. Donnall Thomas, James Thomson and sir Ian Wilmutt.
2. Ann a. Kiessling, human embryonic stem cells: An introduction to the science and therapeutic potential, Jones and bartett, 2003.
3. Peter J , Quesenberry, stem cell biology and gene therapy, 1st ed, willyless,1998.
4. Developmental Biology, (2018), 11th edition by Michael J. F. Barresi, Scott F. Gilbert. Reference.
5. Book Human Embryology & Developmental Biology (2019), 6th edition by Bruce M. Carlson.
6. Principles of Development (2019), 6th edition by Cheryll Tickle; Lewis Wolpert; AlfonsoMartinez Arias.

7. Freshney RI. 2016. Culture of animal cells: A manual of basic technique and SpecializedApplications. 7th Edn. Wiley- Blackwell. United States of America.
8. Singh, B., Mal, G., Gautam, S.K., Mukesh, M.2019 Advances in animal biotechnology 1stEdnSpringer International Publishing. Switzerland.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

https://www.youtube.com/watch?v=dXknfffXeDM
https://courseware.cutm.ac.in/courses/biochemistry-and-enzyme-technology/
https://freevideolectures.com/course/85/enzyme-science-and-engineering
E-Journals: Reproductive Biology, Stem cell biology, Fertility and Sterility, Urology

Based on the guidelines and structure provided in your document, here are the four **Course Outcomes (COs)** tailored specifically to this Developmental Biology and Stem Cell Biology syllabus (Units I to V).
The outcomes are systematically aligned with Bloom's Taxonomy evaluation levels ($K1$ to $K6$) across all five units.

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the ultrastructure of gametes, explain the molecular mechanisms of fertilization, morphogen gradients, and germ layer formation, and outline core concepts of stem cell biology including potency, self-renewal, epigenetic reprogramming, and cryopreservation protocols.

CO2 (K3 - Apply): Apply developmental and stem cell principles to track cell lineages and cell fates, utilize cluster of differentiation (CD) antigens to characterize differentiating stem cells, and employ standardized isolation and expansion protocols for distinct adult stem cell populations (neuronal, mesenchymal, cardiac, and hematopoietic).

CO3 (K4 - Analyze): Analyze the genetic and cellular regulation behind morphogenesis and organogenesis in model organisms (*Drosophila* and Chick), contrast the functional properties of embryonic vs. adult stem cells, and examine the impacts of cell death pathways, genomic equivalence, and teratogenic factors on aging and birth defects.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the clinical and therapeutic potential of autologous vs. allogenic stem cell transplantation within regenerative medicine, appraise national and international bioethical guidelines governing stem cell banking, and synthesize integrated conceptual pipelines to engineer induced pluripotent stem cells (iPS cells) for targeted biomedical applications.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs	PSOs

	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	**CORE PRACTICAL-II**
Title of the Course	**LAB IN IMMUNOLOGY AND GENETIC ENGINEERING**
Credits	**4**
Hours/Week	**6**

Units	**Course Contents**	**Teaching hours**
Unit I	**IMMUNOLOGY** 1. Blood grouping 2. Radial immuno-diffusion test. 3. Ouchterlony double diffusion 4. Immuno electrophoresis 5. Rocket Immunoelectrophoresis 6. Latex Agglutination 7. Quantitative Precipitin assay 8. Complement fixation test 9. ELISA 10. Western Blotting 11. Antigen-antibody reaction (precipitation and agglutination reaction tests).	30 hours
Unit-II	**GENETIC ENGINEERING** 1. Isolation of genomic DNA from the given sample and its molecular weight determination 2. Isolation of RNA from the given sample and its molecular weight determination 3. Isolation of plasmid DNA from the given sample 4. Restriction digestion of Lambda phage DNA 5. Ligation of DNA and analysis by electrophoresis 6. DNA amplification by PCR and RAPD 7. Preparation of competent cells and transformation by CaCl2 method and Selection oftransformed colony by X-Gal method	25 hours

	8. Determination of molecular weight of proteins by SDS-PAGE	
		55 Hours

Method of Evaluation: (50 Internal marks + 50 External Marks=100)

Distribution for internals Test (CIA I + CIAII)	End Semester Examination	Total marks
50	50	100

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): State , the working principles, chemical foundations, and safety guidelines for antigen-antibody interactions, nucleic acid/protein extractions, restriction digestion, ligation, PCR amplification, and colorimetric selection methods.

CO2 (K3 - Apply): Demonstrate advanced bench-top proficiency in executing clinical immunodiagnostics ($ELISA$, Western blotting, blood grouping, latex agglutination), preparing competent bacterial host cells, performing $CaCl_2$ mediated transformations, and running multi-matrix gel electrophoreses.

CO3 (K4 - Analyze): Analyze and interpret molecular and immunoelectrophoretic gel bands to determine the molecular weight of proteins via SDS-PAGE, estimate genomic/plasmid DNA size, quantify precipitin rings via radial immunodiffusion, and analyze RAPD polymorphisms.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the experimental validity, efficiency, and sensitivity of specific immune assays (like complement fixation) versus nucleic acid amplification protocols, and troubleshoot or adapt experimental pipelines to optimize vector-insert ligation, restriction digestion, and transformant selection protocols.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs	PSOs

	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	**ELECTIVE – III**
Title of the Course	**(A) MEDICAL LABORATORY TECHNOLOGY**
Credits	**2**
Hours/Week	**4**
Course Objectives	1.To teach the physical and chemical nature of Body fluids 2.To teach the safety measures in diagnostic laboratory 3.To learn knowledge about laboratory techniques 4.To learn hematology and pathology laboratory techniques 5.To teach advanced methods in collection and storage, preparation, analysis of body fluids, andresults.

Units	**Course Contents**	**Teaching hours**
Unit I	General Laboratory and instrumentation: Code of conduct for laboratory personnel-safety measures, the laboratory-chemical/Reagents, labeling, storage and usage. First aid in laboratory accidents-Precautions and first aid equipments. Sterilization and preparation of reagents. The general approach to quality control and quality control of quantitative data.	5 hours
Unit-II	Clinical Pathology: Urine analysis: Collection, composition, preservation, gross examination, chemical examination. Significance of sugar in the urine, ketone bodies, bile pigment, hematuria, uric acid. Microscopic examination of the urinary sediments: stool Examination-specimen collection, pH, Interfering substances. Test for occult blood, fecal fat, and microscopic examination of a stool specimen.	5 hours
Unit-III	Clinical Hematology: Collection of blood-Anticoagulant, preservation, Estimation of Hb, PCV, WBC (TC & DC), RBC, platelets, ESR Clotting time, Bleeding time - normal value, Clinical interpretation. Serology-VDRL, CRP, RA, HIV and HBs Ag.	5 hours

Unit-IV	Histology: Basic concepts of different mammalian tissues and their histological structure. Different human organs and their gross and histological structure and functions. Receiving of biopsy specimens at the laboratory (Clinical notes/fixatives). Fixation of tissues – different fixatives and their mode of action. Methods of decalcification. Use of microtomes, selection and maintenance of knives, the technique of section cutting &mounting on slides. Staining of tissue sections, Preparation of different stains, Staining methods for Haematoxylin & Eosin.	5 hours
Unit-V	Blood banking: blood group (ABO & Rh) - methods of grouping & reverse grouping. Basic blood banking procedures - collection of blood, anticoagulants used, cross-matching, different screening, Tests including Coomb"s Test for incomplete antibodies, Preparation of different blood components for use and how to serve a requisition. Preparation of red cell suspension. Blood transfusion & hazards. Detect the time when to discard blood in the blood bank, computerized record.	5 hours
Unit-VI	Internal Assessments, Seminars, and Guest lecture	05 hours
	Total Teaching hours	30

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Textbook:

1. Hand book medical laboratory technology 2nd edition - V.H.Talib CBS publishers& 2008.
2. Clinical laboratory practices in CMC procedure, CMC, Vellore
3. Text book of Medical lab technology, 1st Edition-Ranmniksood.jaypee2006.
4. Laboratory manual in Biochemistry-Jayaraman New Age International Pvt Ltd publishers2011.

Reference Book:

1. Kanai L. Mukherjee and Anuradha Chakravarthy, Medical Laboratory Technology, Procedure Manual for Routine Diagnostic Tests, Vols. I, II and III. Tata McGraw Hill Publishing Company Ltd., 2017.
2. Ramnik Sood, Concise Book of Medical Laboratory Technology Methods and Interpretations. Jaypee Brothers Medical Publishers (P) Ltd., New Delhi, 2015.
3. N. Pattabiraman. Laboratory Manual in Biochemistry, 4th Edition. All India Publishers & Distributors, 2015.
4. Namita Jaggi. Microbiology Theory for MLT. 2nd Edition. Jaypee Brothers Medical Publishers

(P) Ltd., 2013.
5. Alan H. Lowenclock. Varley's Practical Clinical Biochemistry, 6th Edition. CBS Publishers and Distributors, 1988.

Course Material:

Website links:https://library.fvtc.edu/MLT/Links, https://libguides.gvsu.edu/MLS/websites,E-Books: https://www.pdfdrive.com/medical-laboratory-technician-e23958474.html,
E-journals : https://onlinelibrary.wiley.com/journal/10982825,

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Identify laboratory safety rules, first aid measures, and quality control requirements, while explaining the chemical and structural compositions, histological structures of human tissues, and the principles underlying automated/manual assays in clinical pathology, hematology, serology, and blood banking.

CO2 (K3 - Apply): Apply standardized procedures to collect, preserve, and chemically examine clinical specimen lines (urine, stool, and blood), process tissue biopsies using specific fixatives and microtomes, perform diagnostic screenings (such as VDRL, CRP, HIV, and HBs Ag), and conduct routine manual counts.

CO3 (K4 - Analyze): Analyze and interpret microscopic findings from urinary sediments, stool samples, and Hematoxylin & Eosin stained tissue cuts, and distinguish normal physiological indices from pathological variations regarding clotting profiles, erythrocyte sedimentation rates, and tissue morphology.

CO4 (K5 & K6 - Evaluate & Create): Evaluate blood bank inventory parameters (cross-matching anomalies, Coombs' test metrics, computer logs) to securely approve or discard blood components, assess clinical transfusion hazards, and formulate rigorous quality control and safety protocols for diagnostic laboratories.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1

CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	**ELECTIVE III**
Title of the Course	**(B) FOOD & NUTRITION**
Credits	**2**
Hours/Week	**4**
Course Objectives	1. To enable the students to learn the basic concepts of nutrition and different categories of foods. 2. To enable the students to gain knowledge of different nutrient contents and their importance. 3. To make them learn the basics of nutritive and calorific value. 4. To enable the students to know food adulterants and food poisoning, disadvantages &healthproblems. 5. To enable the students learn the food spoilage and preservation methods.

Matching Table (Put Yes / No in the appropriate box)

Unit	i. Remembering	ii. Understanding	iii. Applying	iv. Analyzing	v. Evaluating	vi. Creating
1	Yes	Yes	No	Yes	Yes	No
2	Yes	Yes	Yes	Yes	Yes	No
3	Yes	Yes	Yes	Yes	Yes	No
4	Yes	Yes	Yes	Yes	Yes	No
5	Yes	Yes	Yes	Yes	Yes	Yes

Unit	**Course Content**	**Teaching Hours**
UNIT I	Definition and basis of food and nutrition, Different food groups and classification, Nutritional significance and physiological role of food groups, Protein Energy Malnutrition (PEM), definition and types, Treatment and preventive measures of PEM.	5 hours
UNIT-II	Introduction to Vitamins, Fat soluble vitamins and Water soluble vitamins	5 hours
UNIT – III	Introduction to calorific value and nutritive value, Bomb calorimeter, Measurement of calorific value and nutritive of foods, RQ value, BMR and SDA of food stuffs, their measurements and influencing factors, Nutritive value of proteins and amino acids, Balanced diet, composition of balanced diet for pregnant woman, infants and old age.	5 hours

UNIT – IV	Definitions of food adulterations and food poisoning, Sources of foods and types of adulterants, advantages and disadvantages of adulteration, Constituents of foods, carbohydrates, proteins, fats, oils, Flavours, colours and natural toxicants, Sources, causes and remedies for acidity, gastritis, indigestion and constipation.	5 hours
UNIT-V	Introduction to food spoilage, food preservation and food processing, Causes and types of food spoilage, types of food preservation and food processing, Food sterilization and pasteurization.	5 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lectures	05 hours
	Total Lecture hours	30

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text book:

1. Albanese, Anthony A Ed, Protein And Amino Acid Nutrition Academic Press New York 1959.
2. Devlin T.M., Biochemistry by Stryer Text book of Biochemistry with clinical correlations.
3. Lehninger, Principles of Biochemistry, by 4th Ed. By Nelson D.L. and Cox. M.M. 6
4. Murray R.K., Grammer, D.K., Mayer P.A., Rodwell V.W., Harpers Biochemistry, alange medical book 26thEd. Mc. Graw Hill, Health Professions Division.
5. West. E.S., Todal, W.R., Mason H.S. and Van Brygen J.T., Text Book of Biochemistry.
6. Mayer, J., Human Nutrition, Charles, C. Thomas, spring field.
7. Michael, J. Gibney, Barrie, M. Margetis, John, M. Kearney. Lenore Arab. PublicHealth Nutrition. Blackwell science, Blackwell Publishing Company (2004).
8. Frazier, We, Food Microbiology, Tata Mc Graw Hill 19789. Meyer, Lilian H. Ed. (1987), Food chemistry. Indian Ed. CBS Publishers and Distributors
9. Barker, D.J. P (1998), Mothers, Babies and Health in later life. Edinburgh, Churchill livingstone.
10. Ward, R.H.T; Smith, S.K. Donnai, D. (Eds.) (1994) Early fetal Growth and Development. London, & COG Press.
11. Wallace, H.M. and Giri, K. (1990), Health care of women and children in developing countries, third party publishing co.Oakland.

Reference Book:

1. Seema yadav: - Food Chemistry, Anmol publishing (P) Ltd, NewDelhi
2. Car H.Synder: -the extraordinary chemistry for ordinary things, John Wiley & sonsinc, NewYork, 1992.
3. B. Sivasankar – food processing and preservation – PHI learni9ng (P) LTD, New Delhi – 11001.

Course Material: website links, e-Books and e-journals

1. https://chico-primo.hosted.exlibrisgroup.com

COURSE OUTCOMES (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Define the fundamental concepts of food groups, vitamins, and metabolic metrics (BMR, SDA, RQ), and describe the causes, symptoms, and preventive measures for Protein Energy Malnutrition (PEM) and food spoilage.

CO2 (K3 - Apply): Apply nutritional principles to design balanced diets for specific demographic groups—including infants, pregnant women, and the elderly—and implement appropriate food preservation and processing methods to extend shelf life.

CO3 (K4 - Analyze): Analyze the calorific and nutritive value of food substances using tools like the Bomb calorimeter, and differentiate between various types of food adulterants, natural toxicants, and causes of gastrointestinal distress (gastritis, acidity).

CO4 (K5 & K6 - Evaluate & Create): Evaluate the safety and quality of food products by assessing adulteration risks and toxicological constituents, and synthesize therapeutic dietary remedies to address nutritional deficiencies and food-borne illnesses.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	2	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	2	3	2	3	2	1	2	2
CO3	2	3	2	3	0	2	1	3	3	2	3	2	2	2
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	3

Course	ELECTIVE - III
Title of the Course	(C) BIODIVERSITY
Credits	2
Hours/Week	4
Course Objectives	1. To learn the basic concepts of ecosystem and ecology 2. To teach various biodiversity across the country and globe face. 3. To understand the History, guiding principles, conservation of ecology and biodiversity as perICUN. 4. To learn the importance of pollution damages environmental through how it influencebiodiversity 5. To teach and understand how water pollution affects environment and its remedies.

Units	Course Contents	Teaching Hours
UNIT I	Ecosystem –Concept, Introduction and overview of ecosystem ecology - History of ecosystem ecology, Ecosystem structure and functioning, Ecosystem diversity and landscapes, Ecosystem resilience and change, Trophic dynamics and temporal dynamics, Ecological efficiencies	5 hours
UNIT-II	Biodiversity and its origin, Global and local trends, Mega biodiversity countries, hot spots and heritage sites. Types of diversity, levels of biodiversity (genetic, species and ecological diversities), value of biodiversity.	5 hours
UNIT – III	History, guiding principles, conservation challenges and models of conservation biology. IUCN Red list categories and criteria, habitat management and establishment of wildlife corridors and protected areas, bio-indicators. Biosphere reserves, in situ and ex situ conservations (sanctuaries, national parks, zoological parks, botanical gardens and Oceanorium).	5 hours
UNIT – IV	Environmental Pollution - Causes, effects and control measures of air pollution, water pollution, soil pollution, noise pollution, thermal pollution and solid waste management. Environment Protection Act: Air, water, forest and wild life acts, issues involved in enforcement of environmental Legislation.	5 hours
UNIT-V	Water conservation, Rain water harvesting & watershed management and environmental ethics. Climate change, Global warming, acid, rain, ozone layer depletion. Environmental protection act, population explosion. Disaster management.	5 hours

UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lectures	5 hours
	Total Lecture hours 50 hours	30 hours

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Textbooks

1. Alcock J 2013 Animal Behavior: An Evolutionary Approach, 10th edition (Sinauer Associates, Inc.)

2. Bolhuis J J and L Giraldeau (eds) 2005, The behavior of animals (Blackwell Pub.)

3. Breed and Moore 2011 Animal Behavior, 1st Edition (Academic Press) 4. Burnse D(ed.) 2001Animal: the definitive visual guide to worlds‟ wildlife (Cambridge University Press)

4. Collen B, Pettorelli N, Baillie J E M and Durant S M (Eds) 2013 BiodiversityMonitoring and Conservation: Bridging the Gap between Global Commitment and Local Action (Wiley Blackwell)

5. GL. Karia and R.A. Christian, West Water Treatment, Concepts and Design Approach, Prentice Hall of India, 2005.

6. Benny Joseph, Environmental Studies, Tata Mc Graw Hill, 2005

Reference book

1. Introduction to bioethics (2018), 2nd edition by J.A. Bryan

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1. https://swayam.gov.in/nd1_noc20_hs18/preview2. https://nptel.ac.in/courses/109/106/109106092/
3. https://onlinecourses.nptel.ac.in/noc20_hs18/preview4. https://nptel.ac.in/courses/102/104/102104068/
5. https://www.futurelearn.com/courses/biosecurity

Based on the guidelines and structure provided in your document, here are the four **Course Outcomes (COs)** tailored specifically to this Ecosystem Ecology, Biodiversity, and Environmental Management syllabus (Units I to V).
The outcomes are systematically structured using Bloom's Taxonomy evaluation levels ($K1$ to $K6$) across all five units.

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the structural and functional components of

ecosystems, identify global biodiversity hotspots, and outline the core principles of conservation biology, IUCN Red List categories, environmental protection legislations, and global climate change phenomena.

CO2 (K3 - Apply): Apply ecological principles to calculate trophic and ecological efficiencies, use bio-indicators to monitor ecosystem health, and implement practical solutions for local environmental issues through water conservation, rainwater harvesting, and watershed management models.

CO3 (K4 - Analyze): Analyze the causes, cascading effects, and mitigation strategies of various types of environmental pollution (air, water, soil, noise, thermal) and solid waste, and analyze the socio-ecological impacts of global warming, ozone depletion, population explosion, and natural disasters.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the effectiveness of *in situ* versus *ex situ* conservation strategies and environmental protection acts, appraise current challenges in ecological enforcement and environmental ethics, and synthesize comprehensive disaster management or habitat restoration plans to enhance ecosystem resilience.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	ELECTIVE IV
Title of the Course	**(A) GENOMICS & PROTEOMICS**
Credits	**2**
Hours/Week	**3**
Course Objectives	1. To provide the basic knowledge of gene characteristic feature and mapping concepts 2. To understand about the sequencing technologies 3. To provide the basic concept for protein analysis 4. To understand about protein sequencing 5. To Enrich the students' knowledge with respect to metagenomic and applications

Units	Course Contents	Teaching Hours
UNIT I	Organization of genes across living systems, interrupted genes, overlapping genes, alternative genes, (RNA editing and RNA Splicing) etc. Identification and characterization of insert DNA fragments, gene content and C value paradox – gene cluster and gene families. Restriction mapping, chromosome walking and chromosomal localization of genes. RFLP and other uses of cloned sequences, Cloning of microbial genes.	10 hours
UNIT-II	Methods of preparing genomic DNA, DNA sequence analysis methods, Sanger Di deoxy method, next generation sequencing, SNP – Single Nucleotide Polymorphism, Expressed Sequenced Tags (ESTs), Gene disease association, Site directed mutagenesis and molecular chimeras, fungal genome and genomics. PCR based analysis, DNA Fingerprinting.	08 hours
UNIT – III	Scope of proteomics, Protein separation techniques – ion exchange chromatography, size – exclusion and affinity chromatography techniques, protein analysis (includes measurement of concentration, aminoacid composition and N-terminal sequencing); SDS-PAGE, Two dimensional gel electrophoresis and Image analysis.	13 hours

UNIT – IV	Introduction to Mass spectrometry; strategies for protein identification ; protein sequencing ; protein modifications and proteomics ; applications of proteome analysis to drug; Protein – protein interaction (Two hybrid interaction screening), Analysis and sequencing individual spots by Mass spectrometry (Maldi toff) and Protein microarrays .	08 hours
UNIT-V	Genomics – construction, vector design and screening of meta genomic libraries- biotechnological applications of meta genomics.	08 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lecturers	5 hours
	Total Lecture hours	**50 hours**

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text Books

1. Introducing proteomics (2011) Josip lovric. John Wiley Publication
2. Principles of proteomics (2013). R. M Twyman. Taylor and Francis publishers.

Reference Books

1. Expression Genetics: accelerated and High Throughput Methods (1999). Edited by M. McClelland and A. Pardee, Eaton Publishing, MA.
2. Microbial Functional Genomics (2004). J. Zhou, D.K. Thomson, Y. Xu and J.M. Tiedje, WileyLiss.
3. Reviews and articles from Journals such as Nature, Science, PNAS (USA), Nucleic AcidsResearch, Trends and Current Opinion Series.
4. Principles of Gene Manipulation and Genomics (2013) Sandy B. Primrose, Richard Twyman – Blackwell Publishing.
5. An Introduction to Genetic Engineering 3rd Edition Desmond, S. T. Nicholl Cambridge University Press
6. Molecular Biotechnology: Principles and Applications of Recombinant DNA 4th EditionBernard R. Glick, Jack J.Pasternak, Cheryl L. Patten ASM Press
7. Post-translational modifications in host cells during bacterial infection, D. Ribert, P. Cossart, FEBS letters, 2010.
8. Proteomics in practice: a laboratory manual of proteome analysis (2002).Westermeier, R., &Naven, T. John Wiley& Sons, Inc.
9. Proteomics for biological discovery. Veenstra, (2006). Timothy D. and John R. Yates John Wiley& Sons,
10. Plant proteomics: methods and protocols. (2007). Thiellement, H., Zivy, M., Damerval, C. and Méchin, V. eds. Totowa (NJ): Humana Press.

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the complex organization of genes (interrupted, overlapping, and gene families), outline the concepts of the C-value paradox, and explain the core operational principles of high-throughput technologies including Next-Generation Sequencing (NGS), MALDI-TOF Mass Spectrometry, two-hybrid screenings, and metagenomics.

CO2 (K3 - Apply): Apply genetic and molecular techniques to construct restriction maps, execute chromosome walking, identify single nucleotide polymorphisms (SNPs), perform site-directed mutagenesis to build molecular chimeras, and utilize downstream chromatography profiles to isolate specific proteins.

CO3 (K4 - Analyze): Analyze and interpret multi-dimensional data outputs, such as RFLP patterns, DNA fingerprints, Sanger sequencing chromatograms, Expressed Sequence Tags (ESTs) for gene-disease associations, and protein spots on 2D-gel electrophoresis images.

CO4 (K5 & K6 - Evaluate & Create): Evaluate target protein modifications, interactions, and microarrays for pharmaceutical drug discovery, and synthesize scalable biotechnological workflows to construct, design vectors for, and screen complex environmental metagenomic libraries.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	ELECTIVE -IV
Title of the Course	(B) ENVIRONMENTAL SCIENCES
Credits	2
Hours/Week	3
Course Objectives	1.To introduce students to the basics of Environment. 2.To enable the students learn basic structure and functions of ecosystem. 3.To make students understand the distribution of life and life forms on earth. 4.To make students aware of the different forms of energy in environment. 5.To make the students understand the different pollutants and pollution and their Management.

Units	Course Contents	Teaching Hours
UNIT I	Definitions, principles and scope of environmental science. Structure and composition of atmosphere, hydrosphere, lithosphere, biosphere. Meteorological parameters. Environmental education and awareness. Environmental Ethics.	5 hours
UNIT-II	Introduction to origin of life and speciation, Ecosystem structure andfunctions, food chains and webs, Basis of ecosystem classification, Biotransformation, water and air borne microbes, Bioremediation, Bioindicators, Biofertilizers, Biofuels and Biosensors.	5 hours
UNIT – III	Introduction to origin of earth, components of earth, zones of earth, Climates of India, weather reactions, erosion, transport, deposition of sediments, Soil forming minerals and process, identification and characterization of clay minerals, Ground water quality, pollution of ground water and mitigation of its impacts.	5 hours
UNIT – IV	Sources of energy, Sun as source of energy, Solar radiation and its spectral characteristics, Characteristics and energy content of coal, petroleum and natural gases, Energy usage pattern in world and India, Pollutants, emissions of CO_2 and Global warming.	5 hours
UNIT-V	Introduction to pollution, air, noise, water, soil, thermal, marine and radioactive Pollution, Concept of Waste management, Solid and hazardous waste management, Electrical energy generation, e-waste, fly ash, plastic waste, Environmental management system standards, IPCC, UNEP, IGBP, Global environmental issues-Biodiversity loss, climate change, Ozone depletion and sea level rise.	5 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lecturers	5 hours
	Total Lecture hours	30 hours

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text book:

1. Hardy, J.T. 2003. Climate Change: Causes, Effects and Solutions. John Wiley & Sons.
2. Harvey, D. 2000. Climate and Global Climate Change. Prentice Hall.
3. Minkoff, E.C. 1983. Evolutionary Biology. Addison Wesley. Publishing Company.
4. Nei, M. & Kumar, S. 2000. Molecular Evolution and Phylogenetics. Oxford University Press.
5. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2006. Environmental and Pollution Science. Elsevier Academic Press.
6. Purohit, S.S. & Ranjan, R. 2007. Ecology, Environment & Pollution. Agrobios Publications.
7. Owen, O.S, Chiras, D.D, & Reganold, J.P. 1998. Natural Resource Conservation –Management for Sustainable Future (7^{th} edition). Prentice Hall.
8. Elliott, D. 1997. Sustainable Technology. Energy, Society and Environment (Chapter 3). New York, Routledge Press.
9. Bagchi, A. 2004. Design of Landfills and Integrated Solid Waste Management. John Wiley & Sons.
10. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. & Sen, K. 2004. Climate Change and India. Universities Press, India.

Reference Books:

1. Botkin, Daniel B. (2011). Environmental Science: Earth as a living Planet, John Wiley and Sons,New Delhi.
2. Chapman. J. L. and Reiss, M.J. (2005). Ecology, Principles ad Applictions, Cambridge UniversityPress, London.
3. Dash, M.C. (1994).Fundamentals of Ecology, Tata Mc Graw Hill, New Delhi.
4. Gunther, O. (1998) Environmental Information Systems. Berlin, New York, Springer.
5. Miller G. Taylor and Scot Spoolman. (2011). Essentials of Ecology, Books/ Cole Learning, U.S.A.
6. (Pub.),New Delhi.
7. Strahler, A. V. and Strahler, A.A (1973). Environmental Geoscience, Wiley International.
8. Primack R.B. 2014. Essentials of Conservation Biology, Oxford University Press, USA.

Course Material: website links, e-Books and e-journals

1. https://www.hzu.edu.in/bed/E%20V%20S.pdf.
2. https://www.intechopen.com/books/1882.

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the structure and composition of the Earth's spheres (atmosphere, hydrosphere, lithosphere, biosphere), identify geological zones, soil-forming processes, and list the characteristics of renewable/non-renewable energy sources and types of environmental pollution.

CO2 (K3 - Apply): Apply biotechnological tools such as biofertilizers, biofuels, biosensors, and bioindicators to monitor and solve environmental challenges, and implement practical bioremediation and waste management systems for hazardous, electrical (e-waste), and plastic wastes.

CO3 (K4 - Analyze): Analyze the dynamics of ecosystem structures, food webs, and biotransformations, contrast energy usage patterns between India and the global landscape, and examine the geochemical properties of ground water pollution and sediment transport.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the environmental impacts of CO_2$ emissions and global warming trends, assess compliance with environmental management system standards alongside frameworks established by international bodies (IPCC, UNEP, IGBP), and synthesize strategic mitigation models to address global climate change, ozone depletion, and biodiversity loss.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	ELECTIVE - IV
Title of the Course	(C) HERBAL BIOTECHNOLOGY
Credits	2
Hours/Week	3
Course Objectives	1. To enable the students to learn about the biochemical parameters used in the identificationand utilization of medicinal plants 2. To enable the students to learn about the extraction of phytochemicals and procedures 3. To exploit and explore the medicinal values of plants 4. know the evaluation techniques for the herbal drugs To provide knowledge on biotech-based production of Herbal medicines

Units	Course Contents	Teaching hours
Unit I	Study of on history and scope of herbals - Introduction to the Indian system of medicine – Herbal drugs and importance- Herbal Cosmetic and Cosmeceuticals - Formulation Development of herbal preparations - Herbal Drug discovery and Novel drug delivery systems.	10 hours
Unit-II	Important medicinal herbs in treating diseases- Phytochemistry of medicinal plants- alkaloids - flavones- flavonoids and xanthones - furocoumarins - glycosides - naphthoquinones - phenols and acylphloroglucinols - resins, oleoresins and gum resins. Saponins - sterols and steroid-like compounds - tannins and terpenes.	08 hours
Unit-III	Biotechnological methods of plant propogation. - Micropropagation – Somatic Embryogenesis and somoclonal variation. Herbal gardening and maintenance - Standardization of cultivation protocols of selected medicinal plants; *in vitro* production of secondary metabolites. Polyhouse Technology - Important diseases of medicinal plants and their management.	13 hours
Unit-IV	Methods involved in secondary metabolite production - Organ culture, Cell culture, Biotransformation (Microbial and Plant cells) - Scaleup – Enhancement of product formation by elicitation - Immunodiagnostics and molecular diagnostics in selection of elite plant species.	08 hours

Unit-V	Introduction to analysis and quality controls of herbal products (TLC, HPLC, IR, NMR and mass spectroscopy). Pharmaceutical application of alkaloids, terpenoids, glycosides, volatile oils, tannins and resins - Intellectual Property Rights - Regulatory Affair herbal pharmaceuticals – Entrepreneurship Management.	08 hours
Unit-VI	Internal Assessments, Seminars, and Guest lecture	5 hours
	Total Teaching hours	**50 hours**

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Reference & Text Books:

1. Harborne, J.B., 1998. Phytochemical methods to modern techniques of plant analysis. Chapman & Hall, London.
2. Trease G. E, M. C. Evans, 1979. Textbook of Pharmacognosy12th ed. Balliere-Tindal, London.
3. Irfan A. Khan and Atitya Khanum (Eds.). 2004. Role of Biotechnology in Medicinal andAromatic plants, Vols. I-X.Ukaaz Publications, Hyderabad. Analytical techniques in DNA Sequencing edited by Brian K. Nunnally. 97
4. Agrawal S.S. and M. Paridhavi, Herbal Drug Technology, University press 2007.
5. Henry, R. J. 1997. Practical Applications of Plant Molecular Biology. Chapman &Hall, London, UK.
6. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (ed), Concepts in Biotechnology, University, Press, 1996.
7. Anderson, F.J Illustrated History of the Herbals. New York: Columbia University press.2009.
8. Callow, J. A., Ford-Lloyed, B. V. and Newbury, H. J. 1997. Biotechnology and PlantGenetic Resources: Conservation and Use, CAB International, Oxon UK.
9. Gokhale, S.S,C.K. Kokate and A.P. Purohit (1994). Pharmacognosy. Niraliprakashan, Pune.
10. Faroogi, A.A. and B.S. Sreeramu (2004), Cultivation of Medicinal and Aromatic crops. University Press (India) P.Ltd., Hyderabad.
11. Pal. D.C and S.K. Jain (1998), Tribal medicine, Naya Prakash, 206, Bidhan Sarani, Calcutta.
12. Thirugnanam, Akbarsha and Krishnamurthy (2010), Indian Medicinal plants and Home

Course Material:

1. Rasheeduzzafar (2006), Medicinal plants of India, CBS publication.
2. International Journal of Herbal Medicine
3. Journal of Herbal medicine Elsevier
4. en.wikipedia.org/wiki/Herbal medicine

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Describe the history and scope of the Indian system of medicine, identify different classes of plant secondary metabolites (such as alkaloids, flavonoids, and tannins), and outline the principles of micropropagation, polyhouse technology, quality control methods, and regulatory affairs in herbal pharmaceuticals.

CO2 (K3 - Apply): Apply biotechnological propagation methods (micropropagation, somatic embryogenesis) and elicitation strategies to enhance secondary metabolite production in organ and cell cultures, and use analytical techniques (TLC, HPLC, IR, NMR, Mass Spectroscopy) to extract and standardize herbal products.

CO3 (K4 - Analyze): Analyze the phytochemical profiles of medicinal plants to resolve their therapeutic and cosmetic properties, investigate plant diseases to implement management protocols, and differentiate the use of immunodiagnostics versus molecular diagnostics in identifying elite plant chemotypes.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the quality, safety, and commercial viability of herbal formulations and novel drug delivery systems, appraise Intellectual Property Rights (IPR) and entrepreneurship opportunities within the biosector, and design scalable biotransformation or cultivation pipelines for premium herbal products.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	1	0	1	1	3	2	1	2	1	2	1
CO2	2	3	3	2	0	1	1	3	2	3	2	1	2	1
CO3	2	3	2	3	0	2	1	3	3	2	3	2	3	1
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	1

Course	**SKILL ENHANCEMENT COURSE-I**
Title of the Course	**(A) MUSHROOM CULTIVATION AND APICULTURE**
Credits	**2**
	2

Course Objectives	1.To make the students to know about mushroom and their types. 2.To enable the students to learn the mushroom spawn production conditions. 3.To make the students learn about mushroom cultivation and maintenance. 4.To make the students to know about apiculture scope and bee keeping and types. 5.To enable the students to understand the importance of honey and applications.

Units	**Course Contents**	**Teaching hours**
UNIT I	History of Mushroom cultivation and its practice, Introduction to mushroom cultivation, Classification of Mushrooms and different types, Edible Mushrooms - types and their origin, Poisonous Mushrooms- types and their origin.	5 hours
UNIT-II	Introduction to mushroom cultivation, Sources of beds and types, Spawn, Sources, spawn run, cultivation set up, Culture ventilation and humidity management, temperature, lighting, moisture, pH, CO_2, Culture chambers - Preparation, Sterilization, Instructions, precautions, handling and sensors.	5 hours
UNIT – III	Mushroom cultivation maintenance, conditions and duration, Spawn collection, preparation, storage, Spawning techniques, Environmental conditions, temperature, moist, Fruiting initiation, monitoring, maintenance and harvest.	5 hours
UNIT – IV	Introduction to apiculture, definitions, history, scope, importance of apiculture, Bee Keeping methods practiced in world and in India, Traditional Bee keeping techniques, Modern Bee keeping methods, Urban Beekeeping methods.	5 hours
UNIT-V	Introduction to nutritional product of honey and its constituents, Honey - properties, biological activities, medicinal values, Applications of Honey in various fields, Honey types and value added honey products.	5 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lecturers	5 hours
	Total Lecture hours 65 hours	30 hours

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text book:

1. Paul Stamets, J.S. and Chilton, J.S. 2004. Mushroom cultivation A practical guide to growing mushrooms athome, Agarikon Press.
2. Tewan and Pankaj Kapoor S.C. 1993. Mushroom cultivation. Mittal Publication. Delhi.
3. Marimuth et al., 1991. Oyster Mushrooms. Dept. of Plant Pathology, TNAU, Coimbatore.
4. Nita Bahl. 1988. Hand book of Mushrooms, 2nd Edition, Vol I & II.
5. Shu Fing Chang, Philip G. Miles and Chang, S.T. 2004. Mushrooms Cultivation, nutritional value, medicinal effect and environmental impact. 2nd ed., CRC press.
6. Prost, P. J. (1962). Apiculture. Oxford and IBH, New Delhi.
7. Bisht D.S., Apiculture, ICAR Publication.
8. Singh S., Beekeeping in India, Indian council of Agricultural Research, New Delhi

Reference Book:

1. Laidlaw, H.H., 1997. Contemporary queen rearing. Published by Dadant and Sons. R. A. Morse, Rearing queen honeybees. Wicwas press, NY.
2. Alison Benjamin, By (author) Brian Mc Callum, 2008. Keeping Bees and Making Honey. David & Charles, NewtonAbbot.
3. Kim Pezza, 2013. Backyard Farming: Keeping Honey Bees: From Hive Management to Honey Harvesting and More. Hatherleigh Press, U.S.
4. Kim Flottum, 2014. The Backyard Beekeeper: An Absolute Beginner's Guide to KeepingBees in Your Yard and Garden. Quarry Books.
5. Kannaiyan, S. Ramasamy, K. (1980). A hand book of edible mushroom, Today & Tomorrows Printers &Publishers, New Delhi.
6. Pandey B P 1996. A textbook of fungi. Chand and Company N Delhi.

Course Material: website links, e-Books and e-journals

1.https://books.google.co.in/books/about/Mushroom_Cultivation_in_India.
2.https://books.google.co.in/books/about/Mushroom_Cultivation_in_India.html?id=6AJx99 OGT KEC&redirhttps:// books.google.co.in/books/about/Mushroom_Cultivation_in_India.html?id=6AJx99OGTKE C&re dir

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Identify edible and poisonous mushroom species, explain the lifecycle and environmental requirements (temperature, humidity, pH, CO_2) for spawn running, outline the history and scope of apiculture, and describe traditional versus modern beekeeping methods.

CO2 (K3 - Apply): Apply standardized procedures to prepare, sterilize, and manage mushroom culture chambers, implement spawning and harvesting techniques, and utilize modern apiary management tools to establish urban or agricultural beekeeping units.

CO3 (K4 - Analyze): Analyze the influence of abiotic factors (lighting, moisture, ventilation) on

fruiting initiation and yield in mushroom cultivation, and examine the chemical constituents, biological activities, and medicinal properties of different types of honey.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the quality and safety parameters of harvested mushrooms and hive products, appraise the economic viability of agricultural setups, and formulate innovative business frameworks to manufacture value-added honey products and optimized mushroom substrates for commercial biotechnology sectors.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	2	0	1	1	3	2	1	2	2	2	2
CO2	2	3	3	2	0	1	1	3	2	3	2	2	2	3
CO3	2	3	2	3	0	2	1	3	3	2	3	3	2	3
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	3

Course	**SKILL ENHANCEMENT COURSE -1**
Title of the Course	**(B) VERMICULTURE TECHNOLOGY**
Credits	**2**
	2
Course Objectives	1. To enable the students learn about Vermiculture compositing. 2. To enable the students to know the humus cycle, soil transformation 3. To enable the students analyze the nutritional composition of vermicompost. 4. To enable the students to learn Vermiculture technology. 5. To enable the students to learn the harvest of vermicompost.

Units	**Course Contents**	**Teaching hours**
UNIT I	Introduction to Vermiculture technology, definition, meaning and history, Economic importance of Vermiculture, their value in soil texture, Concept of recycling, Concept of four r' s reduce, reuse, recycle and restore.	5 hours
UNIT-II	Introduction to matter, types of matter, Introduction to Humus, Humus cycle, sources, quality of products for Humus formation, Ground population and transformation process in organic matter.	5 hours

UNIT – III	Introduction of plant fertilizers, nutritional value and their importance, Vermicompost - composition and its nutritional value, Importance of vermicompost as fertilizer for plants, Comparison of vermicompost with other fertilizers.	5 hours
UNIT – IV	Introduction to vermibeds, sources, types, Preparation of vermibeds, measurements, Maintenance of vermicompost, Composting conditions, moist, temperature and aeration.	5 hours
UNIT-V	Vermicompost identification, conditions and separation, Compost packing, sources and methods, Compost - storage, conditions and durations, Vermicompost handling and transport.	5 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lecturers	5 hours
	Total Lecture hours 65 hours	30 hours

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text book:

1. Kevin, A and K.E. Lee (1989) " Earthworm for Gardeners and Fisherman" (CSIRO, Australia, Division of Soils)
2. Rahudakar V.B. (2004). Gandul khatashivay Naisargeek Paryay, Atul Book Agency, Pune.
3. Satchel, J.E. (1983) "Earthworm Ecology" Chapman Hall, London.
4. Wallwork, J.A. (1983) "Earthworm Biology" Edward Arnold (Publishers) Ltd. London.
5. Sultan Ahmed Ismail, 2005. The Earthworm Book, Second Revised Edition. Other IndiaPress, Goa, India. 2. Bhatnagar & Patla, 2007.
6. Earthworm vermiculture and vermin-composting, Kalyani Publishers, New Delhi

Reference Book:

1. Bhatt J.V. & S.R. Khambata (1959) "Role of Earthworms in Agriculture" Indian Council of Agricultural Research, New Delhi 2.

2. Dash, M.C., B.K.Senapati, P.C. Mishra (1980) " Verms and Vermicomposting" Proceedings of the National Seminar on Organic Waste Utilization and Vermicomposting Dec. 5-8, 1984, (Part B), School of Life Sciences, Sambalpur University, Jyoti Vihar, Orissa.

3. Edwards, C.A. and J.R. Lofty (1977) "Biology of Earthworms" Chapman and Hall Ltd., London.

4. Lee, K.E. (1985) "Earthworms: Their ecology and Relationship with Soils and Land Use" Academic Press, Sydney. 5. Kevin, A and K.E. Lee (1989) "Earthworm for Gardeners and Fisherman" (CSIRO, Australia, Division of Soils)

5. Mary Violet Christy, 2008. Vermitechnology, MJP Publishers, Chennai.

6. Aravind Kumar, 2005.Verms & Vermitechnology, A.P.H. Publishing Corporation, New Delhi.

Course Material: website links, e-Books and e-journals

1. Vermiculture Technology, Earthworms, Organic Wastes, and EnvironmentalManagement Edited By Clive
2. A. Edwards, Norman Q. Arancon, Rhonda L. Sherman,https://www.scirp.org/journal/paperinformation.aspx?paperid=2490, DOI: 10.4236/ti.2010.13019

COURSE OUTCOMES (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Identify suitable earthworm species (such as *Lampito mauritii*) for vermicomposting, describe their reproductive biology, outline the processing workflows, and state the nutrient profiles of vermicompost and vermiwash.

CO2 (K3 - Apply): Apply specific standard techniques to collect, preserve, and culture earthworms using diverse small-scale setups (pot, dual-bin, wooden box, or hanging basket methods), including the pre-treatment of organic feedstock waste.

CO3 (K4 - Analyze): Analyze critical operational parameters (such as temperature, moisture, and pH) that affect worm propagation, and compare the functional design layouts of small-scale vs. large-scale commercial composting modules.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the chemical and biological quality of produced vermiwash, and design a scalable, cost-effective commercial vermiculture project model capable of operating as a self-employment venture.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	2	0	1	1	3	2	1	2	2	2	2
CO2	2	3	3	2	0	1	1	3	2	3	2	2	2	3
CO3	2	3	2	3	0	2	1	3	3	2	3	3	2	3
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	3

Course	**SKILL ENHANCEMENT COURSE -1**
Title of the Course	**(C) VALIDATION OF MEDICINAL PLANTS**
Credits	**2**
	2
Course Objectives	1. To enable the students to understand the importance of medicinal plants. 2. To enable the students to identify the medicinal plants. 3. To enable the students to learn the techniques of validation of medicinal plants. 4. To enable the students to learn the cultivation methods and maintenance of medicinal plants. 5. To enable the students to understand the importance of medicinal plant in human health.

Units	**Course Contents**	**Teaching hours**
UNIT I	Introduction to Medicinal plants, meaning, definition and types, Medicinal properties of plants and their importance, Medicinal values in plant parts, fruits, stem, leaves and roots, Leaf, fruit, root and stem modifications, aerial and underground.	5 hours
UNIT-II	Introduction to Medicinal plant identification, Elementary knowledge of binomial nomenclature, Bentham and Hooker classification, Herbarium, preparation and preservation.	5 hours
UNIT – III	Introduction to validation of medicinal plants, Macroscopic characteristics of medicinal plants, Microscopic characteristics of medicinal plants, Chemical compounds and tests of medicinal plants, Chromatographic techniques for validation TLC, HPLC, HPTLC & Gas Chromatography.	5 hours
UNIT – IV	Introduction to medicinal plant cultivation, Cultivation techniques and factors affecting the cultivation of medicinal plants, Propagation of medicinal plants and different methods of propagation, Management and Maintenance of medicinal plants.	5 hours

UNIT-V	Importance of medicinal value in plants, Medicinal properties of plants in human health and its role, advantages, Role of medicinal plants in prevention and treatment of human diseases, Traditional knowledge and utility of Indian medicinal plants.	5 hours
UNIT-VI	Internal Assessment: Assignments, Seminars and Guest lecturers	5 hours
		30 hours

Method of Evaluation: (25 Internal marks + 75 External Marks=100)

Distribution for internals Test (CIA I + CIAII + CIA III)	Seminars	Assignment	End Semester Examination	Total marks
15	05	05	75	100

Text book:

1. Indian Medicinal Plants by P.C. Trivedi (2009).
2. Medicinal Plants of Indian Himalaya by S.S. Samant and U. Dhar.
3. Indian Medicinal Plants (Vol 1- 4) by K.R. Kirtikar and B.D. Basu (2006).
4. Indigenous Medicinal Plants Social Forestry & Tribals by M.P. Singh et al. (2003).
5. Ayurvedic Drugs and their Plant Sources by V.V. Sivarajan & I. Balachandran, Oxford &IBH(1994).
6. The Handbook of Ayurveda Shantha by Godagama, Bishen Singh Mahendrpal Singh, Dehradun(2004).
7. Direct uses of medicinal plants and their identification by Vardhana, Sarup and Sons, AnsariRoad, Dariyaganj, New Delhi (2008).
8. Medicinal plants, applied biology of domestication and export by K. Singh, S.K. Tyagi,Bishen Singh Mahendrapal Singh Dehradun.
9. Quality Control Methods for Medicinal Plants Materials, W.H.O. (1998).
10. Evaluation of herbal medicinal products by Houghton

Reference Book:

1. A Class Book of Botany. A.C. Dutta. Oxford University Press.
2. Cultivation of Medicinal Plants by C.K. Atal & B.M. Kapoor.
3. Hartmann, H.T & Kester, D.E (1989). Plant Propagation – Principles and Practices. Prentice Hall ofIndia
4. Awadesh N, Ghoeami A and Sharma R, Indigenous Health Care and Ethnomedicine, Sarupand Sons.
5. Medicinal Plants Cultivation: A Scientific Approach by S.S. Purohit, (2004).
6. Bruneton Jean, Caroline K. Hatton, Pharmacognosy, Phytochemistry, Medicinal plants. Lavoisier,1999.ISBN 1898298637.

7. Nikolaus J. Sucher, Maria C. Carles, Genome-Based Approaches to the Authentication ofMedicinal Plants. Planta Med., 74: 603–623; 2008.
8. WHO guidelines on good agricultural and collection practices (GACP) formedicinal plants, World Health Organization, Geneva, 2003.
9. Iqbal Ahmad, FarrukhAqil, and Mohammad Owais, Modern Phytomedicine: Turning Medicinal Plants into Drugs. WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim,2006. ISBN-10: 3-527-31530-6.
10. Ved D.K. & Goraya, G.S. Demand & supply of medicinal plants in India, NMPB,New Delhi & FRLHT,Bangalore, India, 2008.

Course Material: website links, e-Books and e-journals

1. Planta Medica, Issue 13 · Volume 79 · August 2013. https://www.thieme-connect. Com / products / ejournals
2. https://www.sciencedirect.com/book/9780128008744/evidence-based-validation-of- herbal-medicine.
3.https://www.tandfonline.com/doi/citedby/10.1080/13880200902800196?scroll=top&needAcces s=true.

Course Outcomes (CO)

On completion of this course, the learners will be able to:

CO1 (K1 & K2 - Remember & Understand): Define the core terms, types, and advantages of medicinal plants, outline the rules of binomial nomenclature, describe the Bentham and Hooker classification system, and explain the anatomical modifications of roots, stems, and leaves that hold therapeutic value.

CO2 (K3 - Apply): Apply practical taxonomic skills to collect, prepare, and preserve standard herbarium specimens, utilize diverse vegetative and structural propagation techniques to cultivate medicinal plants, and implement maintenance protocols to manage crops against unfavorable environmental factors.

CO3 (K4 - Analyze): Analyze the microscopic and macroscopic characteristics of plant tissues to validate their identity, and differentiate between specific analytical profiles—such as Thin-Layer Chromatography (TLC), HPLC, HPTLC, and Gas Chromatography (GC)—to characterize chemical compounds within plant extracts.

CO4 (K5 & K6 - Evaluate & Create): Evaluate the medicinal efficacy and therapeutic roles of traditional Indian medicinal plants in preventing and treating human diseases, appraise qualitative validation benchmarks for safety and purity, and compile sustainable, standardized cultivation and extraction strategies optimized for the herbal pharmacognosy sector.

MAPPING OF COURSE OUTCOMES (Cos) WITH PROGRAMME OUTCOMES(Pos) AND PROGRAMME SPECIFIC OUTCOME(PSOs)

	POs							PSOs						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
CO1	3	2	1	2	0	1	1	3	2	1	2	2	2	2
CO2	2	3	3	2	0	1	1	3	2	3	2	2	2	3
CO3	2	3	2	3	0	2	1	3	3	2	3	3	2	3
CO4	2	3	3	3	0	2	2	3	3	3	2	3	3	3