UPES
UNIVERSITY OF TOMORROW

SCHOOL OF
HEALTH SCIENCES
AND TECHNOLOGY

B.Sc. Microbiology

Four-Year Program

Program Structure | 2023-2027

UPES Bidholi Campus, P.O. Bidholi via Prem Nagar, Dehradun, Uttarakhand-248007
Tel: +91 0135 2770137 | Website: www.upes.ac.in

School of Health Sciences and Technology

[B.Sc. Microbiology Four-Year Program]

Program Structure

Template

2023-2027

UPES Campus, “Energy Acres”
P.O Bidholi via Prem Nagar, Bidholi
Dehradun, Uttarakhand-248001

Tel: + 91-135-2776053/54
Fax: + 91-135-2776090
URL: www.upes.ac.in

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1.0 Abbreviations

Cat	-	Category
L	-	Lecture
T	-	Tutorial
P	-	Practical
Cr	-	Credits
UC	-	University Core
PC	-	Program Core
PRJ	-	Project Work (including Seminars, Dissertation, and Internships)
PE	-	Program Elective (includes Specialization courses)
UE	-	University Elective (includes Signatory, Exploratory, and Open Electives)
TC	-	Total Credits

2.0 Vision and Mission of the University

Vision of UPES

To be an Institution of Global standing for developing professionally competent talent contributing to nation building

Mission of UPES

- Develop industry-focused professionals with an international outlook.
- Foster an effective outcome-based education system to continually improve teaching-learning and research.
- Inculcate integrative thought process among students to instill lifelong learning.
- Create global knowledge ecosystem through training, research & development and consultancy.
- Practice and promote high standards of professional ethics and develop harmonious relationship with the environment and society.

3.0 Vision and Mission of the School

Vision of SoHST

Leadership in Health Sciences & Technology for improving Planetary, and Public Health

Mission of SoHST

To create thought leaders and change makers.

To d**esign** appropriate, holistic and sustainable programs

To converge multi-disciplinary efforts to make a difference for people and the planet.

4.0 Programme Educational Objectives

PEO1: Graduates will be accomplished professionals, innovators or entrepreneurs actively involved in bio-medical research, academics and technology development.

PEO2: Graduates will function in their profession with ethics, social awareness and responsibilities.

PEO3: Graduates will engage with professionals in the field of allied health and environmental sciences for collaborations and knowledge exchange.

PEO4: Graduates will be successful in pursuing higher studies in allied health sciences.

PEO5: Graduates will pursue career paths in academia or research.

5. Program Outcomes (POs):

At the end of the program students should be able to:

- **PO 1:** Gain knowledge of basic and applied aspects of microbiology and allied sciences.
- **PO 2:** Demonstrate basic laboratory skills in microbiology and understanding of advanced analytical tools to gather scientific evidence.
- **PO3:** Ability to comprehend basic analytical problems, apply critical thinking skills and offer scientific solutions.
- **PO4:** Demonstrate and execute time management during the completion of academic exercises, assignments and research projects.
- **PO5.** Demonstrate awareness of the roles, responsibilities and ethical standards as per academia and industry alignments.
- **PO6:** Demonstrate leadership abilities, problem-solving capability and decision making with high ethical standards.
- **PO 7:** Demonstrate good interpersonal communication skills.
- **PO 8:** Demonstrate eagerness for tackling critical societal issues concerning human and planetary health.
- **PO 9:** Recognize the need for and prepare to engage in life-long learning to adapt to technological changes.

Program Specific Outcomes (PSOs) for Microbiology

- **PSO 1:** Demonstrate knowledge of the diversity of microbes, microbial life processes, microbial interactions in the environment and higher hosts, and strategies to obtain valuable microbial metabolites for societal benefits.

- **PSO 2:** Ability to apply elements of research methodology to design and execute basic experiments and work towards developing solutions for emerging health, social and environmental problems.

- **PSO 3:** Apply knowledge of microbiology to pursue a wide range of careers in higher academia and research, public health, environmental organizations, societal organizations, relevant industries and entrepreneurial activities.

6.0 Overview of Credit Allocation/ Credit Break up

Category-wise Credit distribution

Category	Number of Credits	Credit Percentage (%)
Programme Core (PC)	115	71.88
Programme Elective (PE)	14	8.75
University Elective (UE)	0	-
Projects (PRJ)	15	9.38
Mandatory Non-Credit Courses	7	-
University Core (UC)	16	10.0
Total	160	100

- University core subjects are those subjects that are mandatory to all similar programs.
- Program Core courses in a curriculum are program specific. To be eligible for the degree, students must successfully finish each of the PC-listed courses.
- Program Elective courses provide the students the opportunity to study courses that are more complex and specialized, in their field of specialization.
- University electives are courses that a student can opt for outside of his/ her program from across the university. This allows students to pursue their interests in other subjects as well. The number of credits that a student may take under University Elective is regulated.

7.0 Programme Structure

The term "Program Structure" refers to a list of courses (Core, Elective, and Open Elective) that make up an academic program, describing the syllabus, credits, hours of instruction, assessment and examination systems, a minimum amount of credits necessary for program graduation, etc.

7.1 Programme Grid

B.Sc. Microbiology Programme (2023-2027)

SEMESTER I

Cat	Course Code	Course Title	L	T	P	TC
	HSMB 1010	Biosciences	3	1	2	6
	HSMB 1011	Introduction to Microbiology	3	1	2	6
	HSMB 1012	Cell and Molecular Biology	3	1	2	6
		Living Conversations (SFL)	1	1	0	2
		Ability Enhancement / Co-curricular				0

SEMESTER II

Cat	Course Code	Course Title	L	T	P	TC
PC		Principles of Biochemistry	2	1	1.5	4.5
PC		Computer Application and Bioinformatics	2	1	1.5	4.5
PC		Fundamentals of Biostatistics	2	1	1.5	4.5
UC		Critical Thinking and Writing (SFL)	1	1	0	2
PE		Elective Course	2	1	1.5	4.5

SEMESTER III

Cat	Course Code	Course Title	L	T	P	TC
PC		Prokaryotic Microbiology	2	1	1.5	4.5
PC		Eukaryotic Microbiology	2	1	1.5	4.5
PC		Microbial Physiology and Metabolism	2	1	2	5
UC		Environmental Science	3	1	0	4
UC		Leadership and Teamwork	1	1	0	2
MNC		Ability Enhancement / Co-curricular				0

SEMESTER IV

Cat	Course Code	Course Title	L	T	P	TC
PC		Agricultural Microbiology and Plant Pathology	2	1	1.5	4.5
PC		Environmental Microbiology and Biogeochemistry	2	1	1.5	4.5
PC		Biosafety and Aseptic Techniques	2	1	1.5	4.5
UC		Working with Data	2	0	0	2
MNC		Ability Enhancement / Co-Curricular				0
PE		Elective Course	2	1	1.5	4.5

SEMESTER V

Cat	Course Code	Course Title	L	T	P	TC
PC		Medical Microbiology and Diagnostics	2	1	1.5	4.5
PC		Epidemiology and Global Health	2	1	1.5	4.5
PC		Immunology	2	1	1.5	4.5
PC		Bioinstrumentation	2	1	1.5	4.5
UC		Design Thinking	1	1	0	2
MNC		Ability Enhancement / Co-curricular	0	0	0	0
MNC		Industrial Training / Survey / Project			4	Q*

SEMESTER VI

Cat	Course Code	Course Title	L	T	P	TC
PC		Microbial Genetics and Biotechnology	3	1	2	6
PC		Microbiome and Omics	3	1	2	6
PC		Food Microbiology	3	1	2	6
UC		Start your Start up (SFL)	1	1	0	2
MNC		Ability Enhancement / Co-curricular	0	0	0	0
MNC		Industrial Training / Survey / Project			4	Q*

SEMESTER VII

Cat	Course Code	Course Title	L	T	P	TC
PC		Microbial Systems Biology	3	1	1	5
PC		Industrial Microbiology	3	1	1	5
PC		Research Methodology	3	1	1	5
PC		Good Laboratory and Manufacturing Practices	3	1	1	5

SEMESTER VIII

Cat	Course Code	Course Title	L	T	P	TC
PRJ		**Industrial Training / Start up** (For BSc Honours Students) **Research Project** (For BSc Honours Students with Research)	-	-	15	15
PE		Elective Course	3	2	-	5

*Q – Qualifying

Note:
Common courses highlighted in Red

8.0 List of Electives as per NEP

8.1 ELECTIVES (SEMESTER II)

Cat	Course Code	Course Title	L	T	P	TC
PE		Laboratory Safety Guidelines	2	1	1.5	4.5
PE		Introduction to Microbiology	2	1	1.5	4.5
PE		One health Perspectives	2	1	1.5	4.5

8.2 ELECTIVES (SEMESTER IV)

Cat	Course Code	Course Title	L	T	P	TC
PE		Biosafety and Aseptic Techniques	2	1	1.5	4.5
PE		Environmental Microbiology and Biogeochemistry	2	1	1.5	4.5
PE		Food contamination and food borne infections	2	1	1.5	4.5

8.3 ELECTIVES (SEMESTER VIII)

Cat	Course Code	Course Title	L	T	P	TC
PE		Microbial Quality Control and Assessment	3	2	0	5
PE		Industrial Microbiology	3	2	0	5
PE		Microbial Bioprospecting	3	2	0	5

8.0 List of Electives as per NEP

S.N.	Electives	Credits
1	Skill Enhancement/Vocational-I: **Living Conversations (SFL)**	2
2	Ability Enhancement/Co-curricular-I	Qualifying
3	Skill Enhancement/Vocational-II: **Critical Thinking and Writing**	2
4	Ability Enhancement/Co-curricular-II	Qualifying
5	Minor Elective (Exploratory Elective) either in I or II Semester	4.5
6	Skill Enhancement/Vocational-III: **Environmental Science**	4
7	Skill Enhancement/Vocational-IV: **Leadership and Teamwork**	2
8	Ability Enhancement/Co-curricular-III	Qualifying
9	Skill Enhancement/Vocational-V: **Working with Data**	2
10	Ability Enhancement/Co-curricular-IV	Qualifying
11	Skill Enhancement/Vocational-VI: **Design Thinking**	2
12	Industrial Training/Survey/Project	Qualifying
13	Ability Enhancement/Co-curricular-V	Qualifying
14	Skill Enhancement/Vocational-VII: **Start your Start Up (SFL)**	2
15	Ability Enhancement/Co-curricular-VI	Qualifying
16	Industrial Training/Survey/Project	Qualifying
17	Industrial Internship/Startup - BSc Honours students Research Project-BSc Honours with Research students	15
18	Minor elective	5

9.0 Course Syllabus

SEMESTER I

HSCC XXXX	BIOSCIENCES	L-T-P-C: 3-1-2-6

COURSE OBJECTIVES

This introductory level course gives information on components of the living world, fundamental evolutionary principles, classifications of kingdom Plantae, anatomy and physiology of plants and humans. This course will serve as a foundation for studying the myriad interactions between microorganisms with plants and humans.

COURSE OUTCOMES

After completion of this course, students should be able to:

CO1. Discuss fundamental concepts of the living world and evolution, classifications of Kingdom Plantae, plant morphology and physiology.

CO3. Explain the gross morphology, structure and relate coordinated functions of various organs and organ systems of the human body.

CO3. Demonstrate skills to identify and describe basic components of plant and human anatomical features and tissue level organizations

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	-	-	-	-
CO 2	3	3	3	-	-	-	-	-	-	-	-	-
CO 3	3	3	3	-	-	-	-	-	-	-	1	-
Average	3	3	3	-	-	-	-	-	-	-	1	-

1 – Weakly Mapped (Low); 2 – Moderately Mapped (Medium); 3 – Strongly Mapped (High);
"_" means there is no correlation

SYLLABUS

UNIT I: LIVING WORLD AND EVOLUTION 8 Hrs

Diversity and classifications of living world - Binomial nomenclature, Taxonomic hierarchy, Whittaker's Five kingdoms of life and salient features of Monera, Protista, Fungi, Animalia, Plantae and Virus.

Origin of life (theories), Basic Concepts and Evidences of Evolution, Theories of evolution: Lamarckism, Darwinism, Neo-Darwinism. Evolution of populations, Concepts of Species, Mechanisms of speciation, Brief history of evolution of Plants and Humans.

UNIT II: PLANT BIOLOGY AND PHYSIOLOGY 20 Hrs

Kingdom Plantae: Cryptogams (Thallophytya, Pteridophyta and Bryophyta) and Phanerogams (Gymnosperms and Angiosperms); Classification, Habitat, General characteristics, Salient features, Economic importance, Morphology and Life Cycles of Pteridophytes, Bryophytes, Gymnosperms and Angiosperms.

Plants and mineral nutrition, transpiration, photoperiodism and biological clocks, Photosynthetic apparatus and mechanisms of Photosynthesis (Light and Dark reaction - C3, C4 and CAM pathway, Photophosphorylation), Factors affecting photosynthesis, Photosynthetic efficiency - Fv/Fm, CO_2 fixation pathways, Plant respiration and photorespiration; Plant growth phases and development, Plant growth regulators.

UNIT III: INTRODUCTION TO HUMAN ANATOMY 8 Hrs

Definition and scope of anatomy and physiology, levels of structural organization and body systems, basic life processes, homeostasis, and basic anatomical terminology.

Structure and functions of the cell, transport in the cell membrane, cell division, cell junctions. General principles of cell communication, intracellular signaling pathway activation by extracellular signal molecule, Forms of intracellular signaling: a) Contact-dependent b) Paracrine c) Synaptic d) Endocrine

Tissue Level of Organization: Classification of tissues, structure, location and functions of epithelial, muscular and nervous and connective tissues.

UNIT IV: CIRCULATORY AND CARDIOVASCULAR SYSTEM 8 Hrs

Circulatory System: Human circulatory system, Composition of blood, hemopoiesis, formation of hemoglobin, anemia, mechanisms of coagulation, blood grouping, Rh factors, transfusion, its significance and disorders of blood; Lymphatic system - lymph circulation and functions of lymphatic system

Cardiovascular System: Basic Anatomy of heart, blood circulation, blood vessels, structure and functions of artery, veins and capillaries, elements of the conduction system of heart and heartbeat, its regulation by autonomic nervous system, cardiac output, cardiac cycle. Regulation of blood pressure, pulse, electrocardiogram and disorders of heart.

UNIT V: DIGESTIVE, RESPIRATORY AND EXCRETORY SYSTEM 8 Hrs

Digestive System: Human alimentary canal and digestive glands, Role of digestive enzymes, Digestion, absorption and assimilation of digested food

Respiratory System: Human respiratory system, Mechanism of breathing and its regulation, Exchange of gases, transport of gases and regulation of respiration, Respiratory volumes.

Excretory System: Modes of excretion, Human excretory system- structure and function, Urine formation, Rennin angiotensin system

UNIT VI: NERVOUS, ENDOCRINE AND REPRODUCTIVE SYSTEM 8 Hrs

Nervous System: Definition and classification of nervous system, Structure of a neuron, Generation and conduction of nerve impulse, Structure of brain and spinal cord, Functions of cerebrum, cerebellum, hypothalamus and medulla oblongata

Endocrine System: Endocrine glands and their secretions, Functions of hormones secreted by endocrine glands

Reproductive System: Human reproduction, Parts of female reproductive system, Parts of male reproductive system, Spermatogenesis and Oogenesis, Menstrual cycle.

PRACTICALS: 60 Hrs

1. Study of anatomical, histological details and reproductive bodies through permanent slides / temporary mounts:
   a) Bryophytes
   b) Pteridophytes
   c) Gymnosperms
   d) Root - Monocot and dicot, b) Stem- Monocot and dicot, c) Leaf- Monocot and dicot.
2. Study of angiosperm ovules (permanent slides/ specimens/photographs)
3. Study of different types of flowers from fresh / preserved specimens of angiosperms
4. Study of different types of fruits from fresh/preserved specimens of angiosperms
5. Microscopic study of epithelial and connective tissue
6. Microscopic study of muscular and nervous tissues
7. Identification of axial bones
8. Identification of appendicular bones
9. Determination of blood pressure and Tidal volume
10. Determination of heart rate and pulse rate.

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3. Rastogi VB (2018) Organic Evolution. 13th Ed, Medtech, Scientific International Ltd
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7. Biswas and Johri (2014) The Gymnosperms. Ed 1997. Springer.
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10. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. 3rd Ed, John Wiley and Sons, Inc.
11. Guyton and Hall (2020) Text Book of Medical Physiology. 14th Ed, Elsevier India
12. Ross and Wilson (2022) Anatomy and physiology in Health and Illness. 14th Edition, Church Hill Livingstone.
13. Barret EK, Barman SM, Brooks HL, Yuan J (2022) Ganong's review of medical physiology. 26th Ed, McGraw Hill Medical.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX	INTRODUCTION TO MICROBIOLOGY	L-T-P-C: 3-1-2-6

COURSE OBJECTIVES

This course introduces students to the fascinating world of unseen microbes. Foundational knowledge of microbiology is introduced within a historical narrative in cthe ontext of the major discoveries by important scientists. Students are introduced the two diversities of microbial world in the biosphere, general characteristics of different gromicroorganismsganisms microbes, a brief history of microbial life on Eather rah and scope of microbiology.

COURSE OUTCOMES

After completion of this course, the students will be able to:

CO1. Discuss foundational discoveries in microbiology, contributions of various scientists and diversity of the microbial world and taxonomy

CO2. Describe the classification of microbes and salient features of different groups of microbes

CO3: Demonstrate basic skills in culturing, preparation of simple culture media, staining techniques, preservation and observation of microrganisms using light microscopy.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	-	2	-	-
CO 2	3	3	-	-	-	-	-	-	-	2	-	-
CO 3	3	3	3	2	-	-	1	1	1	2	1	1
Average	3	2	3	2	-	-	1	1	1	2	1	1

1 – Weakly Mapped (Low); 2 – Moderately Mapped (Medium); 3 – Strongly Mapped (High);
"_" means there is no correlation

SYLLABUS

UNIT I: MICROBIAL WORLD **15 Hrs**

Microorganisms, Types of Microorganisms (Bacteria, Archaea, Algae, Fungi, Virus, Protozoa), Microbial cell dimensions, Observation of Microorganisms – Microscopy, resolving power, magnification, working principle and operation of simple and compound microscopes. General characteristics of acellular microorganisms and cellular microorganisms.

Carl Woese's three kingdom classification system, Taxonomic hierarchy and Microbial systematics. Outline of Bergey's manual and its importance in systematic bacteriology

Microrganisms in the Biosphere: Extremophiles, Geological time scales and a brief History of microbial Life on Earth and origin of life, Fossil evidence of microorganisms.

UNIT II: HISTORY AND SCOPE OF MICROBIOLOGY **15 Hrs**

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming.

Role of microorganisms in food fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Koch's postulates, History of vaccines and anti-microbials.

Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

Development of the field of soil and environmental microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.Waksman; Development of the field of marine microbiology and geomicrobiology and other disciplines.

UNIT III: BACTERIA AND VIRUSES **10 Hrs**

Typical Eubacteria, Archaebacteria (extremophiles), Chlamydia & Rickettsia (obligate intracellular parasites), Mycoplasma. Overview of prokaryotic cell structure: Size, shape, arrangement. Ultra structure of prokaryotic cell: bacterial and archaeal - cell wall and cell membranes.
General introduction to Viruses, TMV, poliovirus, T4 and λ phage, lytic and lysogenic cycles, Structure, significance and transmission of Viroids and Prions.

UNIT IV: ALGAE, FUNGI AND PROTOZOA **10 Hrs**

General characteristics of algae, algae cell ultra-structure, pigments, asexual and sexual reproduction and economic importance.
General characteristics of fungi, fungal cell ultra-structure, thallus organization, fungal wall, asexual reproduction and sexual reproduction, economic and medical importance.
General characteristics, mode of reproduction and transmission of protozoa. Concept of Parasitism, Parasite and Vectors.

UNIT V: TECHNIQUES IN MICROBIOLOGY **10 Hrs**

Staining: Nature of stains, principles, mechanism, methods and types of staining, simple, Differential-Gram staining, acid fast staining, capsule staining, endospore, inclusion bodies. Sterilization: Principles, types and techniques - Physical and Chemical. Preservation of microorganisms: Methods of preservation, slant culture, stab culture, soil culture, mineral oil overlaying, glycerol preservation, Lyophilization.

PRACTICALS **60 Hrs**

1. Demonstration and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory.

2. Preparation of culture media for bacterial cultivation using Autoclave and assessment for sterility.

3. Sterilization of glassware using Hot Air Oven and assessment for sterility.

4. Introduction to staining techniques: Gram-staining, Endospore staining, Capsule staining, Acid fast staining.

5. Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air, water, soil etc.

6. Study of *Rhizopus*, *Penicillium*, and *Aspergillus* using temporary mounts.

REFERENCES

1. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2017). Brock Biology of Microorganisms.14th edition. Pearson International Edition.

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Mode of Exam Evaluation Process

Theory Assessment:

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Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
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Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX	CELL AND MOLECULAR BIOLOGY	L-T-P-C: 3-1-2-6

COURSE OBJECTIVES

The main objective of this course is to introduce the basic concepts of cell and molecular Biology. This course addresses the molecules of life – DNA, RNA, and Protein; their structure and function. It discusses the physiology of the basic unit of life that is cell; study of cellular organelles and cytoskeleton. It also focuses on gene regulation, cell signaling and death.

COURSE OUTCOMES

After completion of the course, the student should be able to:

CO1: Discuss structure and function of cells, cellular organelles and cell junctions and structures of nuclei acids.

CO2: Describe processes of cell division, cell signaling, replication, transcription and translation.

CO3: Explain basic elements of prokaryotic and eukaryotic gene regulations

CO4: Demonstrate basic skills in cell fixation, staining and study of cell division processes, isolation of proteins and nucleic acids from microorganisms.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	2	2	-	-	-	-	-	-	2	-	-
CO 2	3	2	2	-	-	-	-	-	-	2	-	-
CO 3	3	2	2	-	-	-	-	-	-	2	-	-
CO 4	3	2	2	2	1	1	1	1	1	-	1	1
Average	3	2	2	2	1	1	1	1	1	2	1	1

1 – Weakly Mapped (Low); 2 – Moderately Mapped (Medium); 3 – Strongly Mapped (High);
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SYLLABUS

UNIT I: CELLS AND PLASMA MEMBRANE 5 Hrs

Overview of cells, Various models of plasma membrane structures, Transport across membranes: active and passive transport, facilitated transport; Cell-cell junctions, structures, and functions: Tight junctions, adherens junctions, gap junctions.

UNIT II: CELLULAR ORGANELLES 15 Hrs

Nucleus - Structure of Nucleus, Nuclear envelope, Nuclear pore complex, Transport of molecules across the nuclear membrane, Chromatin: euchromatin, heterochromatin, and packaging, nucleosome, nucleolus, Salient features of DNA and types of RNA (mRNA, rRNA and tRNA); Watson and Crick model of DNA;

Structure and function of Endoplasmic reticulum, lysosomes, Golgi bodies, peroxisomes; Vesicular transport from ER to Golgi apparatus, Mitochondria - Structure, Endo-symbiotic hypothesis; Respiratory chain, Chemiosmotic hypothesis, and ATP Synthase; Cytoskeleton: Microtubules, Microfilaments, and Intermediate filaments.

UNIT III: CELL DIVISION AND SIGNALING 5 Hrs

Mitosis, Meiosis, Cell Signalling through G-protein coupled receptor (GPCR), apoptosis. Difference between prokaryotes and eukaryotes

UNIT IV: DNA REPLICATION AND TRANSCRIPTION 10 Hrs

Genetic material – DNA, RNA, and protein. Replication in prokaryotes and eukaryotes – replication machinery, semi-conservative, bidirectional, and semi-discontinuous replication, Transcription - Machinery and mechanism of transcription in prokaryotes and eukaryotes-RNA polymerases, Transcription unit, Transcription factors, Synthesis of mRNA.

UNIT V: TRANSLATION 10 Hrs.

Description of ribosomal cycle including phenomena of initiation, elongation, termination; description of factors involved in these processes; genetic code and Wobble hypothesis; tRNA: clover-leaf structure & function; rRNA: structure and function; role of aminoacyl tRNA synthetases, Concept of introns and exons, splicing mechanisms, RNA editing, Inhibitors of protein synthesis.

UNIT VI: GENE REGULATION 15 Hrs

Overview of Regulation of Gene Expression, Prokaryotic Gene Regulation, Concepts of operon, promoter, operator, activator, inducers, repressors, lac operon and trp operon; Overview of

transcription regulation in eukaryotes: epigenetic, transcriptional, post-transcriptional, translational, post-translational.

Gene silencing and Genetic imprinting, DNA Repair Mechanisms, Pyrimidine dimerization and mismatch repair, Regulatory RNAs, Ribo-switches; RNA interference: miRNA and siRNA.

PRACTICALS **60 Hrs**

1. To Study the principle of the light microscopy, cell fixation and staining.
2. Mitosis and the Cell Cycle in Onion Root-Tip Cells
3. Isolation of proteins from microbes (Prokaryotic)
4. Isolation and estimation of plasmid DNA from microbes (prokaryotic)
6. Isolation and estimation of genomic DNA from microbes (prokaryotic / eukaryotic)
7. Isolation and estimation of RNA from microbes (prokaryotic)

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1. Cooper, G.M., Hausman, R.E. (2018) The Cell: A molecular approach. 8th Ed, ASM Press and Sinauer Associates.
2. Becker, Kleinsmith, and Hardin. (2017) The World of the Cell. 9th Ed, Benjamin Cummings Publishing, San Francisco.
3. Karp, G. (2013). Cell and Molecular Biology: Concepts and Experiments (7th Ed) John Wiley & Sons Inc.
4. De Robertis, E.D.P. and De Robertis, E.M.F. (2009) The Cell and Molecular Biology, Lippincott Williams & Wilkins. Philadelphia.
5. Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Robert Keith and Watson James. (2017) Molecular Biology of the Cell. 7th Ed, Garland publishing Inc. New York and London.
6. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2013) Molecular Biology of the Gene. 7th Ed, Cold Spring Harbour Lab. Press, Pearson Pub.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

Living Conversations (SFL)Credits 2

Ability Enhancement/Co-curricular

SEMESTER II

HSCC 1002	Principles of Biochemistry	L-T-P-C:2-1-1.5-4.5

COURSE OBJECTIVES

The main objective of the course will be to expose students to thermodynamics basis, bioenergetics of reaction, the basic role of biomolecules and their chemical interactions inside the cell. It provides deeper insight into structures, properties and functions of major biomolecules and metabolic pathways in the living systems.

COURSE OUTCOMES

After the completion of course, the students will be able to:

CO1: Discuss thermodynamics basis of life, bioenergetics of a reaction and pathway and different intermolecular interactions in structural organization of proteins.

CO2: Describe the structure and functions of different chemical building blocks (carbohydrates, proteins and lipids) of life.

CO3: Identify and draw structures of various types of biomolecules (carbohydrate, lipids, and proteins).

CO4: Classify enzyme in different categories and explain what enzyme does, how enzyme works and primary biochemical pathways leading to synthesis and catabolism of major biomolecules.

CO5: Demonstrate skills to prepare the solutions, buffers and identify and analyse any biological molecules in the given sample.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	-	-	-	-	-	-	1	-	-	-
CO 2	2	-	-	-	-	-	-	-	1	-	-	-
CO 3	2	2	-	-	-	-	-	-	1	-	-	-
CO 4	2	2	2	2	1	-	1	-	1	-	2	-
CO 5	2	2	2	2	1	-	1	-	1	-	2	-
Average	**2**	**2**	**2**	**2**	**1**	**-**	**1**	**-**	**1**	**-**	**2**	**-**

1 – Weakly Mapped (Low); 2 – Moderately Mapped (Medium); 3 – Strongly Mapped (High);
"_" means there is no correlation

SYLLABUS

UNIT I: INTRODUCTION TO BIOPHYSICS 12 Hrs

Introduction and history of biophysics, main features of quantum theory, elementary particles and their interactions. Bioenergetics, endergonic and exergonic reactions, Laws of thermodynamics, entropy, enthalpy, Gibb's free energy, standard Gibb's free energy, ATP and different high energy compounds. Properties and role of water. Buffers - action, capacity, relationship between pH & pKa (Henderson -Hasselbalch equation) and its importance.

UNIT-II: PROTEINS & ENZYMES 11 Hrs

Amino acids and peptides- classification, chemical and physical properties, Introduction to protein structure and function, secondary, tertiary and quaternary structure of proteins, fibrous and globular proteins, protein folding and Anfinsen's experiment. Amino acid metabolism-Amino acid deamination and transamination, urea cycle. Introduction to enzymes, classification of enzymes, mechanism of action, Michaelis-Menten equation and significance of Km, Vmax and Kcat.

UNIT-III: CARBOHYDRATES 12 Hrs

Monosaccharides-structure of aldoses and ketoses, open and ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers. Disaccharides-maltose, lactose and sucrose. Polysaccharides-homo and heteropolysaccharides, structural and storage polysaccharides. Anabolism and catabolism, glycolysis citric acid cycle and gluconeogenesis.

UNIT-IV: LIPIDS **10 Hrs**

Definition, biological functions, general formulae, nomenclature and properties of fatty acids, essential and non-essential fatty acids, classification of lipids, building blocks of lipids - fatty acids, glycerol, ceramide, saponification number and iodine number, suitability of triglycerides as storage lipids, saponification number and iodine number. Introduction to lipid micelles, monolayer and bilayer, transport of fatty acids.

PRACTICALS **45 Hrs**

1. To prepare different solutions based molarity, normality and percentage.
2. To prepare buffer solution and pH measurement
3. Qualitative test for carbohydrates
4. Qualitative test for amino acids.
5. Titration of Amino acid (Neutral) with a strong base and acid.
6. Quantitative estimation of protein by Bradford/Bicinchoninic acid method
7. Assay of salivary amylase.
8. Qualitative test for lipids.
9. Quantitative test for lipids- Salkowski/Lieberman-Burchard test.
10. Colorimetric estimation of urea/blood urea nitrogen (BUN).

Reference Books

1. Leininger: Principles of Biochemistry (2017) 7th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN 13: 978-1464126116.
2. Textbook of Biochemistry with Clinical Correlations an Indian Adaptation (2022) 7th ed., Devlin, T.M., John Wiley & Sons, Inc., ISBN: 978-9354641558.
3. Biochemistry (2019) 9th ed., Berg, J.M., Tymoczko, J.L. and Stryer, L., W.H Freeman and Company (New York), ISBN 13: 978-1319114671.
4. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8th ed., Wilson, K. and Walker, J. Cambridge University Press, ISBN 13: 978-1316614761.
5. Introduction to Practical Biochemistry, Sawhney, S.K. and Singh R. so Narosa Publishing House (New Delhi), ISBN-13: 978-8173193026.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX	Computer Applications and Bioinformatics	L-T-P-C:2-1-1.5-4.5

COURSE OBJECTIVES

- The basic objective is to give students an introduction to the basic practical techniques of Computer Application and Bioinformatics.
- Emphasis will be given to the application of Computer Application and Bioinformatics and biological databases to problem solving in real research problems.
- The students will become familiar with the use of a wide variety of internet applications, computer application, biological database, sequence alignment, biological database management, molecular docking and drug designing and will be able to apply these methods to research problems.

COURSE OUTCOMES

After completion of the course, students will be able to

CO1: Understand the basics of computer application and bioinformatics.
CO2: Identify and define the basic concepts of bioinformatics and its significance in biological data analysis.
CO3: Demonstrate the ability to choose the methods to symbolise and manage the different types of biological database, sequence alignment and phylogenetic tree analysis.
CO4: Overview about biological macromolecular structures and structure prediction methods, molecular docking and drug designing.
CO5: Develop competency in bioinformatics for solving different biological problems, data handling process and data retrieval process from different, biological databases, usage of different software for analyzing biological data, sequence alignment, molecular docking and drug designing.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	-	-	-	-	-	-	1	-	-	-
CO 2	2	2	-	-	-	-	1	-	1	-	2	-
CO 3	2	2	-	-	-	-	1	-	1	-	2	-
CO 4	2	2	2	2	1	-	1	-	1	-	2	-
CO 5	2	2	2	2	1	-	1	-	1	-	2	-
Average	**2**	**2**	**2**	**2**	**1**	**-**	**1**	**-**	**1**	**-**	**2**	**-**

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: INTRODUCTION TO COMPUTER APPLICATION 05 Hrs

Basics of computer hardware, software, and networking. Operating Systems software and Application Systems software. Windows features, Microsoft office, data format for biological samples.

UNIT II: BIOLOGICAL DATABASES 10 Hrs

Definition and History and Applications of Computational Biology and Bioinformatics, Internet resources, various databases and bioinformatics tools, organization of databases. Sequencing database, 3D Structure Database, Chemical Structure database, Gene Expression database, Derived Databases, Structure classification database, Protein-Protein interaction database and Pathway database.

UNIT III: SEQUENCE ALIGNMENT AND PHYLOGENETIC TREE 10 Hrs

File formats, Basic concepts of sequence analysis, Scoring matrices, Pair wise sequence alignments, Multiple sequence alignment, Database Searches: Keyword-based searches and Sequence-based searches. Phylogenetic Trees: phylogenetic tree representation, building phylogenetic trees,

UNIT IV: STRUCTURE PREDICTION **10 hrs**

Overview and Introduction to Protein Structure, Sequence-Sequence Alignment Methods, Sequence Based Secondary Structure Prediction. Visualization of structures using Rasmol or ADT. Fundamentals of the methods for 3D structure prediction, Homology/comparative Modeling. AI based protein structure prediction.

UNIT V: MOLECULAR DOCKING AND DRUG DESIGNING **10 hrs**

General approach to discovery of new drugs, lead discovery, lead modification physiochemical, principles of drug action, 3D database search, computer aided drug design, AI based drug screening, docking, molecular modelling in drug design, structure-based drug design.

PRACTICAL **45 hrs**

1. Referencing in Scientific literature and their practical usage, PubMed
2. Sequence retrieval
3. Biological Databases: Study of different biological databases (esp. the ones given below), Format.
4. Pair wise sequence alignment, Local and Global alignment – Algorithms
5. DOT matrix analysis
6. Databases search for homologous sequence using (BLAST) and (FASTA)
7. MSA: (Clustal W, Clustal X), Algorithms-MSA, Progressive alignment etc, Problems with MSA method, Statistics behind MSA
8. MUSCLE, T-COFFEE
9. Protein structure prediction tools (2D and 3D structure prediction)
10. Molecular Docking using Autodock
11. Drug Designing using Chemsketch
12. AI application in computational biology and bioinformatics

Recommended Books/ Resources:

- Bioinformatics and Computational Biology-A Primer for Biologists by Basant K. Tiwary. 2022, ISBN : 978-981-16-4240-1
- Lopes H, editor. Computational Biology and Applied Bioinformatics. InTech; 2011. Available from: http://dx.doi.org/10.5772/772
- Encyclopedia of Bioinformatics and Computational Biology-ABC of Bioinformatics. Shoba Ranganathan, Kenta Nakai, Christian Schonbach. August 21, 2018, ISBN: 9780128114148
- Introduction to Bioinformatics, Teresa Attwood, David Parry-Smith, Pearson Education. ISBN: 978-8178085074
- Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Second Edition, Andreas D. Baxevanis, B. F. Francis Ouellette. A John Wiley & Sons, Inc., Publication. ISBN: 978-0471478782
- Jianyuan Deng and others, Artificial intelligence in drug discovery: applications and techniques, Briefings in Bioinformatics, Volume 23, Issue 1, January 2022, bbab430, https://doi.org/10.1093/bib/bbab430

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
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Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
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Weightage (%)	30	20	20	20	10	100

HSCC XXXX	Fundamentals of Biostatistics	L-T-P-C: 2-1-1.5-4.5

COURSE OBJECTIVES

This course introduces the fundamental principles and techniques of Biostatistics. It emphasizes the application of statistical methods in Health Sciences & Technology. Students will learn to analyse and interpret data, conduct hypothesis testing, and apply statistical techniques to make evidence-based decisions in various healthcare and research settings. The course provides hands-on experience with statistical software and practical exercises to reinforce the concepts learned.

COURSE OUTCOMES

Upon completion of the course, students will be able to

CO1. Understand the basic concepts and principles of biostatistics and its relevance to healthcare and clinical research.

CO2. Apply appropriate statistical techniques to analyse and investigate scientific questions in healthcare and research settings.

CO3. Design and conduct basic experiments or studies to investigate scientific questions in the relevant disciplines.

CO4. Apply statistical software tools to perform data analysis, interpret the output, and effectively communicate the findings of statistical analyses in healthcare and clinical research.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	-	-	-	-	-	-	1	-	-	-
CO 2	2	2	-	-	-	-	1	-	1	-	2	-
CO 3	2	2	-	-	-	-	1	-	1	-	2	-
CO 4	2	2	2	2	1	-	1	-	1	-	2	-
Average	**2**	**2**	**2**	**2**	**1**	**-**	**1**	**-**	**1**	**-**	**2**	**-**

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: INTRODUCTION TO BIOSTATISTICS AND DATA TYPES 5 Hrs

Understand the importance of biostatistics in healthcare and clinical research. Define different types of data. Variables: continuous, nominal, ordinal. Scales of measurement.

UNIT II: DESCRIPTIVE STATISTICS AND PROBABILITY DISTRIBUTIONS 10 Hrs

Measures of central tendency: mean, median and mode. Measures of variability: range, variance, and standard deviation. Frequency distributions and graphical representations of data: histograms, box plots, and scatter plots. Basic principles of Probability. Discuss probability distributions: discrete and continuous, normal distribution.

UNIT III: SAMPLING TECHNIQUES AND SAMPLING DISTRIBUTIONS 5 Hrs

Understand different sampling techniques and their applications. Discuss sampling distributions and the Central Limit Theorem. Calculate confidence intervals and understand their interpretation.

UNIT IV: HYPOTHESIS TESTING – PARAMETRIC AND NON-PARAMETRIC METHODS 15 Hrs

One-Sample Tests: formulate null and alternative hypotheses, conduct hypothesis tests for one-sample mean and proportion, Interpret test results and inferencing. Two-Sample Tests:

hypothesis testing for two independent samples, Compare means and proportions between groups. Paired t-tests. Analysis of Variance (ANOVA), Understand the principles of analysis of variance, one-way ANOVA and result interpretation. Apply post hoc tests for multiple comparisons.

Nonparametric tests for situations with violated assumptions and their interpretations: Chi square tests, Wilcoxon-Signed rank test, Kruskal-Wallis, Fischer's Exact Test. Compare parametric and nonparametric tests.

UNIT V: CORRELATION AND REGRESSION ANALYSIS 5 Hrs

Understand the concepts of correlation and regression. Correlation coefficients. Perform simple linear regression and assess the model's goodness of fit. Multiple regression for multiple variables.

UNIT VI: SURVIVAL ANALYSIS 5 Hrs

Understand the principles and applications of survival analysis. Estimate survival probabilities using Kaplan-Meier curves. Apply Cox proportional hazards regression.

PRACTICALS 4-5 Hrs

1. Perform basic data manipulation tasks such as importing, exporting, and cleaning data using suitable statistical software (e.g., R, SPSS, or SAS).
2. Calculate measures of central tendency (mean, median, mode) and variability (range, variance, standard deviation), construct frequency distributions and generate box plots, scatter plots, histograms using the given data.
3. Formulate null and alternative hypotheses. Perform one-sample and two-sample hypothesis tests. Interpret and communicate results using appropriate statistical language.
4. Conduct one-way ANOVA to compare means across multiple groups and perform post hoc tests for multiple comparisons and interpret the results.
5. Apply nonparametric tests and compare the results with their parametric counterparts.
6. Perform chi-square tests to analyse categorical data. Test for independence and homogeneity in contingency tables and interpret results to assess associations between variables.
7. Calculate correlation coefficients between variables, interpret and evaluate the strength of the relationship.
8. Perform simple linear regression analysis. Make predictions using regression models.
9. Design a basic study and analyse the experimental data using appropriate statistical tests and draw conclusions.

REFERENCES

1. Dawson, B. and Trapp, R.G. 2019. Basic and Clinical Biostatistics. 5th ed. Lange medical books/McGraw-Hill Inc.
2. Zar, Jerrold H. 2014. Biostatistical Analysis. 5th ed. Pearson Education.
3. Selvin, S. 2011. Biostatistics: Statistical Tools for Epidemiological Research. Oxford University Press.
4. Lepš, J. and Šmilauer, P. 2020. Biostatistics with R: An introductory guide for Field Biologists. 1st ed. Cambridge University Press.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

Critical Thinking and Writing	**Credits 2**

Ability Enhancement/Co-curricular-I	**Qualifying**

Elective Course	**L-T-P-C:2-1-1.5-4.5**

SEMESTER III

XXXX XXXX	**Prokaryotic Microbiology**	L-T-P-C: 2-1-1.5- 4.5

COURSE OBJECTIVES

This is an intensive core microbiology course intended to deliver the basic knowledge of bacteria, archaea and viruses, emphasizing on their morphology, structures and functioning, growth, cellular and molecular biology aspects and practical skills.

COURSE OUTCOMES

After completion of this course the students will be able to:

CO1. Discuss morphology, genomics and reproduction of prokaryotes.

CO2: Describe prokaryotic secretion systems, signaling mechanisms and virulence factors.

CO3. Describe principles of virology, viral transmission, replication processes and salient features of viral nuclei acids.

CO4. Apply practical skills to prepare various minimal and complex media, isolation of bacteria and bacteriophages, viral identification, culture purification techniques, biochemical characterization and strain identification using phylogentic analysis.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	1	3	-	-
CO 2	3	3	-	-	-	-	-	-	1	3	-	-
CO 3	3	3	-	-	2	-	-	-	1	3	-	-
CO 4	3	3	3	2	2	1	2	2	1	3	2	2
Average	3	3	3	2	2	1	2	2	1	3	2	2

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: PROKARYOTES 12 Hrs

Overview of prokaryotic cell structure: Size, shape, arrangement. Ultra structure of prokaryotic cells: bacterial and archaeal - cell wall and cell membrane. Components external to cell wall - capsule, slime, s-layer, pili, fimbriae, flagella; structure, motility, chemotaxis. Cytoplasmic matrix - Cytoskeleton, ribosome, inclusion granules: Composition and function. Nuclear Material – bacterial structure (its differences with the Eukaryotic chromosome); Extra Chromosomal material.

Routine culturable bacteriological techniques: Minimal, Complex and differential media, Various Biochemical tests for identification and characterization, Strain purification, preservation and maintenance. Bacteria and Archaeal strain identification using ribosomal DNA sequencing and phylogenetic analysis.

UNIT II: PROKARYOTIC GENOME AND REPRODUCTION 5 Hrs

Organization of bacterial genomes, Mode of reproduction in bacteria, Endospore: habitat, function, structure, formation, stages of sporulation, examples of spore forming organisms, Binary fission, Budding and other modes of reproduction.

UNIT III: PROKARYOTIC SECRETION SYSTEMS AND SIGNALLING 08 Hrs

Types of secretion systems, secretion pathway, Sec B secretion pathway, SRP pathway, Tat pathway, Type I, II, III (T3SS; injectosome), Type IV, Type VI, SecA2, sortases and Type VII secretion system. Secretion systems and virulence.

Two-component signaling systems: The concept of signaling in bacteria with specific examples such as *Myocbacterium tuberculosis*, DevR-DevS and *Yersinia pseudotuberculosis* and others.

Quorum sensing: Discovery, role as in bioluminescence (*Vibrio fisheri, Vibrio harveyi*), Virulence (*Pseudomonas aeruginosa, Staphylococcus*), Quorum quenching: impact and mechanism.

UNIT IV: PRINCIPLES OF VIROLOGY 10 Hrs

Introduction to Virology, Virus Structure and Classification, Virus Entry and Viral Pathogenesis, Koch's Postulates for viruses. Virus genome types: Double stranded DNA (dsDNA). Gapped DNA genomes. Single-stranded (ssDNA) genomes. Double stranded RNA (dsRNA). Single stranded RNA (ssRNA): (+) strand RNA. Single stranded (+) sense RNA with DNA intermediate. Single stranded RNA (-) sense. Anti-sense RNA genomes, reverse transcribing viruses, Viriods and Hepatitis Delta Virus and Prions, Bacteriophages. Viruses and cancer, Applications of Virology;

Techniques for virus isolation, identification using SEM imaging and phylogenetic analysis.

UNIT V: VIRAL TRANSMISSION, SALIENT FEATURES OF VIRAL NUCLEIC ACIDS AND REPLICATION 10 Hrs

Modes of viral transmission: Persistent, non-persistent, vertical and horizontal. Salient features of viral Nucleic acid: Unusual bases (TMV,T4 phage), overlapping genes (ϕX174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends

(lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV). Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses as per Baltimore classification (phi X 174, Retroviridae, Vaccinia, Picorna), Assembly with example of Polio virus and T4 phage, maturation and release of virions.

REFERENCES

1. Carter, J., Saunders, V., & Saunders, V. A. (2013). *Virology: principles and applications*. John Wiley & Sons.
2. Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (5 Ed). *Microbiology*.
3. Prescott, L. M., Harley, J. P., & Klein, D. A. (2016). Microbiology. 10th International Edition.
4. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education
5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition

PRACTICALS **45 Hrs**

1. Preparation of different media: minimal media, complex media- Nutrient agar, McConkey agar, EMB agar.
2. Isolation of pure cultures of bacteria by streaking method (quadrant and simple streaking).
3. Staining techniques: Gram staining and Endospore staining
4. Preservation of bacterial cultures by various techniques (Agar slant, glycerol stocks).
5. Estimation of CFU count by spread plate method/pour plate method.
6. Motility test of bacteria.
8. Catalase & Oxidase test
10. IMViC tests for biochemical characterization and differentiation of coliforms.
11. Studying isolation and propagation of animal viruses by chick embryo technique (through tutorial).
12. Isolation of bacteriophages (Plaque assay)

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
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Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX	Eukaryotic Microbiology	L-T-P-C: 2-1-1.5-4.5

Course Objective

This is a core microbiology course intended to deliver the basic knowledge as well as a big picture on the importance of Eukaryotic microbes – algae, fungi and protozoa on human health and environment, emphasizing on their morphology, structures and functioning, growth, cellular and molecular biology aspects.

Course Outcomes

After the completion of this course the students will be able to:

CO1. Discuss the structure, classification and biodiversity of eukaryotic microbes – algae and fungi and lifecycles of important protozoa.

CO2. Describe the socio-economic as well as the medical importance of eukaryotic microbes.

CO3. Explain the impact of eukaryotic microbes on health and environment.

CO4: Apply skills to isolate, characterize and identify algae, fungi and demonstrate protozoa from various samples.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	1	3	-	-
CO 2	3	3	-	-	-	-	-	-	1	3	-	-
CO 3	3	3	-	-	2	-	-	-	1	3	-	-
CO 4	3	3	3	2	2	1	2	2	1	3	2	2
Average	3	3	3	2	2	1	2	2	1	3	2	2

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SYLLABUS

UNIT I: FUNGI **15 Hrs**

Classification and Salient features, Division and Subdivision of Fungal Kingdom, Structure of Fungal cells and growth; Hyphae and non-motile unicells, motile cells, spores, dormancy, growth of population and colonies, Mechanism of growth in Fungi, Measurement and kinetics of growth, nutritional and environmental requirements; Prevention of fungal growth. Heterothallism, parasexuality, sex hormones in fungi; physiological specialization, phylogeny of fungi.

UNIT II: FUNGI AND ECOSYSTEM **5 Hrs**

Substrate groups: saprophytic, parasitic, keratinophilic, coprophilous substrate successions, parasitism, predation, mutualism and symbiosis with plants and animals. Diversity of aquatic and marine fungi. Economic importance of fungi.

UNIT III: ALGAE **15 Hrs**

Distribution, morphology and classification of Algae; Isolation from soil and water; algal ecology, Media and methods used for culturing algae, measurement of algal growth, strain selection and large-scale cultivation, Symbiotic algae: *Lichens*, *Coral reef* and *sea sponges*. Structure and reproduction of *Spirogyra*, *Euglena*, *Exuviaella*, *Diatoms*, *Dinoflagellates, Sargassam* and *Porphyra*. Biological and economic importance of Algae: as primary producers, as commercial products [food, green energy (biofuel) and therapeutic uses], heavy metal removal, immobilized and labeled algae, harmful algal blooms and toxins.

UNIT IV: PROTOZOA **10 Hrs**

Introduction, structure, and significance LIFE CYCLE of: *Leishmania*, *Trichomonas*, *Entamoeba*, *Plasmodium*, cultivation of protozoa, Brief introduction of Parasitism, Host parasite relationship.

Practical **45 HRS**

1. Isolation and characterization of fungi from soil.
2. Isolation and characterization of fungi from plant material: Epiphytic fungi, endophytic fungi.
3. Growth measurement of fungi- linear and biomass.
4. Effect of environmental (pH, temperature) and nutritional factors (carbon, nitrogen sources) on growth of fungi.
5. Identification and demonstration of microscopic algae from soil and water.
6. Identification and demonstration of protozoa from environmental samples.

REFERENCES

1. Mark F. Wiser. (2010). Protozoa and Human Disease. Garland Science

2. K R Sridhar. (2009). Frontiers in Fungal Ecology, Diversity and Metabolites. I.K. International Publishing House Ltd. New Delhi.

3. Nagamani. (2006). Handbook of Soil Fungi. I.K. International Publishing House. New Delhi.

4. A.V.S.S. Sambamurty. (2005). A Textbook of Algae. I.K. International Publishing.

5. Nick Talbot. (2005). Molecular and Cellular Biology of Filamentous Fungi: A Practical Approach Oxford

6. Mehrotra, R.S. and Aneja, K.R. (2002). An Introduction to Mycology, New Age Publications.

7. Singh, P.K., Dhar, D.W., Pabbi, S., Prasanna R., Arora, A. (2000). Biofertilizers- Blue Green Algae and Azolla, National Center for Conservation of Blue Green Algae,

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX	MICROBIAL PHYSIOLOGY AND METABOLISM	L-T-P-C: 2-1-2-5

Course Objective

This course provides important information on sources of energy and its utilization by diverse microorganisms. Microorganisms are metabolically diverse and conserve energy by various means both aerobically and anaerobically. By this process they create not only diverse metabolites applicable for human health but also for ecological functioning of diverse ecosystems.

Course Outcome

After the conclusion of this course, the students will be capable of:

CO1. Explain microbial growth, growth-kinetics and environmental factors affecting growth.

CO2. Define types of membrane transport for nutrient uptake and protein excretion

CO3. Describe nutritional requirements for growth and mechanisms of energy conservation for Phototrophy, Chemolithotrophy, Fermentation and Anaerobic respiration.

CO4. Differentiating concepts of aerobic and anaerobic respiration and link it to microbial growth, physiology and metabolism

CO5. Demonstrate advanced skills for cultivation of extremophiles, anaerobes and complex nutritional groups

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	1	3	-	-
CO 2	3	3	-	-	-	-	-	-	1	3	-	-
CO 3	3	3	-	-	2	-	-	-	1	3	2	-
CO 4	3	3	3	2	2	1	2	2	1	3	2	-
CO5	3	3	3	2	2	1	2	2	1	3	2	2
Average	3	3	3	2	2	1	2	2	1	3	2	2

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: MICROBIAL GROWTH AND EFFECT OF ENVIRONMENT 8 Hrs

Microbial Growth – Definition, balanced and unbalanced growth, growth curve, mathematical expression of growth, generation time, specific growth rate, batch and continuous culture, synchronous growth, diauxic growth curve; Effect of environmental factors on microbial growth: temperature, pH, water activity, pressure, oxygen, nutrient concentration, etc., Nutritional types of microorganisms

UNIT II: NUTRIENT UPTAKE AND TRANSPORT. 5 Hrs

Metabolite transport in microbes - passive and facilitated, primary and secondary, active transport, group translocation, symport, antiport and uniport, Iron uptake and transporters: Ton system and ABC transporter.

UNIT III: CHEMOHETEROTROPHIC METABOLISM - AEROBIC RESPIRATION 8 Hrs

Aerobic respiration in microorganisms, anaerobic respiration and fermentation, Sugar degradation pathways i.e., EMP, ED, Pentose phosphate pathway, TCA cycle, Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, oxidative phosphorylation.

UNIT IV: CHEMOHETEROTROPHIC METABOLISM- ANAEROBIC RESPIRATION AND FERMENTATION 8 Hrs

Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration; fermentative nitrate reduction), Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways.

UNIT V: CHEMOLITHOTROPHIC AND PHOTOTROPHIC METABOLISM 8 Hrs

Introduction to aerobic and anaerobic chemolithotrophy with an example each, Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction); Introduction to phototrophic metabolism - groups of phototrophic microorganisms, oxygenic and anoxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria.

UNIT VI: PHYSIOLOGY AND METABOLISM OF EXTREMOPHILES 8 Hrs

Microbial life in various extreme environments; Taxonomy, physiology and metabolism of Extremely Halophilic Archaea and halophiles, Halophilic Cytoplasmic Components, Bacteriorhodopsin and Light-Mediated ATP Synthesis in Haloarchaea; Methanogens – Diversity, Physiology and metabolism, Methanogenic pathways and their substrates; Hyperthermophiles, Protein and Membrane Stability at High Temperatures; Microbial life in cold temperatures and psychrophiles.

Practical: **60 Hrs**

1. Effect of environmental factors on microbial growth (pH, temperature, oxygen)
2. Cultivation of anaerobic microbes using Hungate's Roll tube method and anaerobic Gas Pack jar
3. Studying diauxic growth curve of *E. coli* by tubidometric method and determination of generation time and specific growth rates of bacteria
4. Enrichment and Isolation of Halophiles and study of salt tolerance.
5. Demonstration of alcoholic fermentation.
7. Isolation and characterization of Fe /or Mn oxidizing bacteria.
9. Demonstration of Winogradsky column and isolation of chemolithotrophs.
10. Demonstration of anaerobic cultivation techniques from Himalayan sedimentary profiles and geothermal-vents using anaerobic GASPAK / Sparging gas in crimped serum vials.

REFERENCES

1. Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition. Prentice Hall International Inc.

2. Moat AG and Foster JW. (2015). Microbial Physiology. 7th edition. John Wiley & Sons.

3. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India.

4. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag.

6. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.

7. Willey JM, Sherwood LM, and Woolverton CJ. (2017). Prescott's Microbiology. 10th edition. McGraw Hill Higher Education.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

Environmental Science	**Credits :- 4**

Leadership and Teamwork	**Credits :- 2**

Ability Enhancement/Co-curricular	**Qualifying**

SEMESTER IV

HSCC XXXX	AGRICULTURAL MICROBIOLOGY AND PLANT PATHOLOGY	L-T-P-C: 2-1-2-5

COURSE OBJECTVES

The purpose of this course is to impart in-depth information on soil and agriculture, make the students understand the role of microbes in agriculture, understand plant microbe interactions, importance of biofertilizers and biopesticides and gain understanding of techniques involved in biofertilizers and biopesticides production.

COURSE OUTCOMES

After completion of the course students will be able to:

CO1: Discuss the formation, profile and types of soils and the distribution of microbes in soil.

CO2: Describe the role of Nitrogen fixers and Phosphate solubilizers in soil fertility.

CO3: Explain microbial interactions with animals and plants and relate biogeochemical cycles.

CO4: Explain role of plant pathogens in crop response and preventive measurements of bacterial, fungal viral pathogens.

CO5: Apply various techniques involved in biofertilizers and biopesticides production, microbial degradation of agricultural products and organic matter decomposition.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	1	3	-	-
CO 2	3	3	-	-	-	-	-	-	1	3	-	-
CO 3	3	3	3	-	2	1	1	1	1	3	2	2
CO 4	3	3	3	2	2	1	2	2	1	3	2	2
CO 5	3	3	3	2	2	1	2	2	1	3	2	2
Average	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**2**	**1**	**3**	**2**	**2**

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: SOIL MICROBIOLOGY **5hrs**

Soil structure – profile, texture; Formation– physical, chemical and biological; Types and classification; Importance of soil; Distribution of microbes in soil –bacteria, fungi, actinomycetes, protozoa and viruses; Methods to detect soil microbes.

UNIT II: MICROBIAL TRANSFORMATIONS OF MINERALS **5 Hrs**

Phosphorous, sulphur, iron and other elements - mineralization and immobilization and oxidation/reduction processes

UNIT III: PLANT MICROBIAL INTERACTIONS **10h**

Legume-Rhizobium symbiosis, Nitrogen fixation in root nodules, Hydrogen Metabolism, action of Hydrogenase - factors controlling the Legume - Rhizobium symbiosis.

Non-Leguminous associations and biofertilizer production *Azotobacter* sp., *Azospirillum* sp. and their functions - Cyanobacteria (BGA) and their associations in Nitrogen fixation. Phosphate solubilizing microbes.

Mycorrhizae, Types, Structures and importance; Plant growth promoting rhizobacteria (PGPR) and characteristics

UNIT IV: PLANT PATHOLOGY 15h

Host parasitic relationship; Disease, Stages in development of a disease (Infection, invasion, colonization, dissemination of pathogens and perennation), causative agent, symptomology. Algal, fungal, bacterial, viral, mycoplasma, Nematode diseases and symptoms.

Mode of entry of pathogens, factors affecting disease incidence - Plant disease resistance and various control measures. Phenolic compounds. Interaction of plant pathogens with host, mode of action and preventive and control measures of bacterial – Blight, Smut, Rust; Fungal – Tikka, Leaf spots; Viral – Mosaic, Vein clearing, Leaf roll; Plant pathogens and their control; Biocontrol agents: Definition and History of various Biopesticides – Viral, Bacterial, Fungal and Protozoan;

UNIT V: AGRICULTURE BIOTECHNOLOGY 10h'

Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters; GM crops - Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals. Composting, Historical background, waste availability, Compost and crop productivity-biomaturity of compost. Vermiculture Technologies: Principles, methods, different types of waste suitable for vermicomposting, factors and quality. Utilization of vermicompost for crop production.

Biofertilizers and types (Bacterial, fungal, algal, actinomycetes), Quality control (BIS specification), marketing, Evaluation of field performance and economics of production. Role of biofertilizer in integrated nutrient management. Regulation and standards, Marketing and Monitoring field performance.

REFERENCES

1. Terry J. Gentry, Jeffry J. Fuhrmann, David A. Zuberer (2021) Principles and Applications of Soil Microbiology, Elsevier
2. Agrios GN. (2016). Plant Pathology. 9th edition. Academic press, San Diego
3. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
4. Lucas JA. (2005). Plant Pathology and Plant Pathogens. 3rd edition. Blackwell, Science, Oxford.
5. Rangaswami G. (2005). Diseases of Crop Plants in India. 4th edition. Prentice Hall of India Pvt. Ltd., New Delhi.
6. Singh RS. (2017). Plant Diseases Management. 15th edition. Oxford & IBH, New-Delhi.

PRACTICALS

60 Hrs

1. Analysis of soil - pH, porosity

2. Selective enrichment, Isolation of microbes (bacteria & fungi) from soil.

3. Selective enrichment and Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.

5. Isolation and Characterization of PGPR bacteria:

a) Production of Indole-3-Acetic Acid

b) Siderophores

c) N_2-fixing bacteria (e.g. Rhizobium from root nodules)

d) DNRA / Denitrification

e) C1-utilizing endophytic microbes

6. Bio-compost making - testing the quality of compost made, fortification of compost by inoculating beneficial microbes.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX	ENVIRONMENTAL MICROBIOLOGY AND BIOGEOCHEMISTRY	L-T-P-C: 2-1-2-5

COURSE OBJECTIVES

To impart knowledge to students about importance and interactive role of microbes in diverse environments, microbial ecology and microbial biogeochemistry. The course will be beneficial for those intending to pursue a career in the environmental field.

COURSE OUTCOME

After completion of this course students will be able to:

CO1: Discuss ecological importance of microrganisms in diverse environments and ecosystems

CO2: Describe various types of microbial interactions in environment and their associations and interactions with higher forms of life

CO3: Demonstrate knowledge in understanding of microbial biogeochemistry and role of microbes in functioning of global elemental cycles and planetary health.

CO4: Explain general succession patterns of microrganisms in organic matter remineralization and diagenesis in various ecosystems / environment.

CO5: Apply knowledge of various environmental factors and microbial metabolism for pollution control, microbial remediation and waste management.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	1	3	-	-
CO 2	3	3	-	-	-	-	-	-	1	3	-	-
CO 3	3	3	3	-	2	1	1	1	1	3	2	2
CO 4	3	3	3	2	2	1	2	2	1	3	2	2
CO 5	3	3	3	2	2	1	2	2	1	3	2	2
Average	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**2**	**1**	**3**	**2**	**2**

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I MICROORGANISMS AND THEIR ENVIONMENTS 15 Hrs

Structure and function of ecosystems: Terrestrial Environments.
Aquatic and Marine Environment: Marine microbial habitats: estuaries, mangroves, salt marshes, beach and coastal ecosystems, reef and coral reefs, water column, sediments, oceanic ecosystems. Processes controlling oceanic carbon and nutrient distributions and cycling, Marine microrganisms, Factors controlling microbial ecology of marine econiches.
Atmosphere: Aeromicroflora; Animal & Human Environment: Microbes in/on human body (Microbiome) & animal (ruminants) body.
Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

UNIT II MICROBIAL INTERACTIONS 10 Hrs

Microbe interactions: Mutualism, synergism, syntrophy, commensalism, competition, Ammensalism, parasitism, predation. Microbe-Plant interaction: Symbiotic and non-symbiotic interactions. Microbe-animal interaction: termite gut microflora, nematophagus fungi and symbiotic luminescent bacteria.

UNIT III MICROBIAL BIOGEOCHEMISTRY 10 Hrs

Carbon cycle, inventories and fluxes, Role of microbes in terrestrial and marine carbon cycling, microbial degradation of cellulose, hemicelluloses, lignin and chitin.
Biogeochemical Cycles: Carbon, Nitrogen, Phosphorus, Sulphur, Iron, Manganese, Arsenic; Microbial succession and decomposition of organic matter.

Unit IV WASTE MANAGEMENT 5 Hrs

Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill). Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment.

Unit V Microbial BIODEGRADATION AND BIOREMEDIATION 5 Hrs

Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inorganic (metals) matter, biosurfactants. Bioremediation of metals: Biochemical and molecular mechanisms of lead, cadmium & As resistance in bacteria/fungi and phytoplankton; Biosorption, Bioprecipitation, biotransformation and Redox reaction, Volatilization.

REFERENCES

1. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th Ed. Pearson/ Benjamin Cummings.
2. Maier RM, Pepper IL and Gerba CP. (2015). Environmental Microbiology. 5th Ed, Academic Press.
4. Okafor, N (2018). Environmental Microbiology of Aquatic & Waste systems. 3rd Ed, Springer, New York.
5. Singh A, Kuhad, RC & Ward OP (2019). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg.

PRACTICALS **60 Hrs**

1. Assessment of microbiological quality of water
2. Nutrient analysis of water samples / pore water:
   a) Nitrate, b) Nitrite, c) Phosphate, d) Silicate e) Ammonia
3. Determination of BOD of waste-water samples
4. Isolation of dissimilatory Fe reducing bacteria from soil/sediments
5. Determination of redox speciation of Fe using Ferrozine method
6. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil and aquatic systems
7. Quantitative assays to detect extracellular enzymes- MUF assay
8. Isolation of DNA from Soil /Water
9. Isolation of RNA from Soil /Water
10. RT-qPCR assay for N2 fixation activity from environmental samples.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

XXXX XXXX	**Biosafety and Aseptic Techniques**	L-T-P-C: 2-1-1.5-4.5

COURSE OBJECTIVES

The course will create an understanding of regulations, infrastructures, precautions required for isolation, cultivation, and maintenance of Biosafety levels – I, II, III and IV organisms.

COURSE OUTCOMES

By the completion of this course the students will be able to:

CO1. Discuss the principles, regulations associated with Biosafety levels: I, II, III and IV.

CO2. Describe the process of risk assessment in various groups of Biosafety levels – I, II, III and IV. Demonstrate to work in I, II, III and IV

CO3. Demonstrate skills for working in BSL-1 and BSL-2 facilities and in professional settings

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	-	3	-	-
CO 2	3	3	-	-	-	-	-	-	-	3	-	-
CO 3	3	3	-	-	-	-	-	-	-	3	2	2
Average	3	3	-	-	-	-	-	-	-	3	2	2

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: PRINCIPLES OF STERILIZATION 5 Hrs

Basic principles and methods of Sterilization: control of microorganisms by physical methods: heat, filtration, and radiation; chemical methods: phenolics, alcohols, halogens, heavy metals, quaternary ammonium compounds, aldehydes, and sterilizing gases; evaluation of antimicrobial agent effectiveness (evaluation of efficacy of disinfectants, determination of phenol coefficient), Principle and functioning of LAF.

UNIT II: BIOSAFETY LEVELS 10 Hrs

Principles of Biosafety levels – I, II, III and IV; CDC guideline for Infrastructure, precaution and biowaste disposal system associated with the transport, cultivation, and maintenance of Biosafety levels I, II, III and IV pathogens.

UNIT III: BIOSAFETY GUIDELINES 10 Hrs

Biosafety guidelines – Department of Biotechnology (DBT), Government of India; Definition of GMOs and LMOs; ICMR and funding agencies, Roles of Institutional Biosafety Committee, the history and incidence of laboratory-acquired infections (LAI), incidents of secondary transmission from the laboratory, Outline the types of laboratory accidents leading to LAIs, Explain the role of aerosols in LAIs, Illustrate the importance of biosafety and biocontainment in minimizing the risk of LAIs.

UNIT IV: STANDARD OPERATING PROCEDURES 10 Hrs

BSL-II level, Aseptic techniques, Wearing appropriate personal protective equipment (PPE), Using BSL: II cabinet. Handling of equipment, glassware, Handling of sample collection, processing, storage, waste disposals.

Media preparation, Handling and maintenance of pure cultures, preservation of various microbes, Cultivation, and preservation methods of eukaryotic cells: Counting and passaging of eukaryotic cells of epithelial and lymphoid origins, SOPs for preservation (for long term storage) and revival of the same under laboratory condition.

PRACTICALS **45 Hrs**

1. Demonstration of various equipment and apparatus used in BSL-I and II laboratory for the cultivation and maintenance.
2. Cultivation, maintenance of pure bacterial culture isolation-pour plate, spread plate, streak plate methods.
3. Aseptic techniques and safety rules, required to follow during cultivation and maintenance in BSL- II laboratory.
4. Prepare and sterilization of cell-culture media
5. Serial passage of cell lines
6. Cultivation, maintenance of eukaryotic cell lines in BSL-II laboratory.

References

1. Meechan PJ et al. (2020) Biosafety in Microbiological and Biomedical Laboratories. 6th Ed, Centers for Disease Control and Prevention, USA https://www.cdc.gov/labs/pdf/CDC-BiosafetyMicrobiologicalBiomedicalLaboratories-2020-P.pdf

2. Guidelines for Biosafety, DBT India https://dbtindia.gov.in/guidelines-biosafety
3. GENERAL GUIDELINES FOR ESTABLISHMENT OF BIOSAFETY LEVEL-3 LABORATORY (ICMR Guidelines) https://main.icmr.nic.in/sites/default/files/upload_documents/Revised_ICMR_Guidelines_2_December.pdf

4. Willey J, Sherwood L. and Woolverton C (2014). Prescott's Microbiology, 9th edi McGraw Hill

5. Bergey's manual systematic Bacteriology (2018) 11th edition

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

Working with Data	Credits-02

Ability Enhancement/Co-curricular	Credits-Qualifying

SEMESTER V

XXXX XXXX	**Medical Microbiology & Diagnostics**	**L-T-P-C: 2-1-1.5-4.5**

COURSE OBJECTIVES

The course will provide a detailed understanding of epidemiology, transmission, pathogenesis, diagnosis, treatment, and prevention of important infectious diseases, caused by bacteria, virus, parasites, and fungal pathogens.

COURSE OUTCOMES

By the completion of this course the students able to:

CO1. Understand the basis of infectious disease biology, caused by bacteria, virus, parasites, and fungal pathogens.

CO2. Describe the epidemiology, transmission, prevention of important infectious diseases.

CO3. Demonstrate methods of laboratory diagnosis of various infectious diseases and associated precaution.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	1	3	-	-
CO 2	3	3	-	-	-	-	-	-	1	3	-	-
CO 3	3	3	3	-	2	1	1	1	1	3	2	2
Average	3	3	3	2	2	1	2	2	1	3	2	2

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I BACTERIAL DISEASES **10 Hrs**

Bacterial diseases: Important human and animal diseases caused by *Staphylococcus; Streptococcus; Neisseria; Bacillus; Corynebacterium; Clostridium; Organisms belonging to Enterobacteriaceae (Escherichia coli, Klebsiella, Salmonella, Shigella and Proteus); Pseudomonas; Haemophilus; Mycobacterium*; their mode of transmission, treatment, and prevention; Antibacterial drugs and susceptibility test; Bacterial vaccines.

UNIT II VIRAL DISAESES **10 Hrs.**

Viral diseases: Mumps; Measles; Influenza; Adenovirus; Enterovirus; Rhinovirus; Poxvirus; Hepatitis; Herpesvirus; AIDS; their mode of transmission, treatment, and prevention; Antiviral drugs; Viral vaccines; Interferons; Tumour inducing viruses; antiviral agents and susceptibility test, Viral vaccines.

Unit III FUNGAL AND PROTOZOAN DISEASES **10 Hrs**

Fungal diseases: Important human and animal diseases caused by fungal pathogens: Candidiasis; Dermatophytosis; Aspergillosis; Cutaneous and subcutaneous mycoses; Systemic mycoses; Opportunistic mycoses; their mode of transmission, treatment, and prevention; Antifungal agents and susceptibility test.

Protozoan diseases: Important human and animal diseases caused by enteric parasites: *Giardia, Cryptosporidium sp.; Blood and tissue parasites; Trypanosoma cruzi, Trypanosoma brucei; Cestodes: Taenia; Trematodes: Schistosoma; Paragonimus; Nematodes: Ascaris;* their mode of transmission, treatment, and prevention; anti-parasitic agents and susceptibility test.

UNIT IV CLINICAL SAMPLING AND PROCESSING **10 Hrs**

Collection of clinical sample and laboratory diagnosis of important bacterial, viral, fungal and protozoan diseases. Collection of clinical samples (oral cavity, throat, skin, Blood, CSF, urine and feces) and precautions required. Method of transport of clinical samples to laboratory and storage. Microscopic Examination- Examination of sample by staining - Gram stain, Ziehl-Nelson staining for tuberculosis, Giemsa-stained thin blood film for blood borne parasites.

UNIT V DIAGNOSTIC METHODS **5 Hrs**

Serological and Molecular Methods of diagnosis: Serological Methods -Agglutination, ELISA, immunofluorescence, Nucleic acid-based methods - PCR, Nucleic acid probes. Kits for Rapid Detection of Pathogens: Typhoid, Dengue and HIV, Swine flu, Covid-19

PRACTICALS **45 Hrs**

1. Preparation of various basic, selective, enrichment and enriched media for isolation, identification, and biochemical characterization of medically important bacterial pathogens.
2. Isolation, identification, and characterization of fungal pathogens from using suitable culture methods.
3. Demonstration and identification of medically important parasites from clinical samples (Permanent Slides)
4. Microbiological analysis of urine specimens
5. Microbiological analysis of skin swab specimens
6. Microbiological analysis of sputum specimens
7. Rapid Kit Test of medically important pathogens
8. To determine antibiotic sensitivity for Gram negative and Gram-positive bacteria by disc diffusion method
9. Determination of MIC using microtiter broth dilution method.

References and Textbooks

1. Arti Kapil. (2017). Ananthnarayan & Paniker's Text book of Microbiology. (11th ed). Universities press (India) Private Limited. ISBN: 9788173718892

2. Subhash Chandra Parija. (2019). Textbook of Medical Parasitology: Protozoology & Helminthology. (5th Ed). All India Publishers & Distributors. ISBN: 9788180040436

3. Collee, J.G., Duguid, J.P., Fraser, A.G. and Marimoin, B.P. (2018). Mackie and Mc Cartney Practical Medical Microbiology. (15th Ed). Churchill Livingstone: London. ISBN: 9788131203934

4. Stefan Riedel et al. (2020) Adelberg's Medical Microbiology, (28th ed). Mc Graw Hill Lange. ISBN: 9781260012026

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
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Weightage (%)	30	20	20	20	10	100

HSCC XXXX	Epidemiology and Global Health	L-T-P-C:2-1-1.5-4.5

COURSE OBJECTIVES

- To describe the science of epidemiology and the etiology of specific diseases.
- To interpret epidemiological information contained in scientific literature.
- To equip with basic epidemiological methods relevant to public health analysis, policy, and planning.
- To appraise and make correct choices for developing designs of epidemiological studies.
- To design interventions for treating and preventing ill health.

The course will also extend students' practical skills and ability to critically review the existing public health policies and Programs. Emphasis will be placed on epidemiological reasoning principles and findings interpretation. At the end of this course, students can apply quantitative and qualitative approaches to address population health challenges and interpret epidemiological information in scientific literature. It encompasses planning an epidemiological study and encouraging the publication of the results.

COURSE OUTCOMES

CO1 Understand and able to comprehend the evolution of epidemiology.

CO2 Develop an understanding of various types of epidemiological studies and ethical considerations involving human subjects.

CO3 Understand the process of investigation of an outbreak and causation in Epidemiology.

CO4 Planning research project and critical reading of published reports.

CO5 Develop analytical approaches to monitoring and evaluation.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	-	-	-	1	-	-	-
CO 2	3	-	-	-	-	-	-	-	1	-	-	-
CO 3	-	-	-	-	3	-	-	-	1	-	-	-
CO 4	-	3	-	2	-	1	1	-	1	-	-	-
CO5	-	3	2	2	3	1	1	3	1	-	2	-
Average	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**3**	**1**	**-**	**2**	**-**

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: EPIDEMIOLOGY: LAYING THE FOUNDATIONS 10 Hrs

Definitions: Epidemiology, Public Health, and Health. Uses of Epidemiology, evolving patterns of morbidity and mortality-Demographics and disease patterns, mortality, and life expectancy trends. Roots of Epidemiology-John Graunt, Germ theory, The London Epidemiological Society, John Snow and William Farr. Global Health and Sustainable Development Goals.

UNIT II: EPIDEMIOLOGICAL STUDY DESIGNS 10 Hrs

Etiologic research- Hypothesis statement**,** Epidemiological variables-Person, place, time, and data. Descriptive versus Analytical, Longitudinal versus cross-sectional. Epidemiological studies. Experimental versus observational, cohort versus case-control. Ethical conduct of studies involving human subjects.

UNIT III: OUTBREAK INVESTIGATION AND CAUSATION 10 Hrs

Background-Initial detection of Outbreaks, goals, and methods. CDC prescribed investigatory steps. Case study on the outbreak investigation of Covid 19 and Foodborne outbreak. Causation in Epidemiology-Natural history of the disease, Variability in the expression of disease, causal models, Concept of cause, Establishing the cause of a disease.

UNIT IV: HEALTH SERVICES AND HEALTH POLICY **5 Hrs**

Healthcare planning and evaluation, Measuring the quality of healthcare, the planning cycle, health public policy in practice, Planning a research project, and critical reading of published reports.

UNIT V: MONITORING AND EVALUATION **10 Hrs**

Monitoring Health Care Systems, Organizations, and Programs

Surveillance, Health services information and Evaluation.

Dimensions of Evaluation, The Evaluation Process, Conceptual Framework for Specifying Evaluation Criteria, and Analytical Approaches to Evaluation.

REFERENCES

1. Pawson, R. & Tilley, N. (2008): *Realistic Evaluation*, Sage Pub. London. Ch. 3, pp. 55-82.
2. Doll R. & Hill A.B. (1950): Smoking and Cancer of the Lung – A Preliminary Report. *BMJ*, Sept. 30. pp.739 – 748.
3. Doll R. and Hill A. B. (1964): Mortality, Relation to Smoking - Ten Years Observation of British Doctors, *British Medical Journal,* 30th May, pp. 1300-1410.
4. Ritu Priya, Atul Kotwal & Imrana Qadeer (2009): 'Towards an Eco-social Epidemiology Approach to Goitre and Other Iodine Deficiency Disorders: A Case study of India's Technocratic Programme for Universal Iodisation of Salt'. *IJHS,* Vol. 39, No.2. pp: 343-362.
5. Susser M. & E. (1996): Choosing a Future for Epidemiology – Parts I and II. *AJPH* 86 (5) pp. 668-673 and 674-677.
6. Gopalan C. (2007): From 'Farms to Pharmacies': Beginnings of a Sad Decline. Economic and Political Weekly, September 1, 2007, pp. 3535-3536.
7. Technical Focus: COVID-19 Early Epidemiologic and Clinical Investigations for public health response.
   https://sdgs.un.org/goals

PRACTICALS **45 Hrs**

1. Write a critical review of any one theory of Disease.
2. Introduction to case study on Covid 19 (Region specific/Uttarakhand)
3. Give a summary of the recommended health strategy and an assessment of whether the health strategy was successful.
4. Project proposal on any one identified public health issue in a selected community.
5. Evaluation of the three articles and recommendation for an effective public health intervention
6. Community Screening: Framing open-ended and close-ended questionnaires/Probing.
7. Development of tools to assess knowledge, attitudes, and practices
8. Report on a Community Visit/Transect walk and social mapping.
9. Seminar
10. Peer reviews

Practical hours include one seminar in which students will give presentations. The project proposal plan of the study will be presented in the seminar and discussed with other students. Students will also be engaged in peer reviews of one another's research plans.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX	IMMUNOLOGY	L-T-P-C:2-1-1.5-4.5

COURSE OBJECTIVES

Upon completion of the course, the student should be able to:

- Understand role of contribution scientists in the field of immunology.
- To know about the different cells and organs associated in immune regulation in the defense mechanism.
- Understand the mechanism of antigens or any foreign substances identification through innate and adaptive immunity.
- To know about the immunological disorders.
- Understand the application of different immunological techniques in disease identification.

COURSE OUTCOMES

After completion of the course, students will be able to:

CO1: Discuss history of scientists who contributed in the field of immunology.

CO2: Describe types of cells and organs that are participated in defense mechanism against the pathogens and other foreign particles.

CO3: Explain defense mechanism through Antibodies, Major histocompatibility complex and Complement systems.

CO4: Describe the dysregulation of normal immune cells and associated abnormal conditions including Autoimmunity, Immunodeficiency and cancer.

CO5: Relate basic technologies in immunology to diagnose different diseases.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	-	-	-	1	-	-	-
CO 2	3	-	-	-	-	-	-	-	1	-	-	-
CO 3	-	-	-	-	3	-	-	-	1	-	-	-
CO 4	-	3	-	2	-	1	1	-	1	-	-	-
CO 5	-	3	2	2	3	1	1	3	1	-	2	-
Average	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**3**	**1**	**-**	**2**	**-**

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: HISTORY OF IMMUNOLOGY **5 hrs**

Introduction to Innate and Adaptive immunity; Contributions of scientists to the development of field of immunology - Edward Jenner, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Rodney Porter and Susumu Tonegawa.

UNIT II: IMMUNITY: CELLS, ORGANS AND ANTIGEN-ANTIBODY INTERACTION 8 HRS

Structure, and Functions of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT.

Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes); T-dependent and T-independent antigens; Adjuvants; Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic); VDJ rearrangements; Monoclonal and Chimeric antibodies.

UNIT III: IMMUNE RESPONSES **8 HRS**

Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response (Self MHC restriction, T cell activation, Co- stimulatory signals).

UNIT IV: MAJOR HISTOCOMPATIBILITY COMPLEX AND COMPLEMENT SYSTEM **8 hrs**

Organization of MHC locus (Mice & Human); Structure and Functions of MHC I & II molecules; Antigen processing and presentation (Cytosolic and Endocytic pathways); Components of the Complement system; Activation pathways (Classical, Alternative and Lectin pathways).

UNIT V: IMMUNOLOGICAL DYSREGULATION AND IMMUNITY IN TUMOUR **8 hrs**

Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - SCID, DiGeorge syndrome, Chediak- Higashi syndrome, Leukocyte adhesion deficiency; Types of tumors, tumor Antigens, causes and therapy for cancers.

Unit VI: Immune technology **8 hrs**

Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, Western blotting, Immunofluoresence, Flow cytometry, Immunoelectron microscopy.

REFERENCES

1. Abbas AK, Lichtman AH, Pillai S. (2020). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.

2. Delves P, Martin S, Burton D, Roitt IM. (2016). Roitt's Essential Immunology.12th edition Wiley Blackwell Scientific Publication, Oxford.

3. Goldsby RA, Kindt TJ, Osborne BA. (2017). Kuby's Immunology. 8th edition W.H. Freeman and Company, New York.

4. Murphy K, Travers P, Walport M. (2018). Janeway's Immunobiology. 9th edition Garland Science Publishers, New York.

5. Peakman M, and Vergani D. (2019). Basic and Clinical Immunology. 4th edition Churchill Livingstone Publishers, Edinberg.

6. Richard C and Geiffrey S. (2019). Immunology. 8th edition. Wiley Blackwell Publication.

PRACTICALS **45 Hrs**

1. Identification of human blood groups.
2. Perform Total Leukocyte Count of the given blood sample.
3. Perform Differential Leukocyte Count of the given blood sample.
4. Separate serum from the blood sample (demonstration).
5. Perform immunodiffusion by Ouchterlony method.
6. Perform DOT ELISA.
7. Perform immunoelectrophoresis.
8. Perform WIDAL test
9. Perform Rapid Plasma Reagin (RPR) Test

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX	Bioinstrumentation	L-T-P-C:2-1-1.5-4.5

COURSE OBJECTIVES

This course is introduced with an idea to fill the gap between academia and research. This course introduces analytical techniques along with working principal, common instrumentation, and their applications. This course engenders students with the fundamental knowledge of analytical techniques required for research careers in allied health and environmental fields.

COURSE OUTCOMES

After the completion of course, the students will be able to:

CO1: Discuss different analytical techniques and their instrumentation, and operation.

CO2: Develop skill in carrying out research projects by employing centrifugation, and chromatographic and electrophoresis-based separation techniques.

CO3: Comprehend the terms, principle, instrumentation, operation, and applications of molecular spectroscopic and microscopic techniques.

CO4: Apply appropriate bioanalytical technique for identification, separation, isolation and purification of biomolecules.

CO5: Apply principles of various analytical devices used in research and enhance problem solving techniques.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	-	-	-	1	-	-	-
CO 2	3	-	-	-	-	-	-	-	1	-	-	-
CO 3	3	3	2	-	3	-	-	-	1	-	2	-
CO 4	3	3	2	2	-	1	1	-	1	-	2	-
CO 5	3	3	2	2	3	1	1	3	1	-	2	-
Average	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**3**	**1**	**-**	**2**	**-**

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT-I CENTRIFUGATION **6 Hrs**

Basic principles of centrifugation, standard sedimentation coefficient, types of centrifuges on the basis of speed, different types of rotors, principles and applications of differential, rate zonal and density gradient centrifugation.

UNIT-II CHROMATOGRAPHY **10 Hrs**

Introduction to chromatography, principle and applications of paper chromatography, thin layer chromatography, column chromatography (adsorption, gel filtration, ion exchange, and affinity) and high-performance liquid chromatography (HPLC).

UNIT-III ELECTROPHORESIS **8 Hrs**

Introduction to electrophoresis, polyacrylamide and agarose gel electrophoresis SDS and Native-PAGE, isoelectric focusing (IEF) and 2-D gel electrophoresis.

UNIT-IV SPECTROSCOPY **11 Hrs**

Introduction to spectroscopy, electromagnetic spectrum, Jablonski's diagram, Lambert-Beer law, principle, instrumentation and applications of UV-visible, fluorescence, Fourier-transform infrared (FT-IR) and nuclear magnetic resonance (NMR). Introduction, principle and applications of mass spectrometry, types of ionization methods (Electron impact, chemical ionisation, ESI, MALDI).

UNIT-V MICROSCOPY **10 Hrs.**

Principle of microscopy, resolving powers of different microscopes, magnification, principle and applications of: Compound microscopy, dark field microscopy, fluorescent microscopy, phase contrast microscopy, confocal and electron microscopy (SEM & TEM), Fixation and staining.

PRACTICALS **45 Hrs**

1. Separation of components of a given mixture using a laboratory scale centrifuge.
2. Separation of mixtures by paper / thin layer chromatography.
3. Separation of mixtures of molecules by any form of chromatography.
4. Separation of protein mixtures by sodium-dodecyl sulphate-polyacrylamide gel electrophoresis (SDS-PAGE).
5. Quantification of carbohydrates by DNS/Anthrone method using UV-Visible spectrophotometer.
6. Determination of fluorescence in bovine serum albumin.
7. Fluorescence spectroscopy-based confirmational analysis of protein molecules.
8. To perform simple direct staining to study the morphology of bacterial culture.

REFERENCES

6. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8th ed., Wilson, K. and Walker, J. Cambridge University Press, ISBN 13: 978-1316614761.
7. Introduction to Practical Biochemistry (2009) Sawhney, S.K. and Singh R. Narosa Publishing House (New Delhi), ISBN-13: 978-8173193026.
8. Biophysical Chemistry: Principles and Techniques (2016) Upadhyay A., Upadhyay K. and Nath N. Himalaya Publishing House, ISBN 13: 978-8183188654.
9. Principles of Fluorescence Spectroscopy (2010) 5th ed. Lakowicz J.R. Springer, ISBN 13: 978-0387312781.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

Design Thinking	**Credits 2**

Ability Enhancement/Co-curricular	**Qualifying**

Industrial Training/Survey/Project Qualifying

SEMESTER VI

HSCC XXXX **Microbial Genetics and Biotechnology** **L-T-P-C: 3-1-2-6**

COURSE OBJECTIVES

The course provides the students with a conceptual and experimental background in the broad discipline of microbial genetics. Emphasis has been laid on mutations, significance of phages, transposons and plasmids in genetic analysis and biotechnology domains. The course also introduces the students to the scope and relevance of microbial genetics and biotechnology in the field of medicine, agriculture, and industry.

Course Outcomes:
Upon completion of the course students will be able to:

CO1: Discuss basic mechanism of point mutations, acquaintance with bacterial genetics. Conceptual understanding of molecular cloning tools and vectors.

CO2: Describe bacteriophages, plasmid and transposon in genetic analysis.

CO3: Describe chronological developments in biotechnology.

CO4: Explain various techniques employed in microbial genetics and biotechnology along with construction and screening of DNA libraries.

CO5: Apply knowledge of various applications of microbial genetics and biotechnology in industry, such as vaccine designing, etc.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	1	-	-	-
CO 2	3	3	-	-	-	-	-	-	1	-	-	-
CO 3	3	3	3	-	2	1	1	1	1	-	-	-
CO 4	3	3	3	-	1	1	2	2	1	3	-	-
CO 5	3	3	3	2	1	1	2	2	1	3	2	1
Average	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**2**	**1**	**3**	**2**	1

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: Introduction to gene and mutagenesis **5 Hrs**

Genetic and molecular basis of mutation and recombination. Physical and chemical mutagens. Spontaneous mutations- random and non-adaptive mutation, mutation rates, origin. Genetic analysis of mutants

UNIT II: Bacterial genetics **10 Hrs**

Gene transfer mechanisms-Transformation- molecular mechanism, mapping and other uses of transformation, Transduction- generalized transduction, co transduction and linkage, mapping by co transduction, specialized transduction, specialized transducing phage as a cloning vehicle. Bacterial conjugation- insertion of F in E. coli, Hfr transfer, recombination in recipient cells. Chromosome transfer in other bacteria.

UNIT III: Plasmids, Transposons and Bacteriophages **10 Hrs.**

Plasmids- types and properties, F-factors description. Colicins and col factors. Plasmids as vectors for genetic cloning. Plasmid replication. Transposons- types, genetic phenomena mediated by transposons in bacteria. Use of plasmid and transposons in genetic analysis. Bacteriophages, Lytic phages-T7 and T4. Lysogenic phages Lambda phage, and P1, M13 and φ X174 life cycles, Phage MU and their uses in microbial genetics.

Unit IV: DNA amplification and DNA sequencing **10 Hrs**

Sanger's method of DNA Sequencing, Genome Sequencing, Primer walking and shotgun sequencing. Genomic and cDNA libraries: Preparation and uses, Screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping.

UNIT V: Applications of microbial genetics and biotechnology **10 Hrs**

Microbial genetics and design of vaccines. BCG and design of vaccine for TB and leprosy. DNA vaccines, design and advantages. Expression vectors: *E.coli* lac and T7 promoter-based vectors, yeast YIp, YEp and YCp; vectors, Baculovirus based vectors, mammalian SV40-based expression vectors. Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, Gene therapy, recombinant vaccines.

REFERENCES

1. Henkin and Peter (2020) Snyder and Champness Molecular Genetics of Bacteria. 5th Ed, ASM Press.
2. TA Brown (2020) Gene cloning and DNA Analysis. An introduction. 8th Ed. Blackwell Science
3. Stanley R et al. (2000) Microbial Genetics. 4th Ed. Jones and Barlett Publishers,
4. Biotechnology-The biological principles: MD Trevan, S Boffey, KH Goulding and P.F. Stanbury
5. Madhuri A (2023) Molecular Biology and Microbial Genetics with Practicals. Divya Lakshmi Publishers

Practical: **60 Hrs**

1. Preparation of Master and Replica Plates
2. Study the effect of chemical (HNO2) and physical (UV) mutagens on bacterial cells
3. Study survival curve of bacteria after exposure to ultraviolet (UV) light
4. Isolation of Plasmid DNA from E coli
5. Study different conformations of plasmid DNA through Agarose gel electrophoresis.
6. Demonstration of Bacterial Conjugation
7. Demonstration of bacterial transformation and transduction
8. Demonstration of AMES test

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

XXXX XXXX	**Microbiome and Omics**	L-T-P-C: 3-1-2-6

COURSE OBJECTIVES

This course aims to build a foundation for understanding the background and methods involved in microbiome analysis. Increase knowledge, appreciation and use of genomics and transcriptomics pertaining to the breadth of microbial diversity across a wide variety of organisms and habitats using methods that do not require culturing of the myriad of inhabitants. Students will use practice analysis and interpretation of genomic, proteomics and metabolomics data sets to understand different omics techniques.

Course Outcomes:

After completion of the course students will be able to:

CO1. Discuss ecological principles of the environmental, plant and human microbiomes and their role in biogeochemical cycling, health and diseases

CO2. Understand how microbiome changes may impact human health and environment

CO3. Summarize OMICS tools and experimental strategies for studying the microbiome

CO4. Apply the principles and application of NGS in multi-omic and human health.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	2	3	2	1
CO 2	3	3	-	-	-	-	-	-	2	3	2	1
CO 3	3	3	3	2	2	2	2	2	2	3	2	1
CO 4	3	3	3	2	2	2	2	2	2	3	2	1
Average	3	3	3	2	2	2	2	2	2	3	2	1

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SYLLABUS

UNIT I INTRODUCTION TO MICROBIOME 5 Hrs.

Introduction to Microbiome. Culturable versus Non-Culturable microbes, Great Plate count anomaly; VBNC state. High throughput methods for culturome. Microbiomes of different environments – terrestrial, aquatic, marine and their importance in biogeochemistry; Plants Microbiome and their role in diseases and health.

Humans and ecology of the microbiome, Human Microbiome Project (HMP), Causality in human microbiome research (Koch's postulates still apply). Dysbiosis of human gut microbiome and role in health and diseases.

UNIT II: UNDERSTANDING AND OVERVIEW OF NEXT GENERATION SEQUENCING (NGS) AND OMICS 10 Hrs

Brief history and development of NGS. Generations of NGS. Basic concepts of generating NGS. Data types and different omic type. Applications. Modern sequencing and new developments. Case studies of NGS and multi-omic application in human disease.

UNIT III Metagenomics approach to study Microbiome 15 Hrs

Understanding bacterial diversity using metagenomics approach: DNA-based analysis of microbial communities, 16S rRNA gene amplicon sequencing and shotgun metagenomics sequencing methods. Assignment of taxonomy; generating OTU tables, quality control; Describing the complexity of the microbiome eg. alpha and beta-diversity; Comparing microbial communities, phylogenetic trees, Uni Frac, principal coordinate analyses, Venn diagrams, heat maps; Prospecting genes of biotechnological importance using metagenomics; Functional analysis of the microbiome from DNA sequence.

UNIT IV Transcriptomics and epigenomics approach to study Microbiome 10 Hrs.

Transcriptomics, Introduction to typical wet lab workflow, library preparation, and analysis pipeline, Choice of sequencing methods and tools for read mapping, assembly, identification of splicing variants and differential expression analysis, Tools available for pathways analysis, Gene Ontology; Applications of transcriptomics using case studies. Introduction to epigenetics and emerging application of epigenetics in microbiome.

UNIT V Proteomics approach to study Microbiome 10 Hrs

Proteomics-Basic concepts of Proteomics, components of proteomics, importance and application of proteomics in biological functions, different tools of proteomics for separation and identification of proteins, software packages and available tools for proteomics data analysis. Difference gel electrophoresis (DIGE), Mass Spectrometry (ESI and MALDI), mass fingerprinting, Tandem-MS, ICAT-MS analysis.

UNIT VI Metabolomics approach to study Microbiome **10 Hrs**

Metabolomics: Tools and techniques available for metabolomics analysis, targeted vs non-targeted metabolomics, experimental design and sample preparation, workflow, data analysis tools and repositories, data formats and key challenges, metabolite identification, metabolic fingerprinting, applications of metabolomics.

Practical: **30 Hrs**

1. Perform extraction of environmental DNA / RNA and RT-qPCR
2. Installation of QIIME2 / Galaxy Tools etc. and downloading of demultiplexed sequence data and sample meta data
3. Downloading NGS data sets.
4. Perform a QC control of the data files
5. Interpretation of the quality of the NGS data.
6. Understanding QIIME 2 files and using command qiime tools export.
7. Generate a visualization file to examine the sequence quality
8. Analyzing 16SrDNA amplicon sequencing data and perform taxonomic assignments from downloaded data.

References:

1. Mitra S (2023) Metagenomics data analysis. Springer protocols. Methods in Molecular Biology (MIMB, volume 2649)
2. Wang and Sun (2018) Transcriptomics data analysis. Methods in Molecular Biology, (MIMB, volume 1751)
3. Kobe, Guss and Huber (218) Microbial Genomics and Proteomics. Humana publishers
4. Singh et al. (2022) RNA-Based Technologies for Functional Genomics in Plants (Concepts and Strategies in Plant Sciences). Springer Nature

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

XXXX XXXX	FOOD MICROBIOLOGY	L-T-P-C: 3-1-2-6

COURSE OBJECTIVES

To understand the key concepts in food microbiology, role of microbes in contamination and spoilage of foods, gain knowledge on various methods of microbial analysis of food and dairy products and food preservation.

COURSE OUTCOMES

After completion of this course students will be able to:

CO1: Discuss the important types and role of microorganisms associated with Food.

CO2: Describe microorganisms involved in food borne infections and intoxications.

CO3: Compare various physical, chemical and biological methods used in the control of microorganisms.

CO4: Explain principles of quality control and assess criteria for microbiological safety in various food operations.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	-	2	-	-	-	1	2	-	3	-	-
CO 2	3	3	2	-	-	-	-	2	-	3	-	-
CO 3	3	3	2	-	-	-	-	2	-	3	-	-
CO 4	3	3	2	2	3	1	1	2	2	3	2	1
Average	3	3	2	2	3	1	1	2	2	3	2	1

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SYLLABUS

UNIT- I: INTRODUCTION TO FOOD MICROBIOLOGY **15 Hrs**

Important groups of microorganisms associated with foods; concept of probiotics and prebiotics, dairy starter cultures, lactic acid bacteria and their metabolism; factors affecting microbial growth and survival in foods; kinetics of thermal death of microorganisms; culture dependent and independent methods for the estimation of food associated microorganisms

UNIT- II: MICROBIAL CONTAMINATION AND SPOILAGE **20 Hrs**

Microbial Contamination and spoilage of foods of animal origin: sources of contamination, natural microflora, microbial spoilage, and preservation methods of: A) Milk and milk products B) Fish and other sea foods C) Meat and poultry D) Egg

Microbial Contamination and spoilage of plant-based and miscellaneous foods: sources of contamination, natural microflora, microbial spoilage, and preservation methods of: A) Cereals, bread and other cereal products B) Fruits and Vegetables and their juices C) Canned Foods D) Fats and Oils E) Sugar and Sugar Products

UNIT- III: CONTROL OF MICROBES IN FOOD ` 15 Hrs.

Emerging technologies for the reduction of pathogenic and spoilage microorganisms in food, role of bio-preservation in improving food safety: LAB as biopreservative, Bacteriocins, endolysins, antimicrobial peptide (AMP). microbial interference, bacteriophage; Hurdle technology; Food fermentations

UNIT- IV: HAZARD ANALYSIS AND RISK ASSESSMENT 10 Hrs

Hazard Analysis and Risk Assessment: Physical hazards (metals, glass, etc), Chemical hazards (food additive, natural toxins, pesticides, antibiotics, hormones, heavy metals and packaging components), Biological hazards (virus, bacteria and fungi), Evaluation of the severity of a hazard Controlling Food Hazards. Microbiological indicators of food quality and safety, Hazard Analysis Critical Control Point (HACCP) concept.

Practical: **60 Hrs**

1. Determination of the microbiological quality of the milk by plate count and dye reduction methods
2. Determination of the microbiological quality of selected foods
3. Isolation of spoilage microorganisms from spoiled foods (vegetables, juices, fruits, bread, milk, meat)
4. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
5. Microbial fermentation for production of yogurt and saurkraut.
6. Estimation of the thermal death point and thermal death time of heat resistant microorganisms
7. Isolation of thermophilic bacteria from wheat flour
8. Isolation of psychrophilic or psychrotrophic microorganisms from refrigerated foods
9. Calculation of the thermal death time and decimal reduction time of *E. coli*.

REFERENCE BOOK

1. Frazier & Westhoff (2017) Food Microbiology, 5th Ed, Tata McGraw-Hill publishing company Ltd, New Delhi.

2. Nash (2019) Fundamentals of Food Microbiology. Callisto Reference.

3. James MJ (2015) Modern Food Microbiology 6th edition, Aspen Publications and distributors, New Delhi

5. Kumar and Sharma (2019) HACCP: Applications and Challenges. Dreamtech Press

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

Start Your Startup	Credits 2

Ability Enhancement/Co-curricular	Qualifying

Industrial Training/Survey/Project	Qualifying

SEMESTER VII

HSCC XXXX	Microbial Systems Biology	L-T-P-C: 3-1-1-5

COURSE OBJECTIVES

Microbial Systems Biology, a subset of systems biology, is an integrated approach to understand microbial systems with the interplay of genes, proteins, other macromolecules, small molecules, organelles, and the environment. It aims at understanding genotype-phenotype relations brought by cellular networks with a combination of experiments and mathematical approaches.

COURSE OUTCOMES

After the completion of the course student should be able to:

CO1. Recognize, exemplify, and explain basic concepts, ideas, and techniques of Systems Biology

CO2. Implement, simulate, and analyze biology-related mathematical models using available software packages in a programming language of their choice.

CO3. Work on a biological modelling task and communicate their modelling activities for better understanding of microbial behavior and response.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	2	-	-	-	2	-	2	3	2	-
CO 2	3	3	2	-	-	-	2	-	2	3	2	-
CO 3	3	3	2	3	-	-	2	-	2	3	2	-
Average	3	3	2	3	-	-	2	-	2	3	2	-

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: INTRODUCTION TO SYSTEMS BIOLOGY 10 Hrs

Overview of systems biology concepts and approaches, Fundamentals of molecular biology and genetics, introduction to microbial database, importance of microbial database in research and applications

UNIT II: MICROBIAL GENOMICS AND TRANSCRIPTOMICS 15 Hrs

Genome sequence analysis and annotation, Gene expression profiling and analysis, Regulatory networks and transcriptional control, High-throughput sequencing technologies and data analysis, Comparative genomics and evolutionary analysis, functional genomics and transcriptomics, proteomics, and protein analysis.

UNIT III: APPLICATION OF MATHEMATICAL MODELLING IN MICROBIAL SYSTEMS 20 HRS

Application of systems-Level Modeling and Analysis, Understanding Mathematical modeling and simulation of microbial systems, Concepts of Network analysis and reconstruction of microbial interactions, Integration of omics data (genomics, transcriptomics, metabolomics), Metabolic pathways and flux analysis, Quantitative understanding of cellular processes and regulatory networks

UNIT IV: APPLICATION OF COMPUTATIONAL BIOLOGY 15 HRS

Understanding of computational Modeling and Simulation: Applications of mathematical and computational models, Predictive modeling of microbial behavior and response, Simulation of microbial systems to test hypotheses and generate insights, Case studies on engineering microbial systems for specific applications, designing and constructing synthetic gene circuits and pathways to study microbial systems.

Reference:

1. Prof Jeff Gore, system biology graduate class. MIT, USA. (2014)
2. Karoline Faust, et al. Lab of microbial system biology (European research council). (2023)
3. “Brock”: Madigan, Michael, and John Martinko. Brock Biology of Microorganisms. 14th ed. Upper Saddle River, NJ: Pearson Prentice Hall, 2014. ISBN: 9780131443297
4. Environmental microbial system biology. UC san diego university. (2016)
5. Sachin Malik, Dharmender Kumar. (2023) Perspectives of nanomaterials in microbial remediation of heavy metals and their environmental consequences: A review. Biotechnology and Genetic Engineering Reviews 0:0, pages 1-48.
6. Soyer OS, O'Malley MA. Evolutionary systems biology: what it is and why it matters. Bioessays. 2013 Aug;35(8):696-705. doi: 10.1002/bies.201300029. Epub 2013 May 16. PMID: 23681824.

PRACTICALS **30 Hrs**

1. Introduction to Biopython, R studio
2. Introduction to COBRA toolbox in Matlab
3. Microbial Pathway databases KEGG, MetaCyc, BioCyc, EcoCyc
4. Genome assembly and annotation
5. NGS data quality analysis
6. Statistical analysis and visualization of microbiome data using software like QIIME, mothur, or R packages
7. Metabolic Network Reconstruction in MATLAB
8. Metabolic Flux Analysis

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

XXXX XXXX	INDUSTRIAL MICROBIOLOGY	L-T-P-C: 3-1-1-5

COURSE OBJECTIVES

This course will enable students to learn about various bioreactors, industrial production of microbial metabolites (enzymes, antibiotics etc.), processes of fermentation, understand the upscaling, and downscaling of the desired product from bioreactors and microbial strain improvement and applications of industrial microbiology.

COURSE OUTCOMES

Upon completion of the course, the student should be able to:

THEORY

CO1: Describe types of bioreactors, fermentation processes and enzyme kinetics

CO2: Explain various aspects of industrial production processes, regulation and applications of enzymes

CO3. Apply knowledge of microbiology for production of various important microbial metabolites

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	2	3	2	1
CO 2	3	3	-	-	-	-	-	-	2	3	2	1
CO 3	3	3	3	2	2	2	2	2	2	3	2	1
Average	3	3	3	2	2	2	2	2	2	3	2	1

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: INTRODUCTION TO INDUSTRIAL MICROBIOLOGY 10 Hrs

Fermentations, Bioreactors and types of bioreactors Primary and secondary metabolites; Scale up and scale down processes; Types of fermentation (Solid state, surface and submerged fermentation); Operational modes of fermentation (Batch, fed-batch and continuous), kinetics, synchronous growth, methods of growth estimation, stringent response, Thermal death of a bacterial cell.

UNIT II: BASIC ASPECTS OF FERMENTATION & MICROBIAL STRAIN IMPROVEMENT 10 Hrs

Media formulation; Sterilization; Inoculum development; Effect of temperature, pH and high nutrient concentration on fermentation; Basic fermenter design; Types of bioreactors; Downstream processing. Microbial Strain Improvement Strategies for isolation and cultivation of desired microorganisms; Screening for the desired product; Strategies for strain improvement.

UNIT III: **INDUSTRIAL PRODUCTION ASPECTS 10 HRS**

Production aspects (Microbial strains, substrate, flow diagrams, product optimization and applications): Production of antibiotics (penicillin, streptomycin, tetracycline), amino acid (glutamic acid and lysine), biopolymers (dextran) and steroids biotransformation. Production aspects (Microbial strains, substrate, flow diagrams, product optimization and applications): Production of enzymes (amylase, lipase, protease), alcohol and alcoholic beverages, vitamins (B12 and riboflavin)

UNIT IV ENZYME KINETICS 10 Hrs

Michaelis-Menten equation for uni-substrate reactions, Briggs and Haldane theory (rapid equilibrium and steady state theory), Significance of Km, Vmax, Kcat, Kcat/Km. Different plots for the determination of Km & Vmax and their physiological significances, measurement of enzyme activity. Reversible and irreversible inhibition and different enzyme inhibitors with examples.

UNIT V: REGULATION AND INDUSTRIAL APPLICATIONS OF ENZYMES 10 Hrs

General mechanisms of enzyme regulation, control of activities of single enzymes (end product inhibition), covalent modifications of enzymes. Feedback inhibition, allosteric enzymes, Sigmoidal kinetics. Enzyme immobilization, methods of enzyme immobilization, and applications of enzymes in different industries.

UNIT VI: **INDUSTRIAL APPLICATIONS 10 hrs**

Role of microorganisms in the natural system and artificial system. Scope and importance of Microbiology in Biotechnology. Microbial fuel cells; Prebiotics and Probiotics; Vaccines.

PRACTICALS 30 hrs

1. Methods of sterilization.
2. Preservation of industrially important microorganisms.
3. Isolation and screening of industrially important microorganisms.
4. Determination of thermal death point and thermal death time of microorganisms.
5. Production of secondary metabolites.
6. Ethanol production on a laboratory scale.
7. Screening of enzyme producers.
8. Isolation of Yeast and Lactic Acid Bacteria

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX	Fundamentals of Research Methodology	L-T-P-C:3-1-1-5

COURSE OBJECTIVES

Upon completion of the course, the student should be able to:

- understand basic concepts of research and its methodologies
- identify and define a research problem, state a hypothesis, select an appropriate research design, and implement research project
- discuss the concepts and procedures of sampling, ethical considerations, data collection, analysis and reporting
- write a research proposal, review literature, collect and analyse data, and write a report / dissertation

Course Outcomes

CO1: Understand the basics of research, types, steps and application.
CO2: Identify and define a research problem, set hypothesis and select an appropriate research design
CO3: Demonstrate the ability to choose methods appropriate to research aims and objectives
CO4: Conduct literature review, collect data and analyse
CO5: Report and Communicate research findings

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	-	-	-	-	-	-	-	--	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	1	-	-
CO 3	3	2	1	-	3	-	-	-	-	-	2	-
CO 4	3	2	1	-	3	-	-	-	-	-	-	-
CO 5	3	-	1	-	1	-	2	1	-	-	-	1
Average	3	2	1	-	2.3	-	2	1	-	1	2	1

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: INTRODUCTION TO RESEARCH METHODS 12 hrs

Definition of research, objectives of research, applications and types of research, research process and steps involved. Collecting and reviewing literature, types of literature review (survey, systematic, meta-analysis), conceptualization, and formulation of a research problem, constructing hypothesis, identifying variables, Synopsis.

UNIT II: DESIGN OF RESEARCH AND SAMPLE SURVEY 12 hrs

Research Design-Selecting and defining a research problem, need for research design, features of a good research design, different research designs (exploratory, descriptive experimental and diagnostic research); Design of Sample Survey: Census V/s Sample enumerations, objectives and principles of sampling, Types of sampling, Sampling and Non-sampling errors. Designing Questionnaires and interview. Determination of the sample size.

UNIT III: MEASUREMENT OF SCALING CONCEPTS 12 hrs

Scales of measurements, nominal, ordinal, internal and ratio scales, Errors in measurements. Validity and Reliability in measurement, Scale Construction Techniques.

UNIT IV: DATA COLLECTION & ANALYSIS 12 Hrs

Primary & secondary data, Validity and Reliability of data collection procedures, data preparation, exploratory data analysis, parametric and nonparametric tests, correlation and regression analysis, ANOVA, Multivariate Techniques.

UNIT V: RESEARCH ETHICS & SCIENTIFIC COMMUNICATION 12 Hrs

Ethical conduct of research; Ethics and plagiarism in publication; Art of Communicating Scientifically –formats for scientific presentation and writing, conclusion, referencing and, Bibliography; journal publications, Impact factor, Citation index, Research related Software - references management, Plagiarism detection etc.

REFERENCES

1. Kothari C.R., “Research Methodology, Methods, and Techniques, Second edition, (2008), New Age International Publication.
2. Krishna Swamy K.N., Siva Kumar A.I., Mathirajan M., “Management Research Methodology (2006), Pearson Education, New Delhi.
3. Ranjit Kumar: Research Methodology, A step by step guide for beginners, Pearson Education, Sixth Edition 2009.
4. Mark Saunders, Philip Lewis, Adrain Thornhiu: Research Methods for Business Students, Pearson Education.
5. Ram Ahuja, “Research Methods”, (2001), Rawat Publications, New Delhi. 6. Cooper D., Schindler P., Business research methods”, (2003) Tata Mc-Graw Hill, New Delhi
6. https://apps.who.int/iris/bitstream/handle/10665/206929/929061157X_eng.pdf?sequence=1&isAllowed=y

PRACTICALS **30 hrs**

1) Reference management tools (Mendeley, EndNote, etc)

Use of reference management tools and integration into MS office

2) Setting research question

Identify the research area/topic of interest, review the research trends, write about significance of the chosen topic/area, set research question(s), and develop hypothesis.

3) Setting objectives and protocols (methods)

Write specific objectives and designing research methods for each objective.

4) Literature review, data collection and analysis

Detailed review of literature on the chosen topic

5) Report writing and communication

Finalize the report based on the collected and analysed data, communicate for peer-review, etc.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

XXXX XXXX	Good Laboratory and Manufacturing Practices	L-T-P-C: 3-1-1-5

COURSE OBJECTIVE

The main objective of this course is to introduce the basic concepts of Quality assurances in Good Laboratory Practices. This course addresses Federal Food and Drug Law and discusses the Trade and Company Standards Control by National, International. This will also enable the students to know about the scope and importance of GLP and GMP.

COURSE OUTCOMES

Upon completion of the course, the student should be able to:

THEORY

CO1: To know about the detail guidelines on GLP and GMP and study the trade standards of quality Federal Food and Drug Law FDA.
CO2: Understand the concept of Regulatory requirements and approval procedures for New Drugs and technologies.
CO3: Demonstrate basic skills of good Laboratory practices, standardization and validation procedures

CO4: Mastering basic techniques for hygienic manufacturing of products.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	-	-	1	-	-	-	-	-	-	-	-	3
CO 2	-	-	1	-	-	-	-	-	-	-	-	3
CO 3	2	2	1	1	1	1	1	1	1	-	-	3
CO 4	2	2	1	1	1	1	1	1	1	-	-	3
Average	2	2	1	1.2	1	1	1	1	1	-	-	3

1 – Weakly Mapped (Low); 2 – Moderately Mapped (Medium); 3 – Strongly Mapped (High);
"_" means there is no correlation

UNIT I: GOOD LABORATORY PRACTICES **7 hrs**

Introduction to GLP, WHO guidelines on GLP, Quality assurances in Good Laboratory Practices and Quality Standards. Advantages and Disadvantages, Concept of Quality Control. Government and trade standards of quality Federal Food and Drug Law FDA Action BSTI Laws, BSTI action and activities other food laws (Legalization).

UNIT II: VALIDATION OF ANALYTICAL PROCEDURES **8 hrs**

Implications of cGMP and Food plant sanitation. The regulations of cGMPs Planning of Plant Sanitation Programs and Construction factors Hygienic design of food plants and equipments Sanitation in warehousing, storage, shipping, receiving, containers and packaging materials Control of rats, rodents, birds, insects and microbes. Cleaning and Disinfection: Physical and Microbiological Approach. Food Quality and Quality control including the HACCP system (Critical quality control points in different stages of production including raw materials and processing materials)

UNIT III: GOOD MANUFACTURING PRACTICE **7 hrs.**

Good Manufacturing Practice: definitions, requirements and historical background. Quality assurance, quality management, design of quality systems. Principles for documentation in GMP, Site Master File, SMF, Monographs, Protocols (production protocols, standard operating procedures, SOP).

UNIT IV: RISK ANALYSIS AND PRECAUTIONS **8 hrs**

Risk analysis and risk assessment, Qualification and validation, Microbiological test and quality control, Aseptic production, localities, clothing, Audit, monitoring, internal and external inspections

UNIT V: SAMPLING **10 hrs**

Sampling: Introduction, WHO guidelines, sampling plans and techniques, operating characteristics curves, maintenance of sampling records of finished product and packaging material

Ethics in manufacturing and control, Principles of quality by design (QBD). Introduction to the concept of Design of Experiment (DOE) Application of QBD principles in Biotech product development.

PRACTICALS **30 hrs**

1. Basic procedures and precautions for working in a Laboratory
2. Pre-analysis preparation and management of materials.
3. Describe Sampling techniques and perform a sampling of raw materials
4. Accuracy and Precision of analysis method.
5. Validate the analysis method
6. Basic procedures to produce hygiene food and drugs.
7. Procedure to produce a Food product.
8. Storage stability tests for Developed products.
9. Packaging and transportation requirements for a product.

REFERENCES

1. cGMP starter guide: Principles in Good Manufacturing Practices for Beginners, Emmet P. Tobin, Createspace Independent Publishing Platform, April 2016.

2. Good Manufacturing Practices for Pharmaceuticals: GMP in Practice, B Cooper, Createspace Independent Publishing Platform, July 2017.

3. Sarwar Beg and Md Saquib Hasnain, Pharmaceutical Quality by design: Principles and application, Academic press, March 2019.

4. Ron S. Kenett, Shelemyahu Zacks, Daniele Amberti, Modern Industrial Statistics: with applications in R, MINITAB and JMP, 2nd Edition, Wiley, January 2014.

5. N Politis S, Colombo P, Colombo G, M Rekkas D.Design of experiments (DoE) in pharmaceutical development, Drug Dev Ind Pharm. 2017 Jun;43(6):889-901. doi: 10.1080/03639045.2017.1291672.

6. Andrew Teasdale, David Elder, Raymond W. Nims, ICH quality guidelines- An implementation guide, Dec 2017.

7. Singh, G., Agarwal, G. and Gupta, V. Drug regulatory affairs, CBS publication, 2005.

8. Marc P. Mathieu, New Drug Development: A regulatory overview, Nov 2000.

9. ICH guidelines available in the official website “https://www.ich.org”. Course Outcomes: Understand that the areas that come under the Good Laboratory Practices are: personnel and organizational, testing facilities, equipment, testing and controls, records, reports, and protocol for and conduct of non-clinical labs., Understand that the areas that come under GMP are: facilities and buildings, equipment, production, process control, packaging and labeling, laboratory controls, and returned/salvaged drug products., Importance of GMP and GLP for drug regulation.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

ELECTIVES
(SEMESTER II)

XXXX XXXX	Laboratory Safety Guidelines	L-T-P-C: 2-1-1.5-4.5

Course Objectives

Good lab practices are an integral part of conducting research safely. The course will create an understanding of safety regulations, infrastructures, precautions required for isolation, cultivation, and maintenance of Biosafety levels – I, II, III and IV organisms.

Course Outcomes:

By the completion of this course the students able to:

CO1. Understand the principles, regulations associated with safe laboratory practices to handle physical, chemical and biological materials, storage and waste disposal systems.

CO2. Ability to identify risks, handle various chemical and biological hazards and effectively initiate emergency response.

CO3. Apply skills to be accomplished to cooperate efficiently with laboratory personnel,

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	2	-	1	-	-	-	-	-	-	-	1
CO 2	3	2	-	1	-	-	-	-	-	-	-	1
CO 3	3	2	1	1	1	1	1	1	1	1	-	1
Average	3	2	1	1	1	1	1	1	1	1	-	1

1 – Weakly Mapped (Low); 2 – Moderately Mapped (Medium); 3 – Strongly Mapped (High); "_" means there is no correlation

Syllabus

Unit I: General Lab Safety **5 Hrs**

Introduction to general lab safety culture, Common rules for all laboratories, Fire Extinguishers (how they work, types & handling) and Fire safety, Risk Assessment, Medical emergencies, Laboratory access and visitors, Computer and network safety, using personal protective equipment, Electrical Safety and handling lab equipments safely.

Unit II: Chemical Safety-I **15 Hrs**

Introduction of hazardous chemicals, Hazards identification & associated risks, New Safety Data Sheets (SDS) versus the Old Material Safety Data Sheets (MSDS), General Rules for handling chemicals, Essential practices for handling hazardous chemicals: Chemical Segregation, Transfer and Transport, Chemical Fume Hoods (Safety, Types, Operation), Other Types of Ventilation. Laboratory chemical waste management.

Storing, labeling, handling of Chemicals and personal hygiene, Storage of Explosive and reactive hazardous chemicals, Consequences of mixing up incompatibles, Transportation of hazardous chemical, handling chemical spill, handling emergencies and accidents, Spill Containment and Clean-up, Leaking Gas Cylinders & handling, Controlling Exposures and Minimizing Risk, Incident reporting.

Unit III: Chemical Safety II **10 Hrs**

Flammable Substances (Standard Operating Procedures), Working with Highly Reactive or Explosive Substances, Working with Compressed Gases (Parts of the Cylinder, Cylinder Pressure Regulator, Storage Guidelines, Transporting Cylinders, Handling Compressed Gas Cylinders); Working with Cryogenics (Health Hazards, Liquid N2);

Unit IV: Biological safety **10 Hrs**

General Biological safety rules and guidelines, Appropriate personal protective equipment (PPE), Using a biological safety cabinet, Handling of equipment, glassware, handling of samples, collection, processing, storage. Disinfection, decontamination and sterilization, Emergency responses.

Unit V: Biological safety Levels **5 Hrs**

Working safely with biological materials, Introduction to Biosafety levels – I, II, III and IV; Summary of CDC guideline for Infrastructure, precaution and biowaste disposal system associated with the transport, cultivation, and maintenance of Biosafety levels I, II, III and IV pathogens.

References and Textbooks

1- Willey J, Sherwood L. and Woolverton C (2014). Prescott's Microbiology, 9th edi McGraw Hill
2- Bergey's manual systematic Bacteriology(2011) 2nd edition
3- Bisen, P.S. (2014). Microbes in Practices, I K international publication house pvt Ltd
4- R. Mahesh, Sajeev C, N. Sridhar, Laboratory manual on "Instrumental Methods of Analysis" – EDD Notes. 4th Edition., 2003.

Practicals **45 Hrs**

1- Demonstration of general Lab safety guidelines and handling emergency
2- Techniques to handle hazardous chemicals for preparation of solutions and buffers.
3- Safety Demonstrations for containment of Chemical Spills and accidents
4- Techniques to handle and store flammable substances
5- Demonstration of various equipments and apparatus used in BSL-I and II laboratory for the cultivation and maintenance.
6- Demonstration of Aseptic techniques and safety& environment rules, required to be followed during cultivation and maintenance in BSL-I and II laboratory.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX	INTRODUCTION TO MICROBIOLOGY	L-T-P-C: 2-1-1.5-

COURSE OBJECTIVES

This course introduces students to the fascinating world of unseen microbes. Foundational knowledge of microbiology is introduced within a historical narrative in context of the major discoveries by important scientists. Students are introduced to diversity of microbial world in the biosphere, general characteristics of different groups of microrganisms microbes, a brief history of microbial life on Earth and scope of microbiology.

COURSE OUTCOMES

After completion of this course, the students will be able to:

CO1. Discuss foundational discoveries in microbiology, contributions of various scientists and diversity of the microbial world and taxonomy

CO2. Describe the classification of microbes and salient features of different groups of microbes

CO3: Demonstrate basic skills in culturing, preparation of simple culture media, staining techniques, preservation and observation of microrganisms using light microscopy.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	-	2	-	-
CO 2	3	3	-	-	-	-	-	-	-	2	-	-
CO 3	3	3	3	2	-	-	1	1	1	2	1	1
Average	3	2	3	2	-	-	1	1	1	2	1	1

1 – Weakly Mapped (Low); 2 – Moderately Mapped (Medium); 3 – Strongly Mapped (High); "_" means there is no correlation

SYLLABUS

UNIT I: MICROBIAL WORLD **10 Hrs**

Microorganisms, Types of Microorganisms (Bacteria, Archaea, Algae, Fungi, Virus, Protozoa), Microbial cell dimensions, Observation of Microorganisms – Microscopy, resolving power, magnification, working principle and operation of simple and compound microscopes. General characteristics of acellular microorganisms and cellular microorganisms.

Carl Woese's three kingdom classification system, Taxonomic hierarchy and Microbial systematics. Outline of Bergey's manual and its importance in systematic bacteriology

Microrganisms in the Biosphere: Extremophiles, Geological time scales and a brief History of microbial Life on Earth and origin of life, Fossil evidence of microorganisms.

UNIT II: HISTORY AND SCOPE OF MICROBIOLOGY **10 Hrs**

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming.

Role of microorganisms in food fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Koch's postulates, History of vaccines and anti-microbials.

Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

Development of the field of soil and environmental microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.Waksman; Development of the field of marine microbiology and geomicrobiology and other disciplines.

UNIT IV: BACTERIA AND VIRUSES **10 Hrs**

Typical Eubacteria, Archaebacteria (extremophiles), Chlamydia & Rickettsia (obligate intracellular parasites), Mycoplasma. Overview of prokaryotic cell structure: Size, shape, arrangement. Ultra structure of prokaryotic cell: bacterial and archaeal - cell wall and cell membranes.

General introduction to Viruses, TMV, poliovirus, T4 and λ phage, lytic and lysogenic cycles, Structure, significance and transmission of Viroids and Prions.

UNIT V: ALGAE, FUNGI AND PROTOZOA **10 Hrs**

General characteristics of algae, algae cell ultra-structure, pigments, asexual and sexual reproduction and economic importance.

General characteristics of fungi, fungal cell ultra-structure, thallus organization, fungal wall, asexual reproduction and sexual reproduction, economic and medical importance.

General characteristics, mode of reproduction and transmission of protozoa. Concept of Parasitism, Parasite and Vectors.

UNIT VI: TECHNIQUES IN MICROBIOLOGY **5 Hrs.**

Staining: Nature of stains, principles, mechanism, methods and types of staining, simple, Differential-Gram staining, acid fast staining, capsule staining, endospore, inclusion bodies. Sterilization: Principles, types and techniques - Physical and Chemical. Preservation of microorganisms: Methods of preservation, slant culture, stab culture, soil culture, mineral oil overlaying, glycerol preservation, Lyophilization.

Practical **45 Hrs**

1. Demonstration and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory.

2. Preparation of culture media for bacterial cultivation using Autoclave and assessment for sterility.

3. Sterilization of glassware using Hot Air Oven and assessment for sterility.

4. Introduction to staining techniques: Gram-staining, Endospore staining, Capsule staining, Acid fast staining.

5. Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air, water, soil etc.

6. Study of *Rhizopus*, *Penicillium*, and *Aspergillus* using temporary mounts.

REFERENCES:

1. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2017). Brock Biology of Microorganisms.14th edition. Pearson International Edition.

2. Tortora GJ, Funke BR and Case CL. (2018). Microbiology: An Introduction. 13th edition. Pearson Education.

3. Cappucino J and Sherman N. (2014). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited.

4. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 11th Edition. McGraw Hill International.

5. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T. Brown Publishers.

6. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 7 th edition. McGraw Hill Book Company.

7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5 th edition. McMillan.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

XXXX XXXX	ONE HEALTH PERSPECTIVE	L-T-P-C: 2-1-1.5-4.5

COURSE OBJECTIVES

The purpose of this course is to introduce the concept of “One Health” which recognizes that the health of people is connected to the health of animals as well as the environment (Planetary Health and nine boundaries) and some diseases that are shared between animals and people known as zoonotic diseases. The One Health approach supports global health security by enhancing the communication, collaboration and coordination, at the human-animal-environment interface to address shared health threats.

COURSE OUTCOMES

Upon completion of the course, the student should be able to:

CO1. Understand the concept of ONE health and emergence infectious and zoonotic diseases and their applications

CO2. Relate the interconnected nature of human health with planetary health and cascading effects of endangered ‘planetary boundaries’ on human health, non-communicable and communicable diseases, animals and biodiversity.

CO3. Apply the concepts of ONE health perspective for effective management of zoonotic threats, pandemics, communicable and non-communicable diseases

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	2	-	-	-	-	2	-	2	-	-	-
CO 2	3	2	-	-	-	-	2	-	2	-	-	-
CO 3	3	2	1	1	1	1	2	2	2	1	1	2
Average	3	2	1	1	1	1	2	2	2	1	1	2

1 – Weakly Mapped (Low); 2 – Moderately Mapped (Medium); 3 – Strongly Mapped (High); “_” means there is no correlation

SYLLABUS

Unit I Introduction to the One Health 10 Hrs

One Medicine Concept and National & International health/public health, Global Health vs One Health, Basics of Research Ethics. Integrated human and animal disease surveillance systems, Recent success of One Health in control of emerging infectious diseases and the application of One Health

Unit II Emerging infectious diseases 10 Hrs

Process of disease emergence and assessment of the risk factors, Mechanisms of pathogen cross over across species boundaries and emerging infectious disease transmission, and its relevance in the 21st century, Importance of genomics in disease detection, Gaps in current health systems approaches

Unit III Emerging Infectious Diseases and Antimicrobial Resistance 10 Hrs

: Introduction to disease vectors and basics of Medical Entomology, the factors influencing an emerging disease (whether is controlled or becomes endemic/epidemic as illustrated by different emerging diseases -STDs, HIV/AIDS, avian influenza, SARS, Ebola), Antimicrobial resistance a global threat, Importance of antibiotic stewardship program, Introduction of Food Safety and Food Borne Diseases

Unit IV One Health Application in Management of Zoonotic Diseases 5 Hrs

The integration of human, animal and ecosystem health in the control and prevention of these diseases, Community engagement for zoonotic disease control in humans and animals through One Health

Unit V Concept of Planetary Boundaries and One Health 10 Hrs

Planetary boundaries concept and ecosystem functioning, nine planetary boundaries: Biosphere Integrity, Genetic Diversity, Land System Change, Freshwater Use, Biogeochemical Flows (P & N), Ocean acidification, Atmospheric aerosol loading, Stratospheric Ozone Delpetion, Novel entities (e.g., Chemical pollutants, microplastics, carcinogens etc.); Complex interactions between status of planetary bounds and interconnected impacts on human health and diseases.

References:

1. https://onlinecourses.nptel.ac.in/noc23_ge07/preview (SWAYAM NPTEL ONLINE COURSE ONE HEALTH)
2. Mackenzie JS, Jeggo M, Daszak P, Richt JA, editors. One Health: The Human-Animal-Environmental Interfaces in Emerging Infectious Diseases: The Concept and Examples of a One Health Approach (Current Topics in Microbiology and Immunology). Springer; 2013
3. One Health the Theory and Practice of Integrated Health Approaches 2020 Edition by Jakob Zinsstag, Esther Schelling, CABI Publishing
2. One Health: People, Animals, and the Environment (ASM Books) by Ronald M. Atlas and Stanley Maloy.
3. Bhattacharya D, Kshatri JS, Choudhary HR, Parai D, Shandilya J, Mansingh A, et al. (2021) One Health approach for elimination of human anthrax in a tribal district of Odisha: Study protocol. PLoS ONE 16(5): e0251041. https://doi.org/10.1371/journal.pone.0251041
4. Rockstrom et al. (2009) Planetary Boundaries: Exploring the Safe Operating Space for Humanity. Ecology and Society 14(2): 32
5. Whitmee et al. (2005) Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. The Lancet Commission (THE ROCKEFELLER FOUNDATION–LANCET COMMISSION ON PLANETARY HEALTH) 386(10007): P1973-2028 DOI: doi.org/10.1016/S0140-6736(15)60901-1
6. Steffen W Richardson K Rockström J et al. Planetary boundaries: guiding changing planet. Science. 2015; 347: 1-10
7. Planetary Health Watch: integrated monitoring in the Anthropocene epoch. Lancet Planet Health. 2018; 2: e141-e143
8. Planetary health: from concept to decisive action. Lancet Planet Health. 2019; 3: e402-e404

Practicals: **45 Hrs**

1. Basic statistical methods and their application and the measurement of disease frequency
2. Principles of survey design and the concepts of sampling
3. Mixed method research
4. Designing a research project to control any communicable or non-communicable disease using ONE health approach for the state of Uttarakhand.

5. Designing a research project to study the effects of any endangered planetary boundaries on human health.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

ELECTIVES
(SEMESTER IV)

XXXX XXXX	**Biosafety and Aseptic Techniques**	**L-T-P-C: 2-1-1.5-4.5**

Course Objectives

The course will create an understanding of regulations, infrastructures, precautions required for isolation, cultivation, and maintenance of Biosafety levels – I, II, III and IV organisms.

Course Outcomes

By the completion of this course the students will be able to:

CO1. Discuss the principles, regulations associated with Biosafety levels: I, II, III and IV.

CO2. Describe the process of risk assessment in various groups of Biosafety levels – I, II, III and IV. Demonstrate to work in I, II, III and IV

CO3. Demonstrate skills for working in BSL-1 and BSL-2 facilities and in professional settings

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	-	3	-	-
CO 2	3	3	-	-	-	-	-	-	-	3	-	-
CO 3	3	3	-	-	-	-	-	-	-	3	2	2
Average	3	3	-	-	-	-	-	-	-	3	2	2

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

Syllabus

UNIT I: PRINCIPLES OF STERILIZATION **5 Hrs**

Basic principles and methods of Sterilization: control of microorganisms by physical methods: heat, filtration, and radiation; chemical methods: phenolics, alcohols, halogens, heavy metals, quaternary ammonium compounds, aldehydes, and sterilizing gases; evaluation of antimicrobial agent effectiveness (evaluation of efficacy of disinfectants, determination of phenol coefficient), Principle and functioning of LAF.

UNIT II: BIOSAFETY LEVELS **10 Hrs**

Principles of Biosafety levels – I, II, III and IV; CDC guideline for Infrastructure, precaution and biowaste disposal system associated with the transport, cultivation, and maintenance of Biosafety levels I, II, III and IV pathogens.

UNIT III: BIOSAFETY GUIDELINES **10 Hrs**

Biosafety guidelines – Department of Biotechnology (DBT), Government of India; Definition of GMOs and LMOs; ICMR and funding agencies, Roles of Institutional Biosafety Committee, the history and incidence of laboratory-acquired infections (LAI), incidents of secondary transmission from the laboratory, Outline the types of laboratory accidents leading to LAIs, Explain the role of aerosols in LAIs, Illustrate the importance of biosafety and biocontainment in minimizing the risk of LAIs.

UNIT IV: STANDARD OPERATING PROCEDURES 10 **Hrs.**

BSL-II level, Aseptic techniques, Wearing appropriate personal protective equipment (PPE), Using BSL: II cabinet. Handling of equipment, glassware, Handling of sample collection, processing, storage, waste disposals.

Media preparation, Handling and maintenance of pure cultures, preservation of various microbes, Cultivation, and preservation methods of eukaryotic cells: Counting and passaging of eukaryotic cells of epithelial and lymphoid origins, SOP's for preservation (for long term storage) and revival of the same under laboratory condition.

Practical **45 Hrs**

1. Demonstration of various equipment and apparatus used in BSL-I and II laboratory for the cultivation and maintenance.
2. Cultivation, maintenance of pure bacterial culture isolation-pour plate, spread plate, streak plate methods.
3. Aseptic techniques and safety rules, required to follow during cultivation and maintenance in BSL- II laboratory.
4. Prepare and sterilization of cell-culture media
5. Serial passage of cell lines
6. Cultivation, maintenance of eukaryotic cell lines in BSL-II laboratory.

References

6. Meechan PJ et al. (2020) Biosafety in Microbiological and Biomedical Laboratories. 6th Ed, Centers for Disease Control and Prevention, USA https://www.cdc.gov/labs/pdf/CDC-BiosafetyMicrobiologicalBiomedicalLaboratories-2020-P.pdf

7. Guidelines for Biosafety, DBT India https://dbtindia.gov.in/guidelines-biosafety

8. GENERAL GUIDELINES FOR ESTABLISHMENT OF BIOSAFETY LEVEL-3 LABORATORY (ICMR Guidelines) https://main.icmr.nic.in/sites/default/files/upload_documents/Revised_ICMR_Guidelines_2_December.pdf

9. Willey J, Sherwood L. and Woolverton C (2014). Prescott's Microbiology, 9th edi McGraw Hill

10. Bergey's manual systematic Bacteriology (2018) 11th edition

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

HSCC XXXX ENVIRONMENTAL MICROBIOLOGY AND BIOGEOCHEMISTRY L-T-P-C: 2-1-1.5-4.5

COURSE OBJECTIVES

To impart knowledge to students about importance and interactive role of microbes in diverse environments, microbial ecology and microbial biogeochemistry. The course will be beneficial for those intending to pursue a career in the environmental field.

COURSE OUTCOME

After completion of this course students will be able to:

CO1: Discuss ecological importance of microrganisms in diverse environments and ecosystems

CO2: Describe various types of microbial interactions in environment and their associations and interactions with higher forms of life

CO3: Demonstrate knowledge in understanding of microbial biogeochemistry and role of microbes in functioning of global elemental cycles and planetary health.

CO4: Explain general succession patterns of microrganisms in organic matter remineralization and diagenesis in various ecosystems / environment.

CO5: Apply knowledge of various environmental factors and microbial metabolism for pollution control, microbial remediation and waste management.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	1	3	-	-
CO 2	3	3	-	-	-	-	-	-	1	3	-	-
CO 3	3	3	3	-	2	1	1	1	1	3	2	2
CO 4	3	3	3	2	2	1	2	2	1	3	2	2
CO 5	3	3	3	2	2	1	2	2	1	3	2	2
Average	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**2**	**1**	**3**	**2**	**2**

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I MICROORGANISMS AND THEIR ENVIONMENTS 15 Hrs

Structure and function of ecosystems: Terrestrial Environments.
Aquatic and Marine Environment: Marine microbial habitats: estuaries, mangroves, salt marshes, beach and coastal ecosystems, reef and coral reefs, water column, sediments, oceanic ecosystems. Processes controlling oceanic carbon and nutrient distributions and cycling, Marine microrganisms, Factors controlling microbial ecology of marine econiches.
Atmosphere: Aeromicroflora; Animal & Human Environment: Microbes in/on human body (Microbiome) & animal (ruminants) body.
Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

UNIT II MICROBIAL INTERACTIONS 10 Hrs

Microbe interactions: Mutualism, synergism, syntrophy, commensalism, competition, Ammensalism, parasitism, predation. Microbe-Plant interaction: Symbiotic and non-symbiotic interactions. Microbe-animal interaction: termite gut microflora, nematophagus fungi and symbiotic luminescent bacteria.

UNIT III MICROBIAL BIOGEOCHEMISTRY 10 Hrs

Carbon cycle, inventories and fluxes, Role of microbes in terrestrial and marine carbon cycling, microbial degradation of cellulose, hemicelluloses, lignin and chitin.
Biogeochemical Cycles: Carbon, Nitrogen, Phosphorus, Sulphur, Iron, Manganese, Arsenic; Microbial succession and decomposition of organic matter.

Unit IV WASTE MANAGEMENT 5 Hrs

Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill). Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment.

Unit V Microbial BIODEGRADATION AND BIOREMEDIATION 5 Hrs

Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inroganic (metals) matter, biosurfactants. Bioremediation of metals: Biochemical and molecular mechanisms of lead, cadmium & As resistance in bacteria/fungi and phytoplankton; Biosorption, Bioprecipitation, biotransformation and Redox reaction, Volatilization.

References:

1. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th Ed. Pearson/ Benjamin Cummings.
2. Maier RM, Pepper IL and Gerba CP. (2015). Environmental Microbiology. 5th Ed, Academic Press.
4. Okafor, N (2018). Environmental Microbiology of Aquatic & Waste systems. 3rd Ed, Springer, New York.
5. Singh A, Kuhad, RC & Ward OP (2019). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg.

Practical: **45 Hrs**

1. Assessment of microbiological quality of water
2. Nutrient analysis of water samples / pore water:
3. Nitrate, b) Nitrite, c) Phosphate, d) Silicate e) Ammonia
4. Determination of BOD of waste-water samples
5. Isolation of dissimilatory Fe reducing bacteria from soil/sediments
6. Determination of redox speciation of Fe using Ferrozine method
7. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil and aquatic systems
8. Quantitative assays to detect extracellular enzymes- MUF assay
9. Isolation of DNA from Soil /Water
10. Isolation of RNA from Soil /Water
11. RT-qPCR assay for N2 fixation activity from environmental samples.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			End Term Examination		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

XXXX XXXX	**Food contamination and food borne infections**	L-T-P-C: 2-1-1.5-4.5

Course Objective

This course will enable to understand the various factors that lead to food contaminations and food borne infections and will enable students to gain knowledge on various methods of microbial analysis of food and dairy products.

Course Outcomes

Upon completion of the course, the student should be able to:

CO1: Assess the public health disease burden of key foodborne diseases

CO2: To understand the nature of microorganisms involved in food spoilage, food infections and intoxications and also those used in food biotechnology (food fermentation and various food processing industries)

CO3: To gain knowledge of principles of various techniques used in the prevention and control of the microorganisms in foods (food preservation)

CO4: To understand criteria for microbiological safety in various foods operations to avoid public health hazards due to food contamination

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	-	2	-	-	-	1	2	-	3	-	-
CO 2	3	3	2	-	-	-	-	2	-	3	-	-
CO 3	3	3	2	-	-	-	-	2	-	3	-	-
CO 4	3	3	2	2	3	1	1	2	2	3	2	1
Average	3	3	2	2	3	1	1	2	2	3	2	1

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

Unit I **10 Hrs**

History and development of Food microbiology: History of Microorganisms in Food-developments: Common Food borne Bacteria, Molds Role, and Significance of Microorganisms in Foods. Parameters Affecting Microbial Growth: Intrinsic, Extrinsic. Combined Intrinsic and Extrinsic Parameters-lactic antagonism and hurdle concept.

Unit II **10 Hrs**

Microorganisms in Foods and methods for detection: Fresh meat, Processed meat and poultry, Culture, Microscopic, and Sampling Method for detecting microbes, Physical, Chemical methods, Whole animal assays, Immunological methods.

Unit III **10 Hrs**

Food Preservation & Principles of Quality Control: Chemicals antibiotics, Radiation, Low and high temperature, High-Pressure Processing Pulsed Electric Fields. Aseptic Packaging, Manothermosonication, Microbiological quality standards of food, FDA, HACCP, ISI.

Unit IV **10 Hrs**

Microbial Food Spoilage and Food borne diseases: Staphylococcal, E coli, Salmonellosis, shigellosis, Listerial infections. Mycotoxins, Aflatoxins Alternaria Toxins, Toxigenic Phytoplankton and viruses.

Unit V **5 Hrs**

Applications of Food Microbiology: Beneficial Uses of Microorganisms in Food Intestinal Beneficial Bacteria-Concept of Prebiotics and Probiotics, Genetically modified foods. Biosensors in food

REFERENCES

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education

2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition

3. William C Frazier (2012) Food Microbiology. Fifth Edition

PRACTICALS **45 Hrs**

1. Isolation of bacteria from spoilt food and milk by serial dilution.

2. Estimation of CFU count by spread plate method/pour plate method.

3. Purification of cultures by quadrant streaking.

2. Gram staining, Endospore staining and biochemical characterization of isolates (catalase, oxidase, IMViC)

4. Preservation of bacterial cultures by various techniques (Agar slant, glycerol stocks).

5. Antibiotics susceptibility testing of isolated bacteria

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

Laboratory Assessment:

	Continuous Assessment/Internal Assessment			**End Term Examination**		
Components	Experimental Performance	Viva voce	Lab record	Major Experiments (Practical)	Viva voce	Total
Weightage (%)	30	20	20	20	10	100

ELECTIVES
(SEMESTER VIII)

XXXX XXXX	MICROBIAL QUALITY CONTROL AND ASSESSMENT	L-T-P-C: 3-2-0-5

Course Objectives

The purpose of this course is to familiarize the student with the concepts, principles theories and practicals of quality control and quality assurance in food and pharmaceutical industry.

Course Outcomes:

On completion of this course, the students will be able to

CO1. Understand and apply basic concepts of microbiological quality control, HACCP, GMP, aseptic operation and containment.

CO2. Design standard operating procedures according to various ISO standards and establish related lab infrastructure.

CO3. Conduct microbial quality control.

CO4. Document, assess and evaluate the QC/QA norms for various industries (food, pharma and cosmetic industries).

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	-	2	-	-	-	1	2	-	3	-	-
CO 2	3	3	2	-	-	-	-	2	-	3	-	2
CO 3	3	3	2	2	3	1	1	2	-	3	2	2
CO 4	3	3	2	2	3	1	1	2	2	3	2	2
Average	3	3	2	2	3	1	1	2	2	3	2	2

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: MICROBIOLOGICAL LABORATORY AND SAFE PRACTICES 20 Hrs

Good laboratory practices, Good microbiological practices. Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL-1, BSL-2, BSL-3, and BSL-4. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration. Understanding Quality control, quality assurance and QC trilogy.

UNIT II : DETERMINING MICROBES IN FOOD / PHARMACEUTICALS 20 Hrs

Culture and microscopic methods - Standard plate count, most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products. Molecular methods - Nucleic acid probes, PCR based detection, biosensors.

UNIT III PATHOGENIC MICROORGANISMS OF IMPORTANCE IN FOOD & WATER 15 Hrs

Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar. Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centers (COB, 10 min Resazurin assay).

UNIT IV HACCP FOR FOOD SAFETY AND MICROBIAL 20 Hrs

Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water.

SUGGESTED READING

1. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press.

2. Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.

3. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer.

4. Baird RM, Hodges NA and Denyer SP (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.

5. Peter F. Stanbury, Allan Whitaker and Stephen J. Hall Principles of Fermentation Technology, Third Edition, Pergamon.

Reference Books:

1. Pharmaceutical Quality Assurance, MA Potdar, Nirali Prakashan, Pune

2. Validation of Pharmaceutical process, F. J. Carleton and J. Agalloco, Marcel Dekker Inc.

3. Pharmaceutical Process Validation, Second Ed., Ira R. Ferry & Robert Nash., Marcel Dekker Inc.

4. Quality Planning & Analysis by J. M. Juran and F. M. Gryna, Tata Mcgraw Hill, India.

5. Improving Quality through Planned experimentation by Moen, Tata Mcgraw Hill.

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				**Mid Term Exam**	**End Term Exam**	**Total**
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

XXXX XXXX	INDUSTRIAL MICROBIOLOGY	L-T-P-C: 3-2-0-5

COURSE OBJECTIVES

This course will enable students to learn about various bioreactors, industrial production of microbial metabolites (enzymes, antibiotics etc.), processes of fermentation, understand the upscaling, and downscaling of the desired product from bioreactors and microbial strain improvement and applications of industrial microbiology.

COURSE OUTCOMES

Upon completion of the course, the student should be able to:

CO1: Describe types of bioreactors, fermentation processes and enzyme kinetics

CO2: Explain various aspects of industrial production processes, regulation and applications of enzymes

CO3. Apply knowledge of microbiology for production of various important microbial metabolites

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	2	3	2	1
CO 2	3	3	-	-	-	-	-	-	2	3	2	1
CO 3	3	3	3	2	2	2	2	2	2	3	2	1
Average	3	3	3	2	2	2	2	2	2	3	2	1

1 – Weakly Mapped (Low) 2 – Moderately Mapped (Medium) 3 – Strongly Mapped (High) "_" means there is no correlation

SYLLABUS

UNIT I: INTRODUCTION TO INDUSTRIAL MICROBIOLOGY 10 Hr

Fermentations, Bioreactors and types of bioreactors Primary and secondary metabolites; Scale up and scale down processes; Types of fermentation (Solid state, surface and submerged fermentation); Operational modes of fermentation (Batch, fed-batch and continuous), kinetics, synchronous growth, methods of growth estimation, stringent response, Thermal death of a bacterial cell.

UNIT II: BASIC ASPECTS OF FERMENTATION & MICROBIAL STRAIN IMPROVEMENT 10 Hrs

Media formulation; Sterilization; Inoculum development; Effect of temperature, pH and high nutrient concentration on fermentation; Basic fermenter design; Types of bioreactors; Downstream processing. Microbial Strain Improvement Strategies for isolation and cultivation of desired microorganisms; Screening for the desired product; Strategies for strain improvement.

UNIT III: **INDUSTRIAL PRODUCTION ASPECTS 20 HRS**

Production aspects (Microbial strains, substrate, flow diagrams, product optimization and applications): Production of antibiotics (penicillin, streptomycin, tetracycline), amino acid (glutamic acid and lysine), biopolymers (dextran) and steroids biotransformation. Production aspects (Microbial strains, substrate, flow diagrams, product optimization and applications): Production of enzymes (amylase, lipase, protease), alcohol and alcoholic beverages, vitamins (B12 and riboflavin)

UNIT IV ENZYME KINETICS 15 Hrs

Michaelis-Menten equation for uni-substrate reactions, Briggs and Haldane theory (rapid equilibrium and steady state theory), Significance of Km, Vmax, Kcat, Kcat/Km. Different plots for the determination of Km & Vmax and their physiological significances, measurement of enzyme activity. Reversible and irreversible inhibition and different enzyme inhibitors with examples.

UNIT V: REGULATION AND INDUSTRIAL APPLICATIONS OF ENZYMES 10 Hrs

General mechanisms of enzyme regulation, control of activities of single enzymes (end product inhibition), covalent modifications of enzymes. Feedback inhibition, allosteric enzymes, Sigmoidal kinetics. Enzyme immobilization, methods of enzyme immobilization, and applications of enzymes in different industries.

UNIT VI: **INDUSTRIAL APPLICATIONS 10 hrs**

Role of microorganisms in the natural system and artificial system. Scope and importance of Microbiology in Biotechnology. Microbial fuel cells; Prebiotics and Probiotics; Vaccines.

PRACTICALS 30 hrs

1. Methods of sterilization.
2. Preservation of industrially important microorganisms.
3. Isolation and screening of industrially important microorganisms.
4. Determination of thermal death point and thermal death time of microorganisms.
5. Production of secondary metabolites.
6. Ethanol production on a laboratory scale.
7. Screening of enzyme producers.
8. Isolation of Yeast and Lactic Acid Bacteria

Mode of Exam Evaluation Process

Theory Assessment:

	Continuous Assessment/Internal Assessment (50)				Mid Term Exam	End Term Exam	Total
Components	Surprise Test/Quiz	Assignments	Group Discussion/Presentations	Project Based Learning/ Tutorials based learning			
Weightage (%)	10	10	10	20	20	30	100

XXXX XXXX	MICROBIAL BIOPROSPECTING	L-T-P-C: 3-2-0-5

Course Objectives

This course enables students to appreciate environmental microbes as a rich resource for novel drugs and compounds with various medicinal and industrial applications and the current strategies employed to screen and harness such compounds from diverse environments, plants and animals.

Course Outcomes

After completion of the course, the student should be able to:

CO1. Understand the importance of environmental microbes as a rich source for discovery of new metabolites and drugs

CO2. Explain strategies to screen for such metabolites using culturable and non-culturable techniques

CO3. Describe the legal framework for harnessing microbial potentials from different ecosystems.

CO-PO Mapping

Program Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	3	3	-	-	3	-	-	3	3	3	2	3
CO 2	3	3	-	-	3	2	-	3	3	3	2	3
CO 3	3	3	1	-	3	2	-	3	3	3	2	3
Average	3	3	1	-	3	2	-	3	3	3	2	3

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SYLLABUS

Unit I: Introduction to Bioprospecting 15 Hrs

Concept of harnessing microbial resources from diverse ecosystems – Terrestrial, Aquatic and Marine, Plants and vertebrates and invertebrate animals - and their cellular components. Microbial metabolites, Factors controlling production of Primary and secondary microbial metabolites.

UNIT II: MICROBES AS A SOURCE OF BIOPROSPECTING 20 Hrs.

Bioprospecting/ Pharmaceutical Bioprospecting: for new drugs, common assays in Bioprospecting. Antioxidant assay – Free radical scavenging assay, Antigenotoxicity assay – MTT assay, Antiviral activities of plants – SRB assay, secondary metabolites (polyketides, antimicrobials, small molecules/peptides, metallophores etc.); Sampling and search strategies for novel targets under: microbial cultures, enzymes, therapeutics, antimicrobials, biotransformations and biofuels.

UNIT III: HIGH THROUGHPUT SCREENING STRATEGIES 20 Hrs

i. Conventional: Plating, Enrichment, Extinction culturing; Microscopic techniques, Micro manipulations (FISH), Microautoradiography.

ii. Novel: Function based screens (proteomics and metabolomics), Sequence based screens (genomics), substrate induced gene expression screens (SIGEX) catabolic gene expression screens. Metagenomics, Microarrays, Combinatory chemistry, combinatory biosynthesis and biochemistry assays. Data bases, Natural product libraries

UNIT IV: STRAIN DEPOSITION GUIDELINES 5 Hrs

: Deposition of microbes and biomolecules: Culture collection/ Repository, deposition of sequences of nucleic acids, proteins and structures of microbial molecules and products

UNIT V: Legal Framework 15 Hrs

Current practices in Bioprospecting for conservation of Biodiversity and Genetic resources. Bioprospecting Act: Introduction, Phases of Bioprospecting, Exemption to Act. Fields of Bioprospecting. Legal framework for collection and Conservation of Marine niches and microbes. Convention on Biological Diversity, Rio (1992/1994/2004). Biosafety Protocol, Quarantine regulations, Biopiracy, Cartegena& Montreal, FAO International Treaty (2001-2004), Bonn Declaration on Access and Benefit sharing (ABS), Nagoya Protocol

Reference Books

1. Prof Jeff Gore, system biology graduate class. MIT, USA. (2014)
2. Karoline Faust, et al. Lab of microbial system biology (European research council). (2023)
3. “Brock”: Madigan, Michael, and John Martinko. Brock Biology of Microorganisms. 14th ed. Upper Saddle River, NJ: Pearson Prentice Hall, 2014. ISBN: 9780131443297
4. Environmental microbial system biology. UC san diego university. (2016)
5. Sachin Malik, Dharmender Kumar. (2023) Perspectives of nanomaterials in microbial remediation of heavy metals and their environmental consequences: A review. Biotechnology and Genetic Engineering Reviews 0:0, pages 1-48.
6. Soyer OS, O'Malley MA. Evolutionary systems biology: what it is and why it matters. Bioessays. 2013 Aug;35(8):696-705. doi: 10.1002/bies.201300029. Epub 2013 May 16. PMID: 23681824.

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