S.S. JAIN SUBODH P.G. (AUTONOMOUS) COLLEGE, JAIPUR

(Affiliated to University of Rajasthan)

Syllabus

For

Bachelor of Science (Pass Course)

Subject: Microbiology

Session 2022-2024

SCHEME OF EXAMINATION AND COURSES OF STUDY

FACULTY OF SCIENCE

I. **Course Overview & Course Objectives**

B.Sc. Microbiology is a full-time undergraduate program which is of 6 semesters (**3-years**) duration. Microbiology is a foundation subject for Biotechnology, Genetic engineering, Molecular biology, Biochemistry, Bioinformatics and Medical Microbiology and hence holds the central position in the curriculum of these subjects. This course primarily focuses on the microorganisms and their applications in the field of Research.

Looking to the rapid inventions and technological developments in the field of Microbiology as well as keeping in view the recommendations of UGC, this syllabus has been formulated by the combined and coordinated efforts of all the faculty members of the Life Science Departments of College and University of Rajasthan. This course aims to provide students a detailed study of microorganisms with the help of scientific tools. Composition of Curriculum for a particular subject requires following criteria to be considered:

1. Guidelines and Model curriculum given by the UGC and the University.
2. Regional needs and Present National and International trends in the subject and its relationship with other related subjects.
3. Resources of Educational needs.

Timely review of the Curriculum to incorporate new knowledge and information is a prime criterion of IQAC–NAAC and primary need for the college educational systems. The units of the syllabus are well defined and the scope of each is given in detail. Microbiology being an experimental science, sufficient emphasis is given in the syllabus for training in laboratory skills and instrumentation.

Course Objective: Following objectives have been considered while formulation of the curriculum:

1. To provide an updated, feasible and modern syllabus to the students, with equal emphasis on Knowledge and skill, to build up their valuable college educational and job-oriented career.
2. To frame syllabus in accordance with the semester system and in consultation with all stakeholders.
3. To familiarize students with essential concept of basic techniques and their applications.
4. It is expected that the knowledge gained through this course will make students competent to meet the challenges of academic and professional courses.
5. To train the student in various aspects related to applied microbiology and medical microbiology.

B. Sc. Microbiology

Semester Structure: The details of the courses with code, title assigned is as given below.
Duration: 6 Semesters (3 Years)

Semester–I

33121: Paper - I: Cell Biology
33122: Paper - II: Introduction to Microbiology
33123: Paper - III: Microbial Diversity-I
33124: Practical: Based on Theory Papers

Semester II

33221: Paper - I: Microbial Diversity-II
33222: Paper - II: Bacteriology
33223: Paper - III: Analytical techniques
33224: Practical: Based on Theory Papers

Semester III

33321: Paper - I: Microbial Diversity-III
33322: Paper - II: Microbial Genetics
33323: Paper - III: Microbial Physiology
33324: Practical: Based on Theory Papers

Semester IV

33421: Paper - I: Molecular Biology
33422: Paper - II: Immunology
33423: Paper - III: Biochemistry
33424: Practical: Based on Theory Papers

Semester V

33521: Paper - I: Medical Microbiology
33522: Paper - II: Environmental Microbiology
33523: Paper - III: Recombinant DNA Technology
33524: Practical: Based on Theory Papers

Semester VI

33621: Paper – I: Fermentation Technology
33622: Paper – II: Food and Dairy Microbiology
33623: Paper – III: Soil and Agricultural Microbiology
33624: Practical: Based on Theory Papers

Semester Structure: The details of the courses with code, title assign are as given below.
Duration: 6 Semesters (3 Years)

B. Sc. Semester I

Max. Marks (Theory): 150
(Practical):75

Nomenclature			External Assessment	Internal Assessment	Total Max. Marks	Total Min. Marks
33121	Paper I	Cell Biology	35	15	50	20
33122	Paper II	Introduction to Microbiology	35	15	50	20
33123	Paper III	Microbial Diversity I	35	15	50 150	20
33124	Lab	Practical based on Theory Papers	45	30	75	

B. Sc. Semester -II

Max. Marks (Theory): 150

(Practical):75

Nomenclature			External Assessment	Internal Assessment	Total Max. Marks	Total Min. Marks
33221	Paper I	Microbial Diversity II	35	15	50	20
33222	Paper II	Bacteriology	35	15	50	20
33223	Paper III	Analytical Techniques	35	15	50 150	20
33224	Lab	Practical based on Theory Papers	45	30	75	

B. Sc. Semester -III

Max. Marks (Theory): 150

(Practical):75

Teaching Hours per week for each paper: 2 Hour

Nomenclature			External Assessment	Internal Assessment	Total Max. Marks	Total Min. Marks
33321	Paper I	Microbial Diversity III	35	15	50	20
33322	Paper II	Microbial Genetics	35	15	50	20
33323	Paper III	Microbial Physiology	35	15	50	20
					150	
33324	Lab	Practical based on Theory Papers	45	30	75	

B. Sc. Semester -IV

Max. Marks (Theory): 150

(Practical):75

Teaching Hours per week for each paper: 2 Hour

Nomenclature			External Assessment	Internal Assessment	Total Max. Marks	Total Min. Marks
33421	Paper I	Molecular Biology	35	15	50	20
33422	Paper II	Immunology	35	15	50	20
33423	Paper III	Biochemistry	35	15	50	20
					150	
33424	Lab	Practical based on Theory Papers	45	30	75	

B. Sc. Semester -V

Max. Marks (Theory): 150

(Practical):75

Teaching Hours per week for each paper: 2 Hour

Nomenclature			External Assessment	Internal Assessment	Total Max. Marks	Total Min. Marks
33521	Paper I	Medical Microbiology	35	15	50	20
33521	Paper II	Environmental Microbiology	35	15	50	20
33521	Paper III	Recombinant DNA Technology	35	15	50 150	20
33521	Lab	Practical based on Theory Papers	45	30	75	

B. Sc. Semester -VI

Max. Marks (Theory): 150

(Practical):75

Teaching Hours per week for each paper: 2 Hour

Nomenclature			External Assessment	Internal Assessment	Total Max. Marks	Total Min. Marks
33621	Paper I	Fermentation Technology	35	15	50	20
33622	Paper II	Food and Dairy Microbiology	35	15	50	20
33623	Paper III	Soil and Agriculture Microbiology	35	15	50 150	20
33624	Lab	Practical based on Theory Papers	45	30	75	

SEMESTER –I
PAPER-I: CELL BIOLOGY
Course Code: 33121

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit- I

Cell as a Basic unit of Living Systems: Discovery of cell,TheCell Theory**.** General characteristics of cell.Ultrastructure of prokaryotic and eukaryotic cell (both plant cell and animal cell). Plasma Membrane: Structural organization, concept of unit membrane and fluid mosaic model, functions of plasma membrane.Cell wall: structure and functions.

Unit –II

Cell Organelles (Structure, Function & Biogenesis): Endoplasmic reticulum, Golgi complex, Mitochondria, Chloroplast, Ribosomes, Lysosomes, Peroxisomes, Vacuole, Cytosol and Cytoskeleton structures (Microtubules, Microfilaments and Intermediate filaments).

Unit- III

Nucleus and Chromosomes: Nuclear envelope with nuclear pore complex (NPC), Nucleolus, Nucleoplasm and Chromatin.Chromosomes:Discovery, Morphology and structural organization- Centromere, Secondary constriction, Telomere, Chromonema, Euchromatin and Heterochromatin, nucleosome models.Special types of chromosomes:Salivary gland and Lampbrush chromosmes.

Unit- IV

Cell Cycle: An overview of cell cycle (Amitosis, Mitosis and Meiosis); Components of cell cycle control system; Intracellular and Extra-cellular control of cell division. Elementary idea about programmed cell death (Apoptosis).

Suggested Readings:

1. Karp, G. (2018). Karp's Cell Biology. Global Edition. Wiley Publication.
2. Alberts *et al.*,(2019). Essential Cell Biology 5th Edition, W.W. Norton & Company
3. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. 8thEdition. Lippincott Williams and Wilkins, Philadelphia.

4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C. Sinauer Associates, MA.
5. Rastogi, V.B. (2021). Cell Biology. Medtech Publication.

SEMESTER-I
Paper-II: INTRODUCTION TO MICROBIOLOGY
Course Code: 33122

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit-I

History and Scope of Microbiology: Biogenesis *vs*. abiogenesis (Spontaneous generation), Contributions of Anton Von Leeuwenhoek, Francesco Reddi, Spallanzani, John Needham, Louis Pasteur, Robert Koch (Germ Theory), Joseph Lister, Alexander Fleming.
Establishment in the field of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff and Edward Jenner. Applications and scope of Microbiology

Unit -II

Development of Microbial techniques: Concept of Sterilization- Definition, dry and moist heat sterilization, pasteurization, radiation, ultra sonication, filtration, Physical and chemical methods of sterilization, disinfection, sanitization, antisepsis, sterilants and fumigation.

Unit -III

Systems of classification: Binomial Nomenclature and classification, Whittaker's five kingdom scheme, Carl Woese's three domain classification systems.
Acellular microorganisms: General characteristics of Virus, Viroids, virusoids and Prions.

Unit -IV

Cellular microorganism: General characteristics(occurrence, morphology, mode of reproduction and economic importance): Bacteria, Protozoa, Algae, Fungi (Molds and Yeasts).

Suggested Readings:

1. Tortora, G.J. *et al.* (2019). Microbiology: An Introduction. 4th Edition. Pearson Publication
2. Sharma, P.D. (2019). Microbiology. Rastogi Publication.
3. Ananthanarayan, R. *et al.*,(2020). Textbook of Microbiology. 11th Edition. University Press (India) Pvt. Ltd.
4. Schlegel, H.S. *et al.*(2006). General Microbiology, 7th Edition, Cambridge University Press.
5. Pelczar, M.J. *et. al*.(2006). Microbiology. 5th Edition Tata Mc Graw Publication,

6. Stanier, R.Y., *et al*,(2000). General Microbiology, 5th Edition., Tata-McGraw Hill Publication.
7. Atlas, R.M. (1997). Principles of Microbiology, 2nd Edition. McGraw-Hill Publication.

SEMESTER-I
Paper-III: Microbial Diversity I
Course Code: 33123

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit --I

Bacteria: Bacterial shapes and arrangement, Internal structure-cell membrane, cell wall of bacteria, Nucleoid, ribosomes, mesosome. inclusion bodies, flagella, capsule, slime, fimbriae, and pili. Plasmid. Bacterial endospores-structure, formation and germination. Economic importance of Bacteria.

Unit -II

Archaebacteria: General characteristics, cell wall, phylogeny of Crenarchaeota (*Sulfolobus, Thermoproteus*) and Euryarchaeota [Methanogens (*Methanobacterium),* thermophiles (*Thermococcus*, *Pyrococcus*, *Thermoplasma*)] and Halophiles (*Halobacterium, Halococcus*).

Unit -III

The world of Bacteria-I: A brief outline of bacterial classification according to Bergey's manual of systematic bacteriology with salient features of the following:

Proteobacteria: alphaproteobacteria (Rickettsia), betaproteobacteria (Thiobacillus), Gamma-proteobacteria (*Pseudomonas, E.coli*), Delta-proteobacteria (*Myxococcus*) and Epsilon-proteobacteria (*Campylobacter*); Non proteobacteria; Gram negative bacteria (cyanobacteria, purple and green photosynthetic bacteria)

Unit -IV

The world of Bacteria-II: A brief outline of bacterial classification according to Bergey's manual of systematic bacteriology second edition (2004) with salient features of the following:
Gram positive bacteria: firmicutes (*Mycoplasma, Staphylococcus and Streptococcus*), Actinobacteria (*Streptomyces, Mycobacterium*), *Chlamydiae*, *Spirochaetes,*

Suggested Readings:

1. Madigan, M.T.*et al.*(2014). Brock's Biology of Microorganisms. 14th edition. Pearson International Edition

2. Cappucino, J.G. and Sherman, N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
3. Wiley, J.M. *et. al.*(2013).Prescott's Microbiology. 9th Revised Edition. McGraw Hill Higher Education.
4. Boone, D.R. and Castenholz R.W. (2012). Bergey's Manual of Systematic Bacteriology: Volume I: The Archaea and the Deeply Branching and Phototrophic Bacteria (Bergey's Manual of Systematic Bacteriology. Springer.
5. Jordan, E.O. (2010). A Text-Book of General Bacteriology. Nabu Press.
6. Parks, R. (2018). Textbook of Bacteriology. Syrawood Publishing House.

SEMESTER-I
MICROBIOLOGY PRACTICAL

Maximum practical Marks =75 marks
Internal marks = 30 Marks
External marks = 45 Marks
60 HOURS

1. Microbiology Good Laboratory Practices, demonstration of Laboratory rules, Basic requirements and bioafety measures in Microbiology laboratory.
2. Principles of fixation and various stains and staining techniques.
3. Explanation of principles and various methods of sterilization and cleaning of glass ware.
4. Microscopic Techniques :
    - Simple Microscope: Principle, parts & function, Operation.
    - Light microscopy: Principle, parts & function, Operation.
5. Study of a representative plant and animal cell by microscopy.
6. Study of the structure of cell organelles through electron micrographs.
7. Cell division: Mitotic and meiotic studies in onion root tips, grasshopper testes or flower Buds.
8. Preparation and staining of polytene chromosomes from Drosophila salivary gland.
9. Study of Buccal Epithelium.
10. Bacterial smear preparation.
11. Image analysis of different microbes.
12. Gram's staining.
13. Hanging drop technique demonstrating motility of Bacteria.
14. Sterilization principle & operations-
    - Autoclave
    - Hot Air Oven
    - Filtration
    - Laminar Air Flow
15. Instrumentation, Working Principle and Operation of-
    - Incubator and BOD Incubator
    - Shaker
    - Centrifuge
    - Colorimeter
    - Spectrophotometer

Semester-II
Paper-I: Microbial Diversity II
Course Code: 33221

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks.

Unit -I

Viruse: Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses and prions. Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses.Viral taxonomy: Classification and nomenclature of different groups of viruses.

Unit -II

Bacteriophage: General characteristics, morphology, life cycles, lytic and lysogenic phages (lambda phage) regulation of transcription in lambda phage.

Unit -III

Cyanobacteria: Introduction, general characteristics, reproduction and importance with special reference to genera *Nostoc* and *Oscillatoria.*

Unit -IV

Protozoa: General characteristic features with special reference to *Amoeba*, *Paramecium*, *Plasmodium* and *Euglena*

Suggested Readings:

1. Madigan, M.T. *et al.*,(2010). Brock's Biology of Microorganisms, 10th Edition,Pearson Education, Inc.
2. Singh, V. *et al.*,(2018). Microbiology and Phycology. 1st Edition. Rastogi Publication.
3. Alcamo, I.E. ((2001)). Laboratory fundamentals of microbiology, Jones and Barlett Publishers
4. Willey, J. *et. al*.(2017). Prescott's Microbiology, 6th Edition, Mc Graw Hill Companies,

5. Purohit, S.S. (2012). Microbiology: Fundamentals and Applications, 7th Edition, Student Edition Publication.
6. Sharma, P.D. (2019). Microbiology. Rastogi Publication.

Semester-II
Paper-II:Bacteriology
Course Code: 33222

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit –I

Growth of bacteria: Definition of growth, growthrate, generation time, growth curve, measurement of population growth, batch culture, continuous culture and synchronous growth, Factors affecting growth-Temperature, pH, Oxygen and water availability.

Unit –II

Control of Microorganisms: Physical agents - moist heat, dry heat, filtration, radiation. Chemicals as antimicrobial agents, major groups of disinfectants, antiseptics and chemical sterilants.

Unit –III

Cultivation of microorganisms: Microbiological media, Physical states and chemical content of media, general purpose and special purpose media. Nutrition based classification of Microorganisms. Isolation techniques (Streak plate, pour plate and spread plate method).

Unit –IV

Identification, Staining and preservation of microorganisms: Preparation of microorganisms for light microscopy- wet mount and hanging drop technique. Staining techniques- Simple staining, differential staining (Gram's staining, Acid fast staining, Endospore staining). Special staining techniques (Capsule staining and Flagella staining). Preservation of microorganismsby subculturing, overlaying culture with mineral oil, lyophilization, use of liquid nitrogen.

Suggested Readings:

1. Salle, A.J. (2007). Fundamental Principles of Bacteriology. Dodo Press Publication.
2. Dubey, H.C. (2019). A Textbook of Fungi, Bacteria and Viruses. Agrobios Publisher.
3. Holt, J.G. (1993). Bergey's Manual of Bacteriology 9th Edition. Wolters Kluwer Publisher.

4. Rohilla, A. (2010). Handbook of Bacteriology. Oxford Publisher.
5. Mondal, K.M. (2011). Plant Bacteriology. Kalyani Publishers.
6. Pelczar, M.J.*et al.*(2006). Microbiology 5th edition, Tata McGraw Publication.
7. Cappuccino, J.G. and Sherman, N. (2006). Microbiology-A Laboratory Manual, 6th edition, Addison Wesley, Pearson Education, Inc.
8. Tortora, G. J. (2007). Microbiology-an introduction, 9th edition Pearson Education, Inc.
9. Sequeira, M.G. (2019). An Introduction to Microbiology. New Age International Publishers.

Semester-II
Paper-III: Analytical techniques
Course Code: 33223

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit-I

Microscopy and Autoradiography: Principles and applications of Bright Field and Dark FieldMicroscopy, Fluorescent microscopy and Phase contrast microscopy.Electron Microscope-Principles and applications of Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM).

Unit-II

Centrifugaiton: Preparative and Analytical centrifuge, High speed, low speed and ultracentrifuge, differential and density gradient centrifuge. Rate zonal and Isopycnic centrifuge.Sedimentation velocity and sedimentation equilibrium, Factorsaffecting sedimentation coefficient.

Chromatography: Principle, instrumentation and applications of Adsorption chromatography, Paper chromatography and Thin Layer Chromatography (TLC), Ion-exchange chromatography,Affinity Chromatography.

Unit-III

Eletrophoresis: Basic principle andtypes of electrophoresis. Factors affecting electrophoretic migration- pH, voltage, supporting medium (agar, polyacrylamide, dextran), Technique and uses of Agarose gel electrophoresis, PAGE, SDS-PAGE, Two dimensional gel electrophoresis, Isoelectric focusing (IEF).

Unit-IV

Spectroscopy: Beer-Lambert law and its limitations.Basic design of photoelectric colorimeter and spectrophotometer. Applications of UV-Visible spectroscopic techniques. Flame Photometry. Atomic absorption spectrophotometry (AAS),Infrared and mass spectroscopy, Principle and applications of NMR and ESR techniques.

Suggested Readings:

1. Notting, B. (2009). Methods in Modern Biophysics, Springer Verlag Berlin Heidelberg New York,

2. Wilson, K. and Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology, 8th Edition. Cambridge University Press.
3. Narayanan, P. (2000). Essential's of Biophysics, New Age Int. Pub. New Delhi.
4. Chelamalla, R. (2019). Basic Principles and Practices in Analytical Techniques. Dreamtech Press.
5. Hames, G.G. (2005). Spectroscopy for the Biological Sciences. John Wiley & Sons Inc.
6. Khandpur, R.S. (2015). Handbook of Analytical Instruments. McGraw Hill Education.
7. Chaudhary, N. (2016). Instrumentation, Measurement and Analysis 4th Edition. McGraw Hill Education India Pvt. Ltd.
8. Nakra, B.C. and Chaudhary, K.K. (2017). Instrumentation measurements and analysisTata Mc Graw Hill)
9. Lodish, H. (2016). Molecular cell biology, Global Edition. W.H. Freeman and Co.

Semester-II
MICROBIOLOGY PRACTICAL

Maximum practical Marks	= 75 marks
Internal marks	= 30 Marks
External marks	= 45 Marks
	60 HOURS

1. Identification and study of Cyanobacteria (blue-green algae) - *Nostoc* and *Oscillatoria*.
2. Microscopic examination and study of free-living protozoa (*Amoeba*, *Paramecium* and *Plasmodium*) of a pond.
3. Identification of common morphological forms of bacteria through simple staining.
4. Negative staining for capsule, Flagella and endospore staining. Acid fast staining.
5. Demonstraion of serial dilution technique.
6. Media preparation and their types-liquid and solid media (PDA and NA).
7. Demonstration of culture inoculation techniques-spread plate, streak plate and pour plate method.
8. Demonstration of pure culture and inoculation techniques-isolation of microorganisms by streak plate. Spread plate and pour plate method.
9. Demonstration of bacterial growth curve.
10. Determination of size of a given microorganism using micrometry.
11. Demonstration of pH meter and determination of pH of a given sample.
12. Demonstration of centrifuge and separation of serum and cells from blood sample.
13. Demonstration of Gel electrophoresis.
14. Demonstration of paper chromatography.
15. Demonstration of Thin later chromatography.

Semester III
Paper-I: Microbial Diversity III
Course Code: 33321

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit -1

Algae-I (Phycology): General characteristics, Algal ecology and distribution, Thallus organization, Vegetative, asexual and sexual reproduction, Algae cell ultrastructure, pigments, flagella, food reserves. *Nostoc, Anabaena* and *Chlamydomonas.*

Unit-II

Algae II: Different types of life cycles: Haplontic, Diplontic, Haplobiontic, Diplobiontic and Diplohaplontic. Applications of algae in agriculture (as biofertilizer), Industry, Environment and food. Lichens -Structure, Types: Crustose, Fruticose and Foliose, Ascolichen, Basidiolichen, Deuterolichen. Economic Importance of lichen.

Unit -III

Fungi I (Mycology): General characteristics of fungi including habitat distribution, nutritional requirements, Thallus organization, Fungal cell wall structure, Asexual and sexual reproduction. Economic importance of fungi in agriculture, environment, Industry, medicine, food, biodeterioration and mycotoxins.

Unit-IV

Fungi II: Brief general account, structure, importance and life cycle of some important classes of fungi *viz.*Myxomycetes, Phycomycetes, Oomycetes, Zygomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes.

Suggested Readings:

1. Madigan, M.T. *et al.*,(2018). Brock's Biology of Microorganisms, Global Ed.Pearson Education, Inc.
2. Ananthanarayan, *et al.*,(2020). Ananthanarayan and Paniker's Textbook of Microbiology, 11th Edition, Universities Press (India) Pvt. Ltd.
3. Singh, V. *et al.*,(2018). Microbiology and Phycology. 1st Edition. Rastogi Publication.
4. Bilgrami, K.S. (2018). A Textbook of Algae, CBS Publisher.

5. Kumar. H.D. (1988). Introductory Phycology. Affiliated East-West Press Ltd., Newyork.
6. Singh, V. *et al.*,(2001). A Text Book of Botany. Rastogi and Co.
7. Vashishtha, B.R. and Sinha, A.K. (2016). Botany for Degree students Fungi. S. Chand and Company. NewDelhi.
8. Sharma, P.D. (2017). Mycology and Plant Pathology, Rastogi Publication.
9. Dubey, H.C. (2018). An Introduction to Fungi: 4th Edition. Rastogi Publication. Merrut.
10. Aneja, K.R. and Mehrotra, R.S. (2015). An Introduction to Mycology. New Age International Publishers.

Semester III

Paper-II: Microbial Genetics
Course Code: 33322

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit-I

General characteristics of Plasmids: Types of plasmids - F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmid. Yeast-2 μ plasmid, Plasmid-replication, incompatibility, plasmid amplification, copy number, Applications of Plasmids.

Unit -II

Gene transfer mechanisms in Bacteria: Recombination in bacteria- Site specific recombination, Holliday model for general recombination. Bacterial Transformation: Discovery, mechanism of transformation, Transfection.Transduction- Generalized transduction, specialized transduction, LFT & HFT lysates.Conjugation-Discovery, mechanism of conjugation, F+, F-, Hfr and F' strains.

Unit-III

Phage Genetics: Features of T4 genetics, Genetic basis of lytic *versus* lysogenic switch of phage lambda**.**

Transposable elements-I: Prokaryotic transposable elements –Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Phasmids, Cosmids.

Unit-IV

Transposable elements-II: Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds). Uses of Transposition, Barbara Mc. Clintok Experiment.

Suggested Readings:

1. Klug, W.S.*et al.* (2019). Concepts of Genetics, Global Edition, Pearson Publication.
2. Krebs, J.E.*et al.*,(2020). Lewin's Essential GENES, 4th Edition. Jones and Bartlett Publishers, Inc.
3. Pierce, B. (2016). Genetics: A Conceptual Approach, 4th Ed., W.H. Freeman Publisher.
4. Watson, J. *et al.*,(2022). Molecular Biology of the Gene.7th Edition. Pearson Publication.

5. Gardner, E.J.*et al.*,(2008). Principles of Genetics. 8th Edition. Wiley Publisher.
6. Russell, P.J. (2016).Genetics- A Molecular Approach. 3rd Edition, Benjamin Cummings
7. Gardener, E. J. (2005), Principles of Genetics, 8th edition, John Wiley and Sons Publications,
8. Krishnaiah, G.R. (2019). A Textbook of Microbial Genetics & Molecular Biology. Blue Rose Publishers.
9. Chaudhari, K. (2012). Microbial Genetics. The Energy and Resources Institute, TERI.
10. Maloy, S.R. *et al.*,(1994). Microbial Genetics, 2nd edition. Jones and Barlett Publishers, (1994).
11. Rajan, S.R. (2003). Microbial Genetics. Anmol Publication Pvt. Ltd

Semester III

Paper-III: Microbial Physiology
Course Code: 33323

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit-I

Nutritional requirements of Microorganisms- Autotrophs, Heterotrophs, Chemotrophs, Copiotrophs and Oligotrophs.

Transport Mechanisms- Osmosis, Plasmolysis, Diffusion-passive and Facilitated Diffusion, concept of uniport, symport and antiport, Active transport-Primary and secondary active transport, Group translocation. Role of ionophores.

Unit-II

Photosynthesis: Introduction to aerobic and anaerobic chemolithotrophy with example. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction).

Introduction to phototrophic metabolism-Photosynthetic micorbes, anoxygenicvs. oxygenic photosynthesis.Photophosphorylation, Calvin cycle.

Unit-III

Respiratory Pathways: Concept of aerobic respiration, anaerobic respiration and fermentation.Glycolysis, Oxidative pentose phosphate pathway, Entner-Doudoroff pathway, Krebs cycle, Electron Transport Chain (ETC), oxidative phosphorylation and substrate level phosphorylation. Fermentative pathways: Alcoholic and Lactic acid fermentation,Yeast fermentation, Acetic acid fermentation,

Unit-IV

Nitrogen Metabolism: Biological Nitrogen fixation in symbiotic and free living systems; nitrogen fixation; nitrification, denitrification and ammonifying bacteria; Pathway of nitrate assimilation, transamination and deamination reaction. Components of nitrogenase system.

Suggested Readings:

1. Watson, D. (2017). Microbial Physiology. Callisto Reference Publisher.
2. Cooper, E. (2018). Microbial Physiology: A Practical Approach. Callisto Reference Publisher.
3. Caldwell, D. R. (1995). Microbial Physiology and Metabolism. Brown Publishers.

4. Rajan, S. S. (2008). Microbial Physiology. Anmol Publication Pvt. Ltd.
5. Poole, R.K. (2011). Advances in Microbial Physiology. Volume 59. Academic Press.
6. Moat, A. G.*et al.*,(2009). Microbial Physiology, 4th Edition. John Wiley and Sons, Inc.
7. Powar, C. B. and Daginawala, H. F. (2010). General Microbiology Vol II Himalaya Publishing House.
8. Satyanarayana, U. (2017). Biochemistry. Elsevier India
9. Jain, J. L. and Jain, S. (2021). Fundamentals of Biochemistry. S. Chand Publication.

Semester III

MICROBIOLOGY PRACTICAL

Maximum practical Marks =75 marks
Internal marks = 30 Marks
External marks = 45 Marks
60 HOURS

1. Isolation and identification of blue-green algae from pond water.
2. Isolation and identification of algae from soil.
3. Study of algae by making suitable temporary slides of *Nostoc, Volvox,Chlamydomonas, Vaucheria, Ectocarpus, Polysiphonia.*
4. Isolation and identification of fungi from soil or spoiled food (bread)or from leaves, stems and other aerial parts of the plants.
5. Mushroom cultivation
6. Identification of edible and poisonous mushrooms.
7. Preparation of Master and Replica Plates
8. Study the effect of chemical (HNO2) and physical (UV) mutagens on bacterial cells
9. Study survival curve of bacteria after exposure to ultraviolet (UV) light
10. Demonstration of AMES test.
11. Production of alcohol.
12. Estimation of lactic acid in curd.
13. Estimation of ascorbic acid.
14. Isolation of *Rhizobium* from root nodules.
15. Plasmid Isolation from bacterial Culture.

Semester IV

Paper-I: Molecular Biology
Course Code: 33421

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit –I

DNA Structure and Replication: DNA as a genetic material, Structure of DNA, Types of DNA, Replication in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bidirectional replication, DNA polymerases, Okazaki fragments, Replication complex: Pre-priming proteins, primosome, replisome, Rolling circle replication.

Unit –II

Transcription: Types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA. Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, elongation and termination of RNA.Processing of pre-mRNA: 5' cap formation, polyadenylation, RNA splicing.

Unit –III

Translation & Regulation of Gene Expression: Genetic code and its characteristics, Prokaryotic and eukaryotic Translation: Ribosome structure and assembly, Charging of t-RNA, aminoacyl tRNAsynthetase, Mechanism of initiation,elongation and termination of polypeptide chain.Regulation of gene expression in prokaryotes (lac and Trp operon).

Unit –IV

Mutation, DNA Damage and Repair: Spontaneous and Induced mutations, Mutagens, mechanism of mutation, Forward and Reverse mutation, Transition, Transversion. Methods for mutant selection-direct selection, antibiotic selection, replica plating. Mechanism of DNA repair-photo reactivation, Nucleotide excision repair, mismatch repair.

Suggested Readings:

1. Elliot, D.C. and Elliott, W.H. (2005). Biochemistry and Molecular Biolgoy, 4thEdition, Oxford University press.
2. Malacinski, G.M. (2015). Freifeldersessentials of Molecular Biology, 3rd edition. Jones and Bartlett Publishers.

3. Malathi, V. (2012). Essential of Molecular Biology. 1st Edition, Pearson Education, India.
4. Karp, G. (2018). Karp's Cell Biology. Global Edition. Wiley Publication.
5. Alberts *et al.*,(2019). Essential Cell Biology 5th Edition, W.W. Norton & Company.
6. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. 8thEdition. Lippincott Williams and Wilkins, Philadelphia.
7. Buchanan, B.B. and Gruissem, W. (2015). Biochemistry and Molecular Biology of Plants. Wiley Publisher.
8. Wilson, K. and Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology, 8th edition. Cambridge University Press.
9. Hardin, J. *et. al*., (2017). Becker's World of The Cell. Pearson Publication.
10. Watson, J. D.*et. al*., (2022). Molecular Biology of the Gene 7th Edition. Cold Spring Harbour Lab. Press, Pearson Pub.

Semester IV
Paper-II: Immunology
Course Code: 33422

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks.

Unit –I

Immune system, cells and organs of immune system: Immunity; Definition,Types of Immunity-Innate and adaptive immunity, Innate v/s Adaptive immune response.Active and passive immunity, Hematopoiesis, Cells and organs of the immune system;B andT-lymphocytes, Macrophages, Dendritic cells, NK cells, Eosinophils, Neutrophils and Mast Cells. Structure and function of lymphoid organs (Primary and Secondary).

Unit –II

Antigen and Antibody: Antigenicity, Immunogenicity,antigen,immunogenand superantigens, Adjuvants, Haptens and epitopes.Antibody: structure and types.Immunoglobulins; structure, classification and functions, Antigen-antibody interaction;Precipitation, Agglutination,Neutralization, Opsination.Complement fixing test, ELISA, Radial Immunoassay (RIA) andhybridoma technology.

Unit –III

Antigen processing and Presentation: Structure, Types and Functions of Major histocompatibility complex (MHC) and Human leukocyte antigen (HLA). Immune cells; B and T-Cell Receptor, T-cell maturation, activation and differentiation. B-cell maturation, activation and differentiation.

Unit-IV

Diseases related to Immune system: Immunodeficiency diseases (AIDS), Autoimmune diseases: organ specific disease and systemic autoimmune diseases, Hypersensitive reactions,Transplantation immunology;Organ transplant (Allograft, Xenograft, Autograft), prevention of Graft rejection and Immunosuppressive drugs.

Suggested Readings:

1. Latha, P. M., (2012). A Textbook of Immunology, S. Chand Publication.
2. Punt, J. (2018). Kuby's Immunology. 8th Edition. W. H. Freeman Publisher.
3. Abbas. (2021). Cellular and Molecular Immunology, 10th Edition. Elsevier Publisher.

4. Chapel, H. *et. al*., (2014). Essential of Clinical Immunology, Wiley-Blackwell Publisher.
5. Ivan, M. R. and Peter J. D. (2001), Roitt's, Essential Immunology, 10th edition, Blackwell Science,
6. Sharma, P. and Kumar, P. (2021). Basics of Immunology, IP Innovative Pvt. Ltd.
7. Khan, F. H. (2009). The Elements of Immunology. Pearson Education India.

Semester IV
Paper-III: Biochemistry
Course Code: 33423

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks.

Unit –I

Chemical and Molecular Interaction: Chemical bonding: Ionic bond, covalent bond, hydrogen bond, Vander walls forces, Laws of thermodynamics.Interactions in biological systems:Properties of water,Intra and intermolecular forces, Electrostatic and hydrogen bonds, Disulfide bridges, Hydrophobic and hydrophilic molecules and forces, Water and weak interactions.pH and Buffers, Nature of biochemical reactions, Reversible and irreversible reaction.

Unit –II

Fundamentals of Carbohydrates: Classification, Basic chemical structure of monosaccharides(triose, pentose and hexose), Aldoses and Ketoses, Cyclic structure of Monosaccharides, Stereoisomerism, Anomers and Epimers.Disaccharidesand polysaccharides.

Lipids: General properties,Structure and Classification of major lipids (triacylglycerols, phospholipids, sphingolipids and sterols). Biological functions of lipids.

Unit –III

Amino acids: Classification, Physical and chemical properties, Polar and non polar amino acids, Essential and non-essential amino acids, Functions of amino acids.

Proteins: Peptide bond. Classification based on structure and functions, Primary, Secondary, tertiary and quaternary structure of proteins.Properties and biological importance of Proteins.

Unit –IV

Enzymes: Definition, Classification and Nomenclature of enzymes. Enzyme kinetics, factors influencing enzyme activity (Enzyme inhibition), Isozymes and Allosteric enzymes.Co-enzymes and co-factors.

Vitamins: Classification. Biochemical properties of water soluble and fat soluble vitamins.Vitamin deficiency diseases and Dietary sources. Functions of vitamins.

Hormones: Classification and their Functions (Steroid and Glucocortocoid hormones)

Suggested Readings:

1. Satyanarayana, U. (2021). Biochemistry, 6th Edition. Elsevier India

2. Jain, J. L. and Jain, S. (2021). Fundamentals of Biochemistry. S. Chand Publication.
3. Elliot, D.C. and Elliott, W.H. (2005). Biochemistry and Molecular Biology, 4th Edition, Oxford University press.
4. Wilson, K. and Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology, 8th edition. Cambridge University Press.
5. Lieberman, M. A. (2019). BRS Biochemistry, Molecular Biology and Genetics. Wolters Kluwer India Pvt. Ltd.
6. Voet, *et. al*.(2018). Voet's Principles of Biochemistry, Global Edition. Wiley Publication.
7. Nelson, D. L. and Cox, M. (2021). Lehninger Principles of Biochemistry: International Edition. W.H.Freeman & Co. Ltd.
8. Jain *et. al*., (2021). Basic Techniques in Biochemistry, Microbiology and Molecular Biology: Principles and Techniques. Humana Press.
9. Berg, J.M. (2019). Biochemistry, 9th Edition. W. H. Freeman Publishers.
10. Srivastava, H. S. (2007). Elements of Biochemistry, Rastogi Publication.
11. Jain, J.L. andJain. S. (2009). Fundamentals of Biochemistry,S. Chand publishers New Delhi.

Semester IV
MICROBIOLOGY PRACTICAL

Maximum practical Marks	=	75 marks
Internal marks	=	30 Marks
External marks	=	45 Marks

60 HOURS

1. Isolation of genomic DNA
2. Isolation of total RNA from yeast.
3. Estimation of DNA by diphenylamine.
4. Determination of RNA by orcinol method.
5. Preparation of restriction enzyme digests of DNA samples.
6. Properties of water, Concept of pH and buffers, preparation of buffers and Numerical problems to explain the concepts.
7. Quantitative test for proteins.
8. Identification of Blood Group and Rh factor.
9. Blood film preparation and identification of cells.
10. Counting of RBC and WBC by Hemocytometer.
11. Double diffusion/single diffusion.
12. Radial Immunodiffusion.
13. DOT- ELISA.
14. Widal test.

Semester V
Paper-I: Medical Microbiology
Course Code: 33521

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit- I

Beneficial and Harmful Microbial Interactions with Human: Introduction about Human Microbial Population, Normal microbial population of healthy human body- skin, mouth, upper respiratory tract, intestinal tract, urino-genital tract.

Mechanism of bacterial pathogenicity, Entry of pathogens into the host, colonization and growth. Virulence: Virulence factors- exotoxins, enterotoxins, endotoxins.

Unit- II

Epidemiology: The study of disease in population: Principles of epidemiology, reservoirs of pathogens, acquisition and transmission of infectious agents, Nosocomial infections, Measures for prevention of epidemics. Immunization program inIndia. Fungal diseases: Mycoses, mycotoxicoses.

Unit- III

Bacterial diseases: General idea of infections: symptoms, treatment and preventive measure of diseases caused by Gram positive bacteria: *Mycobacterium* (Tuberculosis and leprosy), *Corynebacterium* (Diphtheria).Gram negative bacteria: *Salmonella* (Typhoid), *Vibrio (cholera), Shigella (Dysentry), Neisseria* (Gonorrhea).

Unit- IV

Viral diseases

Animal viruses- life cycle, pathogenicity, diagnosis, prevention and treatment of RNA viruses- Picorna virus- Poliomyelitis; Orthomyxoviruses- influenza virues.

Paramyxoviruses- Mumps, Measles; retroviruses- HIV, Rabies virus.

DNA viruses- Herpes virus, Varicella zoster virus, Hepatitis viruses-HBV.

COVID-19 and its variants.

Suggested Readings:

1. Apurba, S.S. and Sandhya, B. (2020). Essentials of Medical Microbiology, Revised Edition. Jaypee Brothers Medical Publishers.
2. Murray, P.R. *et al*., (2020). Medical Microbiology. Elsevier Publisher.

3. Levinson, W.E. (2020). Review of Medical Microbiology and Immunology. 16th Edition. McGraw Hill Medical.
4. Morag, C. and Timbury, M.C. (1994). Medical virology-10th Edition.Churchill Livingstone,London.
5. Nester E.W. *et. al*., (1995). Microbiology A Human Perspective, McGraw-Hill Higher Edu. Pub.
6. Ananthnarayanan, R. and Paniker, C.K. J. (1997). Text book of Microbiology, Orient Longman.

SEMESTER-V

Paper II- Environmental Microbiology

Course Code: 33522

Max. Marks: 35

30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit- I

Microbiology of Air, Water and Soil: Microbial population of air, water (drinking and potable) and soil. Population interaction: Neutralism, Commensalism, Synergism, Mutualism, Competition, Ammensalism, Parasitism, and Predation.

Aeromicrobiology: aeromicrobiological pathway, microbial survival in air, extramural and intramural aeromicrobiology.

Unit- II

Terrestrial environment: microorganisms in surface soil, shallow and deep subsurface environment.

Biogeochemical Cycles: Carbon Cycle, Nitrogen Cycle, Sulphur Cycle, Phosphorus Cycle, Iron, heavy metals cycles. Hydrogen and Oxygen cycle.

Unit - III

Solid and Liquid Waste Disposal: Different types of liquid waste treatment: Primary, Secondary and tertiary treatment.Aerobic process – activated sludge, oxidation ditches, and trickling filters, Anaerobic Process – anaerobic digestion, anaerobic filters, up flow anaerobic sludge.Solid Wastes: Sources and management (Sanitary landfills, incineration, composting, vermiculture, methane production).

Unit - IV

Biodegradation and Bioremediation: Biodegradation of natural compounds (cellulose, hemicelluloses, lignin, starch, chitin), Biodegradation of environmental pollutants, Bioremediation of xenobiotics, Bioaccumulation and Biomagnification.

Suggested Readings:

1. Buckley, R. G. (2019). Environmental Microbiology. CBS Publisher.
2. Bolger, A. (2010). Environmental Microbiology. Oxford Book Company.
3. Varnam, A. and Evans, M.G. (2018). Environmental Microbiology. CRC Press.

3. Sharma, P.D. (2016). Environmental Microbiology, Rastogi Publication.
4. Singh, D. P. and Dwivedi, S.K. (2004). Environmental Microbiology and Biotechnology,
5. Ramesh, K. V. (2019). Environmental Microbiology. M.J.P. Publishers.
6. Mohapatra, P. K. (2006). Textbook of Environmental Biotechnology. I.K. International Publications, Mumbai.
7. Madsen, E.L. (2015). Environmental Microbiology: From Genomes to Biogeochemistry. Willey Blackwell Publications.
8. Maier, R.M. *et. al*. (2000). Environment Microbiology. Academic press an imprint of Elsevier(San Diego, San Francisco)

SEMESTER- V
Paper-III: Recombinant DNA Technology
Course Code: 33523

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit -I

Recombinant DNA Tools: Milestones in genetic engineering, Enzymes used in genetic engineering: Exonuclease, endonucleases-S1 nuclease,restriction endonuclease, DNA polymerases and DNA ligases, reverse transcriptase, Terminal deoxynucleotidyltransferase, kinases, alkaline phosphatases Use of linkers and adaptors.

Unit -II

Cloning Vectors: Definition,structure and Properties.Plasmid vectors: pBR^{322} and pUC^{18}, shuttle vector. Bacteriophage, lambda based vectors, Cosmids, BACs and YACs.

Unit -III

Methods in Molecular Biology

Transformation of DNA: Electroporation, Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and, *Agrobacterium* - mediated delivery.Southern blotting, Northern blotting, Western blotting and dot blot techniques

Unit-IV

DNA Amplification and DNA libraries

PCR: Basics of PCR, RT-PCR, Real-Time PCR

Genomic and c-DNA libraries: Preparation and uses, Screening of libraries: Colony hybridization

Applications and products of Recombinant DNA technology.

Suggested Readings:

1. Bangarwa, S.K. (2020). Plant Genomics and Recombinant DNA Technology. Jaya Publishing House.
2. Caligiuri, C. *et. al*., (2018). Recombinant DNA Technology, Amazon Asia-Pacific Holdings Private Limited.
3. Kumar, R.N. (2017). Encyclopedia of DNA Recombinant Technology, Agrotech Press.

4. Laware, S. L. and Sontakke, S.S. (2016). Recombinant DNA Technology. Vision Publication.
5. Brown, T.A. (2010). Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
6. Clark, D.P. and Pazdernik, N.J. (2009). Biotechnology: Applying the Genetic Revolution. Elsevier Academic Press, USA
7. Sandhu, S.S. (2010). Recombinant DNA Technology. I. K. International Publishing House Pvt. Ltd.
8. Primrose, S. B. and Twyman, R. M. (2008). Genomics: Applications in human biology. Blackwell Publishing, Oxford, U.K.
9. Wiley, J. M.*et al.*, (2008). Prescott, Harley and Klein's Microbiology. McGraw Hill Higher Education.

MICROBIOLOGY PRACTICAL V

Maximum practical Marks =75 marks
Internal marks = 30 Marks
External marks = 45 Marks
60 HOURS

1. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis
2. Ligation of DNA fragments
3. Amplification of DNA by PCR
4. Demonstration of Southern blotting.
5. Analysis of soil - pH, moisture content, water holding capacity, percolation, capillary action.
6. Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air.
7. Isolation of microbes (bacteria & fungi) from soil/air (28ºC & 45ºC).
8. Assessment of microbiological quality of water.
9. Determination of dissolve oxygen DO in pond water.
10. Determination of BOD of waste water sample.
11. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil.
12. Isolation of *Rhizobium* from root nodules.
13. Isolation of microorganism from dental carries.

Semester- VI
Paper-I: Fermentation Technology
Course Code: 33621

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit –I

Bioreactors: The fermentation industry, screening of industrially important microorganisms. Factors involved in Bioreactor design, design of a bioreactor, Types of Bioreactors.

Unit –II

Fermentation Process: Types of fermentation- batch, continuous, fed batch, surface, and submerged and solid state fermentation. Inoculum development, media formulation, scale-up. Process control.

Unit- III

Down Stream Processing and Product Recovery

Filtration, centrifugation, cell disruption, solvent extraction, precipitation, chromatography (gel filtration, ion exchange, affinity) membrane process (ultra filtration) and spray drying.

Unit –IV

Industrial Products Derived from Microorganisms

Antibiotic- Penicillin. Steroids, Vaccines. Production of organic acid- Acetic acid, Citric acid, Production of amino acids- Glutamic acid, Industrial alcohol and SCP and Mushroom cultivation.

Suggested Readings:

1. Casida, E. (2005). Industrial Microbiology, New Age International (P) Ltd. Publishers.
2. Reddy, S.M. (2017). Basic Fermentation Technology. New Age International Pvt. Ltd.
3. Kulandaivel, S. and Janarthanan, S. (2016) Practical Manual on Fermentation Technology. I.K. International Publishing House.
4. Aiyer, P.V.D. (2018). Basics of Fermentation Technology. Idea Publishing.
5. Schutzenberger, P. (2011). Fermentation. Read Books Publication.
6. Singh, T. (2016). Fermentation Technology. Agrobios (India) Publisher.

7. Weber, J. (2017). Fermentation: Science and Technology. Larsen and Keller Education.
8. Berenjian, A. (2019). Essential in Fermentation Technology. Springer Publisher.
9. Stanbury, P.F. and Whitaker, A. (2016). Principles of Fermentation Technology 3rd Edition. Butterworth-Heinemann Publisher.
10. Crueger, W. (2017). Cruegers Biotechnology: A Textbook of Industrial Microbiology. Medtech Publisher.
11. Thatoi, H. (2020). Microbial Fermentation and Enzyme Technology. CRC Press.

Semester- VI
Paper II-Food and Dairy Microbiology
Course Code: 33622

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit – I

Food as a substrate for micro-organisms: Importance of microorganisms in food microbiology; Molds, yeasts and bacteria- General Characteristics, Classification and importance.Principles of food preservation- Asepsis -Removal of micro organisms, anaerobicconditions- High temperature and Low temperature Drying, Food additives.Industrial Food fermentations:Introduction, food fermentation. Fermented foods (Soya sauce, bread, Sauerkraut, Idly), fermented beverages (Wine, Beer).

Unit – II

Food spoilage and Preservation: General Principle underlying spoilage: Chemical changes caused by micro organisms. Spoilage of different kinds of foods caused by micro organisms. (Cereals, sugar products, vegetables, fruits, meat, eggs, canned foods)**.** Food preservation by Radiations (UV, Gamma and microwave), Food preservation by low and high Temperature, Chemical preservation and naturally occurring antimicrobials.

Unit – III

Microbiology of Milk: Sources of Milk contamination and their control**.** Microbiology of raw and pasteurized milk, Biochemical changes in fermented milk. (Fermentation of lactose to lactic acid, hydrolysis of proteins and lipid).Study of spoilage organisms in dairy industry.Introduction to Probiotics.

Unit – IV

Industrial Dairy fermentations: Classification of various groups of microorganisms associatedwith dairy industry**.** Acid fermented milks (Yoghurt, Cultured butter milk).
Starter cultures for fermented dairy products (*Streptococcus thermophillus*, *Lactobacillus bulgaricus*).Cheese (Milk, microorganisms, enzymes and other additives). Cheese production: steps involved in manufacture of cheese, preservation, classification and nutritional aspects.

Suggested Readings:

1. Adams, M. R. and Moss, M. O. (2018). Food Microbiology. New Age International Private Limited.

2. Foster, W. M. (2020). Food Microbiology. C.B.C. Publisher.
3. Garg, *et. al*., (2020). Laboratory Manual of Food Microbiology. Dreamtech Press.
4. Frazier, C. W. (2016). Food Microbiology. McGraw-Hill Publisher.
5. Aneja, K. R. (2018). Modern Food Microbiology. Medtech Publisher.
6. Ray, A. B. B. (2017). Fundamental Food Microbiology. 5th Edition. Bibek Ray, Arun Bhunia Publishers.
7. Joshi, R. D. *et. al*., (2018). Dairy Microbiology and Technology. Oxford Book Company.
8. Osei, G. (2017). Handbook of Dairy Microbiology. Agri-Horti Press.
9. David, J. and Khalua, R.K. (2020). Basic Food and Dairy Microbiology. Ocean Publishing House.
10. Marth, E. H. and Steel, J. (2001). Applied Dairy Microbiology: Food Science and Technology. CRC Press.
11. Nader, G. (2020). Applied Dairy Microbiology. White Press Academic.
12. Ango, H. (2021). Applied Dairy Microbiology. Random Publishing UK Ltd.
13. Robinson, R.K. (2002). Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products. Wiley-Interscience Publisher.
14. Casida, L.E.J.R. (2019). Industrial Microbiology. 2nd Edition. New Age International Private Limited.

Semester- VI
Paper-III: Soil and Agricultural Microbiology
Course Code: 33623

Max. Marks: 35
30Hrs.

Scheme of Examination

There will be two parts in end semester theory paper. Part A of the paper shall contain seven short answer questions of 7 marks. Each question will carry one mark for correct answer. Part B of the paper will contain eight questions, out of which four questions are to be attempted from each unit with internal choice. Each question will carry 7 marks

Unit -I

Soil as habitat for microorganisms- Soil Quality, Physico-chemical Properties of Soil (Organic matter, soil, water and Air). Soil Microbes. Rhizosphere and Rhizoplane microorganisms. Factors affecting microbial community in soil.

Unit- II

Organic matter decomposition: Composition of litter(cellulose, hemicelluloses, ligninand proteins). Carbon assimilation and immobilization, microorganisms associated with organic matter decomposition, factors affecting decomposition.

Unit- III

Microbial inoculants, production of bacterial biofertiliser: Green manuring; algae and other biofertilisers; mass cultivation of cyanobacteria biofertiliser. Biofertilisers aiding phosphorus nutrients: production of mycorrhizal biofertilisers.

Unit -IV

Crop protection: Microbial herbicides; Bacterial insecticides*; Pseudomonas , Bacillus* sp. As bacterial insecticides; Virus insecticides; Entomopathogenic fungi- *Verticillium*, *Hirsutella.*

Suggested Readings:

1. Yogranjan, *et. al*., (2020). Essentials of Agricultural Microbiology. IP Innovative Publication Pvt. Ltd.
2. Subba Rao, N.S. (2020). Soil Microbiology. Oxford & IBH Publishing.
3. Vendan, R. (2021). Soil Microbiology. New India Publishing Agency NIPA.
4. Pareek, R.P. (2019). Agricultural Microbiology. Scientific Publishers (India).
5. Mishra, R.R. (2014). Soil Microbiology. CBS Publishers.
6. Nagamani, B. (2017). Soil and Agricultural Microbiology. Margham Publications.
7. Kumar, U. (2014). Soil and Agricultural Microbiology. Lakshi Publishers.

8. Prabhakaran, G. (2018). Introduction to Soil and Agricultural Microbiology. Himalaya Publishing House Pvt. Ltd.
9. Pareek, R.P. and Pareek, N. (2019). Agricultural Microbiology. Scientific Publishers (India).
10. Kumar, A. and Sharma, S. (2020). Microbes and Enzymes in Soil Health and Bioremediation: (Microorganism for Sustainability). Springer Link Publishers.
11. Aneja, K.R. (2017). Fundamental Agricultural Microbiology. New Age International Private Limited.
12. Trivedi, P. C. (2010). Agricultural Microbiology. Pointer Publishers.
13. Purohit, S.S. (2016). Principles of Agricultural Microbiology. Agrobios (India).
14. Paul, E.A. (2014). Soil Microbiology, Ecology and Biochemistry. Academic Press. Publisher.

MICROBIOLOGY PRACTICAL VI

Maximum practical Marks =75 marks
Internal marks = 30 Marks
External marks = 45 Marks
60 HOURS

1. Isolation of industrially important microorganisms
    a. amylase producing microorganism
    b. wine producing microorganism
    c. lipase producing microorganism
2. Isolation of antibiotic producing microorganism from fruits (Papaya).
3. Production of alcohol.
4. Estimation of lactic acid in curd.
5. Demonstration for utilization of sugars by oxidation and fermentation by microbes.
6. Methylene blue reductase time test for checking microbial quality of milk.
7. Isolation of milk fermenting organisms from milk.
8. Production of fermented food using microbial culture (sauerkraut production).
9. Isolation of Rhizosphere and rhizoplane microflora and their Identification.
10. Study of Mycorrhizal biofertilizer.
11. Study of Microbes that can be used as Biopesticides.
12. Industrial visit.