S.S. Jain Subodh P.G. College, Jaipur (Autonomous)

(Affiliated To University of Rajasthan, Jaipur)

SYLLABUS

Scheme of Examination and Courses of Study

M. Sc. Microbiology

Session 2022-23

FACULTY OF SCIENCE

DEPARTMENT OF MICROBIOLOGY

Masters of Science

Subject: Microbiology

Contents:

1. ELIGIBILITY:

10+2+3 with 55% from any recognized University in Science Stream in the concerned discipline/ CGPA of 3.5 in the UGC Seven Point scale. For candidates from outside state of Rajasthan 60% or CGPA of 4.0 in the UGC Seven Point Scale will be applicable irrespective of the category.

2. OBJECTIVES:

The objective of the course M.Sc. Microbiology is to impart knowledge of Microbiology to graduates of Biology with an emphasis on the world of microbes, their evolution to the present forms over time, their habitats and their co-existence with each other. Thus, knowledge of Microbiology is essential to experience the wonders of nature in the fullest. The program enhances students to take up emerging opportunities in Life Sciences, in fields like Aqua Culture, Fisheries, Nanotechnology, Medical Informatics and Environmental Management. Students are provided with requisite skills to take up research, teaching, entrepreneurship and other employment opportunities in Microbiology.

The main Goals and objectives of the course are: The Department stabs to achieve the overall goals and objectives of the college and also focuses on the following special departmental objectives:

- Provide quality education in natural science.
- Inculcate the spirit of resource conservation and love for nature.
- Motivate students for self-employment in applied branches of Microbiology.
- Equip the students for higher education.
- Impart value based education and makes them members of civil society and provide opportunities for professional and personal development through curricular and cocurricular activities.
- Conduct field studies - document biodiversity, water quality, soil profile etc. through student projects and faculty research, and Provide consultancy and organize extension activities.

About the Department:

The Department of Microbiology since its foundation is deeply committed to provide quality education with equal emphasis on holistic theoretical and practical learning for students ensures them the in depth understanding of forefront of microbiology. The Department houses advance instruments like ELISA Reader, PCR-thermocycler, cooling ultracentrifuges, LAF station, BOD Incubator, Spectrophotometer, UV transilluminator and fluorescence microscope, electrophoresis unit, digital colony counter etc. The mandates of the department are to shape microbiologists of excellent caliber with good technical and research skills with essential industrial visits and certified trainings to improve their employability in academia as well as industries. The department aims to place students in good positions in the marketplace, therefore attracts a large number of students looking at the vast scope of the subject. The students from this department are already employed in various National/International academic, research and industrial organizations. Considering modern microbiological approaches and applications, the curriculum is designed to enlighten the students in basics of Microbiology to advancements.

Department offers specialization in several major disciplines of Microbiology

- Genetic engineering, Genomics and Proteomics.
- Pharmaceutical and Clinical Microbiology.
- Biostatistics, Computer application and Bioinformatics.
- Fungal Biotechnology and Agriculture Microbiology.
- Research Methodology, Bioethics, Biosafety and IPR.
- Dissertation or Industrial Training.

Employment Opportunities

- Lecturer / Professor
- Clinical and veterinary microbiologists
- Biomedical professionals, Pharmacologists
- Food technologists
- Scientific/medical laboratory professionals
- Research scientists (life sciences)
- Environmental and Agriculture microbiologists
- Quality assurance technologists

3. SCHEME OF EXAMINATION:

S. No.	Paper	ESE	CIA	Total
1.	Theory	70%	30%	100
2.	Practical	60%	40%	100

Each theory paper syllabus is divided into four units. Each theory paper 3 hours duration. Each Practical /Lab work 6 hours duration

The number of papers and the maximum marks for each paper/ practical shall be shown in the syllabus for the paper concerned. It will be necessary for a candidate to pass in theory part as well as practical part of a subject separately.

Note: Maximum marks for a theory paper is 100 marks which include 70 marks for ESE and 30marks for internal assessment.

Examination Question Paper Pattern for all semester Exams

I- 08 Questions (very short answer questions. Any 7 from 8 questions) 7 x 2 Mark - 14
II- 04 Questions (1 question from each unit with internal choice) 4 x 14 Marks - 56
Total of End Sem. Exam - 70
Internal Assessment - 30
Maximum Marks - 100
Minimum Marks – 40

1. Each theory paper carries 100 marks. The internal assessment will be 30 marks and EoSE shall carry 70 marks. The EoSE will be of 3 hours duration. There will be a practical examination of 200 marks in all Semester.
2. There will be two parts in EoSE theory paper. Part A of theory paper shall contain 10 Short Answer Questions of 14 marks, based on knowledge, understanding and applications of the topics/texts covered in the syllabus. Candidate has to attempt seven questions out of 10 and each question will

carry two marks for correct answer.

3. Parts "B" of EoSE theory paper will consisting of four questions from each unit with internal choice of 14 mark each. The limit of answer will be five pages.
4. Each Laboratory EoSE will be of four hour durations and involve laboratory experiments/exercises/ Seminar presentation / Synopsis presentation/Project work or field study / Industrial Training/ consultancy training and viva-voce examination consisting of 200Marks.
5. The aim of Project work or field study /Research laboratories/ Hospital training is to introduce students to research methodology in the subject and prepare them for pursuing research in theoretical or experimental or computational areas of the subject. The project work or Field Study is to be undertaken under guidance jointly by Head of the Department and a senior faculty or a Scientist or any other suitable person with proven research excellence in the concerned field of study. Project work or field study /Hospital Training/ can also be taken up in an outside institution of repute Department. The guide will make continuous internal assessment of the Project work or field study/Hospital Training. EoSE for Project work or field study / Hospital Training and seminar will be held at department of the college by a board of three examiners consisting of HOD, two senior faculty of the department or expert from interdisciplinary department of the institution.
6. Supplementary/due paper/ special examinations will be resolute as per the institutions autonomous rules.
7. Grade/CGPA/percentage/division will be decided as per the autonomous guidelines of the institution.

4. SEMESTER STRUCTURE: M. Sc. Microbiology

The details of the course with code and title assign are as given below:

Semester I	**Paper Code**	**Name of Paper**
Paper I	MSMB101	General Microbiology
Paper II	MSMB102	Bioinstrumentation and Microbial Techniques
Paper III	MSMB103	Microbial Biochemistry and Physiology
Paper IV	MSMB104	Food and Dairy Microbiology
PR-I	MSMB151	*Based on Theory Papers (1 & 2)*
PR-II	MSMB152	*Based on Theory Papers (3 & 4)*
Semester II	**Paper Code**	**Name of Paper**
Paper I	MSMB201	Bacteriology
Paper II	MSMB202	Molecular Biology and Microbial Genetics
Paper III	MSMB203	Microbial Ecology
Paper IV	MSMB204	Medical Microbiology
PR-I	MSMB251	*Based on Theory Papers (1 & 2)*
PR-II	MSMB252	*Based on Theory Papers (3 & 4)*
Semester III	**Paper Code**	**Name of Paper**
Paper I	MSMB301	Virology
Paper II	MSMB302	Environmental and Agricultural Microbiology
Paper III	MSMB303	Genetic Engineering
Paper IV	MSMB304	Pharmaceutical Microbiology
PR-I	MSMB351	*Based on Theory Papers (1 & 2)*
PR-II	MSMB352	*Based on Theory papers (3 & 4)* Project /Seminar/Educational Tour
Semester IV	**Paper Code**	**Name of Paper**
Paper I	MSMB401	Immunology
Paper II	MSMB402	Industrial Microbiology
Paper III	MSMB403	Bioethics, Biosafety and IPR
Paper IV	MSMB404	Clinical Microbiology
PR-I	MSMB451	*Based on Theory Papers (1 & 2)*
PR-II	MSMB452	*Based on Theory papers (3 & 4) project/presentation /dissertation/Seminar /Educational Tour*

M. Sc. Microbiology course will be completed in two academic years; there will be two semesters in each year. The medium of instruction and examination shall be English only.

Semester–I

MSMB101 Paper I : General Microbiology

MSMB102 Paper II : Bioinstrumentation and Microbial Techniques

MSMB103 Paper III: Microbial Biochemistry and Physiology

MSMB104 Paper IV: Food and Dairy Microbiology

MSMB151 Lab 1 : Based on Theory Papers (1 & 2)

MSMB152 Lab 2 : Based on Theory Papers (3 & 4)

Semester–II

MSMB201 Paper I : Bacteriology

MSMB202 Paper II : Molecular Biology and Microbial Genetics

MSMB203 Paper III : Microbial Ecology

MSMB204 Paper IV : Medical Microbiology

MSMB251 Lab 1 : Based on Theory Papers (1 & 2)

MSMB252 Lab 2 : Based on Theory Papers (3&4)

Semester-III

MSMB301 Paper I : Virology

MSMB302 Paper II : Environmental and agriculture Microbiology

MSMB303 Paper III : Genetic Engineering

MSMB304 Paper IV: Pharmaceutical Microbiology

MSMB351 Lab 1 : Based on Theory Papers (1 & 2)

MSMB352 Lab 2 : Based on Theory Papers (3&4) /Project /Seminar/Educational Tour

Semester-IV

MSMB401 Paper I : Immunology

MSMB402 Paper II : Industrial Microbiology

MSMB403 Paper III : Bioethics, Biosafety and IPR

MSMB404 Paper IV : Clinical Microbiology

MSMB451 Lab 1 : Based on Theory Papers (1 & 2)

MSMB452 Lab 2 : Based on Theory Papers (3 & 4), project/Dissertation/Seminar/Educational tour etc

M. Sc. Semester –I

Max. Marks (Theory): 400 **(Practical): 200**

S. No.	Subject code	Nomenclature	Contact Hours Per Week			ESE Duration (Hours.)		EoSE Assessment			
			L	T	P	Theory	Prac.	Ext.	Int.	Min. Marks	Max. Marks
1	MSMB101	General Microbiology	4		0	3		70	30	36	100
2	MSMB102	Bioinstrumentation and Microbial Techniques	4		0	3		70	30	36	100
3	MSMB103	Microbial Biochemistry and Physiology	4		0	3		70	30	36	100
4	MSMB104	Food and Dairy Microbiology	4		0	3		70	30	36	100
5	MSMB151	*Practical-I*			6		6	60	40	40	100
6	MSMB152	*Practical-II*			6		6	60	40	40	100

M. Sc. II Semester

Max. Marks (Theory): 400 **(Practical): 200**

S. No.	Subject code	Nomenclature	Contact Hours Per Week			ESE Duration (Hours.)		EoSE Assessment			
			L	T	P	Theory	Prac.	Ext.	Int.	Min. Marks	Max. Marks
1	MSMB201	Bacteriology	4		0	3		70	30	36	100
2	MSMB202	Molecular Biology and Microbial Genetics	4		0	3		70	30	36	100
3	MSMB203	Microbial Ecology	4		0	3		70	30	36	100
4	MSMB204	Medical Microbiology	4		0	3		70	30	36	100
5	MSMB251	*Practical-I*			6		6	60	40	40	100
6	MSMB252	*Practical-II*			6		6	60	40	40	100

M. Sc. Semester –III

Max. Marks (Theory): 400 **(Practical): 200**

S. No.	Subject code	Nomenclature	Contact Hours Per Week			ESE Duration (Hours.)		EoSE Assessment			
			L	T	P	Theory	Prac.	Ext.	Int.	Min. Marks	Max. Marks
1	MSMB301	Virology	4		0	3		70	30	36	100
2	MSMB302	Environmental and agricultural Microbiology	4		0	3		70	30	36	100
3	MSMB303	Genetic Engineering	4		0	3		70	30	36	100
4	MSMB304	Pharmaceutical Microbiology	4		0	3		70	30	36	100
5	MSMB351	*Practical-I*			6		6	60	40	40	100
6	MSMB352	*Practical-II*			6		6	60	40	40	100

M. Sc. Semester- IV

Max. Marks (Theory): 400 **(Practical): 200**

S. No.	Subject code	Nomenclature	Contact Hours Per Week			ESE Duration (Hours.)		EoSE Assessment			
			L	T	P	Theory	Prac.	Ext.	Int.	Min. Marks	Max. Marks
1	MSMB401	Immunology	4		0	3		70	30	36	100
2	MSMB402	Industrial Microbiology	4		0	3		70	30	36	100
3	MSMB403	Bioethics, Biosafety and IPR	4		0	3		70	30	36	100
4	MSMB404	Clinical Microbiology	4		0	3		70	30	36	100
5	MSMB451	*Practical-I*			6		6	60	40	40	100
6	MSMB452	*Practical-II*			6		6	60	40	40	100

5. COURSE OUTCOME:

The student will have acquired substantial knowledge in several areas of microbiology by the time the degree is completed. The curriculum seeks to provide students with quality in education and skills so they may follow a profession of their choosing. This is done through stimulating academic advancement and intellectual growth. After completing a two-year M.Sc. in microbiology program, the students will have:

- Capability of explaining diverse Microbiology applications such as Environmental Microbiology, Industrial Microbiology, Food Microbiology, and Medical Microbiology.
- Current understanding of the many methodological and analytical techniques employed within the specialization.
- Develop abilities to communicate as well as experimentation and teamwork, creativity, strategy, and implementation.
- Fundamental knowledge in areas related to and important in microbiology (techniques, biostatistical analysis, computer operations and bioinformatics, scientific writing).
- Develop the capacity to carry out a comprehensive scientific work process autonomously, including theoretical background comprehension, hypothesis creation, gathering and analyzing data, and interpreting and presenting of results.
- Possess high levels of expertise, interdisciplinary project experience, and the capacity to contribute to a multidisciplinary team in the area of certain microbiology-related concepts.
- Ability to recognize health, safety, and environmental (HSE) concerns while handling chemicals and biological materials. They will be aware of how the action will affect the environment, makes risk assessments, and will be knowledgeable about safety guidelines in their field.
- Can participate in national-level competitive examinations like the NET-JRF or GATE or international exams like the GRE-TOEFL and pursue a career in higher education.

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Semester – I
Paper I
General Microbiology

Duration: 4 hrs. Per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- Knowledge about important microbiological discoveries and the various domain classifications of organisms
- Knowledge of the characteristics of prokaryotes (Eubacteria, Archaea, and Cyanobacteria) and eukaryotes (Algae, Fungi, and Protozoa) in general.

Learning outcome

- Students will be able to understand the evolution, diversity, and history of the microbial world and fundamental properties of microorganisms for classical and molecular characterization using current methods.
- Understanding the fundamentals of microbial structure, as well as the similarities and differences between different types of microorganisms, such as bacteria, archaea, cyanobacteria, algae, fungi, and protozoans.

UNIT-I

Historical development and Milestones of microbial world: Pioneers of microbiology and contribution of Anton Von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch, Martinus Beijerinck, Sergei Winogradsky, Alexander Fleming, Selman Waksman; Spontaneous generation controversy. Current thoughts on microbial evolution including the origin of life. Scope and relevance of microbiology. **(15 hours)**

UNIT-II

General introduction and overview of Microbial Evolution and Diversity. Microbial Taxonomy: General introduction and overview of Taxonomic rank. concept of numerical and polyphasic taxonomy. binomial nomenclature. Major characteristics used in Taxonomy-morphological, physiological and metabolic, biochemical, ecological, serological, and molecular characters (%G+C, nucleic acid hybridization, 16S rRNA sequencing). Phylogenetic tree. Outline classification of microorganisms- Whittaker's five kingdom classification, three domain system of classification. **(15 hours)**

UNIT-III

General characteristics of Microorganisms: Structural and functional comparison between prokaryotic and eukaryotic microorganisms.

General characteristic of Acellular infectious agent (viruses, prions, viroid, virusoids)

General characteristics: Bacteria, archaea and cyanobacteria.

General characteristics of protozoa. **(15 hours)**

UNIT-IV

Fungi: General characteristics and economic importance of fungi Morphology of some common fungi- *Saccharomyces cerevisae, Rhizopus, Penicillium and Agaricus*.

Algae: General characteristics of algae, Characteristics of diatoms and dinoflagellates. Economic importance of algae. **(15 hours)**

Suggested Laboratory Exercises:

1. Microbiology good laboratory practices and biosafety.
2. Light and compound microscope and its handling.
3. Common equipment's required in microbiology.
4. Preparation of bacterial smear.
5. Identification of various bacteria: Simple staining.
6. Identification of various bacteria: Gram staining.
7. Identification of various blue green algae and algae.
8. Identification of fungi by lactophenol cotton blue mounting and study of the cultural characteristics of various fungi.
9. Culture and identification of Yeast.
10. Microscopic examination and staining of free- living protozoa from pond water.
11. Permanent slides: From bacteria, fungi, algae and protozoans

**** Any other practical exercise as per theory syllabus.**

(a) Slides to be prepared for submission wherever possible.

(b) Photographs may be supplemented if slides are not available.

Suggested Readings:

- Aneja, K.R., Jain P. and Aneja, R. (2008). A textbook of basic and applied microbiology, New Age Int. Publications. New Delhi.
- Atlas, R. M. (1997). Principles of Microbiology, 2nd Edition. McGraw-Hill Publication.
- Berg, J. M. (2019). Biochemistry, 9th Edition. W. H. Freeman Publishers.
- Dubey, R.C. and Maheswari, D.K. (2000). General Microbiology. S Chand, New Delhi. Edition, Himalaya Publishing House, Mumbai.
- Holt, J.G. and Krieg, N.R. Sneath, P.H.A., Staley, J.T .and Williams, J.T. (1994) Bergey's Manual Determinative Bacteriology 9th Edition, Williams and Wilkins Co Baltimore, Springer.
- Nelson, D. and Cox, M.M. (2009) Principles of Biochemistry, W.H. Freeman & Company, New York.
- Pelczar, M. J., Chan, E.C.S. and Kreig, N.R. (1993). Microbiology.5th Edition, Tata McGraw Hill Publishing Co., Ltd., New Delhi.
- Powar, C.B. and Daginawala, H.F. (1986). General Microbiology Vol. I & II
- Prescott, M. J., Harley, J.P. and Klein, D.A. (2010). Microbiology 5th Edition, WCB McGraw Hill, New York.
- Reddy, S.M. and Reddy, S.R. (1998). Microbiology Practical Manual, 3rd Edition, Sri Padmavathi Publications, Hyderabad.
- Singh, R. P. (2007). General Microbiology. Kalyani Publishers, New Delhi
- Stanier, R.Y., Adelberg, E.A. and Ingram, J.L. (1991). General Microbiology, 5th Ed., Prentice Hall of India Pvt. Ltd., New Delhi.
- Talaro, K.P. and Talaro, A. (2006) Foundations in Microbiology, McGraw Hill Publications.
- Tortora, G.J., Funke, B.R. and Benjamin, C.L.C., (2008). Microbiology: An Introduction, Cummings Publishing Company.
- Wilson K. and Walker J. (2008). Principles and Technique of Biochemistry and Molecular Biology. 6th Edition Cambridge University Press.

Semester - I
Paper II

Bioinstrumentation and Microbial Techniques

Duration: 4 hrs per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- To enhance students' knowledge of microbial cultivation and control through chemical and physical methods and new methodologies commonly employed in current life science research.

Learning outcome

- In-depth knowledge of the microbiological techniques like microscopy, staining and microbial characterization by morphological, biochemical and molecular characters.
- Principles and instrumentation of centrifugation, chromatography, spectroscopy and electrophoresis.

UNIT-I

Basic principles and methods of sterilization and disinfection: Control of microorganisms by physical methods: heat, filtration and radiation; Chemical methods: phenolic, alcohols, halogens, heavy metals, aldehyde, quaternary ammonium compounds and sterilizing gases, Principles and functions of Laminar air flow hood (LAF), Autoclave, Oven.

Cultural characteristics: Types of culture media, preparation of medium, nutritional requirements for culture of bacteria, Method of isolation of pure cultures (Pour plate method, streak plate method and Spread plate method). **(15 hours)**

UNIT-II

Cultivation of bacteria: Aerobic and anaerobic cultivation; Cultivation of molds and Yeast; Cultivation and isolation of viruses; maintenance and preservation of culture: Short-term & long-term; Disposal of cultures.

Basic Principles of microbial cell staining: Gram, negative, Capsule, Flagella, Acid-fast and endospore staining.

Diagnostic tools in bacteriology- Biochemical techniques, serological (ELISA, Dot Blot) techniques, molecular tools used for microbial diagnostics (PCR, Blotting techniques. Molecular Markers: RAPD, RFLP, AFLP).) **(15 hours)**

UNIT-III

Microscopy: Principle and application of Light microscopy (Brightfield, Dark field, Phase contrast, fluorescence microscopy and confocal microscopy), electron microscopy (Scanning and transmission electron microscopy).

Centrifugation: Basic principles of sedimentation. Types of centrifuges: Preparative, analytical, high speed, low speed, ultracentrifuge, differential and density gradient centrifuge.

Spectroscopy: Beer-Lambert detections. Light absorption and transmission. Basic design and applications of colorimeter, UV-Visible, IR spectroscopy. **(15 hours)**

UNIT-IV

Chromatography: General principle of chromatographic separation. Principle and applications of paper and thin layer chromatography, gel filtration, ion exchange, affinity, HPLC, FPLC, Gas-liquid, and GC-MS.

Electrophoresis: Basics of electrophoresis: electrophoretic mobility and affecting factors, Biological applications and interpretation of different types of electrophoresis: PAGE (Native and SDS), Agarose Gel Electrophoresis, 2D Electrophoresis. **(15 hours)**

Suggested Laboratory Exercises:

1. Preparation of culture media (solid, liquid and agar slant).
2. Methods of sterilization.
3. Methods of Isolation of bacteria from different sources (air, water and soil) and microscopic examination and enumeration of bacteria.
4. Staining methods: spore staining, negative staining, flagella, capsule staining and acid fast staining.
5. Isolation and Identification of fungi from different sources (air, water and soil) and their microscopic examination.
6. Biochemical test for bacteria [sugar fermentation (glucose/sucrose/ lactose), IMViC test, catalase test].
7. Cultivation of anaerobic bacteria.
8. Methods of obtaining pure culture of bacteria (streak plate, pour plate, spread plate methods), Serial dilution Agar plate method.
9. Separation of cell components by centrifugation technique.
10. Agarose gel electrophoresis.
11. Perform SDS PAGE.
12. Identification of amino acids using thin layer chromatography (TLC).
13. Demonstration of Blotting techniques
14. Demonstration of DOT ELISA.

**** Any other practical exercise as per theory syllabus.**

Suggested readings:

- Aneja, K.R., Jain P. and Aneja, R. (2008). A textbook of basic and applied microbiology, New Age Int. Publications. New Delhi.
- Baird, R. M., Hodges, N. A., & Denyer, S. P. (2000). Handbook of Microbiological Quality Control in Pharmaceuticals and Medical Devices. CRC Press.
- Denyer, S. P., & Baird, R. M. (2006). Guide to Microbiological Control in Pharmaceuticals and Medical Devices, Second Edition. CRC Press.
- Wilson, K., & Walker, J. (2000). Principles and Techniques of Practical Biochemistry. Cambridge University Press.
- Upadhyay A., Upadhyay K. and Nath, N. (2016). Biophysical Chemistry, 4/e, Himalaya Publishing House, Mumbai.

Semester – I
Paper III
Microbial Biochemistry and Physiology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- The learning objectives of this course are to give the fundamental principles and specialised understanding of carbohydrates, lipids, proteins, enzymes, cellular transport, and metabolism.
- The course encourages students to focus a part of their future study to understanding biochemical and physiological mechanisms and applications.

Learning outcome

- Conceptual knowledge of proteins, lipids, carbohydrates etc,. Learn about microbe nutrition uptake and the numerous mechanisms utilised to transfer ions and chemicals in microbial cells. Understand microbial photosynthesis, aerobic, anaerobic, and fermentation respiration.
- Understand the fundamentals of microbial enzymology, such as the nature of enzymes, their nomenclature, working mechanism, classification based on action. Learn about the various parameters that influence enzyme activity.

UNIT-I

Nutrition and Transport: Concepts and nutritional categories of microbes. Transport of nutrients (diffusion, active transport, group translocation).

Brief account of carbohydrates: Classification, chemistry, properties, and function- mono, di, oligo and polysaccharides.

Lipids: Classification, chemistry, properties and function-free fatty acids, triglycerides, phospholipids, glycolipids & waxes. **(15 hours)**

UNIT-II

Amino acids: General properties and classification, structure and function. Essential amino acids & amphoteric nature of amino acids and reactions and functions of carboxyl and amino groups and side chains.

Proteins: Structural levels of proteins-primary, secondary, tertiary and quaternary, denaturation of proteins

Enzymes: Properties and classification of enzyme. Biocatalysis - induced fit and lock and key models. Coenzymes and Cofactors. Factors affecting catalytic activity. Inhibition of enzyme activity-competitive, noncompetitive, uncompetitive and allosteric. **(15 hours)**

UNIT-III

Bacterial Photosynthesis: Major groups of photosynthetic bacteria and their characteristic features, photosynthetic pigments, metabolism in photosynthetic bacteria, photosynthetic electron transport system; dark reaction; light reaction.

Bacterial Respiration: Aerobic and anaerobic respiration, glycolysis, tricarboxylic acid cycle, electron transport and oxidative phosphorylation, theories of ATP formation, phosphoketolase pathway, pentose phosphate pathway, gluconeogenesis and glyoxylate cycle. Fermentation of carbohydrates- lactic acid fermentation. **(15 hours)**

UNIT-IV

Nitrogen fixation in symbiotic and free-living system: Oxygen and hydrogen regulation of nitrogen fixation; nitrification, denitrification and ammonifying bacteria.

Sporulating bacteria: Architecture of spores, induction and stages of sporulation, Influence of different factors on sporulation. **(15 hours)**

Suggested Laboratory Exercises:

1. Qualitative analysis of Carbohydrates.
2. Qualitative analysis of lipids/protein and amino acids.
3. Colorimetric estimation of proteins by Biuret / Lowry method/ Bradford method.
4. Explain lambert beer law with help of spectrophotometer.
5. Preparation of buffers and adjustment of pH.
6. Effect of substrate concentration, pH, time and temperature on enzyme activity.
7. Isolation of photosynthetic bacteria.
8. Microbial degradation/ decolorization / adsorption of organic dyes.
9. Effect of UV, pH, temperature, disinfectants, and chemicals on microbial growth.
10. Demonstration of AMES test.
11. Separation of amino acid/ secondary metabolites by TLC.
12. Separation of plant pigments by Column chromatography.
13. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microbes.

**** Any other practical exercise as per theory syllabus.**

Suggested Reading:

- Caldwell, D.R. (1995). Microbial Physiology and Metabolism, W.C. Brown Publications, Iowa, USA.
- Cohen, G.N. (2011). Microbial Biochemistry, Second Edition, Springer Publishers
- David, W. (2000). Physiology and Biochemistry of Prokaryotes. 2nd Ed. Oxford University Press New York,
- Gerald K. (2007). Cell and Molecular Biology, Concept and Experiment, 5th Edition, Wiley.
- Harley, J.P. and Prescott, L.M. (2002). Laboratory Exercises in Microbiology. 5th Edition, The McGraw-Hill Companies
- L. Stryer, (2002). Biochemistry, 5th Edition, W.H. Freeman and Co.
- Moat, A.G. and Foster, J.W. (2002). Microbial Physiology, Wiley-Liss, A John Wiley & Sons, Inc. Publications.
- Nelson, D. L., Cox, M.M. (2004). Lehninger's Principle of Biochemistry. 4th Ed. Freeman.
- Prescott. Microbiology. 5th Ed. The McGraw−Hill Companies.
- R.K. Murray, D.K. Grammer, P.A. Mayes, V.W. Rodwell, (2000). Harper's Biochemistry, 25th Edition. Appleton and Lange.
- Rao, S. B. and Deshpande, V. (2007). Experimental Biochemistry: A student companion. I.K. International Pvt. Ltd.
- Roberts, K., Lewis J., Alberts B., Walter P., Johnson A., and Raff. M., (2008). Molecular Biology of the Cell, 5th Edition, Garland Publishing Inc.
- Tymoczko, J.L, Berg, J.M. and Stryer, L. (2012). Biochemistry: A short course, 2nd Ed., W.H. Freeman
- Voet, D., Voet, J.G., Pratt, C.W. (2004). Fundamentals of Biochemistry, 3rd Edition by John Wileyand Sons, New York.

Semester – I
Paper IV
Food and Dairy Microbiology

Duration: 4 hrs. Per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- Learn the principles of food and dairy microbiology as well as the features of good and hazardous microbes found in the food and dairy sources.
- To explore the potential use of fermented foods and food origin-probiotics in the future.

Learning outcome

- Understand the concepts of fermented foods, food deterioration, and foodborne infections. Learn about various food preservation options.
- Understand the concepts of popular milk products, milk examination, and spoiling and the usage and manufacturing of probiotics, prebiotics, and synbiotics, as well as the development and quality evaluation of starter cultures and fermented milk products.

UNIT-I

Basic concept of food Microbiology-Food spoilage: Types of food spoilage, microorganisms involved in food microbiology (molds, yeast, bacteria, virus, algae and protozoa), Different source of contamination in food, Food as a substrate for microorganisms and chemical changes caused by micro-organism in Food spoilage. Spoilage of vegetables, fruits, fish, poultry, milk and canned food. Factors influencing microbial growth in food- extrinsic and intrinsic factors.

Toxins: Bacterial toxins and mycotoxins. **(15 hours)**

UNIT-II

Food preservation: General principles of food preservation by physical and chemical method. Food Preservatives: Chemical and naturally occurring antimicrobial preservative.

Use of microbes in food: SCP, production of fermented food – sausages, sauerkraut, bread, tea, coffee. Food ingredients (flavor enhancer, food additives), Enzymes of microbial origin. **(15 hours)**

UNIT-III

Milk- Contents & their %; Microbiology of milk and milk processing; Microbiology of raw milk**,** Processed milk, Cream & butter, concentrated milk, flavoured milk & dried milk; Microbiology of ice cream & related products. Pasteurization

Starter cultures - Fermented milk, Therapeutic milk, Butter, Yoghurt, Soft cheese & hard cheese; Introduction to probiotics, prebiotics and synbiotics; Hazard Analysis. **(15 hours)**

UNIT-IV

Role of microbes in milk and dairy products; Microbiological examination of raw / pasteurized milk, standard plate count, direct microscopic count and reductase test, composition of milk, sources of contamination of milk, ability of milk to cause diseases.

Pathogens: *Arthrobacter spp*., *Bacillus cereus, Campylobacter spp., Clostridium botulinum, Clostridium perfringens, Escherichia coli, Salmonella spp, Staphylococcus aureus* & *Yersinia enterocolitica, Aspergillus spp., Fusarium spp., Mucor, Penicillin.*

Cleaning and sanitizing in milk production and processing: Control of microorganisms in dairy processing; Regulatory control of milk & dairy products; Treatment of dairy wastes. **(15 hours)**

Suggested Laboratory Exercises:

1. Bacterial contamination in milk.
2. Identification of bacteria in spoiled canned foods.
3. Determination of bacteria number: Direct microscopic count and plate count.
4. Study of casein hydrolysis in milk.
5. Isolation of casein from milk sample.
6. Determination of microbiological quality of milk sample by MBRT.
7. Identification of microbes in fermented milk.
8. Identification of microbes in curd/ buttermilk using staining.
9. Isolation and Identification of food spoilage microorganisms from bread / fruits /vegetables.
10. Preparation of fermented food & beverages: Sauer Kraut, Koji & Soya sauce.
11. Preparation of yogurt /dahi.
12. Sampling & analysis of microbial load on food contact surfaces.
13. Sampling and identification of food microorganisms such as *Lactobacillus/Aspergillus/E.coli* from the different food environments.

**** Any other practical exercise as per theory syllabus.**

Suggested reading:

- Adams M.R., Moss, M.O. (2007). Food Microbiology, 3rd edition Royal Society of Chemistry.
- Anelich, N. (2017). Methods in Food Microbiology, Agri-Horti Press.
- Britz, T. and Robinson, R. K. (2008). Advanced Dairy Science and Technology. Wiley Blackwell.
- Doyle, M.P., Diez-Gonzalez, F. and Colin, H. (2019) Food Microbiology: Fundamentals and Frontiers, Fifth edition, ASM Press.
- Elmer, H.M and James, S. (2001). Applied Dairy Microbiology. 2nd edition. CRC Press.
- Hawkins, R. (2022). Modern Food Microbiology, 1st Edition, Murphy & Moore Publishing.
- Jyoti Prakash Tamang and Kasipathy Kailasa pathy (2010). Fermented Foods and Beverages of the World. 1st edition, CRC Press.
- Matthews. K.R., Kalmia E. K and Montville, T.J. (2019). Food Microbiology: An Introduction, 4th Edition, ASM Press.
- Robinson, R.K. (2002). Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products. 3rdedition Wiley.
- Verma, D.K., Patel, A.R., Srivastav, P.P. Mohapatra, B. Niamah, A.K. (2021). Microbiology for Food and Health: Technological Developments and Advances, 1st edition, Apple Academic Press.
- William C. Frazier, Dennis C. Westhoff, N.M. Vanitha, (2017). Food Microbiology, 5th Edition, McGraw Education
- Yousef, A.E., Waite-Cusic, J.G., Perry, J.J. (2022). Analytical Food Microbiology: A Laboratory Manual, 2nd edition, Wiley.

Semester – II

Paper I

Bacteriology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- The major objective of the course is to establish a firm basis in the study of bacterial cell structure, reproduction, and cultivation.
- Identify different bacteria based on their distinctive characteristics into groups.

Learning outcome

- Describe the features of bacterial cells, cell organelles, the structure of the cell wall, and different appendages such capsules, flagella, and pili. Differentiate bacteria into categories like Archaea, Cyanobacteria, Magnetotactic Bacteria, Bioluminescent Bacteria, Chemolithotrophic Bacteria, etc., based on their distinguishing traits.
- Describe the nutritional needs of bacteria for growth; gain knowledge of how bacteria reproduce and their economic significance.

UNIT-I

Classification, Morphology and ultrastructure of bacteria: Bergey's Manual System of bacterial classifications. Size, shape and arrangement of bacteria, structure and chemical composition of cell wall of Gram Positive and Gram-Negative bacteria. Structure, composition and function of cell membrane, ribosome, capsule, flagella, pili, gas vesicle, cytoplasmic matrix, reserve food materials, nucleoid, plasmids. Endospore: structure and formation. . **(15 hours)**

UNIT-II

Archaeal diversity, cell structure and model organisms: Phylogenetic diversity and key features of different phyla. General characteristics of archaeal cell structure and comparison with eubacteria. Detailed account of methanogens, halophiles, thermophiles and extremophiles (acidophilic, alkaliphilic, barophilic). Model archaeal organisms*: Methanococcus, Halobacterium, Pyrococcus and Sulfolobus***. (15 hours)**

UNIT-III

Oxygenic photosynthetic bacteria (Cyanobacteria): Distribution, cell structure, nutrition, morphological diversity, and reproduction. Economic importance of cyanobacteria. *Nostoc, Oscillatoria*.

Anoxygenic photosynthetic bacteria: general characteristics of purple bacteria and green bacteria. **Magnetotactic bacteria-** General characteristics, Magnetosomes.

Budding bacteria, Gliding bacteria, Chemolithotrophs (hydrogen bacteria, iron bacteria, sulfur bacteria, nitrifying bacteria). Bioluminescent bacteria: mechanism of bioluminescence. . **(15 hours)**

UNIT-IV

Bacterial growth and reproduction: Growth curve, Growth kinetics, Batch, Continuous (chemostats and turbidostats) and Synchronous cultures. Factors influencing the growth of microorganisms (pH, temperature, oxygen concentration, pressure), Measurement of microbial growth. Modes of reproduction in bacteria. Economic importance of bacteria. . **(15 hours)**

Suggested Laboratory Exercises:

1. Preparation of selective and differential media.
2. Quantitation of viable cells in bacterial culture.
3. Micrometry of bacterial cells.
4. Bacterial cell counting by hemocytometer.
5. Study of bacterial growth curve.
6. Observation of bacterial motility: Hanging drop method.
7. Permanent slides: Bacteria and Cyanobacteria.
8. Determination of microbial population growth by spectrophotometer.
9. Effect of different factors-temperature & pH on bacterial growth.
10. Preservation of bacterial cultures by various techniques.
11. Isolation of Cyanobacteria from soil/ paddy field/pond water.
12. Preparation of culture medium and isolation of halophiles and thermophiles.

**** Any other practical exercise as per theory syllabus.**

Suggested Readings:

- Baron, S. (1996). Medical Microbiology. 4th edition, Galveston (TX).
- Brown, A. (1996) Benson's Microbiological Applications Complete Version. (Kindle edition).
- Lehmann, K.B. (2015) Atlas and Principles of Bacteriology and text-Book of Special Bacteriologic Diagnosis. (Karl Berhard) Andesite Press.
- Morrey, C.B. (2019) The Fundamentals of Bacteriology, Good Press Publisher.
- Pelczar, M. J., Chan, E.C.S. and Kreig, N.R. (1993). Microbiology.5th Edition, Tata McGraw Hill Publishing Co., Ltd., New Delhi.
- Powar, C.B. and Daginawala, H.F. (1986). General Microbiology Vol. I & II
- Prescott, M. J., Harley, J.P. and Klein, D.A. (2010). Microbiology 5th Edition, WCB McGraw Hill, New York.
- Snyder, L. Peters, J.E. Henkin, T.M. and Champness, W. (2007). Molecular Genetics of Bacteria. 4th edition. ASM Press.
- Talaro, K.P. and Talaro, A. (2006). Foundations in Microbiology, McGraw Hill Publications.

Semester – II

Paper II

Molecular Biology and Microbial Genetics

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- This course aims to introduce the student to advanced ideas in molecular biology and genetics.
- To comprehend the structure of genetic material i.e., DNA, and RNA. to teach students about the fundamentals of DNA replication transcription and translation and genetic recombination.

Learning outcome

- Students will have an overall understanding of the replication, transcription, and translation processes in prokaryotes and eukaryotes. They will study prokaryotic regulation of gene expression.
- Understanding of the transformation, transduction, and conjugation and are able to define various plasmid or extrachromosomal element types as well as the characteristics of transposable elements and about concepts of mutation.

UNIT-I

DNA and RNA as genetic material: Structure and biochemistry of DNA and RNA, Forms of DNA (A, B, C, D, T and Z), General properties of double stranded DNA and RNA. Denaturation, Renaturation, super helicity in DNA.

DNA Replication: Enzymes involved in DNA replication and DNA replication in prokaryotes and eukaryotes.

Extra chromosomal genetic elements-Plasmids (nature, properties and replication) and transposons (Types of bacterial transposons and their applications). **(15 hours)**

UNIT-II

Transcription (Enzymatic Synthesis of RNA): *E. coli* RNA polymerases, Classes of RNA molecules, processing of t-RNA and r-RNA in *E. coli,* Prokaryotic transcription; chain initiation, chain elongation, chain termination, RNA turnover, Transcription in Eukaryotes. Post transcriptional modification.

Translation: Ribosome, Genetic code and Wobble hypothesis, Translation in Prokaryotes and eukaryotes; charging of t-RNA, initiation of polypeptide synthesis, elongation of polypeptide chain and termination of polypeptide chain. Post translation modification. **(15 hours)**

UNIT-III

Regulation of gene expression in bacteria: Operon Concepts-Negative and positive control of the Lac Operon, Trp operon. Poly and Mono cistronic m-RNA.

Mutations: spontaneous and induced mutation, Types of Mutagens- Physical and Chemical mutagenic agents: UV, Ethidium Bromide and Nitrous oxide. Molecular basis of mutations**:** base substitution, frame shifts; base addition, base deletion, transposition, inversions, tandem duplications, insertions. Mechanism of mutation at DNA level. Outlines of DNA damage and repair mechanisms. **(15 hours)**

UNIT-IV

Bacterial recombination: transformation, transduction, Conjugation.

Bacterial transformation- Competency and resistance. Transduction- transduction phenomenon, methods of transduction, co-transduction, generalized, specialized and abortive transduction, sex-ductions. Bacterial conjugation- Sex factor in bacteria, F and HFR transfer, linkage mapping. **(15 hours)**

Suggested Laboratory Exercises:

1. Isolation of genomic DNA from *E. coli* and Yeast.
2. Study of effects of UV as mutagens on microbes.
3. Replica plating technique.
4. Study of different types of DNA and RNA using micrographs and model/ schematic representations.
5. Estimation of DNA using UV-spectrophotometer.
6. Induction of mutations in bacteria by UV light.
7. Demonstration of PCR technique.
8. Perform bacterial transformation, transduction and conjugation.
9. Isolation of plasmid DNA.

**** Any other practical exercise as per theory syllabus.**

Suggested Reading:

- Freifelder, D. (1997). Microbial Genetics. Narosa Publishing House, New Delhi.
- Gellison, G. and Verlag, V.C.H. (2004). Production of Recombinant Proteins: Novel Microbial and Eukaryotic Expression Systems, Eiley-VCH Verlag GmbH &amp Co.
- Glick, B.P. and Pasternack, J. (1998). Molecular Biotechnology, ASM Press, Washington D.C., USA.
- Lewin, B. (2000). Genes VIII. Oxford University Press, England.
- Ram Reddy, S., Venkateshwarlu, K. and Krishna Reddy, V. (2007) A text Book of Molecular Biotechnology. Himalaya Publishers, Hyderabad.
- Sambrook, J. and Russell, D.W. (2001). Molecular Cloning: A Laboratory Manual Vol. 1, 2 and 3. Cold Spring Harbor Laboratory Press.
- Sinnot, E.W., Dunn,L.C. and Dobzhansky, T.(1958). Principles of Genetics. 5thEdition. McGraw Hill, NewYork.
- Smith, J.E. (1996). Biotechnology, Cambridge University Press.
- Snyder, L. and Champness, W. (1997). Molecular Genetics of Bacteria. ASM press.
- Strickberger, M.W. (1967). Genetics. Oxford & IBH, New Delhi.
- Trun, N and Trempy J. (2004). Fundamental Bacterial Genetics, 1st edition; Blackwell Science Publishers.
- Verma, P.S. and Agarwal, V.K. (2004). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand & Co. Ltd., New Delhi.
- Watson, J.D. Tania A. B, Stephen, P.B, *et al.* (2013). Molecular Biology of the Gene, 7th Edition Benjamin Cummings publishers.

Semester – II
Paper III
Microbial Ecology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- To comprehend fundamental ideas in microbial ecology and to interpret different ecological and evolutionary principles.
- To bring focus on the variety and quantity of pathogens that can be present in soil, water and air. To outline main preventative and monitoring measures that maintain and enhance soil, water, and air quality in terms of microbes. To introduce indicator bacteria specially in water quality monitoring.

Learning outcome

- Understand the fundamental ideas behind microbial ecology, including biotic and abiotic influences, positive and negative microbial interactions, etc.
- Microbes involved and biochemical mechanisms of Carbon, Nitrogen, Phosphorus cycles etc. and to learn about the variety of microorganisms and their quantity, distribution, and importance in the ecology.

UNIT-I

Concept of ecosystem: Biotic and abiotic environment, Composition and structure of environment. Concept of biosphere, communities and ecosystems. Ecosystem characteristics, structure and function. Liebig's law of Minimum, Shelford's law of Tolerance, Food chains, food webs and trophic structures. Ecological pyramids, Ecological succession, Concepts of microcosms and econiches. Microbial biofilms. **(15 hours)**

UNIT-II

Interactions among microbial population: Interaction within a single microbial population (positive and negative), Interaction between diverse microbial population (Neutralism, mutualism, antagonism, competition, commensalisms, amensalism, synergism, parasitism, and predation. Gause's and Hardin's principles of competition. quorum sensing bacteria. Lichens.

Beneficial interactions of microbes with animals: Rumen microbiology, digestion, fermentation and detoxification by microbes, factors influencing rumen microbes.

Beneficial interactions of microbes with plants: Rhizosphere, rhizoplane, siderophore, Mycorrhizae: classification and significance. **(15 hours)**

UNIT-III

Role of microbes in biogeochemical cycles: Carbon cycle, Nitrogen Cycle, Phosphorus cycle, Sulphur cycle, Iron and Manganese cycle. Environmental impact of biogeochemical cycles. **Eutrophication:** causes of eutrophication and microbial changes in eutrophic bodies of water induced by various inorganic pollutants. Effect of eutrophication on the quality of water environment, factors influencing eutrophication, Algae in eutrophication, algal blooms, their effects and toxicity. **(15 hours)**

UNIT-IV

Microorganism in the ecosystem (air, soil and water): Factors affecting microbial community in soil, soil microflora: distribution and contribution to ecosystem. Organic matter decomposition, Microbiology of the deep subsurface. Microorganism in fresh and marine ecosystem. Air microflora.

Assessment of air quality for microbial loads: Brief account of airborne transmission of microbes- viruses - bacteria and fungi, their diseases and preventive measures. Aeroallergy and Aeroallergens.

Microbial assessment of water quality: Disinfection of potable water, microbes as bio-indicators, Brief account of major water borne diseases and their control measures, treatment of municipal water. **(15 hours)**

Suggested Laboratory Exercises:

1. Isolation and identification of air borne microbes-Indoor & outdoor.
2. Isolation and identification of soil microflora.
3. Determination of soil texture and Humic acid.
4. Isolation and identification of microbial flora of water.
5. Soil microbes' interaction *invitro* by dual culture method.
6. Isolation, identification and enumeration of Rhizosphere and Rhizoplane microorganisms.
7. Isolation of *Rhizobium* from roots of leguminous plant.
8. Study of microbial slides as per syllabus.
9. Isolation of *Rhizobium sp*. from root nodules of leguminous plant.
10. Microscopic/ photographic observation of lichen symbiosis.

**** Any other practical exercise as per theory syllabus.**

Suggested Readings:

- Agate, A.D. (1982). Basic Principles of Geo microbiology, tv1ACS, Pune.
- Atlas R.M. and Bartha R. (1998). Microbial Ecology: Fundamentals and Applications.4th edition, Benjamin/ Cummings.
- Barton L. L. and Northup D. E. (2011). The Microbial Habitat: An Ecological Perspective. Wiley.
- Bertrand J-C., Caumette, P., Lebaron P., Matheron R., Normand P. and Sime -Ngando T. (2015). Environmental Microbiology: Fundamentals and Applications. Microbial Ecology. Springer, Netherlands.
- Forster, C.F. and Wase, D.A.J. (Eds.) (2001). Environmental Biotechnology. Ellis Harwood Ltd. Publication. Longman Inc California.
- Harley, J.P. and Prescott, L.M. (2002). Laboratory Exercises in Microbiology. 5th Edition, The McGraw-Hill Companies.
- Kirchman, D. L. (2018). Processes in Microbial Ecology. Oxford University Press, USA.
- Madigan M.T., Martinko JM, Dunlap PV, Clark DP (2014). Brock Biology of Microorganisms, Prentice Hall, USA.
- Maier R.M., Pepper1.L.and Gerba C.H., (2009). Environmental Microbiology. Academic Press.
- Mitchell, R. (1992). Environmental Microbiology. John Wiley &Sons.
- Oladale (2005) Microbial Diversity. Blake well Publishing.
- Osborn, M. and Smith C. (2005), Molecular Microbial Ecology. Taylor & Francis. Press, Elsevier.
- Trivedy, R. K. (1998) Advances in Waste Water Treatment Technologies. Volumes I and II, Global Science Publication.
- Wicket, L. P. and Hershberger, C. D. (2000). Biocatalysis and Biodegradation: Microbial transformation of organic compounds.ASM Publications.

Semester – II
Paper IV

Medical Microbiology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- The goal of this course is to teach students about the numerous characteristics that make microorganisms pathogenic or disease-causing.
- To increase knowledge about various diseases in terms of diagnosis, prevention, and control.

Learning outcome

- Developed a thorough understanding of common bacterial, viral, and fungal diseases.
- Understood the basic and general concepts of causation of disease by the pathogenic microorganisms.
- To learn the epidemiology and pathogenesis, lab diagnosis and treatment of different infectious microbes.

UNIT-I

Normal Microbial flora of human body: Normal microbial flora in human skin, mouth, upper respiratory tract, intestinal tract, urogenital tract & eye) and its role. Pathogenic properties of bacteria-Colonization, invasion, production of toxins: exotoxins & endotoxins); Antimicrobial defenses of host; Cellular mechanisms of antimicrobial agents; Pathogenesis of viral infections; Principles of classification of medically important microorganisms. **(15 hours)**

UNIT-II

General characteristics, morphology, growth, pathogenicity, laboratory diagnosis and therapy of pathogenic bacteria: *Pneumococci, Neisseria,* Enteric bacilli, *Pseudomonas* and other non-fermenting bacilli, *Hemophilus, Bordetella, Clostridia, Mycobacteria, Actinomycetes, Rickettsia, Mycoplasmas, Shigella, Vibrio & Yersinia.* Sexually transmitted diseases caused by bacteria, *Treponema pallidum.*

(15 hours)

UNIT-III

Structure, Reproduction, Pathogenicity, Diagnosis, Therapy and Epidemiology of disease caused by Fungus: *Cryptococcus neoformans, Blastomyces dermatitidis, Trichophyton, Microsporum* spp. *Histoplasma, capsulatum, Coccidioides immitis***,** *Candida albicans, Aspergillus fumigates, Phycomycetes, Sporothrix schenckii, Eumycotic Mycetoma* **(15 hours)**

UNIT-IV

Properties, Pathogenesis, Laboratory diagnosis, Epidemiology, Control & Treatment of virus: Herpes virus (*R. simplex, R. zoster, Epstein-Barr viruses),* Pox viruses, Picorna viruses, Adeno viruses & Rubella virus. Multiplication, Pathogenesis and Oncogenic activity: (a) Oncogenic DNA viruses (Papovaviruses-Papilloma viruses, Hepatitis B virus, Oncogenic Herpes viruses); (b) Oncogenic RNA viruses (Lentivirus, HIV, Primate and Human type C oncovirus). **(15 hours)**

Suggested Laboratory Exercises:

1. Laboratory rules and regulation in Pathological laboratory.
2. Various techniques of sample collections.

3. Techniques for transfer of clinical specimens & selection of primary culture media, Interpretation of culture.
4. Identify bacteria - *E. coli, Pseudomonas, Staphylococcus*, *Bacillus* using laboratory strains on the basis of cultural, morphological and biochemical characteristics.
5. Isolation of bacterial flora of skin by swab method.
6. Perform antibacterial activity using antibiotics.
7. Study of symptoms of the diseases with the help of photographs: Anthrax, Polio, Herpes, chicken pox, HPV warts, Dermatomycoses (ringworms).
8. Study of various stages of malarial parasite in RBCs using permanent mounts.
9. New laboratory technologies for detection of infectious diseases.

**** Any other practical exercise as per theory syllabus.**

Suggested Reading:

- Baron, S. (1996). Medical Microbiology, 4th ed. Galveston (TX).
- Brooks, G.F., Carroll, K.C., Butel, J.S., Morse, S.A. and Mietzner, T.A. (2013). Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. Mc Graw Hill Publication.
- Cossart, P., Boquet, P., Normark, S., Rappuoli, R. (2005). Cellular Microbiology by 2nd edition. American Society for Microbiology Press.
- Delves, P. Martin, S. Burton, D. Roitt, I.M. (2006). Roitt's Essential Immunology.11th ed. Wiley-Blackwell Scientific Publication, Oxford.
- Goldsby, R.A., Kindt, T.J., Osborne, B.A. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
- Hacker, J. and Dorbindt, U. (2006). Pathogenomics: Genome analysis of pathogenic microbes ed. Wiley- VCH.
- Ryan, K.J. and Ray, C.G., Eds. (2004). Sherris Medical Microbiology. 4th Edition, McGraw-Hill, New York.
- Murray, P.R., Rosenthal, K.S. and Pfaller, M.A. (2005). Medical Microbiology. 5th Edition, Elsevier Mosby, Philadelphia.
- Salyers, A.A. and Whitt, D.D. (2002). Bacterial Pathogenesis: A molecular approach, eds. American Society for Microbiology Press, Washington, DC USA.
- Willey, J.M., Sherwood, L.M., and Woolverton, C.J. (2013). Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education.

Semester – III
Paper I
Virology

Duration: 4 hrs. per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- The course will aid in the study of molecular virology by examining common processes and principles in viruses to demonstrate viral complexity and to comprehend viral reproduction.
- It will also provide opportunity for a student to build diagnostic abilities in virology.

Learning outcome

- Students can learn about virus structure, nucleic acid, replication capsid symmetry, isolation, and cultivation.
- Understanding about the biology of bacteriophages and gained knowledge of some common plant and animal diseases caused by different viruses, viruses transmission and control.
- Understand about the viral diagnosis techniques.

UNIT-I

Introduction to virology: Discovery of viruses, Nomenclature and classification of viruses, General characteristics of viruses, morphology and ultrastructure; capsids and their arrangements, types of envelops and its composition, viral genomes: its type and structure, replication of viruses, cyanophages and mycoviruses. Cultivation of viruses: Growth of viruses in embryonated eggs, cell cultures, primary and secondary cell lines. **(15 hours)**

UNIT-II.

Bacteriophages: Structural organization, multiplication cycle, eclipse phase, phage production, burst size, lytic and lysogenic cycle with special reference to T4, Q x174 and M13 phage. Bacteriophage typing, application in bacterial genetics and uses. **(15 hours)**

UNIT-III

Plant viruses and Animal viruses: Classification and nomenclature, disease symptoms, histology, physiology and cytology of plants. Diagnostic techniques and transmission of plant viruses.

Animal viruses: ICTV (International Committee on Taxonomy of Viruses). Baltimore system of classification, families of animal viruses, Human viruses, life cycle, pathogenicity, diagnosis and treatment of viruses. RNA viruses and DNA viruses. **(15 hours)**

UNIT-IV

viral diagnosis and serology: Serological methods- hemagglutination, complement fixation. Assay of viruses: Physical and chemical methods of assay (protein, nucleic acid and radioactive tracers), infectivity assay of plant viruses and animal viruses (plaque method, end point method). **(15 hours)**

Suggested Laboratory Exercises:

1. Study of isolation of phage from different soil samples using laboratory bacterial cultures (*Staphylococcus*, *Bacillus*).
2. Study of plant virus - TMV.
3. Study of plant virus - CaMV.
4. Study of animal viruses.

5. Study of retroviruses.
6. Study of cultivation and preservation of phages.
7. Symptomatic observations / slides of plant viral infections.

**** Any other practical exercise as per theory syllabus.**

Suggested Reading:

- Cann, A.J. (1997). Principles of Molecular Virology. 2nd edition, Academic Press, California.
- Carter, J. and Saunders, V. (2007). Virology; Principles and Applications,1st edition, John Wiley & Sons.
- Conrat, H.F., Kimball, P.C. and Levy, J.A. (1988). Virology. 2nd edition, Prentice Hall, Englewood Cliff, New Jersey.
- Dimmock, N., Easuton, A. and Leppard, K. (2005) Introduction to ModemVirology.5thedition, Blackwell Publishing.
- Dimmock, N.J. and Primrose, S. B. (1994). Introduction to Modern Virology. 4th edition, Blackwell Scientific Publications, Oxford.
- Flint, S.J., Enquist, L.W., Krung, R.., Racaniello, V.R. and Skalka, A.M. (2004), Principles of Virology. ASM Press.
- Granoff, A. and Webster, R.G. (1999). Encyclopedia of Virology. Volume I, II and Ill, San Diego Academic Press.
- Hull, R. (2002). Plant Virology. 4th Edition, Academic Press.
- Knipe, D.M. and Howley, P.M. (2006). Fields Virology. Lippinocott - Raven, Philadelphia, USA.
- Luria, S.E. (1978). General Virology. 3rd edition, Jhon Wiley and Sns. New York.
- Parker, T., Lerline, M., Collier H., (1990) Principles of Bacteriology, Virology and Immunity. 7th Edition.
- Ram Reddy, S. and Reddy S.M. (2007) Essentials of Virology Scientific Publishers (India) Jodhpur.

Semester – III

Paper II

Environmental and Agricultural Microbiology

Duration: 4 hrs. Per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- To familiarize students with the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers.
- Introduce students to general principles and subject knowledge in environmental and agricultural microbiology

Learning outcome

- Developed a thorough grasp of the diverse roles of microorganisms in soil, when combined with plants, and hence in agriculture. Students will gain advanced knowledge on Waste Management treatment and to make students aware of the negative consequences of cultural heritage paper, leather, wood, textile etc.
- Completion of the course will give an overview of relevant use of microbial biofertilizers and biopesticides and sustainably minimize damage from pests or increase agricultural productivity and production.

UNIT-I

Biodegradation and Bioremediation: Microbial degradation of herbicides, pesticides, hydrocarbons including polycyclic (petroleum & polychlorinated biphenyls etc.), oil spills, heavy metals. Biodeterioration of buildings and monuments of cultural heritage, microbial deterioration of paper, leather, wood, textile, paints and metals corrosion. GMO and their impact, microbial plastics. **(15 hours)**

UNIT-II

Waste water treatment: Primary, secondary and tertiary treatment, Anaerobic treatment, Advanced waste water treatment for removal of suspended solids, nutrients (N&P), Oil and grease. Solid waste disposal (sanitary landfills and compositing).

Techniques in environmental microbiology: Methods for determination of numbers, biomass and activities of microbes in soil, water, plant surfaces and dead organic materials; Bioremediation techniques: *in situ* (Bioventing, air sparging, liquid delivery system) and *ex situ* (land farming, compositing, biopiling and slurry-phase), Monitoring of environmental process with biosensors and biological indicators.

(15 hours)

UNIT-III

Microbial biofertilizers and biopesticides: bacterial biofertilizer (*Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium* and *Frankia*). Cyanobacterial biofertilizers (*Anabaena, Nostoc*) Mycorrhizal biofertilizers and their importance in agriculture. Algal and other biofertilizers**.**

Production of microbial herbicides and microbial pesticides: bacterial insecticides, viral insecticides, entomo pathogenic fungi & microbial nematodes. Commercial production of bio-pesticides with reference to *Bacillus thuringiensis.* **(15 hours)**

UNIT-IV

Disease forecasting and basic principles of plant disease control: Pathology, etiology and control of economically important crop diseases of wheat (Rust, smut), paddy (Blast), barley (Smut), bajra (Ergot), maize (Downy mildew), sugarcane (Red rot), potato (Late blight and early blight) caused by fungi. Management and storage of agricultural products, post harvest diseases, their prevention and control.

Microbial diseases of arm animals (Anthrax, fowl cholera), their prevention and control. **(15 hours)**

Suggested Laboratory Exercises:

1. Isolation of *Azotobacter* from soil.
2. Observation and description of any three bacterial and fungal plant diseases
3. Testing for microbial sanitary quality of water (coliform test).
4. Determination of Biological Oxygen Demand (BOD) of waste water samples.
5. Enumeration of soil microorganisms (bacteria, actinomycetes, fungi) by standard plate count.
6. Microbial degradation of organic pollutants and their effect on soil microbial activity.
7. Isolation of cellulose decomposing microbes and estimation of cellulase activity
8. Physico-chemical testing of soil and waste water.
9. Study of microbes utilized in composting.
10. Study of diseases of arm animal (any two).
11. Slides as per Syllabus.

**** Any other practical exercise as per theory syllabus.**

Suggested Readings:

- Agrios, G.N. (1997). Control of Plant Diseases. In: Plant Pathology, 4th Edition, Academic Press, San Diego.
- Atlas, R.M. and Bartha, R. (2000). Microbial Ecology: Fundamentals and Applications. 4th edition, Benjamin/Cummings Science Publishing, USA.
- Baker, K.H. and Herson, D.S. (1994). Bioremediation, McGraw Hills Inc., NY.
- Christen, J.H. (2001). A Manual of Environmental Microbiology. ASM Publications.
- Cook, R.J. and Baker K.F., 1983, The Nature and Practice of Biological Control of Plant Pathogens. America Phyto pathological Society Press, St. Paul, MN.
- Cooper, J.E. and Rao, J.R. (2007). Molecular Approaches to Soil, Rhizosphere and Plant Microorganism Analysis. CABI Publication.
- Coyne, M.S. (2001). Soil Microbiology: An Exp Laboratory Approach. Delmar Thomson Learning.
- Dickinson, M. (2003) Molecular Plant Pathology. BIOS Scientific Publishers, London.
- Dubey, R.C. and Maheswari, D K. (1999). Textbook of Microbiology, S. Chand & Co.
- Evans, G.M. and Furlong, J.C.(2011). Environmental Biotechnology- Theory and application. Wiley-Blackwell.
- Forster, C.F. and John, D.A.(2000). Environmental Microbiology, Ellis Horwood Ltd. Publications.
- George, N.A. (1997) Plant Pathology. 4thedition, Academic Press, New York.
- Mitchel, R. (2009). Environmental Microbiology, 2nd Edition, Wiley-Blackwell.
- Okafor, N. (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York.
- Pepper, I., Gerba, C.P. and Brusseau, M.L. (2006) Environmental and Pollution Science, Academic Press, USA.
- Rittmann, B.E and McCarty, P.L.(2001). Environmental Biotechnology: Principles and Applications (McGraw-Hill Education)
- Singh, A., Kuhad, R.C. & Ward, O.P. (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg.
- Subba Rao, N.S. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi

Semester – III
Paper III
Genetic Engineering

Duration: 4 hrs. Per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- The goal of this course is to familiarise students with contemporary techniques for manipulating/analyzing DNA, RNA, and proteins.
- To understand various vectors, techniques involved in rDNA technology.

Learning outcome

- Will be familiar with the use of various cloning vectors, and methods of DNA, RNA and protein analysis and about the methods on gene transfer and screening of recombinants.
- Understand the principles and applications of advanced molecular technique.

UNIT-I

Basics of recombinant DNA technology: Enzymes used in recombinant DNA technology: Nuclease, DNA ligase, polymerase, reverse transcriptase, terminal deoxy-nucleotidyl transferase, alkaline phosphatase; Modification of restriction fragment ends: Sticky and blunt end ligation with linkers & adapters and homo-polymer tailing. . **(15 hours)**

UNIT-II

Cloning vectors: Properties of plasmids, yeast plasmid (YAC), binary & shuttle vectors, bacteriophages, cosmids, bacterial artificial chromosomes; Ti based vectors, Expression of vectors -use of promoters and expression cassettes; Bacculo virus as expression vector, retroviruses; Isolation and purification of genomic and plasmid DNA; Gene libraries: Genomic library, screening of libraries (shot gun approach) & cDNA library. . **(15 hours)**

UNIT-III

Introduction of recombinant vectors and screening of recombinants: Introduction of recombinant vectors into bacterial and nonbacterial cells; Selection of recombinant clones; Colony hybridization, Plaque hybridization, immunochemical methods.

Applications of genetic engineering: Scientific, medical, industrial, agricultural and environmental applications; mechanism of CRISPR-CAS technology & application; Human genome project. **(15 hours)**

UNIT-IV

Polymerase chain reaction (PCR): Basic principle, components of PCR, PCR techniques: Standard PCR, Inverse PCR, reverse transcriptase mediated PCR, Anchored PCR, Asymmetric PCR & Real time PCR, PCR for mutagenesis;

Molecular DNA sequencing: Dideoxy method (Sanger sequencing), Chemical degradation (Maxam-Gilbert method); Strategies for sequencing large DNA fragments; Automated sequencing and pyro sequencing.

Molecular markers- Types and applications, DNA chip technology, microarrays, Brief description of Probes: Types; RFLP, AFLP and RAPD; Southern, Western and Northern blotting. . **(15 hours)**

Suggested Laboratory Exercises:

1. Isolation of bacterial genomic DNA.
2. Visualization and documentation of bacterial genomic DNA using gel doc system.
3. Restriction digestion and ligation of bacterial genomic DNA.
4. Recovery of genomic DNA embedded in Agarose gels (freeze squeeze, column).
5. Amplification of DNA by PCR techniques.
6. Plasmid preparation from *E.coli.*
7. Analysis of Plasmid on agarose gel electrophoresis.
8. SDS-PAGE-Bacterial proteins.
9. Demonstration of Southern hybridization technique.

**** Any other practical exercise as per theory syllabus.**

Suggested Readings:

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2007). Molecular Biology of the Cell, 5th Edition, Garland Science, New York and London.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2008). Biochemistry, 5th Edition, Freeman W.H. and Company New York, USA, Biology of the Gene, 6th Edition, Benjamin Cummings, San Francisco, USA.
- Brown, TA. (2010). Gene Cloning and DNA Analysis, An Introduction. 6th edition. (6th ed.) John Wiley & Sons Ltd
- Glover, D.M. and Hames, B.D. (1995). DNA Cloning: A Practical Approach. IRL Press at Oxford University Press, Oxford.
- Lewin, B. (2007). Gene IX, Jones and Bartlett Publishers, Sudbury, Massachusetts.
- Sambrook, J. and Russell, D.W. (2001). Molecular Cloning: A Laboratory Manual. 3rd Edition, Vol. 1, Cold Spring Harbor Laboratory Press, New York
- Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., Losick, R., and CSHLP, I. (2007). Molecular biology of the gene, 6th ed. Pearson/Benjamin Cummings; Cold Spring Harbor Laboratory Press, San Francisco; Cold Spring Harbor, N.Y.
- Weaver, R.F. (2007). Molecular Biology, 4th Edition, McGraw Hill, New York, USA.

Semester – III
Paper IV
Pharmaceutical Microbiology

Duration: 4 hrs. Per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- This course is intended to provide a fundamental and in-depth understanding of major pharmaceutical microorganisms, microbiological methods used in the pharmaceutical business, and pharmaceutical products created via the use of microorganisms in order to teach pharmaceutical professionals.
- To promote development of entrepreneurship and build up Professionals in Pharmaceutical Analysis, teaching and R&D work.

Learning outcome

- Get hands-on knowledge of disinfection, sterilization, microbial assays, pharmacopoeia standards and antimicrobial agents with an overview of Microbial production and Spoilage of Pharmaceutical Products
- Will have knowledge about Regulatory practices and applications in Pharmaceuticals and Antimicrobial chemotherapeutic Agents.

UNIT-I

Microbes and pharmaceuticals: Introduction, importance, scope of pharmaceutical microbiology; Role of pharmaceutical microbiologist. Antibiotics and synthetic antimicrobial agents (Aminoglycosides, f3 lactams, tetracyclines, annamycin, macrolide antibiotics); Antifungal antibiotics; Antitumor substances; Peptide antibiotics; Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents; Chemical disinfectants, antiseptics and preservatives. . **(15 hours)**

UNIT-II

Mechanism of action of antibiotics: Inhibitors of cell wall synthesis, nucleic acid and protein synthesis, bacterial resistance to antibiotics; Molecular principles of drug targeting; Drug delivery system in gene therapy; Mode of action of non-antibiotic antimicrobial agents; Penetrating defenses-how the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion). **(15 hours)**

UNIT-III

Microbial production and Spoilage of Pharmaceutical Products: Pharmaceuticals produced by microbial fermentations (Streptokinase, Streptodornase); microbial contamination & spoilage of pharmaceutical products (sterile injectibles, non injectibles, ophthalmic preparations and implants) and their sterilization; Macromolecular, cellular and synthetic drug carriers; New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines and Vaccine clinical trials.

(15 hours)

UNIT-IV

Regulatory practices and applications in pharmaceuticals: Elementary idea of IP, BP and USP; Government regulatory practices and policies and FDA perspective; Rational drug design; Regulatory aspects of quality control; Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification; sterilization control and sterility testing (heat sterilization, D value, Z value, survival curve, Radiation, gaseous and filter sterilization), Chemical and biological indicators. **(15 hours)**

Suggested Laboratory Exercises:

1. Identification and cultivation of pharmaceutically relevant Bacteria and Fungi
2. Microbial cell count by serial dilution and pour plate Technique
3. Perform qualitative test for primary metabolites carbohydrate, proteins, lipids,
4. Perform qualitative test for secondary metabolites flavonoids and alkaloids
5. Isolation and enumeration methods of microbes
6. Isolation of identification of secondary metabolites from microbes/plants by TLC.
7. Methods of microbial strain preservation
8. To determine MIC method.
9. Sterility testing by *Bacilluss tearothermophilus.*
10. Sampling of pharmaceuticals for microbial contamination and load (syrups, suspensions, creams and ointments, ophthalmic preparations).

**** Any other practical exercise as per theory syllabus.**

Suggested Readings:

- Coulson, C.J. (1994). Molecular Mechanisms of Drug Action (2nd ed.). CRC Press.
- Denyer, S. P., Hodges, N. A., & Gorman, S. P. (2008). Hugo and Russell's Pharmaceutical Microbiology. John Wiley & Sons
- Hanlon, G., and Hodges, N. A. (2012). Essential Microbiology for Pharmacy and Pharmaceutical Science. John Wiley & Son
- Kar, A. (2020). Essentials of Pharmaceutical Microbiology, Second edition, New Age International
- Prasad, G.P. and Srisailam, K. (2019). Pharmaceutical Microbiology: A Laboratory manual, Pharma med.
- Ryan, K. and Ray, C. G. (2004). Sherri's Medical Microbiology: An Introduction to Infectious Diseases. 4th edition. McGraw-Hill Medical.
- Sandle, T. (2015). Pharmaceutical Microbiology: Essentials for Quality Assurance and Quality Control, 1st edition, Wood head Publishing Pharmaceutical Microbiology, 8th edition Wiley-Blackwell Publication Press Private Limited.
- Shanson, D. C. (1989). Microbiology in Clinical Practice. John Wright.
- Sood, R. (2004). Medical Laboratory Technology Methods and Interpretations. Jaypee Brothers Medical Publishers (P) Ltd. New Delhi.
- Sydney H. Willin, Murray M. Tuckerman, William S. Hitchings IV, Good Manufacturing practices of pharmaceuticals, second Ed., Mercel Dekker NC New York.

Semester – IV
Paper I
Immunology

Duration: 4 hrs. Per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two mark for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- This course provides an overview of the immune system, covering its cells, organs and receptors, antigen-antibody interactions and to combine immunology with health and to improve understanding of autoimmune diseases and allergic reactions.

Learning outcome

- Learn about the source and method of infection. antigens, antibodies and their functions in the immune system, learn about the range of antibodies.
- Conceptualized the protective mechanisms underlying the immune system and its response to pathogenic microorganisms with theoretical knowledge of various diseased conditions generated due to interplay of immune system components.

Unit-I

Historical background; Innate immunity, Adaptive immunity (cell mediated and humoral), Natural and artificial immunity; Active and Passive immunity, Barriers to infection; Phases of Immune responses; Clonal selection hypothesis. Hematopoiesis; Cells of immune system; Lymphoid organs- Primary and Secondary. **Immunoglobulins-** General structure, Isotypes- structure and function. **(15 hours)**

Unit-II

Antigens- Properties, Types (lsotypes, Allotypes, ldio types), Antigen specificity, super antigen, Determinants-linear, conformational and neo-antigenic, Haptens, Adjuvants

Characteristics of primary antigen- antibody interactions; antigen-antibody interactions (Precipitations, Agglutinations, RIA, ELISA, Immuno electrophoresis, Crossed antigen- anti body electrophoresis, Western blotting etc).

Complement pathways (Classical, alternative and lectin), Biological significance and deficiencies.

Hybridoma technology-Monoclonal antibodies and it's applications; Production of polyclonal antibody and it's applications. **(15 hours)**

Unit-III

Mechanism of various types of Immunity: Mechanism of cell mediated and humoral immunity. MHC types and structure, Exogenous and endogenous antigen capture and presentation to the lymphocytes, Cross presentation of exogenous antigens.

Vaccine-Route of immunization, Natural immunization schedule, Types: attenuated and inactivated vaccine, synthetic peptide, DNA vaccine, Recombinant vaccine, subunit vaccine, vaccine delivery system. Immunity to microbes: Bacteria, Fungi, Virus and Helminthes, Pathogen recognition receptor (PRR). **(15 hours)**

Unit-IV

Cytokines: Properties, receptors, cytokine related disease and cytokine-based therapy. **Hypersensitivity**: Classification, types and diseases.

Autoimmune diseases: Addison's disease, Graves' disease, Hashimoto's thyroiditis, autoimmune hemolytic anemia; rheumatoid arthritis, Good pasture's syndrome.

Immune deficiencies: B Cell and T cell deficiencies. **(15 hours)**

Suggested Laboratory Exercises:

1. Identification of human blood groups.
2. Separate serum from blood sample (demonstration).
3. Separation of albumin and globulins from blood sample
4. Estimation of blood hemoglobin.
5. Immunodiffusion by Ouchterlony method
6. Single radial immunodiffusion
7. Rocket immunoelectrophoresis
8. Agglutination test-Widal test
9. ELISA.
10. Blood smear preparation and identification of WBC.
11. WBC & RBC counting from blood sample.

Suggested Reading:

- Abbas, A. K., Lichtman, A. H., & Pillai, S. (2014). Cellular and Molecular Immunology E-Book. Elsevier Health Sciences
- Delves, P., Martin, S., Burton, D., Roitt, I.M. (2006). Roitt's Essential Immunology.11th edition Wiley-Blackwell Scientific Publication, Oxford. Edition, Saunders, 2007.
- Freeman (2006). Garland Science, Taylor & Francis Group, 2008.
- Golds, R.A., Kindt, T.J. and Osborne, B.A. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
- Paul, W. E. (2008) Fundamental Immunology, 6th Edition, Lippincott Williams and Wilkins.

Semester – IV
Paper II
Industrial Microbiology

Duration: 4 hrs. Per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- The course seeks to offer essential understandings for using microbes to produce products of significant industrial value.
- The course combines engineering and science with different biochemical processes to produce things including food, chemicals, vaccines, and medication.

Learning outcome

- Students will learn about down-stream processing, solid-state and liquid-state fermentation, and other areas of industrial microbiology.
- Have acquired a detailed knowledge of number of products which are produced by industrial fermentation processes.
- Formulating immobilisation techniques, benefits and applications, and extensive enzyme immobilisation applications.

UNIT-I

Upstream processing: Isolation, preservation and strain improvement of industrially important micro-organisms (mutagenesis, protoplast fusion and transformation, genetic engineering). Industrial fermentation: Batch, continuous, fed batch. Fermenter design – parts & their functions. Media formulation for fermentation: Water, carbon and nitrogen source, minerals, growth factors, precursors, aeration and antifoam agents, oxygen, antifoams. Sterilization of media and fermenters. Types of Fermentation- Submerged and Solid state. **(15 hours)**

UNIT-II

Downstream processing of microbial products: Cell harvesting, cell disruption (homogenization, ball milling, and ultrasonic, permeabilization), Clarification and enrichment of extract (centrifugation, liquid extraction, precipitation, ultrafiltration), Purification: Chromatography (ion exchange, affinity, hydrophobic, gel filtration, adsorption chromatography), Dialysis and electrodialysis, Distillation, Crystallization and drying. **(15 hours)**

UNIT-III

Important microbial products and technology for production of beer, industrial ethanol from starch and lignocellulose waste, organic acids (citric acid and acetic acid), amino acids (l-lysine, l-glutamic acid), enzymes (protease and amylase), Vitamins (Vit. C, Vit. B12), penicillin, Immobilization of microbial cells and enzymes – methods and applications. **(15 hours)**

UNIT-IV

Production of recombinant vaccine and proteins (Hepatitis vaccines, Insulin, Human growth hormone), Microbial leaching (copper, gold and uranium). Biofuel production**,** metabolic engineering and industrial applications of microorganisms. **(15 hours)**

Suggested Laboratory Exercises:

1. Isolation of amylase producing microorganisms from soil.
2. Isolation of protease producing microorganism.
3. Demonstration of immobilization of enzyme.
4. Demonstration of fermenters.
5. Production of wine from grapes.
6. Growth curve and kinetics of any two industrially important microorganisms.
7. Microbial fermentation for the production of ethanol from fruit juice.
8. Microbial fermentation for the production and estimation of citric acid.
9. Study of Biogas production
10. Secondary metabolite isolation using plants/microbes
11. Production of penicillin.

Suggested Readings

- Casidal, E.J.R. (2015). Industrial Microbiology. New Age International, New Delhi
- Crueger, W. and Crueger A. (1991). Biotechnology. A Textbook of Industrial Microbiology, Sinauer Associates.
- Reed G., Prescott S. C., Dunn C. G. (1987). Prescott and Dunn's Industrial Microbiology.4th edition CBS, New Delhi.
- Shuler, M.L. and F. Kargi. (2001). Bioprocess Engineering Basic Concepts. (Prentice- Hall International Series in the Physical and Chemical Engineering Sciences) Prentice Hall.
- Stanbury, P. F., Whitaker, A. and Hall, S. J. (2003). Principles of Fermentation Technology.2nd edition, reprinted. Butterworth-Heinemann.
- Vogel, H.C., Todaro, C.L and Todaro. C.C. (1997). Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment. Noyes Data Corporation/ Noyes Publications.

Semester – IV
Paper III
Bioethics, Biosafety and IPR

Duration: 4 hrs. Per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- To introduce fundamental safety and ethical principles that are crucial for microbiology labs. Should be aware of the steps necessary for intellectual property protection.
- To provide information on the many signed accords. To learn more about applying for patents.

Learning outcome

- Have knowledge pertaining to Intellectual Property Rights and their protection.
- Create a scientific mindset in students to help them become critical thinkers and curious about the purpose, operation and future of commercial microbiology.

UNIT-I

Bioethics-Introduction. Animal Ethics, Animal Rights, Ethical issues related to research in embryonic stem cell cloning. Ethical, Legal and Social Implications (ELSI) of Human Genome Project. Ethical issues, moral values on experimental animals, ethical implications of technologically developed products and techniques. social and ethical implications of biological weapons. **(15 hours)**

UNIT-II

Biosafety and risk assessment issues: Introduction, Different levels of Biosafety, Biosafety levels of specific Microorganisms; Recommended Biosafety levels for infectious agents and infected animals, Biosafety Issues in research. Biological Safety Cabinets; Containments- Types. Basic Laboratory and Maximum Containment Laboratory.

The Cartagena protocol on biosafety, Risk management issues - Cross border movement of germplasm; containment. r-DNA guidelines, experimental protocol approvals, levels of containment, regulatory bodies in biotechnology and biosafety committee. **(15 hours)**

UNIT-III

Biosafety regulation and national and international guidelines: Operation at national level; GMO's and LMO's- definition, institutional biosafety committee, RCGM, GEAC, for GMO applications in food and agriculture, Assessment and management of risks associated with GMO. Definition of IPR, function and importance. Importance of IPR in developing world with special reference to India. **(15 hours)**

UNIT-IV

IPRs in Biotechnology/ Microbiology. Intellectual Property Management: Intellectual property rights, WTO, TRIPS, Patent application process (national and International), specifications, claims, prior art and patent designs, methods of applications of patents, Land mark cases in Indian patent history. Forms of protection: Copyright and related rights, Patents, Industrial Designs, Trademarks, Trade Secrets and farmer rights. **(15 hours)**

Suggested Laboratory Exercises:

1. Proxy filling of Indian product patent.
2. Safety measurement of microbiological laboratory.
3. A case study on clinical trial of drugs in India with emphasis on clinical issues.
4. Cleaning and sterilization of glasswares in laboratory.

5. Study the principles and applications of important instrument used in the microbiology lab.
6. Planning of establishing a hypothetical microbiology/biotechnology industry in India.
7. IPR and its applications.

Suggested Readings:

- Aneja. K.R. (2007). Laboratory Manual of Microbiology and Biotechnology, New Age International Publisher.
- Ganguly, P. (2007). Intellectual Property Rights. Tata McGraw Hill.
- Goel, D. (2013). IPR, Biosafety, and Bioethics. Pearson Education India
- Guidelines for examination of biotechnology application for patent (2013) Office of the Controller.
- Guidelines for processing patent applications relating to traditional knowledge and biological material (2013) Office of the Controller General of Patents, Trademarks and Designs.
- Joshi, R. (2007). Biosafety and Bioethics. Isha Book Publisher. Nambisan, P. (2017). An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology, Academic Press.
- Kankanala, K., Narasani, A., & Radhakrishnan, V. (2012). Indian Patent Law and Practice. OUP India
- Sateesh, M.K. (2010). Bioethics and Biosafety, I. K. International Pvt Ltd.
- Sree Krishna, V. (2007). Bioethics and Biosafety in Biotechnology, New Age international publishers.
- Wooley, D. P. and Byers, K. B. (2017). Biological Safety. John Wiley & Sons.

Semester – IV
Paper IV
Clinical Microbiology

Duration: 4 hrs. Per week **Max. Marks: 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain 7 short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist of four questions, one question from each unit with internal choice. Each question will carry 7 marks.

Learning objectives

- It illustrates the mechanism of metabolic disorders at molecular level. To train to determine potency of antibiotics using various standard methods.
- It facilitates in employability in diagnostic and research institutes.

Learning outcome

- Gather information as to how the infectious diseases may be diagnosed using newer diagnostic tools and what automated equipment are available for use in diagnostic microbiology laboratories.
- Methods of prevention and control- isolation of patients, quarantine and incubation period of various infectious diseases.

UNIT-I

Specimen collection and processing: Basic principles of specimen collection (blood, sputum, urine, stool, CSF, vaginal smears etc), preparation of container and swabs for collection of specimens for microbiological examination, preservation storage and transport of specimens, documentation of specimen. **(15 hours)**

UNIT-II

Microbiological examination of clinical specimens: Microscopic examination, use of colonial morphology for presumptive identification, biochemical identification of microorganisms. Role of microbiological diagnosis and control of infections, Application of molecular diagnostics: Nucleic acid hybridization, nucleic acid amplification. . **(15 hours)**

UNIT-III

Clinical syndromes and their laboratory diagnosis: Upper and Lower respiratory tract infections (Pharyngitis & pneumonia), Skin and soft tissue infection (Impetigo, folliculitis, furuncle, carbuncle, cellulites and erysipelas), Infection of central nervous system (Meningitis and Encephalitis); Sexually transmitted diseases, Sexually acquired Zika virus, Hantavirus, Ebola, Mad cow disease, Anthrax; Infection in special populations (Malignancy, AIDS, Tuberculosis and leprosy). **(15 hours)**

UNIT-IV

Epidemiology, surveillance and control of community and hospital infections. Antimicrobial chemotherapy, emergence of drug resistance (MRSA, ESBL and MDR TB). Methods of prevention and control- isolation of patients, quarantine and incubation period of various infectious diseases. Management of patients in infectious disease hospital. Determination, management, safety and quality control in medical microbiology laboratory, Laboratory response to bioterrorism. **(15 hours)**

Suggested Laboratory Exercises:

1. Biosafety measurement in clinical laboratory
2. Study of collection, transport and preservation of different clinical specimens (Sputum, CSF, blood, urine, stool and swabs from different sites of infection).
3. Isolation and identification of microorganism from different clinical specimens.
4. RBC and WBC counting.

5. Blood group test
6. Demonstration of malaria parasite from blood sample.
7. Demonstration of different skin infection using chart.
8. Effect of disinfectants and antimicrobial agents on microbes /microbial growth.
9. Study of pathogenic microorganism.
10. Rapid detection tests: DOT EIA for detection of typhoid fever.

Suggested readings:

- Sandle, T. (2015). Pharmaceutical Microbiology: Essentials for Quality Assurance and Quality Control, 1st edition, Wood head Publishing Pharmaceutical Microbiology, 8th edition Wiley-Blackwell Publication Press Private Limited.
- Shanson, D. C. (1989). Microbiology in Clinical Practice. John Wright.
- Sood, R. (2004). Medical Laboratory Technology Methods and Interpretations. Jaypee Brothers Medical Publishers (P) Ltd. New Delhi.