ರಾಯಚೂರು ವಿಶ್ವವಿದ್ಯಾಲಯ RAICHUR UNIVERSITY

DEPARTMENT OF MICROBIOLOGY
M.Sc. DEGREE (SEMESTER) COURSE UNDER CBCS SCHEME
SCHEME OF TEACHING AND EXAMINATION
(Effective from the academic year 2023-24 and onwards)

PAPER	Teaching Hours/week	Examination Hours	Marks	IA	Credits
I SEMESTER:					
1.1 HC Fundamentals of Microbiology	4	3	75	25	4
1.2 HC Cell Biology and Biochemistry	4	3	75	25	4
1.3 HC Bacteriology	4	3	75	25	4
1.4 SC Virology and Mycology	4	3	75	25	4
1.5 Practical Based on paper 1.1	4	3	35	15	2
1.6 Practical Based on paper 1.2	4	3	35	15	2
1.7 Practical Based on paper 1.3	4	3	35	15	2
1.8 Practical Based on paper 1.4	4	3	35	15	2
II SEMESTER:					
2.1 HC Microbial Physiology and Metabolism	4	3	75	25	4
2.2 HC Microbial Genetics and Molecular Biology	4	3	75	25	4
2.3 SCT Environmental Microbiology (A)	4	3	75	25	4
2.3 SCT Biophysics, Biostatistics and Bioinformatics (B)	4	3	75	25	4
2.4 OE Microbes in Human Welfare	2	2	35	15	2
2.5 Practical Based on paper 2.1	4	3	35	15	2
2.6 Practical Based on paper 2.2	4	3	35	15	2
2.7 Practical Based on paper 2.3 (A)	4	3	35	15	2
2.8 Practical Based on paper 2.3 (B)	4	3	35	15	2
III SEMESTER:					
3.1 HC Recombinant DNA Technology	4	3	75	25	4
3.2 HC Immunology and Immunotechnology	4	3	75	25	4
3.3 SCT Food and Dairy Microbiology (A)	4	3	75	25	4
3.3 SCT Microbial Enzymology (B)	4	3	75	25	4
3.4 OE Microbes and Environment	2	2	35	15	2
3.5 Practical Based on paper 3.1	4	3	35	15	2
3.6 Practical Based on paper 3.2	4	3	35	15	2
3.7 Practical Based on paper 3.3 (A)	4	3	35	15	2
3.8 Practical Based on paper 3.3 (B)	4	3	35	15	2
IV SEMESTER:					
4.1 HC Fermentation Technology and Bioprocess Engineering	4	3	75	25	4
4.2 HC Medical Microbiology and Diagnostics	4	3	75	25	4
4.3 HC Industrial Internship/Project – Dissertation	4	3	75	25	4
4.4 SC Agricultural Microbiology	4	3	75	25	4
4.5 Practical Based on paper 4.1	4	3	35	35	2
4.6 Practical Based on paper 4.2	4	3	35	35	2
4.7 Project colloquium and Viva	4	3	35	35	2
4.8 Practical Based on paper 4.4	4	3	35	35	2
TOTAL MARKS (I TO IV SEMESTERS)					

HC – Hard core, SC – Soft core, OE – Open Elective

Department: **Microbiology** Course: **M.Sc Microbiology**

Paper Code	Paper and Title	Credits	No of Hours/ week Theory/ Practical	Duration of Exam (SEE)	Marks		Total
					Internal 25	SEE 75	
HCT 1.1	Fundamentals of Microbiology	4	4	3	25	75	100
HCT 1.2	Cell Biology and Biochemistry	4	4	3	25	75	100
HCT 1.3	Bacteriology	4	4	3	25	75	100
SCT 1.4	Virology and Mycology	4	4	3	25	75	100
	Practical Based on paper 1.1	2	4	3	15	35	50
	Practical Based on paper 1.2	2	4	3	15	35	50
	Practical Based on paper 1.3	2	4	3	15	35	50
	Practical Based on paper 1.4	2	4	3	15	35	50
MICHCT21	Microbial Physiology and Metabolism	4	4	3	25	75	100
MICHCT32	Microbial Genetics and Molecular Biology	4	4	3	25	75	100
MICSCT21	Environmental Microbiology (A)	4	4	3	25	75	100
	Biophysics, Biostatistics and Bioinformatics (B)	4	4	3	25	75	100
MICOET21	Microbes in Human Welfare	2	2	2	15	35	50
	Practical Based on paper 2.1	2	4	3	15	35	50
	Practical Based on paper 2.2	2	4	3	15	35	50
	Practical Based on paper 2.3	2	4	3	15	35	50
MICHCT31	Recombinant DNA Technology	4	4	3	25	75	100
MICHCT32	Immunology and Immuno-technology	4	4	3	25	75	100
MICSCT33	Food and Dairy Microbiology (A)	4	4	3	25	75	100
	Microbial Enzymology (B)	4	4	3	25	75	100
MICOET31	Microbes and Environment	2	2	2	15	35	50
	Practical Based on paper 3.1	2	4	3	15	35	50
	Practical Based on paper 3.2	2	4	3	15	35	50
	Practical Based on paper 3.3	2	4	3	15	35	50
MICHCT4.1	Fermentation Technology and Bioprocess Engineering	4	4	3	25	75	100
MICHCT4.2	Medical Microbiology and Diagnostics	4	4	3	25	75	100
	Internship/Project – Dissertation	4	4	3	25	75	100
MICSCT4.1	Agricultural Microbiology	4	4	3	25	75	100
	Practical Based on paper 4.1	2	4	3	15	35	50
	Practical Based on paper 4.2	2	4	3	15	35	50
	Project colloquium and Viva	2	4	3	15	35	50
	Practical Based on paper 4.4	2	4	3	15	35	50

INTERNAL ASSEMENT PARAMETERS

I-IA TEST	II-IA TEST	ATTENDANCE REPORT	TOTAL
11 Marks	11 Marks	3 Marks 75-85% -->1 Mark 85-95% -->2 Marks Above 95% -->3 Marks	25 Marks

Program Specific Outcome for M.Sc. Microbiology:

PSO-1 In depth understanding of basic and applied aspects of microbiology and develop inclination towards own professional goals over a wide range of career options expanding from R&D, Industrial or Govt. sector or as an Entrepreneur.
PSO-2 To independently be able to formulate research projects on microbiology and allied interdisciplinary or multidisciplinary fields through literature search, finding research gaps and framing objectives in order to strive for innovation.
PSO-3 Uphold the responsibility as a global citizen maintaining professional and ethical values and ability to upgrade knowledge independently and act upon means of improvement for lifelong learning.

Paper – 1.1 HC: Fundamentals of Microbiology

1.	Historical Development and Major Milestones: Origin and Evolution of Microorganisms; Theories of Spontaneous generation; Biogenesis and Germ theory of disease; Contributions of Antonie van Leeuwenhoek, Edward Jenner, Joseph Lister, Louis Pasteur and Robert Koch. Microorganisms: Major groups of microorganisms; General characteristics of major groups of microorganisms; Types of Prokaryotes and Eukaryotes; comparative account of Prokaryotes and Eukaryotes; General structure and functions of cell membrane, membrane bound organelles and cell organelles.	**12 h**
2.	Distribution of Microorganisms: Distribution of microorganisms in soil, air and water; Ubiquitous nature of microorganisms. Microscopy: Working principle, construction and operation of different types- simple, compound, Phase contrast, Fluorescent and Electron microscopes. Sterilization and Disinfection: Principles, Types and techniques. Physical, Chemical, Radiation and Mechanical methods.	**12 h**
3.	Microbiological Media: Components, Preparations and Types-Basal, Special, Differential, Indicator, Enriched and Transport media. Pure culture techniques: Isolation of different microorganisms from different environments. Sample collection, preservation and enrichment. Different methods of isolation-pour plate, spread plate, serial dilution.	**12 h**
4.	Maintenance and Preservation of microbial cultures: Slant culture, stab culture, soil culture, mineral oil overlaying and glycerol preservation. Lyophilzation. Type culture collection centres-Indian and global-ATCC, MTCC and NCIM etc. Types and nature of Stains: Simple, Differential and Gram's staining. Identification and nomenclature of microorganisms: Different schemes of identification and phylogenetic relationships.	**12 h**

5.	Working principle and operation of instruments used in microbiology laboratory- Autoclave, Laminar air flow system, Incubator, pH meter, Spectrophotometer, Electrophoretic Unit, Centrifuge, Chromatography, X-ray diffraction crystallography; NMR and Mass spectroscopy. Safety measures of microbiological laboratory, Levels of laboratory and good laboratory practices.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1: Understand the origin and evolution of microorganisms, theories of spontaneous generation, biogenesis, and germ theory of disease.

CO-2: Describe the contributions of Antonie van Leeuwenhoek, Edward Jenner, Joseph Lister, Louis Pasteur, and Robert Koch to microbiology.

CO-3: Compare and contrast prokaryotes and eukaryotes in terms of their general structure and functions of cell membrane, membrane-bound organelles, and cell organelles.

CO-4: Explain the distribution of microorganisms in soil, air, and water and their ubiquitous nature.

CO-5: Describe the working principle, construction, and operation of different types of microscopes such as simple, compound, phase contrast, fluorescent, and electron microscopes.

CO-6: Demonstrate pure culture techniques such as isolation of different microorganisms from different environments using sample collection, preservation, enrichment methods such as pour plate method, spread plate method or serial dilution method.

CO-7: Identify different types and nature of stains such as simple stain, differential stain or Gram's stain.

Prescribed Books:

1. Booth, C. (2019). Methods in microbiology (5th ed.). Elsevier.
2. Pingond, A. (2019). Biochemical methods (3rd ed.). Wiley VCH Publ.
3. Pommerville, J. C. (2021). Fundamentals of microbiology (2nd ed.). Bartlett Series.
4. Stanier, R. Y., Adelberg, E. A., & Ingraham, J. L. (1976). General microbiology (4th ed.). MacMillan Publ.
5. Lammert, J. M. (2019). Techniques in microbiology: A student handbook (2nd ed.). Pearson.
6. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H., & Stahl, D. A. (2022). Brock biology of microorganisms (16th ed.). Pearson.
7. Atlas, R. M., & Bartha, R. (1998). Microbial ecology: Fundamentals and applications (4th ed.). Benjamin Cummings.
8. Pelczar Jr., M.J., Chan, E.C.S., & Krieg, N.R.(1986). Microbiology: Concepts and applications (2nd ed.). McGraw Hill Book Co.
9. Davis, B.D., Dulbecco, R., Eisen, H.N., & Ginsberg, H.S.(1990). Microbiology Vol I &II(4th ed.). Himalaya Publ.
10. Cappuccino, J.G., & Sherman, N.(2019). Microbiology: A Laboratory Manual(12th ed.). Pearson Education Inc.

Reference Books:

1. Tortora, G. J., Funke, B. R., & Case, C. L. (2016). Microbiology: An Introduction. Pearson.
2. Engelkirk, P., & Burton, G. (2019). Microbiology for the Healthcare Professional. Jones & Bartlett Learning.
3. Prescott, L. M., Harley, J. P., & Klein, D. A. (2017). Microbiology. McGraw-Hill Education.

Digital References/ Study material:

https://archive.nptel.ac.in/course.html
https://archive.nptel.ac.in/courses/102/103/102103015/
https://onlinecourses.swayam2.ac.in/cec19_bt11/preview

Practical Based on paper 1.1 Fundamentals of Microbiology

1. Safety Measures in Microbiology laboratory
2. Microscopy – Compound, Dark field, Phase contrast, Fluorescent, Electron, (SEM and TEM).
3. Sterilization technique – physical methods and chemical methods.
4. Preparation of media and stains for microbial work.

5. Preparation of culture media – broth, semisolid, and solid media.
6. Study of Instruments – Autoclave, Hot air Oven, Incubator, Laminar airflow, Centrifuge, pH meter, Colorimeter, Spectrophotometer.
7. Isolation of different groups of microorganisms by various methods
   a. Isolation of pure culture microorganism and cultivation
   b. Isolation and enumeration of microorganisms by serial; dilution methods.
8. Calibration of Microscope and Micrometry
9. Staining of different groups of microorganisms-
   a. Simple and Negative Staining
   b. Differential staining – Gram staining. Acid fast staining,
   c. Structural Staining - flagellar staining, Endospore staining, capsule staining and cell wall staining
10. Camera Lucida
11. Study of motility of cells by hanging drop technique
12. Effect Temperature and pH on growth curve of bacteria (*E.coli*)

1.2 HC CELL BIOLOGY AND BIOCHEMISTRY	
Course Credits: 4	**Total No. of Hours: 60** **No. of Teaching Hours per Week: 4 Hrs**

Unit 1: a) Evolution of cell: **10 Hrs**

Cell as a unit of living organism, Cell organelles, structure of prokaryotic cell,\Cell cycle in bacteria, fungi and eukaryotes, endosymbiotic theory. Plasma membrane: structure and organization of plasma membrane, models if plasma membrane, membrane structure and transport mechanisms; membrane channels and pumps. cell signalling and signal transduction pathways; Molecular motors.

b) Bio-molecules **10 Hrs**

Chemical and physical foundations of biomolecules, water, water as solvent, theories of acids, bases and buffers, Stanley Miller experiment

Amino acids: Classification, chemical reactions and physical properties; biosynthesis and catabolism; principles of thermodynamics; Bioenergetics and energy metabolism in cells.

Unit 2: Nucleotides, lipids and carbohydrates **10 Hrs**

Chemistry of carbohydrates: Definition, Classification, Structure and general properties, inter conversion of monosaccharide's. Importance and properties of glucose; Disaccharides fructose, sucrose, lactose, maltose; Polysaccharides starch, celluolose, dextrins, hemicellulose, gellans, pulluans, lignins, agar and bacterial cell wall polysaccharides.

Nucleotides; biosynthesis and catabolism Classification, structure and function; synthesis and oxidation of fatty acids Vitamins; structure and functions.

Unit 3: a) Protein **08 Hrs**

Proteins Qualitative detection methods of protein structure of protein chemical reaction, classification.

b) Lipids: Properties classification, chemical reaction detection methods

Unit –4: Enzymes: **10 Hrs**

Classification, nomenclature, general properties principles of catalytic power and specificity of enzymes, kinetics, coenzymes, activator inhibitors, isoenzymes, multi-enzyme complex, allosteric enzymes, mechanism of enzyme action.

Unit -5: Biochemical techniques: **12 Hrs**

a. Centrifugation techniques: Basic principles of sedimentation. Methods and applications of density-gradient centrifugation, preparative centrifugation, ultracentrifugation.

b. Chromatographic techniques: General principles and techniques. Methods and applications of paper chromatography, thin-layer chromatography, exclusion

chromatography affinity chromatography, ion-exchange chromatography, HPLC, Gas- liquid chromatography. MALDI-TOF, LC-MS/MS.

c. Electrophoretic techniques: General principles and applications of electrophoresis and isoelectric focusing.

d. Spectroscopic techniques: General and laws of radiation, colorimetry, ultraviolet-visible spectrophotometry.

e. Radio isotopic techniques: General principles, nature of radio activity, detection and measurement of radioactivity, applications of radioisotopes in biological investigation.

Course Outcome for M.Sc. Microbiology:

After successful completion of this course students are expected to be able to:

CO-1 Overview of major biomolecules –carbohydrates, lipids, proteins, amino acids, nucleic acids, classification, structure, function of the above mentioned biomolecules

CO-2 Describe the concepts of electrolytes and electrolytic dissociation, pH and its biological significance, buffers, Henderson-Hasselbalch equation, biological buffer systems and their importance.

CO-3 Understanding the laws of thermodynamics, concepts of entropy, enthalpy and free energy changes and their application to biological systems and various biochemical studies and reactions.

CO-4 Conceptual knowledge of aerobic and anaerobic respiration and various intermediary mechanisms involved, oxidative phosphorylation properties, structure, function of enzymes, Application of enzymes in large scale industrial processes.

References:

1. Stryer, L. (2022). Biochemistry (9th ed.). W. H. Freeman & Co.
2. Nelson, D. L., & Cox, M. M. (2022). Lehninger Principles of Biochemistry (8th ed.). W. H. Freeman & Co.
3. Moat, A. G., Foster, J. W., & Spector, M. P. (2022). Microbial Physiology (5th ed.). Wiley-Blackwell.
4. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2021). Molecular Biology of the Cell (7th ed.). Garland Science.
5. Karp, G. (2019). Cell and Molecular Biology: Concepts and Experiments (8th ed.). Wiley.
6. De Robertis, E. M., & De Robertis, E. M. F. (2019). Cell and Molecular Biology (11th ed.). Oxford University Press.
7. Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., Baltimore, D., & Darnell Jr., J. E. (2016). Molecular Cell Biology (8th ed.). W.H.Freeman.

Practical Based on paper 1.2 Cell Biology and Biochemistry

1. Cell count using haemocytometer
2. Preparations of temporary mount and study the different stages of Mitosis (Onion root tip).
3. Study of meiosis in onion flower buds.
4. Depicting nature of cellular membranes: Osmosis, Hypertonicity, Hypotonicity, Isotonicity
5. Instrumentation: Spectrophotometer, Electrophoresis, Centrifuges, Micropipettes, Chromatographic techniques: Column, HPLC, GLC, GC-MS and NMR.
6. Demonstration of Beer-Lambert's Law.
7. Determination of pH using Indicators.
8. Determination of pKa value of acetate buffer.
9. Titration of strong acid with strong base.
10. Titration of weak acid and weak base.
11. Titration of mixture of strong and weak acids.
12. Titration curves of amino acids.
13. Separation of amino acids from thin layer chromatography

Paper-1.3 HC: Bacteriology

1.	Introduction: Origin, Discovery and Evolution of Bacteria. Morphology and ultrastructure of bacteria: Size, shape and arrangement - structure, chemical composition of cell wall of archaebacteria, Gram-negative bacteria, Gram-positive bacteria and acid-fast bacteria; Fine structure, composition and function of cell membrane, capsule, flagella, pili, gas vesicles, ribosomes, mesosomes, reserve food materials, magnetosomes and phycobilisomes, bacterial nucleic acids and genome organization.	**12 h**
2.	Principles, mechanism, method and types of differential staining: Acid fast staining, Vital staining, negative staining, capsule, cell wall, endospore, inclusion bodies and flagella staining. Bacterial systematic: classification systems, major characteristics used, nucleic acid, serology, chemical composition and phylogenetic mode of classification. Use of catabolic and anabolic keys. Numerical Taxonomy, cluster analysis and construction of taxonomy groups based on dendrograms and similarity matrix. International codes, rules, recommendations, construction of names in bacterial nomenclature and its role in taxonomy. Diagnostic procedures, keys and schemes. Salient features of Bergy's Manual of Systematic Bacteriology; Characteristics of major groups of bacteria.	**12 h**
3	Reproduction in bacteria: Binary cell division, septum formation, planes of cell division, other forms of bacterial reproduction control of cell division. Bacterial endospore: Spore forming bacteria-formation, properties and germination of endospores, induction of endospore formation. Archaebacteria: General characteristics and classification; Extremophilic nature; Type studies - adaptations, role of archaebacteria in the evolution of microbial world and their economic importance.	**12 h**
4	General characteristics, classification, diversity, distribution and economic importance of Actinobacteria and Cyanobacteria. Bioluminescent bacteria: Characteristics and examples, mechanism of bioluminescence, applications. Mycoplasma: General characteristics and examples, growth and multiplication, their significance.	**12 h**
5	Rickettsia and Chlamydia: General characteristics and examples, life cycle, growth and multiplication, their significance. Diversity of bacteria: Concept, Significance and conservation of biodiversity; Methods of assessing bacterial diversity, Culturable and non-culturable bacteria	**12 h**

After successful completion of this course students are expected to be able to:

CO-1:Understand the basic concepts of microbial diversity and how the microbe concept emerged.

CO-2:Understand the structural similarities and differences among various physiological groups of bacteria/archaea.

CO-3:Understand the methods of assessing bacterial diversity.

Prescribed Books:

1. Frost, W. D., &McCampbell, E. F. (2010). Textbook of general bacteriology (2nd ed.). Bibliobazaar.
2. Woodford, N., & Johnson, A. P. (2013). Molecular bacteriology (1st ed.). Springer.
3. Struthers, J. K., &Westram, R. P. (2018). Clinical bacteriology (2nd ed.). Manson Publishing Ltd.

4. Holt, J. G., Krieg, N. R., Sneath, P. H. A., Staley, J. T., & Williams, S. T. (Eds.). (1994). Bergey's manual of determinative bacteriology (9th ed.). Lippincott Williams & Wilkins.
5. Salle, A. J. (1974). Fundamental principles of bacteriology (1st ed.). Tata McGraw Hill Education.
6. Gillespie, S. H., &Hawkey, P. M. (2018). Principles and practice of clinical bacteriology (2nd ed.). John Wiley & Sons.
7. Meynell, G. G., & Meynell, E. (2000). Theory and practice of experimental bacteriology (2nd ed.). Cambridge University Press.
8. Hawkey, P., & Lewis, D. (1990). Medical bacteriology (1st ed.). Oxford University Press.
9. Krieg, N.R., Staley, J.T., Brown, D.R., Hedlund, B.P., Paster, B.J., Ward, N.L., Ludwig,W., &Whitman,W.B.(Eds.).(2010). Bergey's manual of systematic bacteriology: Volume 3: The Firmicutes (2nd ed.). Springer.
10. Madigan, M.T., Martinko,J.M., Bender,K.S., Buckley,D.H., &Stahl,D.A.(2015). Brock biology of microorganisms (14th ed.). Pearson Education Inc.

Reference Books:

1. Mahon, C. R., Lehman, D. C., &Manuselis, G. (2014). *Textbook of diagnostic microbiology* (5th ed.). Saunders
2. Murray, P. R., Rosenthal, K. S., &Pfaller, M. A. (2015). *Medical microbiology* (8th ed.). Elsevier/Mosby
3. Brooks, G. F., Carroll, K. C., Butel, J. S., & Morse, S. A. (2013). *Jawetz, Melnick &Adelberg's medical microbiology* (26th ed.). McGraw-Hill Medical

Practical Based on paper 1.3 Bacteriology

1. Isolation of microorganism: Serial dilution, pure culture techniques
2. Isolation of antibiotic producing microorganisms from soil and determination of the antimicrobial spectrum of the isolates.
3. Isolation of enzyme producing microorganisms from soil
4. Culturing and cultural characteristics of microorganisms:
5. Autotrophic - Benecks broth, Chu's medium
6. Heterotrophic- Nutrient agar, glucose peptone media
7. Selective - MRS, actinomycetes agar
8. Enriched - Dorsetts egg growth medium, chocolate agar
9. Differential - MacConkey, Blood agar, EMB, DCA
10. Staining techniques: Simple, Differential: acid-fast, endospore, capsule, cell wall, cytoplasmic inclusion vital stains: flagella, spore and nuclear staining.
11. Biochemical tests for identification of Bacteria: Catalase, oxidase, IMViC, motility, gelatinace test, urease, levan formed from glucose, H_2S in TSIA and lead acetate paper, coagulase, optochin sensitivity, lecithinase, nitrate reduction, acid and gas from Carbohydrates (glucose, arabinose, inosital, lactose, maltose, mannitol, rhamnose, salicin, trehalose, sucrose, xylose, fructose), ONPG acid, hippurate hydrolysis, chitin, starch, casein, Tween 80 hydrolysis, pectin, arginine hydrolysis, lysine decarboxylase, ornithine, esculin hydrolysis. Identification of bacteria by API system.
12. Bacterial growth measurement (cell count, turbidometry, plate count) 12. Isolation of bacteriophages from sewage

Paper-1.4 SC: Virology and Mycology

1.	Introduction to Virology: History, origin, development and evolution of viruses. General structure of viruses: configuration and symmetry- helical and icosahedra; Physical and chemical components - capsomere, capsid, matrix and envelop; Viral genome, nucleoprotein organization, multiplication of viral genomes, one step growth. Isolation, purification and cultivation of viruses, Detection of viruses- physical, biological, immunological and molecular methods. Taxonomy of viruses: Salient features of viral classification- Baltimore classification of viruses, ICTV classification of viruses,	**12 h**

2.	Phages: Bacteriophages, cyanophages, mycophages and phycophages-General characteristics, isolation, identification and cultivation, replication of phages, classification significance and applications. Plant viruses: General characteristics; Isolation, identification, cultivation classification; Translocation and distribution of viruses in plants; different modes of transmission of plant viruses -Structure and life cycle of some important plant viruses; Type studies and significance of plant viruses.	**12 h**
3.	Animal viruses: General characteristics; Isolation, Identification and cultivation and Classification; Dissemination of animal viruses - direct and indirect contacts, through vectors; zoonotic infections, Structure and life cycle of some of the important animal viruses; Type studies and significance of animal viruses. Oncogenic viruses: Definition, general characters, types, transmission, propagation, and mechanism of cell transmission. Sub viral particles; characteristics and their significances: satellite virus, satellite RNA Prions, and viriods.	**12 h**
4.	Introduction to Mycology: General characteristics of fungi and classification of fungi with distinguishing characteristics up to class level, distribution of fungi. Fungal structure: Fine structure of hypha, mycelium and yeast; structure and composition of fungal walls, plasma membrane, septa, cytoskeleton**.** Modes of nutrition, fungal adaptations for nutrient capture (apical growth, enzyme secretion, defense of territory).	**12 h**
5.	Reproduction in fungi: Vegetative reproduction- fragmentation, fission, budding, spawns, sclerotia, rhizomorphs; Asexual reproduction- endospores, conidia, oidia, chlamydospores, pycniospores, ascospores, basidiospores, uredospores and telutospores; Sexual reproduction - planogametic copulation, gametangialcontact, gametangial copulation, spermatogamy, somatogamy; reduction of sex in fungi. Diversity, taxomony and Economic importance of fungi: Life cycle of economically important yeasts, molds, Mycorrhiza and Lichens.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1: Understand the structure, characteristics, and classification of viruses and fungi.

CO-2: Describe the characteristics and diseases caused by pathogenic viruses and fungi.

CO-3: Understand basic laboratory techniques in mycology, isolate fungus from clinical samples for disease diagnosis, understand different methods of virus cultivation, and understand collection, transportation, and preservation methods of clinical specimens.

Reference Books:

1. Benson's Microbiological Application: Lab Manual in General Microbiology by A.E. Brown (15th ed.). (2022). McGraw Hill
2. Jawetz's Medical Microbiology by GF Brooks (28th ed.). (2020). McGraw Hill
3. Fraenkel-Contrat H. edited; Virology (2nd ed.). (2019). Academic Press
4. AnejaK.R., Experiments in Microbiology (6th ed.). (2017). New Age International
5. Cappuccino Sherman's Microbiology- A Laboratory Manual (12th ed.). (2016). Pearson Education India
6. Topley and Wilson's Microbiology and Microbial infections, Vol-2: Virology (10th ed.). (2010). Wiley-Blackwell
7. Dubey RC & Maheshwari DK, Practical Microbiology (3rd ed.). (2011). S Chand & Co Ltd
8. Mathuew's Plant Virology by Roger Hull (5th ed.). (2020). Academic Press, U.K
9. George Agrios; Plant pathology (6th ed.). (2005). Elsevier Academic Press, New York.
10. Sullia SB &Shantharam S, General Microbiology (3rd Ed.). (2019). Oxford & IBH Publ., New Delhi.

Digital References/ Study material:

https://archive.nptel.ac.in/course.html
https://archive.nptel.ac.in/courses/102/103/102103015/
https://onlinecourses.swayam2.ac.in/cec19_bt11/preview

Practical Based on paper 1.4 Virology and Mycology

1. Isolation of plant viruses from sap.
2. Isolation of lipolytic microbes from soil-plate method and estimation of total lipid
3. Isolation of slime molds, fungi from water, soil, air, cereals and cereal based products.
4. Staining of fungi (Lactophenol cotton blue).
5. Isolation of fungi from plant material: Epiphytic fungi, washing method, implant method, impression method, maceration method; endophytic fungi.
6. Growth measurement of fungi- linear and biomass.
7. Effect of environmental (pH, temperature) and nutritional factors (carbon, nitrogen sources) on growth of fungi.
8. Screening for antibiotic producing microbes (antibacterial, antifungal)
9. Study of fungal metabolites
10. Measurement of concentration of fungal conidia by Haemocytometer.
11. Measurement of fungal cells by Micrometer.
12. Study of the following representative genera: *Aspergillus, Penicillium, Fusarium, Neurospora, Saccharomyces, Erysiphae, Polyporus, Agaricus, Puccinia, Ustilago, Alternaria, Drechslera, Saprolegnia, Rhizopus, Trichoderma* and symbiotic fungi-Lichens.

Paper-2.1 HC: Microbial Physiology and Metabolism

1.	Microbial Nutrition: Classification of organisms based on Carbon source, energy source and electron source, Macro and Micronutrients. Microbial growth: Phases of growth, factors influencing growth, Measurement of growth, Continuous and Synchronous growth.	**12 h**
2.	Microbial Photosynthesis: Light Energy, Photolysis of Water, Photosynthetic Pigments, Cyclic and Non-Cyclic Photophosphorylation, Calvin's Cycle. Biological Oxidation: Electron Transport System, Oxidative Phosphorylation, Mechanism and Inhibitors of oxidative phosphorylation. Energetics of Oxidative Phosphorylation.	**12 h**
3.	Fermentation Reactions: Types of fermentation reactions, Homo and Hetero-fermentation pathways; Alcohol and Lactic acid fermentation pathways. Bioenergetics: Laws of thermodynamics, Free energy, Enthalpy, Entropy, High energy compounds, Oxidations and Reductions, Redox potential. Carbohydrate metabolism: Glycolysis-significance, energetics and regulation. Glycogenesis, glycogenolysis, gluconeogenesis-Significance, regulations; TCA cycle-significance, energetics and regulations. Glyoxylate cycle. Amphibolic nature of TCA cycle. HMP shunt.	**12 h**
4.	Lipid Metabolism: Fatty acid oxidation (β-oxidation), energetics of palmitic acid oxidation. Ketone bodies, ketogenesis, utilization of ketone bodies, overproduction of ketone bodies (Ketonemia, ketonuria, ketosis), extra mitochondrial biosynthesis of long fatty acids (palmitate), significance and regulation. Synthesis of triacylglycerols, metabolism of phospholipids and glycolipids. Biosynthesis and degradation of cholesterol.	**12 h**

5.	Metabolism of amino acids: Transamination, deamination, decarboxylation; Urea cycle - regulation. Metabolism of ammonia; Synthesis and degradation of Glycine, phenylanine and Tyrosine, Synthesis and degradation of Sulfur containing amino acids. Nucleotide metabolism: Synthesis of IMP, AMP and GMP, Salvage pathway for purines, degradation of purine nucleotides. Biosynthesis and degradation of pyrimidine nucleotides.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1: Gain a fundamental understanding of cellular composition, membrane transport, energy metabolism, and the ways microorganisms grow, proliferate, and die in a given environment.

CO-2: Understand the regulation of biochemical pathways and possible process modifications for improved control over microorganisms for microbial product synthesis.

CO-3: Understand the microbial physiology and know the various Physical and Chemical growth requirements of bacteria and get equipped with various methods of bacterial growth measurement

Reference Books:

1. Lehninger, A. L. (2017). *Lehninger principles of biochemistry* (7th ed.). W.H. Freeman and Company.
2. Harper, H. A., & Rodwell, V. W. (2018). *Harper's illustrated biochemistry* (31st ed.). McGraw-Hill Education.
3. Powar, R., &Dhaginawala, A. (2019). *Biochemistry* (4th ed.). Himalaya Publishing House.
4. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular biology of the cell* (6th ed.). Garland Science.
5. Moat, A. G., Foster, J. W., & Spector, M. P. (2016). *Microbial physiology* (5th ed.). Wiley-Blackwell.
6. Doelle, S. W., & van der Werf, M. J. (2013). *Microbial growth on C1 compounds* (1st ed.). Springer Science & Business Media.
7. Dewey, I. W., & Sutherland, J. W. (2018). *Microbial physiology* (2nd ed.). Academic Press.
8. Rose, A. H., & Tempest, D. W. (1970). *Advances in microbial physiology* (Vol. 4). Academic Press.
9. Voet, D., Voet, J.G., & Pratt C.W.(2022). *Fundamentals of Biochemistry: Life at the Molecular Level* (6th ed.). Wiley.
10. Caldwell DR.(1996). Microbial Physiology and Metabolism. Brown Publishers.
11. Oren A., PapkeR.T.(2010) Molecular Physiology of Microorganisms.Caister Academic Press.
12. Berg JM,Tymoczko JL,StryerL.(2021) Biochemistry(9th ed.).W.H.Freeman and Company.

Digital References/ Study material:

https://archive.nptel.ac.in/course.html
https://archive.nptel.ac.in/courses/102/103/102103015/
https://onlinecourses.swayam2.ac.in/cec19_bt11/preview

Practical Based on paper 2.1 Microbial Physiology and Metabolism

1. Determination of growth curve and generation time.
2. Determination of optimum pH, temperature for growth of bacteria and fungi.
3. Lipid saponification value of fats, Iodine number of fatty acids.
4. Qualitative analysis of lipids.
5. Estimation of microbial enzymes – amylase, protease, invertase, cellulase, lipase, catalase and phosphatase.
6. Determination of K_m and V_{max}. and K_I
7. Extraction and separation of aflatoxin by paper chromatography.
8. Effect of pH, temperature, enzyme concentration, substrate concentration and inhibitors on enzyme activity.
9. Qualitative and quantitative estimation of carbohydrates.
10. Effect of different substrate (Primary, secondary &tertiary) on microbial growth
11. De-amination of Amino acids.
12. De-carboxylation of Amino acids.

Paper-2.2 HC: Microbial Genetics and Molecular Biology

1.	Historical Preview of Genetics: Development of microbial genetics, contributions of various scientists, time line of the development of microbial genetics Chemical basis of heredity; early concepts of genes; discovery of the chemical basis of heredity - experimental evidences, Mendelian principles and classical genetics, Genetic concepts, use of microorganisms in genetic studies Genomic structure and organization: Organization of genetic material - Genome organization in viruses, bacteria and eukaryotes. Interrupted genes, gene clusters. Structure of nucleosome, chromatin and chromosome.	**12 h**
2.	Genetic recombination: In bacteria; transformation, conjugation, competence, lysogeny, generalized and restricted transduction, sexduction, fine structure mapping, recombination in viruses Transposable elements: Replicative transposition, Non-replicative transposition, Excision and transposase-mediated rearrangements, Insertion sequences, transposons, and integrons. Regulation of transposition, Use of transposons. Chromosomal rearrangements, Transposons and evolution.	**12 h**
3.	Mutations: Types of mutations, null, leaky, and conditional mutations, mutations as random or adaptive events; Mutagenic agents – physical, chemical and biological; molecular basis of mutations; Mutants – isolation, selections, screening and enrichments, Uses of mutants. Reversion and suppression - Reversion assays –Ames Test. Structure of nucleic acids: Structure of DNA and its elucidation, structural polymorphism in DNA, extra-chromosomal DNA. Structure of RNA Systems that safeguard DNA: DNA repair mechanisms – photo reactivation, mismatch repair, recombination repair, SOS repair. Replication of DNA, evidence of semi-conservative replication. Mechanism and enzymology of DNA replication. Regulation of DNA replication. Replication of RNA.	**12 h**
4.	Transcription: Biosynthesis of RNA in prokaryotes and eukaryotes, DNA dependent RNA polymerase, initiation, elongation and termination of transcription. Post transcriptional processing - removal of intron transcripts, addition of 5' cap and 3 poly A tail, processing of mRNA, rRNA and tRNA. Reverse transcription. Genetic code and translation: Elucidation and salient features of genetic code, wobble concept, Involvement of ribosome in translation, ribosome structure, initiation, elongation and termination of polypeptide chain synthesis in prokaryotes and eukaryotes, extra ribosomal factors, post translation modifications of proteins, ribosome cycle.	**12 h**
5.	Regulation of gene expression: Enzyme induction and repression, constitutive expression and housekeeping genes, Operon concept, negative and positive regulation, catabolite repression, regulation of lac Operon, trp Operon, arabinose Operon, divergent Operon, attenuator regulation, translational regulation, feedback inhibition. Gene silencing: Transcriptional – genomic imprinting, paramutation, transposon silencing, histone modifications, position effect; Post transcriptional – RNA interference, RNA silencing.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1: Understand the genetic, epigenetic, and genomic mechanisms governing microbial physiology in a changing environment.

CO-2: Explain the principles and concepts of prokaryotic and eukaryotic genetics, viral genetics, and their application in research.

CO-3: Explain mutagenesis, mutation, and mutants and their significance in microbial evolution

Reference Books

1. Hays, W. (2023). The genetics of bacteria and their viruses. CBS Publ. New Delhi.

2. Jenkins, J.B. (2022). Genetics. Houghton Mifflin Co., Boston.
3. Strickberger, M.W. (2023). Genetics. MacMillan Publ. Co. Inc. New York.
4. Stent, G.S., & Calendar, R. (2022). Molecular Genetics. Freeman & Co., San Francisco.
5. Lewin, B. (2023). Genes VIII. John Wiley & Sons, New York.
6. Watson, J.D., et al. (2022). Molecular biology of the Gene. Pearson Education India.
7. Hartwell, L.H., et al. (2023). Genetics – from Genes to Genomes. McGraw Hill Publ.
8. Miller, G., et al. (2022). An introduction to Genetic Analyses. Freeman & Co., NY.
9. Maloy, S.R., Cronan, J.E., &Freifelder, D.M. (2023). Microbial Genetics. Jones & Bartlett Series.
10. Streps, U.N., &Yasbin, R.E. (2022). Modern Microbial Genetics. Wiley Blackwell Publ.

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Practical Based on paper 2.2 Microbial Genetics and Molecular Biology

1. Isolation of Genomic DNA from *E. coli*.
2. Agarose gel electrophoresis for separation of Nucleic acids
3. Estimation of DNA, RNA and plasmids, and determination of purity and concentration of isolated DNA using spectrophotometer.
4. Separation of proteins by SDSPAGE, salt fractionation of Yeast protein and quantification, estimation of protein by Lowry's method, RFLP and RAPD analysis, and restriction digestion of DNA.
5. Isolation of plasmids from bacteria by agarose gel electrophoresis, digestion of the gene of interest with suitable restriction enzymes, and ligation of the digested gene in a vector.
6. Preparation of competent *E. coli* cells for Bacterial transformation, transformation of the vector into the host cell and selection of the desired clones, induction of gene expression and purification of the induced protein from the host, and amplification, purification and separation of PCR product.
7. Induction and study of physical and chemical mutagens in bacteria/fungi.
8. Study of mutagenic effect and Induction of mutation in yeast/bacteria by chemical/radiation method.
9. Plasmid curing in bacteria
10. Transformation and selection of transformants
11. Conjugation and gene mapping in *E.coli*
12. Isolation of bacteriophages and phage titration, and study of replica plating technique.

Paper-2.3 SCT (A): Environmental Microbiology

1.	Introduction: Origin, Concept and Development of Environmental Microbiology. Microbial Community: Ecosystem, habitat and niche. Concept and dynamics of microbial population and community. Structure and functions of microbial communities. Ecological succession. Microbial diversity: Diversity of microorganisms in different environments. Conventional and molecular methods of studying microbial diversity. Microbes in extreme environments. Extremophiles - Psychrophilic, thermophilic, acidophilic, alkalophilic, halophilic and barophilic. Mechanism of adaptation in extremophilic microorganism.	**12 h**

2.	Water Pollution: Sources, Characteristics of water pollutants, health hazards due to water pollution. Standard water quality criteria, Water quality testing (MPN technique). Eutrophication - causes, consequences and prevention. Waste water treatment: Primary-physical processes; Secondary-biological treatment by fixed biofilm systems (trickling filters, RBC, fluidized bed reactors), suspended systems (activated sludge process, oxidation lagoons, anaerobic digesters, septic tank); Tertiary- Filtration (sand beds & membrane filters) chlorination, ozonization, radiation and reverse osmosis.	**12 h**
3.	Air pollution and Radiation hazards: Sources and characteristics of air pollutants; Health hazards due to air pollution; Green house gases and green house effect. Ozone hole and acid rain. Radiation hazards and safety measures – sources, effect of radiations and safety measures. Soil pollution: Sources and characteristics of soil pollutants. Effects of soil pollution on human health and crop productivity.	**12 h**
4.	Solid waste management: Handling and treatment of solid wastes. Sludge handling and disposal- sludge processing, screening, dewatering, thickening, conditioning; stabilization-aerobic and anaerobic digestion (biomethanogenesis). Handling of biohazard and hospital wastes. Biodegradation of xenobiotics: Microbial degradation of pesticides, polycyclic aromatic hydrocarbons, natural and synthetic polymers (cellulose, pectin, lignin, detergents, plastics).	**12 h**
5.	Microbiological indicators: Concept and significance. Microbiological indicators of water and air pollution. Microbial remediation: Concept and scope of bioremediation. Methods and types of bioremediation of contaminated soil and water using microorganisms. Microbial leaching: Origin and concept. Mechanism and role of microorganisms in recovery of important minerals - Iron, Copper and Gold.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1: Understand the general biology of microorganisms and the general concept of microbial ecology.

CO-2: Understand the role of microorganisms as agents of environmental change.

CO-3: Understand microbial processes aimed at solving environmental problems

Reference Books:

1. Brock, T.D. (1987). *Principles of microbial ecology* (2nd ed.). Prentice Hall Publ. Co.
2. Alexander, M. (2007). *Microbial Ecology* (2nd ed.). John Willey & Sons.
3. Atlas, R.M., & Bartha, R. (2018). *Microbial ecology: Fundamentals and applications* (5th ed.). Benjamin/Cummings.
4. Bitton, G. (2011). *Wastewater Microbiology* (4th ed.). John Willey & Sons.
5. Mitchell, R. (2010). *Environmental Microbiology* (2nd ed.). John Willey & Sons.
6. Hurst, C.J., Crawford, R.L., Knudsen, G.R., McInerney, M.J., Stetzenbach, L.D., & Walter, M.V. (Eds.). (2019). *Manual of Environmental Microbiology* (5th ed.). ASM Press.
7. Fletcher, M., & Gray, T.R.G. (Eds.). (1988). *Ecology of microbial communities*. Cambridge University Press.
8. Rose, R.D. (1991). *Air Pollution & Industry*. Reinhold Co.
9. Tchobanoglous, G., Burton, F.L., &Stensel, H.D. (2003). *Wastewater Engineering: Treatment and Reuse* (4th ed.). McGraw Hill Int. Publ.
10. APHA, AWWA, WEF. (1998). *Standard Methods for the Examination of Water and Wastewater* (20th ed.). American Public Health Association

Digital References/ Study material:

Practical Based on paper 2.3 Environmental Microbiology (A)

1. Detection of coli forms for determination of purity of potable water samples MPN method
2. Isolation of Bacteriophages from sewage water samples
3. Study of micro flora of industrial waste and effluents
4. Determination of DO, DOC, CO_2, BOD, COD and TDS of water samples (RO water, Tap water, Pond water and Sewage waste water)
5. Isolation of Xenobiotic degrading bacteria by selective enrichment technique
6. Study on Biogenic methane production
7. Estimation of phosphate, sulphates, nitrates and major cations (Na, K, Mg, and Ca) in water samples
8. Effect of industrial effluents/ heavy metals on seed germination and seedling growth
9. Sampling and quantification of airborne endotoxins by Limulus Amoebocyte Assay.
10. Field excursion to an industrial area to assess environmental impact
11. Isolation and determination of Iron and Manganese reducing bacteria
12. Selective enrichment of auxotrophic and antibiotic (Tet^R, Ref^R) mutants (Isolation of antibiotic resistant microbes from Hospital waste)

SCT2.3 (B) BIOPHYSICS, BIOSTATISTICS AND BIOINFORMATICS

Course Credits: 4	Total No. of Hours: 60 No. of Teaching Hours per Week: 4 Hrs

Unit 1- Introduction to Biophysics **10 Hrs**

Chemical buildings blocks; structure of atoms, bonds within molecules – ionic, covalent, hydrogen, electrostatic, disulphide and peptide bonds, vander Waals forces, bond length, bond energies, bond angles; isomerism - structural, geometrical, optical isomerism; secondary bonding; weak interactions.

Unit 2Proteins: **10 Hrs**

Molecular organization of proteins – primary, secondary, tertiary and quaternary structures; principles of ionization; predicting properties from amino acid composition; unusual amino acids, stabilizing forces, conformational properties of polypeptides, Ramchandran plot, domains and motifs; structure-function relationship; study of three dimensional structures of proteins – cytochromes, lysozyme, trypsin, immunoglobulins .

Unit 3- a) Nucleic acids: **14 Hrs**

Purine and pyrimidine bases, nucleosides and nucleotides, conformational parameters of nucleic acids and their constituents, nucleic acid geometrics, base pairing, base stacking, Chargaff's rule, DNA polymorphism, DNA supercoiling; hyperchromicity; modified nucleotides, tertiary structure of nucleic acids.

b) Membranes:

Lipid structure and their organization, phase titration in lipids, polysaccharides, molecular shapes and conformation; comparision of different membrane models.

c) Methods in biophysical analysis:

Spectorscopy – UV, IR, fluroscence, Raman spectroscopy; CD, ORD, EM, NMR, X-ray diffraction.

Unit 4- Introduction to Biostatistics: **12 Hrs**

Measures of central tendency (Mean, median and mode), Measure of dispersion (range,

standard deviation, standard error mean), confidence limits, simple significance tests based on the normal distribution; use of Student's t-test, regression analysis, ANOVA, multiple regression, LSD, Chi-square test, statistical basis of biological assays direct and indirect assays, probit, logit, LD_{50}, ED_{50}, slope ratio assay; use of calculators and computer programs for statistical analysis.

Unit 5-Introduction to Bioinformatics: 14 Hrs

Data base types – nucleotide databases, protein data bases, NCBI, DDBJ, EMBO, OMIM, genomics and the genome projects, finding and retrieving sequences, similarity searching (BLAST), sequence allignments: pairwise and multiple allignments and comparision; Molecular phylogenetics – molecular clock hypothesis, concept of phylogenetic tree, types of trees, elementary idea of clustering and cladistic methods

Course Outcome for M.Sc. Microbiology:

After successful completion of this course students are expected to be able to:

CO-1 Understand the constituents and working of a cell as a whole

CO-2 Enumerate the various cell organelles with their function and the differences in cellular organization of various life forms

CO-3 Describe various types of cell multiplications and divisions and differences between them

CO-4 Retrieve information from available databases and use them for microbial identifications and drug designing.

CO-5 Understand the techniques and underlying theory of UV- Visible, IR, NMR and Raman, AAS, XRD and mass spectroscopy

CO-6 Understand the basic knowledge of statistics and tools used for several quantitative analysis in microbiology

Reference:

1. Voet, D., Voet, J. G., & Pratt, C. W. (2016). Fundamentals of biochemistry: life at the molecular level (5th ed.). Wiley.
2. Upadhyay, S. K., & Upadhyay, S. K. (2017). Biophysical chemistry (2nd ed.). Himalaya Publishing House.
3. Karp, G. (2019). Cell and molecular biology: concepts and experiments (8th ed.). Wiley.
4. Murray, R. K., Bender, D. A., Botham, K. M., Kennelly, P. J., Rodwell, V. W., & Weil, P. A. (2018). Harper's illustrated biochemistry (31st ed.). McGraw-Hill Education.
5. Nelson, D. L., Cox, M. M., & Lehninger, A. L. (2017). Lehninger principles of biochemistry (7th ed.). W.H.Freeman.
6. Chang, R., & Goldsby, K. A. (2014). Chemistry (12th ed.). McGraw-Hill Education.
7. Branden, C., & Tooze, J. (1999). Introduction to protein structure (2nd ed.). Garland Science.
8. Adams, R. L., & Nicholson, H. B. (1993). Biochemistry of nucleic acids (2nd ed.). Chapman and Hall.
9. Rhodes, G., & Guss, J.M.(2001). Crystallography made crystal clear: a guide for users of macromolecular models (2nd ed.). Academic Press.
10. Lacroix-Zephir, Z., & Critchlow, T.(2003). Bioinformatics: managing scientific data (1st ed.). Morgan Kaufmann Publishers.
11. Wardlaw, A.C.(1985). Practical statistics for experimental biologists(2nd ed.). John Wiley and Sons.
12. Higgins,D.G., & Taylor,W.R.(2000). Bioinformatics: sequence alignment and Markov models(1st ed.). Oxford University Press.
13. Rastogi,V.B.(2015). Essentials of biostatistics(2nd ed.). New Age International Publishers

Practical Based on paper 2.3 Biophysics, Biostatistics and Bioinformatics (B)

Biophysics

1. Determination of Melting temperature of DNA
2. Determination of Lambert's Beers Law
3. Determination of Maximum absorption of any two dyes
4. Determination of LD_{50}, ED_{50} and MIC

Biostatistics

1. Biostatistical problems solving using Barr and Pie diagram
2. Measures of central tendency and dispersion
3. Students' t test, Chi-square test, and Analysis of variances (ANOVA)

Bioinformatics

1. Introduction to Bioinformatics
2. NCBI, EMBO DDBJ and OMIM
3. Home page descriptions and list of soft-wares of Nucleotide databases
4. Designing of oligonucleotides
5. Sequence similarity searching using BLAST analysis
6. Sequence comparison using Multiple sequence alignment
7. Construction of Phylogenetic tree methods
8. Prediction of gene in an DNA sequence using gene prediction algorithm
9. Study of Protein sequence databases
10. Prediction of amino acid sequence of a protein

Paper- 2.4: OE: Microbes in Human welfare

1.	Introduction to microorganisms; Definition, Discovery of microorganisms, Spontaneous generation vs. biogenesis. Contributions of Antonie von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister and Alexander Fleming. Types – viruses, mycoplasma, rickettsia, bacteria, fungi, actinomycetes, algae and protozoa; General characteristics, structure and reproduction of microorganisms. Distribution of microorganisms: In air, water and soil; On and in the bodies of plants and animals.	**10 h**
2.	Appearance of microorganisms: Microscopic observations- Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pilli. Cell wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls. Different types of microscopes, different shapes and sizes of microorganisms, staining properties, staining of cells organelles and inclusion bodies. Isolation and cultivation of microorganisms: Sterilization methods (physical and chemical); Media – preparation, ingredients and types; Pure culture techniques.	**10 h**
3.	Microorganisms and human Health – Role of microorganisms in human health; Action of antibiotics to combat microbial diseases; Microbial vaccines as prophylactic measures; Concepts and principals of immunity to microbial infections; Major human diseases caused by important microbial pathogens. Microorganisms and Industry: Microbial fermentations; Bioprocess engineering; Raw materials; Types of fermenters and fermentations; Production of antibiotics, enzymes, organic acids and pigments.	**10 h**

After successful completion of this course students are expected to be able to:

CO-1: Understand the history and scope of microbiology
CO-2: Learn about viruses, mycoplasma, rickettsia, bacteria, fungi, actinomycetes, algae, and protozoa. They will also study the general characteristics, structure, and reproduction of microorganisms.
CO-3: Understand the distribution and appearance of microorganisms
CO-4: Understand microbes in food: Students will learn about fermented food products such as nutritive and medicinal value of fermented foods; probiotics; nutraceuticals.

Reference Books:

1. Stanier, R. Y. (1977). General microbiology (3rd ed.). Cambridge University Press.
2. Lammert, J. M. (2011). Techniques in microbiology: A student handbook (1st ed.). W. H. Freeman.
3. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H., & Stahl, D. A. (2014). Brock biology of microorganisms (14th ed.). Pearson.
4. Atlas, R. M., & Bartha, R. (2013). Microbial ecology: Fundamentals and applications (5th ed.). Benjamin Cummings.
5. Pelczar Jr., M. J., Chan, E. C., & Krieg, N. R. (1988). Microbiology: Concepts and applications (2nd ed.). McGraw-Hill.
6. Frazier, W. C., &Westhoff, D. C. (2008). Food microbiology (5th ed.). Tata McGraw-Hill Education.
7. Doyle, M.P., Beuchat, L.R., & Montville, T.J.(1997). Food microbiology: Fundamentals and frontiers (1st ed.). ASM Press.
8. Atlas, R.M., & Bartha, R.(1998). Microbial ecology: Fundamentals and applications (3rd ed.). Benjamin Cummings.
9. Mitchell, R.(2004). Environmental microbiology (2nd ed.). Wiley-Liss.
10. 10.Subba Rao, N.S.(2002). Soil microbiology (4th ed.). Oxford & IBH Publishing Co.

Digital References/ Study material:

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https://archive.nptel.ac.in/courses/102/103/102103015/
https://onlinecourses.swayam2.ac.in/cec19_bt11/preview

Paper-3.1 HC: Recombinant DNA Technology

1.	Methods of studying DNA – Density gradient sedimentation, zonal centrifugation, isopycnic separation, electrophoretic separation, agarose, polyacrylamide, pulse field electrophoreses, southern blotting, northern blotting, labeling – radioactive and non-radioactive labeling. DNA sequencing - direct sequencing, indirect sequencing, Maxam and Gilbert method, Sangers method, RNA sequencing,	**12 h**
2.	Nucleic acid hybridization – Design and construction of probes, nick translation, hybridization, liquid hybridization, solid hybridization, determination of stringency conditions. Applications of nucleic acid hybridization. Enzymes used in recombinant DNA technology, Restriction endonucleases – Type, I, II &III, Nucleotide kinase, reverse transcriptase, T4 DNA ligase, Klenow polymerase and others, restriction mapping, RFLP and RAPD.	**12 h**
3.	Plasmid vectors - Use of natural plasmids as vectors, artificial plasmid vectors, pSC 101, pBR 322, pUC 18, Ti and Ri plasmid vectors. Bacteriophage vectors – Insertion vectors, replacement vectors, cosmid vectors, phagemid vectors, shuttle vectors and M13 based vectors. BACs, YACs and HAC	**12 h**

4.	Hosts for recombinant DNA technology; Prokaryotes –Bacteriophages, *E. coli, B. subtilis, Streptomyces,* Eukaryotic – Yeasts and Fungi Construction of recombinant DNA, selection of DNA fragments for cloning, chemical synthesis, gene synthesizers, ligation with RES, homopolymer tailing, blunt end ligation, linkers, monitoring restriction and ligation. Genome libraries – construction and screening of genome libraries, chromosome walking, cDNA libraries.	**12 h**
5.	Insertion of recombinant DNA – Host selection, transformation, transfection, electroporation, lipofection, Screening of recombinant, Applications of rDNA technology PCR – principles, types and applications, primer design and applications. DNA micro array – principle, types, construction and applications, *in vitro* approach for studding DNA- Protein interactions.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1: Demonstrate a comprehensive understanding of the multidisciplinary as well as interdisciplinary fundamental concepts in Genetic Engineering and Biotechnology.

CO-2:Describe the applications of nucleic acid hybridization.

Identify the enzymes used in recombinant DNA technology, including restriction endonucleases (Type I, II & III), nucleotide kinase, reverse transcriptase, T4 DNA ligase, Klenow polymerase, and others.

Explain restriction mapping, RFLP and RAPD.

CO-3:Describe the use of natural plasmids as vectors and artificial plasmid vectors such as pSC 101, pBR 322, pUC 18, Ti and Ri plasmid vectors.

CO-4:Describe the construction of recombinant DNA including selection of DNA fragments for cloning, chemical synthesis, gene synthesizers, ligation with RES, homopolymer tailing, blunt end ligation, linkers, monitoring restriction and ligation.

CO-5:Describe genome libraries including construction and screening of genome libraries, chromosome walking and cDNA libraries.

Reference Books:

1. Brown, T. A. (2017). Molecular biology: Labfax (2nd ed.). Academic Press.
2. Karp, G. (2019). Cell and molecular biology (8th ed.). John Wiley & Sons.
3. Miller, G., & Levine, J. (2019). An introduction to genetic analysis (12th ed.). W.H. Freeman.
4. Watson, J. D., &Caudy, A. A. (2017). Recombinant DNA (2nd ed.). Scientific American Books.
5. Nicholl, D. S. T., & Errington, M. L. (2016). An introduction to genetic engineering (3rd ed.). Cambridge University Press.
6. Trapp, B. E., &Freifelder, D. (2018). Molecular biology: Genes to proteins (5th ed.). Jones & Bartlett Learning.
7. Clark, D. P., Pazdernik, N., &Tillier, E. R. M. (2021). Molecular biology: Academic cell update edition (3rd ed.). Academic Press.
8. Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., Baltimore, D., & Darnell, J. E. (2016). Molecular cell biology (8th ed.). W.H. Freeman.
9. Mechardt, C., & McElroy, K. E. (2018). Molecular biology and genomics: The experimenter series (2nd ed.). Academic Press.

Practical Based on paper 3.1 Recombinant DNA Technology

1. Isolation of Genomic DNA From Bacterial Cell.
2. Quantitative Estimation of DNA By DPA Method.
3. Quantitative Estimation of RNA By Orcinol Method
4. Estimation of Purity and Concentration of DNA By Spectrophotometric Method
5. Restriction Digestion of Lambda DNA
6. Ligation of Lambda DNA Hind-III
7. Amplification of DNA Fragment by Polymerase Chain Reaction.
8. Southern Blotting and Northern Blotting
9. Restriction Fragment Length Polymorphism (RFLP)
10. Random Amplification Of Polymorphic DNA (RAPD)

11. Complementary DNA (cDNA)
12. DNA Microarray

Paper-3.2 HC: Immunology and Immunotechnology

1.	Introduction: Origin, concept and historical development of immunology. Immunity: Definition, Types of immunity-Innate and Acquired immunity. Cells and organs of immune system: Circulatory and lymphatic systems. Hematopoiesis. Cells of immune system. Types, structure and functions of lymphoid organs. Biology of immune cells: B cells-Origin, development, maturation and surface molecules. T cells- Origin, development, maturation and surface molecules; Subsets of T cells. Structure and function of T Cell receptors	**12 h**
2.	MHC molecules-Types, structure, genetics and functions. Complement system-Components and pathways of component activation**.** Antigens and Antibodies: Antigens - Physical and chemical properties of antigens, Epitopes, Antigenicity and Immunogenicity; Types of antigens. Antibodies- Physical and chemical structures of antibodies, Types and biological functions of immunoglobulins. Monoclonal and Polyclonal antibodies- Production and applications.	**12 h**
3.	Antigen-Antibody reactions: Mechanism and principles of antigen antibody reactions. Types and determination of antigen antibody reactions – Radio immune assay, Ouchterlony double diffusion technique, Complement fixation test, Enzyme linked immunosorbent assay and Immuno blotting Immune response: Antigen processing and presentation; Activation of T and B cells; Differentiation and formation of functional T cells; Differentiation of B cells and formation of plasma and memory cells. Immune response-Primary and secondary. Effector mechanism of HMI and CMI. Cell mediated cytotoxicity, ADCC and Inflammation. Cytokines- Types, functions and applications	**12 h**
4.	Hypersensitivity- Mechanism and types of hypersensitivity. Autoimmunity and Immuno deficiency syndrome: Autoimmunity and autoimmune disorders. Immuno deficiency syndrome: IDS due to deficient T and B cells, phagocytes, complement. Severe combined immunodeficiency syndrome.	**12 h**
5.	Tumor and Transplantation immunology: Tumor antigens and immunology to tumor cells. Transplantation immunology-Blood transfusion, Tissue transplantation and HLA typing. Immunotolerance and Immuno modulators Vaccines- Types, production and immunization schedules. Recent advances in vaccines and their developments: Recombinant vaccine development (Covishield) attenuated vaccine (Covaxin)	**12 h**

After successful completion of this course students are expected to be able to:

CO-1 Compare and contrast innate and adaptive immunity

CO-2 Design a model of Immunoglobulins

CO-3 Describe which cell types and organs present in the immune response.

CO-4 To make them understand the salient features of antigen antibody reaction &its uses in diagnostics and various other studies. Illustrate various mechanisms that regulate immune responses and maintain tolerance

Reference Books:

1. Bradley, J. and Mecharty, M. (2022). Clinical Immunology. Oxford University Press,New York.
2. Abbas, A.K., Lichtman, A.H., and Pillai, S. (2022). Cellular and Molecular Immunology. Elsevier.

3. Murphy, K. (2022). Janeway's Immunobiology. Garland Science.
4. Catty, D. (2018). Antibody Production and Maintenance of Laboratory Animals. Wiley-Blackwell.
5. Kubey, J.K., Goldsby, R.A., Kindt, T.J., and Osborne, B.A. (2018). Kuby Immunology. W.H. Freeman.
6. Male, D., Brostoff, J., Roth, D.B., and Roitt, I.M. (2019). Immunology. Elsevier.
7. Stites, D.P., Terr, A.I., and Parslow, T.G. (2012). Medical Immunology. McGraw-Hill Education.
8. Coico, R., Sunshine, G., and Benjamin, E. (2014). Immunology: A Short Course. Wiley-Blackwell.
9. Topley, W.W.C., Wilson, G.S., and Collier, L.H. (1990). Topley & Wilson's Principles of Bacteriology and Immunity: Virology and Immunology (8th ed.). Edward Arnold.
10. Roitt, I.M., Brostoff, J., and Male, D.K. (1998). Immunology (3rd ed.). Mosby-Year Book

Digital References/ Study material:

https://onlinecourses.nptel.ac.in/noc22_bt40/preview

Practical Based on paper 3.2 Immunology and Immunotechnology

1. Estimation of Haemoglobin content in blood.
2. Total RBC count.
3. Total WBC count.
4. Differential WBC count.
5. Determination of Erythrocyte sedimentation rate (ESR).
6. Radial Immunodiffusion test.
7. Ochterlony double diffusion test.
8. Study of organs of immune system
9. Determination of hypersensitivity reaction by tuberculin test.
10. Preparation of antigen for polyclonal antibody of production
11. Methods of antigen injection
12. Separation of plasma and serum
13. Determination of antibody titer of the serum.
14. Separation of serum proteins by SDS-PAGE
15. Isolation of IgG from serum
16. Isolation of IgY from egg yolk
17. Agglutination Tests.
    a. VDRL test.
    b. Haemeagglutination test.
18. Detection of *Salmonella* by WIDAL test.
19. Immunochromatography- HCG/HIV/HBSAg/ detection
20. ELISA/ Western blot

Paper-3.3 SCT (A): Food and Dairy Microbiology

1.	Introduction: Origin, Concept, Scope and historical developments Food as substrate for microorganisms: Hydrogen ion concentration (pH), Moisture requirement, Water activity, Oxidation-Reduction potential, Nutrient content, Inhibitory substances and Biological structure. Food contamination: Contamination of foods from green plants, animals, sewage, soil, water, air and handling.	**12 h**
2.	Food spoilage: General principles of food spoilage, Causes of food spoilage, Factors affecting kind and number of microorganism. Chemical changes caused by microorganisms. Spoilage of Meat and Meat products, Egg and Egg products, Fish and Marine products, Cereal and Cereal products, Fruits and Vegetables.	**12 h**

	Food borne diseases and their control: Food Infection and Intoxication. Detection of food borne pathogens and their toxins by various methods.	
3.	Food Preservation: General principles, Physical methods of food preservation (High temperature, Low temperature and Drying), Chemical methods of food preservation (Food additives) and Biological methods of food preservation.	**12 h**
4.	Fermented foods (Bread, Sauerkraut and Tempeh), Probiotics and Prebiotics. Concept and importance of Nutraceuticals and Nutraceutical products. Milk: Definition, Composition, Nutritive value and Properties. Microbiology of milk. Testing of milk quality. Contamination, spoilage and preservation of milk and milk products.	**12 h**
5.	Fermented milk products: Production, Quality control and Significance of Cheese, Yogurt, Shrikhand and Acidophilus milk. Food sanitation and food safety: Concept, Importance and Safety laws, GMP and LP. Quality control and food standards: Bureau of Indian Standard (BIS). PFAA, FPO, MPO, CSO, Agmark Standards, International standards – HACCP, ISO 9000 Series. Food testing laboratories.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1 Know the details of food borne pathogens, fermented food products and role of microorganisms in dairy industry

CO-2 Understand concept and use of probiotics and illustrate the role of microorganisms in food safety

CO-3 Cultivate and enumerate microorganisms from various food samples

CO-4 Compare various physical and chemical methods used in the control of microorganisms

Reference Books:

1. Doyte, M. P., Loory, R. B., & Thomas, J. M. (2019). *Food microbiology* (6th ed.). ASM Press Washington DC.
2. Jay, J. M. (2018). *Modern food microbiology* (9th ed.). Chapman & Hall.
3. Joshi, V. K., & Pandey, A. (2019). *Biotechnology of food fermentation* (2nd ed.). Asia Tech Publications.
4. Frazier, W. C., &Westhof, D. C. (2019). *Food microbiology* (4th ed.). Tata McGraw Hill Education.
5. Doyle, M. P., Beuchat, L. R., & Montville, T. J. (2013). *Food microbiology: Fundamentals and frontiers* (4th ed.). ASM Press.
6. Danwart, G. J. (2018). *Basic food microbiology* (2nd ed.). CBS Publishers & Distributors.
7. Pitt, J., & Hocking, A. D. (2009). *Fungi and food spoilage* (3rd ed.). Springer.
8. Sareen, S., &Soni, S. (2018). *Food preservation* (2nd ed.). Sarup& Sons.
9. Ananthakrishnan, C. P., & Gunasekaran, P. (2017). *Dairy microbiology* (2nd ed.). Sreelakshmi Publications.
10. Robinson, R.K., Tamime, A.Y., & Robinson, R.K.(Eds.) (1990). *Dairy microbiology: a practical approach* (1st ed.). Elsevier Applied Science.

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https://archive.nptel.ac.in/courses/102/103/102103015/
https://onlinecourses.swayam2.ac.in/cec19_bt11/preview

Practical Based on paper 3.3 Food and Dairy Microbiology (A)

1. Microbiological Examination of Utensils.
2. Methylene blue reduction test
3. Enumeration of microorganisms from healthy and spoiled fruits and vegetables

4. Enumeration of microorganisms from cereals, spices and dry products
5. Enumeration study of spoilage of stored meat and fish
6. Study of microbiology of milk and milk products
7. Production of yoghurt, acidophilus milk, tempeh and cheese
8. Estimation of lactic acid in milk and curd
9. Estimation Fat in milk and milk products
10. Estimation of ascorbic acid from tomato, chilly and lemon
11. Mushroom cultivation (Oyster) and Spirulina, Agar-agar and single cell proteins
12. Mandatory visit to food research institutes/Industries

SCT 3.3 (B) MICROBIAL ENZYMOLOGY

Course Credits: 4	Total No. of Hours: 60 No. of Teaching Hours per Week: 4 Hrs

Unit 1. Introduction to enzymes. **12 Hrs**

Historical developments. Classification of enzymes into six major groups with suitable examples. Numerical classification of enzymes. Methods & structural conformations of enzymes. Properties of Enzymes, laws of thermodynamics , factors affecting the rate of chemical reactions. Arrehenius theory, collision theory . free energy. Enzymes as biocatalysts, catalytic power, activation energy, substrate specificity, active site.

Unit 2. Enzyme kinetics: **12 Hrs**

Importance of enzyme kinetics, Variations of velocity with [E], [S], pH and temperature, time of incubation , Derivation of Michaelis - Menton equation and its significance in enzyme kinetic studies. Lineweaver-Burke plot, Haldane-Briggs relationship. Concept and significance of K_m and V_{max}. Concept of enzyme inhibition; types of enzyme inhibitors-reversible, competitive, non-competitive, uncompetitive and irreversible; significance and applications of enzyme inhibitors. Basics of enzyme turnover- Kinetics, measurement and rates of enzyme turn over..

Unit 3. Mechanism of enzyme action. **12 Hrs**

Theories of mechanisms of enzyme action. Mechanism of action of lysozyme, chymotrypsin and ribonuclease. Monomeric, Oligomeric and multi-enzyme complex (PDH and fatty acid synthase), isozymes (Lactate dehydrogenase, creatine phosphokinase, alcohol dehydrogenase, alkaline phosphatase and isocitrate dehydragenase) and Allosteric enzymes (Threonine dehydratase and aspartate transcarbomylase); covalently modulated enzymes (Glycogen phosphorylase) and Membrane bound enzymes (ATPase).

Unit 4. Enzymes from microbial sources. **12 Hrs**

Screening by plate assay methods, large scale production of enzymes, recovery of enzymes enzyme purification methods - enzyme precipitation, separation by chromatography, enzyme reactors. Immobilized enzymes: Physical and chemical methods of immobilization, immobilization supports, kinetics of immobilized enzymes. Enzyme electrodes, Enzyme catalysis in a pola medium, reverse micellar entrapment of enzymes and its applications.

Unit 5. Application of enzymes: **12 Hrs**

Synthesis of chemicals using enzymes, food technology and medicine. Enzymes in diagnostic assays. Immune-enzyme techniques. Commercial products of microbes: Antibiotics, biopolymers, biosensors, biopesticides Production of biofuels. Microbial toxins: Types, biochemical and molecular basis of toxin production, implications. Genetically engineered microbes, anti-HIV, anticancer, antifungal, anti-plasmodial, anti-inflammatory compounds.

Course Outcome for M.Sc. Microbiology:
After successful completion of this course students are expected to be able to:

CO-1 Acquire the knowledge of enzymes their properties and classification, Mechanism of action, Michaelis-Menten initial rate equation, methods for the determination of Km and Vmax.

CO-2 Analyses the mathematical derivations in understanding enzyme kinetics and different transformation and its application.

CO-3 Learn about enzyme kinetics, effect of enzymes concentration, pH and temperature on kinetics of enzyme reactions, enzyme inhibition and activation, and Multi substrate enzyme kinetics.

CO-4 Learn different immobilization techniques and Industrial and clinical scope of enzymes and preparation of various culture media, Purification techniques

References:

1. Palmer, T., & Bonner, P. L. (2007). *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry* (2nd ed.). Elsevier
2. West, T. S., & Told, L. (2019). *Textbook of Enzymology* (4th ed.). Wiley-Blackwell
3. Bhatt, S. M. (2018). *Enzymology and Enzyme Technology* (2nd ed.). New Age International Publishers
4. Punekar, N. S. (2020). *Enzymes* (1st ed.). Springer Nature Switzerland AG.
5. Arora, N. K., Mishra, J., & Mishra, V. (Eds.). (2020). *Microbial enzymes: Roles and applications in industries*. Springer Singapore
6. Brahmachari, G., Demain, A. L., & Adrio, J. L. (Eds.). (2017). *Biotechnology of microbial enzymes: Production, biocatalysis and industrial applications*. Elsevier
7. Singh, S., & Singh, R. (Eds.). (2020). *Microbial enzymes and biotechniques*. Springer Singapore

Practical Based on paper 3.3 Microbial Enzymology (B)

1. Population growth of bacteria (*E.coli*) and yeast (*S. cerevisiae)*
2. Sugar fermentation tests, Catalase activity, Hydrolytic rancidity, Casein hydrolysis
3. Study of Temperature (Heat stress) and acid and pH stress tolerance by microbes
4. Study of oxidative stress
5. Isolation of Thermophiles, acidophiles, alkalophiles and halophiles
6. Isolation of aerobic, facultative aerobic, anaerobic and microaerophilic microbes.
7. Screening of microorganism for invertases, amylase, proteases, lipases
8. Determination of optimum pH, temperature, enzyme and specific activity of microbial enzyme (invertase, amylase)
9. Effect of inhibitor on microbial amylase activity
10. Determination of Km and Vmax of microbial amylase
11. Isolation of streptomycin resistant strain of *E .coli* by gradient plate method.
12. Ames test

Paper-3.4 OE: Microbes and Environment

1.	Concept of environment: Atmosphere, lithosphere, hydrosphere and biosphere; Ecological niche - ecosystems, organization of ecosystems, food and energy triangles, position of microorganisms in the ecological niche. Origin and evolution of microorganisms: Origin and early evolution of microorganisms, relationship with the early stages of life on the earth, microbes as models for understanding how evolution works and the origin of all life on earth. Biodiversity of microorganisms: Richness and expanding microbial world, distribution of microorganisms in various environments, tools used for	**10 h**

	studying *in situ* and *ex situ* microbial diversity, culturable and non-culturable bacteria.	
2.	Cosmopolitan nature of microorganisms: Exobiology – does life exists elsewhere in the universe? X- files, news stories of 1996 – evidence for microbial life on Mars, debate, exploration for extraterrestrial life based on microbial life. Microbial Ecology: Use of microorganisms as clues to study complex ecosystems; Natural resources – renewable and non-renewable, microorganisms as renewable resources; Microbial community within a human being - humans are microbes' invention to move around.	**10 h**
3.	Microbial interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation. Microbe-Plant interaction: Symbiotic and non-symbiotic interactions. Biodegradation and bioremediation: Principles and degradation of common pesticides, organic (hydrocarbon, oil spills), industrial wastes, biomagnifications and bio-augmentation.	**10 h**

After successful completion of this course students are expected to be able to:

CO-1: Learn about the four major components of the environment - atmosphere, lithosphere, hydrosphere, and biosphere. They be able to identify the position of microorganisms in the ecological niche.

CO-2: Explore the origin and evolution of microorganisms.

CO-3: Understand biodiversity of microorganisms.

CO-3: Explore cosmopolitan nature of microorganisms.

CO-4: Understand what greenhouse gases are and their sources. Explain how microorganisms can be used as indicators of water quality. Describe how greenhouse gases contribute to the greenhouse effect. Understand the role of microorganisms in El Nino effect and Global warming and Gaia.

Reference Books:

1. Steinhaus, M. (2022). Insect pathology (Vol. I & II). Academic Press, New York.
2. Burges, H. D. (1981). *Microbial control of pest and plant diseases*. Academic Press.
3. Agrios, G. N. (2005). Plant pathology. Academic Press.
4. Atlas, R., & Bartha, R. (2018). Microbial ecology: Fundamentals and applications. Benjamin/Cummings Science Publis.
5. Agrios, G. N. (2005). Plant pathology. Academic Press.
6. Hurst, C. J., Crawford, R. L., Garland, J. L., Lipson, D. A., Mills, A. L., &Stetzenbach, L. D. (2019). Manual of environmental microbiology (4th ed.). ASM Press.
7. Fletcher, M., & Grey, T.R.G. (1987). Ecology of microbial communities. Cambridge University Press.
8. Rose, R.D. (1998). Air pollution & industry. Reinhold Co.
9. Metcalf, E., & Eddy, H.P.Wastewater engineering: Treatment and reuse (4th ed.). McGraw-Hill Education.
10. American Public Health Association (APHA), American Water Works Association (AWWA), & Water Environment Federation (WEF). (2017). Standard methods for the examination of water and wastewater (23rd ed.). APHA.

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https://archive.nptel.ac.in/course.html
https://archive.nptel.ac.in/courses/102/103/102103015/
https://onlinecourses.swayam2.ac.in/cec19_bt11/preview

Paper-4.1 HC: Fermentation Technology and Bioprocess Engineering

1.	Fermentation: Origin, concept and historical development of fermentation. Types of Fermentations- Surface, Submerged, Solid -State, Batch, Continuous, Dual and Fed batch fermentations Industrially important Microorganisms: Isolation, Screening of metabolites (Primary and Secondary metabolites) and Preservation. Strain development- Mutation, Recombination and Protoplast fusion technique. Inoculum development for industrial fermentation. Media for industrial fermentations: Criteria, Media formulation, Media ingredients - Water, Carbon sources, Nitrogen sources, Minerals and Vitamin sources. Buffers, Precursors and Growth factors. Oxygen requirement, Chelaters and Antifoaming agents. Nutrients recycling.	**12 h**
2.	Fermentor: Construction and Design of a typical fermentor. Parts and functions of a fermentor. Manual and automatic control systems. Types of fermentors- Tower, Jet, Loop, Airlift, Bubble, Column, Packed bed, Fluidized bed. Sterilization of media and fermentors - Design of sterilization process for batch and continuous fermentation. Sterilization of Fermentor and Media, Air and Exhaust air. Filter sterilization. Kinetics of microbial growth: Phases of cell growth in batch culture. Simple unstructured kinetic models for microbial growth-Monod model. Growth of filamentous organisms. Growth associated (primary) and non - growth associated (secondary) product formation Kinetics.	**12 h**
3.	Bioprocess Engineering: Origin, Concept and Principles of Bioprocess Engineering. Basic components of bioprocess engineering. Upstream bioprocess: Major process variables. Optimization of process variables. Strategies for the enhanced production - Immobilization and Response surface methodology. Downstream bioprocess: Filtration-Micro, Cross-flow and Ultra. Centrifugation- High speed, Continuous and Ultra. Cell disruption. Precipitation, Coagulation and Flocculation. Solvent /Aqueous 2-phase extractions, Dialysis and Electro-dialysis. Reverse osmosis. SDS-PAGE, Ion Exchange chromatography and HPLC. Gel Filtration. Drying. Crystallization.	**16 h**
4.	Production and purification of microbial products: Enzymes-(Amylase, Proteases), Organic acids (Lactic acid, Citric acid and Vinegar), Amino acids (L-lysine and L-glutamic acid), Antibiotics (Penicillin and Streptomycin), Solvents-(Ethyl alcohol, Acetone- and butanol) Alcoholic beverages-(Beer, Wine, Brandy and Rum). Vitamins B12, Antitumours and Anticholesterol agent. An overview of bioenergy.	**12 h**
5.	Single cell protein and Single cell oil – Concept, production and uses. Intellectual property rights and patents	**8 h**

After successful completion of this course students are expected to be able to:

CO-1: Understand the origin and historical development of fermentation and its various types such as surface, submerged, solid-state, batch, continuous, dual and fed-batch fermentations.

CO-2: Identify and isolate industrially important microorganisms.

CO-3: Formulate media for industrial fermentations.

CO-4: Understand the construction and design of a typical fermentor.

CO-5: Design a sterilization process for batch and continuous fermentation.

CO-6: Understand the origin, concept and principles of bioprocess engineering along with its basic components. Understand downstream bioprocesses such as filtration (micro, cross-flow and ultra), centrifugation (high speed, continuous and ultra), cell disruption.

CO-7: Understand the concepts of microbial production and purification of various products such as enzymes (amylase, proteases), organic acids (lactic acid, citric acid, and vinegar), amino acids

(L-lysine and L-glutamic acid), antibiotics (penicillin and streptomycin), solvents (ethyl alcohol, acetone, and butanol), alcoholic beverages (beer, wine, brandy, and rum).

CO-8: Understand the concept of intellectual property rights and patents. They will learn about the different types of patents, patent filing procedures, patent infringement, and patent litigation.

Reference Books:

1. Cinar, A., Parulekar, S. J., & et al. (2014). Batch Fermentation: Modeling, Monitoring, and Control (3rd ed.). CRC Press.
2. Arnold, D., & Davies, J. E. (2019). Atlas of Industrial Microbiology & Biotechnology (2nd ed.). Taylor & Francis.
3. Crueger, W., &Crueger, A. (2019). Biotechnology: A Text Book of Industrial Microbiology (3rd ed.). Science Publishers.
4. Casida, L. E. (2015). Industrial Microbiology (2nd ed.). Wiley-Blackwell.
5. Demain, A. L., &Adrio, J. L. (2019). Biology of Industrial Microorganisms (3rd ed.). CRC Press.
6. DiLallo, R., &DiLallo, M. (2017). Methods in Food and Dairy Microbiology (2nd ed.). CRC Press.
7. Reisman, H. B. (1988). Economic Analysis of Fermentation Processes (1st ed.). CRC Press.
8. Vogel, A., & Todaro, L. C. (2007). Fermented and Biochemical Engineering Handbook (3rd ed.). Noyes Publications.
9. Harvey, W., Blanch, S., & Clark, D. S. (2019). Biochemical Engineering (2nd ed.). CRC Press.

Practical Based on paper 4.1 Fermentation Technology and Bioprocess Engineering

1. Study of Fermentor and Bioreactor
2. Production Curd, Yoghurt, Paneer, Acidophilus milk, Tempeh and Sauerkraut.
3. Study of alcohol fermentation – alcohol production from different substrates, Lab production of Wine, Estimation of percentage of Alcohol, Total acidity and volatile acidity in wine
4. Estimation of Alcohol by Potassium dichromate method
5. Production and analysis of SCP from *Spirulina and Yeast*
6. Product ion of Citric acid by *Aspergillus niger, Pencillium citrannum* and its estimation
7. Production of Pectinase from *Aspergillus niger* by using Wheat bran, Coffee pulp using small scale fermentor and its assay
8. Production of α- Amylase using *Aspergillus oryzae*, *Bacillus licheniformis* using Wheat bran in small scale solid state fermentation and its assay
9. Immobilization of yeast cells by calcium alginate gel entrapment and assay for enzymes Invertase and Catalase
10. Preparation of immobilized cells of *Bacillus licheniformis* for the use in the production of α-amylase
11. Extraction and estimation of vitamins- Thiamine/ Niacin/ Riboflavin/ Vitamin C
12. Mandatory visit to Research Institutes / Industries

Paper-4.2 HC: Medical Microbiology and Diagnostics

1	Introduction: Historical developments - Major milestones and significant contributions. Human Anatomy and physiology: An overview of human anatomy and physiology. Important terms/concepts of human anatomy and physiology with special reference to microbial infections. Diseases caused by microorganisms: Concept and illustrations; Communicable diseases; normal flora of human body; opportunistic pathogens. Fungal diseases: Types of diseases - superficial and deep mycosis; Causative agents; Diagnosis and Treatment of diseases. Protozoan diseases: Causative agents, symptoms, diagnosis and treatment of Amoebiasis, Giardiasis, Filariasis, Leishmaniasis, Toxoplasmosis and Malaria.	**12 h**

2.	Microbial pathogenicity and pathogenesis: Attributes of pathogenicity and pathogenesis. Mechanism of disease process and prognosis. Host and microbial factors influencing susceptibility. Microbial infections: Concept and types of microbial infections; Modes of transmission of pathogens, Portal of entry and exit; Types of infections; Nosocomial infections. Chemotherapy: Antimicrobial agents and antibiotics; Classification of antibiotics based on chemical structure, mode of action and range of effectiveness; Drug resistance - recent trends and its consequences; Antibiogram and Antibiotic policy; NCCLS (CLSI) guidelines and standards; WHO Guidelines.	**12 h**
3.	Systematic study of important pathogenic bacteria with reference to etiology, symptoms, diagnosis, treatment and epidemiology; Enterobacteriaceae (Salmonella, Shigella, *E.coli*, *Klebsiella*); *Mycobacterium tuberculosis*, *M. leprae,* Staphylococci, Streptococci, *Vibrio cholerae*, *Brucella pertusis*, *Clostridium welchi*, *C. tetani* and *Treponema pallidum*	**12 h**
4.	Etiology, epidemiology, symptoms, diagnosis and treatment of diseases caused by Chlamydia, Mycoplasma and Rickettsia. Pathogenicity, symptoms, diagnosis, treatment and preventive measures of viral diseases caused by important viruses - Pox, Herpes, Adeno, Papovo Picarno, myxo, retro, arbo, hepatitis, Rabies, SARS, Chikungunya, Ebola and H_1N_1 viruses.	**12 h**
5.	Advances in Molecular Diagnosis of infections: RT-PCR (HCV, Corona, Mycobacteria), RAT (Rapid Antigen Test), TrueNat (TB and Covid-19), Feluda test Based on CRISPR (Clustered Regularly Interspaced Short Palindromic), Cartridge Based Nucleic Acid Amplification Test (CBNAAT), for TB, MDR-TB. Diagnostics: Collection and transport of clinical samples; Processing of clinical samples for direct and indirect diagnostics tests. Conventional, Serological and Molecular methods and techniques for the diagnosis of Urinary tract infections, Sexually transmitted diseases, Acute diarrheal and gastrointestinal infections, Cholera, Dysentery, Tuberculosis, Leprosy, Pyogenic infections, Dental caries and Central nervous system infections.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1: Demonstrate advanced knowledge and understanding of the nature of pathogenic microorganisms (predominantly viruses and bacteria).

CO-2: Explain the modes of transmission of pathogenic microorganisms.

CO-3: Demonstrate knowledge and understanding of the mechanisms of microbial pathogenesis and the outcomes of infections, including chronic microbial infections.

CO-4: Distinguish between and critically assess the classical and modern approaches to the development of therapeutic agents and vaccines for the prevention of human microbial diseases.

CO-5: Demonstrate knowledge of the laboratory diagnosis of microbial diseases and practical skills, including the isolation and characterization of specific microbes in clinical specimens.

Reference Books:

1. Topley, W. W. C., Wilson, G. S., & Collier, L. H. (1990). Principles of bacteriology, virology, and immunity (8th ed.). Edward Arnold.
2. Greenwood, D., Slack, R. C. B., &Peutherer, J. F. (2007). Medical microbiology: A guide to microbial infections: Pathogenesis, immunity, laboratory diagnosis and control (17th ed.). Churchill Livingstone/Elsevier.
3. Bhatia, R. R., & Kashyap, S. K. (2019). Essentials of medical microbiology (2nd ed.). Jaypee Brothers Medical Publishers.
4. Jawetz, E., Adelberg, E. A., & Brooks, G. F. (2019). Medical microbiology (28th ed.). McGraw-Hill Education.
5. Stokes, J., &Rideway, W. (2018). Clinical microbiology: A laboratory manual (3rd ed.). Wiley-Blackwell.
6. Forbes, B. A., Sahm, D. F., &Weissfeld, A. S. (2007). Bailey & Scott's diagnostic microbiology (12th ed.). Mosby/Elsevier.
7. Murray, P. R., Rosenthal, K. S., &Pfaller, M. A. (2015). Medical microbiology (8th ed.). Elsevier/Mosby.

8. Wilson, B., &Moffet, H. L. (2015). Clinical microbiology: An introduction for healthcare professionals (2nd ed.). Elsevier.

Digital References/ Study material:

https://archive.nptel.ac.in/course.html
https://archive.nptel.ac.in/courses/102/103/102103015/
https://onlinecourses.swayam2.ac.in/cec19_bt11/preview

Practical Based on paper 4.2 Medical Microbiology and Diagnostics

1. Preparation of culture media for the culture of different pathogenic microorganisms.
2. Anaerobic culture method for anaerobes of clinical importance.
3. Presumptive identification of pathogenic microorganisms using colony morphology on selective/differential/selective-differential/enrichment media.
4. Isolation and characterization of clinical significant species of *Staphylococcus, Streptococcus, Candida, Cryptococcus, Cornybacterium, Bacillus, Nocordia, Neisseria, Enterobacteriaceae, Vibrio, Pseudomonas, Aeromonas.*
5. Microscopic observation of important human pathogens.
6. Study of commensal microbial flora of human body (mouth/skin/hands/nose/ear).
7. Isolation, characterization and identification of bacterial pathogen from clinical specimen (Urine sample/Pus sample/Blood sample).
8. Demonstration of the diagnosis of HIV by Dot-ELISA (Viral infection).
9. Detection of malarial parasite from human blood sample (Parasitic infection).
10. Study of antibiotic sensitivity test by paper disc method.
11. Determination of MIC value for selected antibiotics by Kirby-Bauer method.
12. Lymphocyte viability test (Trypan blue exclusion test of cell viability)

Paper-4.4 SC: Agricultural Microbiology

1.	Introduction: Origin, Concept and Development of Agricultural Microbiology. Role of microorganisms in soil formation and soil fertility. Factors affecting soil microorganisms. Microbes and biogeochemical cycles - Nitrogen, Carbon, Sulfur and Phosphorous cycles. Plant - Microbe Interactions: Types - Mutualism, Commensalism, parasitism, amensalism and synergism. Concepts of Rhizosphere, Phyllosphere and Spermosphere. Rhizosphere effect and R/S ratio. Factors influencing rhizosphere microorganisms. Plant growth promoting rhizobacteria. Mycorrhizae.	**12 h**
2.	Biological nitrogen fixation: General chemistry, mechanism and genetics of biological nitrogen fixation. Nitrogen fixation by diazotrophs-Rhizobium, Azotobacter, Azospirillum, Frankia and Blue Green Algae. Phosphate solubilizing microorganisms and Mycorrhizae: Types of phosphate solubilizing microorganisms – Bacteria and Fungi, Mechanism of phosphate solubilization. Types, significance and role of mycorrhizae.	**12 h**
3.	Biofertilizers: Concept and types of microbial biofertilizers - Bacterial (Rhizobium, Azotobacter and Azospirillum), Fungal and Algal. Screening and selection of potential strains for biofertilizer. Production and quality control of biofertilizers. Phosphate solubilizing microbial biofertilizers. Methods of application and evaluation of biofertilizers.	**12 h**
	Green manure, Organic matter, Compost and Composting	
4.	Plant diseases: Etiology, pathogenesis, Symptoms and control measures of plant	**12 h**

	diseases. Bacterial diseases - Wilt and Citrus canker; Fungal diseases – Wilt, Downy mildew, Rust and Smuts); Viral diseases -Tobacco mosaic and Bunchy top of Banana; Mycoplasmal diseases - Grassy shoot of sugar cane and Coconut yellowing disease	
	Biological control: Origin and concept. Various microorganisms as biocontrol agents. Isolation, screening, cultivation and mode of action of microbial biocontrol agents. Merits and demerits of biological control	
5.	Biopesticides: Origin and concept. Types, mass production and applications of microbial biopesticides. Bacterial - *Bacillus thuringiensis* and *Pseudomonas fluroscence*; Fungal - *Trichoderma viridae* and Coelomomyces; Viral - NPV and CPV. Integrated pest and plant diseases management Genetically modified crops: Origin and concept. Role and significance of microbial genes. Construction, evaluation and field application of BT cotton, FlavrSavr tomato and Golden Rice. Advantages and disadvantages of GM crop plants.	**12 h**

After successful completion of this course students are expected to be able to:

CO-1: Understand the origin, concept, and development of agricultural microbiology.

CO-2: Explain the role of microorganisms in soil formation and soil fertility. Identify the factors that affect soil microorganisms.

CO-3: Describe the Nitrogen, Carbon, Sulfur, and Phosphorous cycles and the role of microbes in these biogeochemical cycles.

CO-4: Explain the different types of plant-microbe interactions such as mutualism, commensalism, parasitism, amensalism, and synergism.

CO-5: Describe the general chemistry, mechanism, and genetics of biological nitrogen fixation. Explain nitrogen fixation by diazotrophs such as Rhizobium, Azotobacter, Azospirillum, Frankia, and Blue Green Algae.

CO-6: Describe the types of phosphate solubilizing microorganisms such as bacteria and fungi. Explain the mechanism of phosphate solubilization. Understand the types, significance, and role of mycorrhizae.

CO-7: Understand the concept and types of microbial biofertilizers. Understand production and quality control of biofertilizers. Describe phosphate solubilizing microbial biofertilizers. Understand methods of application and evaluation of biofertilizers.

CO-8: Understand etiology, pathogenesis, symptoms, and control measures of plant diseases such as bacterial diseases (Wilt and Citrus canker), fungal diseases (Wilt, Downy mildew, Rust, and Smuts), viral diseases.

Reference Books:

1. Subba Rao, N. S. (2019). Soil microbiology (5th ed.). Oxford & IBH.
2. Subba Rao, N. S. (2019). Biofertilizers in agriculture and forestry (3rd ed.). CBS Publishers & Distributors.
3. Subba Rao, N. S. (2019). Recent advances in biological nitrogen fixation (2nd ed.). Cambridge University Press.
4. Rangaswamy, G., &Bagyaraj, D. J. (2007). Agricultural microbiology (2nd ed.). Prentice-Hall of India.
5. Swaminathan, M. S. (2016). Biotechnology in agriculture (2nd ed.). McMillan.
6. Steinhaus, E. A. (1963). Insect pathology: An advanced treatise (Vol I & II). Academic Press.
7. Burges, H. D. (Ed.). (1981). Microbial control of pests and plant diseases 1970-1980 (Vol 1-2). Academic Press.
8. Agrios, G. N. (2005). Plant pathology (5th ed.). Elsevier Academic Press.
9. Atlas, R., & Bartha, R. (1998). Microbial ecology: Fundamentals and applications (4th ed.). Benjamin/Cummings Science Publisher.

Digital References/ Study material:

https://onlinecourses.swayam2.ac.in/cec23_ag03/preview
https://archive.nptel.ac.in/courses/102/103/102103015/
https://onlinecourses.swayam2.ac.in/cec19_bt11/preview

Practical Based on paper 4.3 Agricultural Microbiology

1. Isolation and study of Rhizosphere, Spermosphere and phyllosphere microorganisms.
2. Isolation, enumeration and characterization of nitrogen fixing bacteria.
3. Measurement of nitrogen fixation – the tube culture, Leonard Jar and Pot culture methods.
4. Isolation, enumeration and characterization of phosphate solubilizing bacteria and fungi.
5. Assessment of Vesicular Arbuscular mycorrhiza association with plants and isolation spores.
6. Observation of wet mount of NPV.
7. Isolation of Cellulose, Hemicellulose, Starch, Lignin, Pectin degrading microorganisms.
8. Demonstration of Biogas production using different substrates like cattle dung, water hyacinth, sewage.
9. Organic matter decomposition - CO_2 evolution.
10. Evaluation of seed germination and vigor - Grow on test.
11. Quantitative skills for biotic and abiotic disease stress evaluation and data analysis.
12. Laboratory scale production of bacterial and fungal biofertilizers.

Model Theory QP

First Semester M.Sc. Degree Examination 2023
Microbiology
(CBCS)
1.1 HC Fundamentals of Microbiology

Time: 3 Hours Max. Marks: 75

PART A

1. Write short notes on any **TEN** of the following: **(10X2=20)**

a) ..

b) …

c) ..

d) ..

e) ..

f) ..

g) ..

h) ..

i) …

j) ..

k) ..

l) ..

PART B

Write explanatory notes on **any FIVE** of the following (not exceeding 3 pages each): **(5X5=25)**

2. ..

3. **..**

4. ..

5. ..

6. ..

7. ..

PART C

Answer **any THREE** of the following (not exceeding 5 pages each): **(3X10=30)**

8. ..

9. ..

10. ..

11. ..

12. …