ROYAL GLOBAL UNIVERSITY
GUWAHATI

ROYAL SCHOOL OF BIO - SCIENCES

(RSBSC)

DEPARTMENT OF MICROBIOLOGY

COURSE STRUCTURE

&

SYLLABUS

M.Sc. Microbiology

Year- 2022-23

Table of contents

Scheme of Evaluation

Theory Paper (T):

- **Continuous Evaluation:** 15% (Assignment, Class Test, Viva, Seminar, Quiz: Any Three)
- **Mid-term examination:** 10%
- **Attendance:** 5%
- **End Term Examination:** 70%

Practical Papers (P):

- **Continuous Evaluation:** 25% (Skill Test, lab copy, viva, lab involvement: Any three)
- **Attendance: 5**%
- **End term examination:** 70%

Combined Theory & Practical Papers (TP):

- **Continuous Evaluation:** 15% (Assignment, Class Test, Lab Experiment, Lab Copy, Viva: Any Three)
- **Mid-term examination:** 10%
- **Attendance: 5**%
- **End term examination:** 70%

Preamble

Microbiology is the study of microorganisms or microbes such bacteria, viruses, fungi, algae, cyanobacteria, protozoa and prions. They are extremely important as their diverse activities range from causation of deadly diseases in humans, animals and plants to production of highly useful products like antibiotics, enzymes, alcohol, fermented foods, and recycling of dead and decaying organic matter in the nature. Thus the science of microbiology has an important role to play in health, agriculture, environment and industry. Several discoveries in the last two to three decades, which significantly impact this area, have put Microbiology on the centre stage of teaching, research and development all over the globe. The Choice Based Credit System (CBCS) curriculum for Microbiology at the Postgraduate level has now been developed into a new system called Learning Outcome Curriculum Framework (LOCF) under the recommendations and guidance of University Grants Commission (UGC). The LOCF approach first envisioned the programme learning outcomes of the Msc program in Microbiology as well as the learning outcomes of the courses being taught under this programme, keeping in view the Post graduate attributes of the subject. The curriculum was then developed in tune with the learning outcomes. It is envisaged that the students trained under this curriculum will have the required attributes of knowledge, skills, temperament and ethics related to the subject of Microbiology. Besides the contents of the curriculum, the teaching learning processes have also been designed to achieve these attributes. A variety of learning assessment tasks has been included in the curriculum. Besides assessing the knowledge/skills acquired by the students, these tasks would also help to supplement the teaching learning processes. There are core courses (CC) which encompass all important aspects of the discipline of Microbiology and are all compulsory courses. The choice based Discipline Specific Elective (DSE) courses are designed to enhance the expanse of the subject. DSE also give the students a chance to apply their knowledge of microbiology to study societal problems and suggest solutions in the form of small project under the mentorship of their teachers. These are also designed to expose the students to leaders / innovators in the areas related to microbiology for inspiration. Ability Enhancement Compulsory Courses (AECC) with 2 Credits each, is introduced to develop communication skills and awareness about our environment. To comply with the education policy of Govt. of India namely access, equity and quality we have included Online Courses (OLC) which are available on NPTEL or SWAYAM portals under MOOCS programme being developed by MHRD to provide opportunity to the most disadvantaged students and to bridge the digital divide. The online courses would also inculcate the habit of self-study at their own pace by the students and also acclimatize them to future technologies of learning processes.

1. Introduction:

In the increasingly globalized society, it is important that the younger generation especially the students are equipped with knowledge, skills, mindsets and behaviors which may enable them to perform their duties in a manner so that they become important contributors to the development of the society. This will also help them to fully utilize their educational training for earning a decent living so that the overall standard of their families and surroundings improve leading to development of welfare human societies. To achieve this goal, it is imperative that their educational training is improved such that it incorporates the use of newer technologies, use of newer assessment tools for mid-course corrections to make sure that they become competitive individuals to shoulder newer social responsibilities and are capable of undertaking novel innovations in their areas of expertise. In the face of the developing knowledge society, they are well aware about the resources of self-development using on-line resources of learning which is going to be a major component of learning in the future. The learning should also be a continuous process so that the students are able to re-skill themselves so as to make themselves relevant to the changing needs of the society. In the face of this need, the educational curricula, teaching learning processes, training, assessment methods all need to be improved or even re-invented. The higher educational institutions (HEI) all over the globe are in the grip of this urgent task and India needs to keep pace with all these developments.

2.Learning Outcomes based approach to Curriculum Planning:

Learning Outcome based approach to curriculum planning (LOCF) is almost a paradigm shift in the whole gamut of higher education such that it is based on first and foremost identifying the outcomes of the learning required for a particular subject of study, and then planning all components of higher education so as to achieve these outcomes. The learning outcomes are the focal point of the reference to which all planning and evaluation of the end learning is compared and further modifications are made to fully optimize the education of the individuals in a particular subject. For the subject of Microbiology the outcomes are defined in terms of the understanding and knowledge of the students in microbiology and the practical skills the students are required to have to be competitive microbiologist so that they are able to play their role as microbiologist wherever required in the society such as the diseases caused by the microbes, their diagnosis and remedies; the role of microbiologists in the biotechnology industry and how they may be able to fit the bill in the industry. The students will also trained in such a way that they develop critical thinking and problem solving as related to the microbiology. The curriculum developed and the teaching and the evaluation tasks are such that the students are able to apply their knowledge and training of microbiology to solve the problems of microbiology as these exist or appear from time to time in the society. The curriculum envisions that the student, once graduate as specialists in a discipline, have an important role to play in the newer developments and innovations in the future in the subject for advancement of the discipline.

2.1 Nature and extent of the M.Sc. Programme:

After obtaining this degree, a microbiologist will enter into the job market or opt for undertaking further higher studies in the subject. After Post graduation the students may join industry, academia, public health and play their role as microbiologists in a useful manner contributing their role in the development of the welfare society. Thus the LOCF curriculum developed will

have a very wide range covering all aspects of Microbiology with reasonable depth of knowledge and skills so to as to diversify them in various specialties of the subject and play their role professionally as expected of them. It is also imperative that microbiologists will be evaluated in a manner appropriate to assess their proper development as microbiologists. The current LOCF in Microbiology has been designed in keeping all these important points in mind.

2.2 Aims of Master degree programme in Microbiology:

The aim of the Post graduate degree in Microbiology is to make students knowledgeable about the various basic concepts in a wide ranging contexts which involve the use of knowledge and skills of Microbiology. Their understanding, knowledge and skills in Microbiology will be developed through a thorough teaching learning processes in the class, practical skills through the laboratory work, their presentation and articulation skills, exposure to industry and interaction with industry experts, write short research-based projects where they will be guided and mentored by the academic and other experts of the subject.

3. Post graduate Attributes in Microbiology:

The students Post graduating in this degree will have understanding of basic knowledge or understanding of the fundamentals of Microbiology as applicable to wide ranging contexts. They will have the appropriate skills of Microbiology so as to perform their duties as microbiologists. They will be able to analyze the problems related to microbiology and come up with most suitable solutions. As microbiology is an interdisciplinary subject the students will have to take inputs from other areas of expertise. So the students will develop the spirit of team work. Microbiology is a very dynamic subject and practitioners will have to face several newer problems. To this end, the microbiologists will be trained to be innovative to solve such newer problems. Several newer developments are taking place in microbiology. The students are trained to pick up leads and see the possibility of converting these into products through entrepreneurship. To this end, the students are made to interact with industry experts so that they will be able to see the possibility of their transition into entrepreneurs. They are also made aware of the requirements of developing a Microbiology enterprise by having knowledge of patents, copyrights and various regulatory processes to make their efforts a success. Besides attaining the attributes related to the profession of Microbiology, the post graduates in this discipline should also develop ethical awareness which is mandatory for practicing a scientific discipline including ethics of working in a laboratory work and ethics followed for scientific publishing of their research work in future. The students post graduating in microbiology will also develop excellent communication skills both in the written as well as spoken language which are must for them to pursue higher studies from some of the best and internationally acclaimed universities and research institutions spread across the globe.

4. Qualification Descriptors:

The following will serve as the important qualification descriptors for a PG degree in Microbiology: 1. Knowledge of the diverse places where microbiology is involved. 2. Understanding of diverse Microbiological processes. 3. Basic skills such as culturing microbes, maintaining microbes, safety issues related to handling of microbes, Good Microbiological practices etc. 4. Moderately advanced skills in working with microbes such as pilot scale culturing, downstream processes, diagnostics etc. 5. Generation of new knowledge through small research

projects 6. Ability to participate in team work through small microbiology projects. 7. Ability to present and articulate their knowledge of Microbiology. 8. Knowledge of recent developments in the area of Microbiology. 9. Analysis of data collected through study and small projects. 10. Ability to innovate so as to generate new knowledge. 11. Awareness on how some microbiology leads may be developed into enterprise. 12. Awareness of requirements for fruition of a microbiology-related enterprise.

5. Programme Outcomes of M.Sc. Microbiology course:

A candidate who is conferred PG degree in microbiology will developed following competencies during the programme of the study:

1. Acquired knowledge and understanding of the microbiology concepts as applicable to diverse areas such as medical, industrial, environment, genetics, agriculture, food and others.

2. Demonstrate key practical skills/competencies in working with microbes for study and use in the laboratory as well as outside, including the use of good microbiological practices.

3. Competent enough to use microbiology knowledge and skills to analyze problems involving microbes, articulate these with peers/ team members/ other stake holders, and undertake remedial measures/ studies etc.

4. Developed a broader perspective of the discipline of Microbiology to enable him to identify challenging societal problems and plan his professional career to develop innovative solutions for such problems.

Name of the programme

Programme Structure

1st semester								2nd semester								
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**	**Sl. No.**	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects (please use rows as required)								**Core Subjects (please use rows as required)**								
1	**MIB154C101**	**General Microbiology**	**4**	**0**	**0**	**4**	**4**	**1**	**MIB154C201**	**Immunology**	**4**	**0**	**0**	**4**	**4**
2	**MIB154C102**	**Mycology, Phycology and Virology**	**4**	**0**	**0**	**4**	**4**	**2**	**MIB154C202**	**Molecular Biology and recombinant DNA technology**	**4**	**0**	**0**	**4**	**4**
3	**MIB154C103**	**Microbial genetics**	**4**	**0**	**0**	**4**	**4**	**3**	**MIB154C203**	**Applied Microbiology & Enzyme technology**	**4**	**0**	**0**	**4**	**4**
4	**MIB154C114**	**Practical I**	**0**	**0**	**8**	**4**	**8**	**5**	**MIB154C214**	**Practical II**	**0**	**0**	**8**	**4**	**8**
Ability Enhancement Compulsory Course (AECC)*								**Ability Enhancement Compulsory Course (AECC)***								
5	**CEN984A101**	**Communicative English - I**	**1**	**0**	**0**	**1**	**1**	**5**	**CEN984A201**	**Communicative English - II**	**1**	**0**	**0**	**1**	**1**
6	**BHS984A103**	**Behavioural Science - I**	**1**	**0**	**0**	**1**	**1**	**6**	**BHS984A203**	**Behavioural Science - II**	**1**	**0**	**0**	**1**	**1**
								Ability Enhancement Elective Course (AEEC) (Skill Based):								
								7		**AEEC/SEC/-1***	**2**	**0**	**0**	**2**	**2**
Elective: Discipline Specific DSE								**Elective: Discipline Specific DSE**								
7	**MIB154D101/ MIB154 D102**	**DSE - 1**	**4**	**0**	**0**	**4**	**4**	**8**	**MIB154D201/ MIB154D202**	**DSE - 2**	**4**	**0**	**0**	**4**	**4**
8	**Total**		**18**	**0**	**8**	**22**	**26**				**20**	**0**	**8**	**24**	**28**
3rd semester								**4th semester**								
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**	**Sl. No.**	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects (please use rows as required)								**Core Subjects (please use rows as required)**								
1	**MIB154C301**	**Parasitology, Medical and Veterinary Microbiology**	**3**	**0**	**0**	**3**	**3**	**1**	**MIB154C401**	**Soil and Environmental Microbiology**	**3**	**0**	**0**	**3**	**3**

2	**MIB154C302**	**Food Microbiology**	**3**	**0**	**0**	**3**	**3**	**2**	**MIB154C402**	**Industrial Microbiology and Fermentation Technology**	**3**	**0**	**0**	**3**	**3**
3	**MIB154C313**	**Practical III**	**0**	**0**	**4**	**2**	**4**	**3**	**MIB154C413**	**Practical IV**	**0**	**0**	**4**	**2**	**4**
Ability Enhancement Compulsory Course (AECC)*								**Ability Enhancement Compulsory Course (AECC)***							
3	**CEN984A301**	**Comm. Eng. III**	**1**	**0**	**0**	**1**	**1**	**3**	**CEN984A401**	**Comm. Eng. IV**	**1**	**0**	**0**	**1**	**1**
Ability Enhancement Elective Course (AEEC) (Skill Based):															
4		**AEEC/SEC/-2***	**2**	**0**	**0**	**2**	**2**								
Elective: Discipline Specific DSE								**Elective: Discipline Specific DSE**							
5	**MIB154D301**	**DSE - 3**	**4**	**0**	**0**	**4**	**4**	**4**	**MIB154D401**	**DSE - 6**	**4**	**0**	**0**	**4**	**4**
6	**MIB154D302**	**DSE - 4**	**4**	**0**	**0**	**4**	**4**	**5**	**MIB154D402**	**DSE - 7**	**4**	**0**	**0**	**4**	**4**
7	**MIB154D303/MIB154 D304**	**DSE - 5**	**4**	**0**	**0**	**4**	**4**	**6**	**MIB154C403/MIB15404**	**DSE - 8**	**4**	**0**	**0**	**4**	**4**
Project Dissertation								**Project Dissertation**							
8	**MIB154C323**	**Minor Project**	**0**	**0**	**0**	**4**	**4**	**7**	**MIB154C423**	**Major Project**	**0**	**0**	**0**	**8**	**16**
9	**Total credits**		**21**	**0**	**4**	**27**	**29**		**Total credits**		**19**	**0**	**4**	**29**	**39**

Total credit: 22+24+27+29=102

I. Core courses may be of the following:

(i) Theory (4) =Credit 4 with no tutorial

(ii) Theory(3) + Tutorial (2) = Credit 4 for theory paper

(iii) Theory (3)+ Practical(2)= Credit 4 for Theory and Practical combined

(iv) Practical (4) =Credit 4 for Only practical papers

Note: There may be variations in Core component of the structure from dept. to dept.
It is expected the variation should not be too large in terms of number of papers or in terms of credits.

II. Ability Enhancement Compulsory Course (AECC)*

(i) Communicative English : Four courses in all semester – Credit assigned: 1

(ii) Developing Oral Communication & Listening Skills

(iii) Conversation & Public Speaking

(iv) Communication & Presentation Skills

(v) Effective Workplace Communication

(Subjects may be offered after consultations with Royal School of Languages and requirements of the department.)

(b) Behavioural Science: 2 courses in 1st and 2nd semesters –Credits assigned: 1*

(i) Introduction to behavioural science

(ii) Development of Individuals and Behavioural Skills

(Subjects may be offered after consultations with Royal School of Behavioural& Allied Sciences and requirements of the department.)

III. Ability Enhancement Elective Course (AEEC) (Skill Based):

	AEEC/SEC-1 (in second semester) (Choose any one)	**AEEC/SEC-2(in third semester) (Choose any one)**
1	ILD-1	ILD-2
2	FRENCH-1	FRENCH-2
3	C++	LATEX
4	SCILAB	
5	MATLAB	Any other skill based courses offered by other schools of RGU and opted by Student
6	Any other skill based courses offered by other schools of RGU and opted by Student	

IV. Elective: Discipline Specific DSE

	FIRST SEMESTER (Choose Any one) Out of 2 choices	**SECOND SEMESTER (Choose any one) Out of 2 choices**	**THIRD SEMESTER (Choose any three) Out of 4 choices**	**FOURTH SEMSTER (Choose any three) Out of 4 choices**
1	Agriculture Microbiology	Basic and Applied Microbiology	Bioinstrumentation and computational biology	Plant microbe interaction and plant disease
2	Microbial Biochemistry	Microbial Diseases and its diagnosis	Antibiotic resistance in bacteria	Microbes in extreme environment
3			Inheritance Biology	Marine Microbiology
4			Parasitology	Metagenomics and its applications

The course structure shared is at par with the CBCS system of UGC. Any difference found should be brought to notice immediately

SYLLABUS (1ST SEMESTER)

Paper I: General Microbiology		**Subject code: MIB154C101**
L-T-P-C-4-0-0-4	**Credit units: 4**	**Scheme of evaluation: (T)**

Course Objective:

The course is developed with the following objectives:

- To enable the students to develop a historical perspective of the subject of microbiology
- To understand the fundamental principles of microbiology like Koch's postulates
- To explain the scientific organization of microbial organisms into taxons and introduce to the students, the major system of microbial classification
- To enable understanding of the general and ultra-structural organization of the bacterial cell
- To impart the basic skills for the culture of microbes

Course Outcome:

- CO-1: Remember the basic concepts of General Microbiology and History.
- CO-2: Understanding of media preparation, sterilization techniques, and cultivation of microbes.
- CO-3: apply the knowledge of microbiology techniques and concepts in research.
- CO-4: Analysis of the problem associated with microbes in humans, animals, and plants.
- CO-5: Evaluate their understanding of expanding their future prospect for pursuing an entrepreneurial venture

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Introduction to the world of microbes, Scope of microbiology, major contribution of scientists in development of microbiology, Refutation of a biogenesis. Classification of Micro-organism: History of bacterial classification. Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese; Basis of microbial classification, molecular approaches in microbial classification, concept of microbial species; Principle and classification of bacteria on the basis of *Bergey's manual of Determinative bacteriology*.	**12**
II	Overview of prokaryotes and their differences with eukaryotic organism. Morphology and fine structure of bacteria, archaea**:**cell walls of archaea, Gram negative, Gram positive eubacteria, cell membranes – structure, composition and properties.	**12**

III	Structure and function of cell appendages and inclusions: capsule, flagella, fimbrae, pili, cilia, gas vesicles, chromosomes, carboxysomes, magnetosomes, phycobillisomes, nucleoid, plasmids (types of plasmids and function); Bacterial spores: Regulation of spore formation. Reserve materials, inorganic and organic inclusions.	**12**
IV	Microbial nutrition, culture media, culture methods- pure culture techniques, Growth curve, generation time, synchronous, batch and continuous culture; Measurement of growth and factors affecting growth, Sterilization and disinfection, Microbial diversity and extremophiles: Microbial diversity, distribution ecological niche, abundance and density. Extremophiles – Psychrophiles, acidophiles, alkaliphiles, thermophiles, barophiles etc., non-culturable bacteria (Metagenomics), Methanogens, Methanotrophs and Methylotrophs.	**12**
Total		**48**

Textbooks:

1. Pelczar MJ, Chan ECS and Krieg NR. (2010). *Microbiology*. 8th edition. McGraw Hill Book Company.
2. Sharma PD. (2005). *Microbiology.* 4th edition (reprint). Rastogi Publication, Meerut.
3. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
4. Ananthanarayan R and Paniker CKJ. (2005). *Textbook of Microbiology*. 7th edition (edited by Paniker CKJ). University Press Publication.

References:

1. Atlas RM. (2005). *Principles of Microbiology*. 4th edition. WMT. Brown Publishers.
2. Cappucino J and Sherman N. (2010). *Microbiology: A Laboratory Manual*. 9th edition. Pearson Education limited.
3. Frazier WC and Westhoff DC. (2005). *Food Microbiology*. 5th edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
4. Martin A. (1977). *An Introduction to Soil Microbiology*. 2nd edition. John Wiley & Sons Inc. New York & London.

Paper II: Phycology, Mycology and Virology		Subject code: MIB154C102
L-T-P-C-4-0-0-4	Credit units: 4	Scheme of evaluation: (T)

Course Objective:

- This course introduces the basic features of algae, fungi and their importance.
- The contents are also designed to help students understand about their habitat and the reproduction of these organisms.
- Further, the course also provides a detailed study of viruses, virusoids, and prions.

Course Outcome:

- CO-1: Memorize the basic concepts of Algae, Fungi, and viruses.
- CO-2:Understanding of the diversity, distribution, cell structure, life cycles and economic importance of both algae and fungi.
- CO-3: Demonstrate knowledge of microbiology techniques and concepts in phycology and mycology and virology research.
- CO-4: to categorize the problem and disease associated with fungus and virus in human, animals and plants.
- CO-5: Conclude their future prospect for pursuing an entrepreneurial venture.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Mycology: History and development of mycology, structure and cell differentiation, Criteria for fungal classification, Habitat, morphology and reproduction of Myxomycetes, Phycomycetes, Ascomycetes, Basidiomycetes, and Deuteromycetes.	**12**
II	Homothallism and Heterothallism, Hetrokaryosis, Sex hormones in fungi physiological specialization in fungi, fungal succession on decomposing litter Mycorrhiza- Ectomycorriza, endomycorrhiza and vesicular arbuscularmycorrhiza, its importance in agriculture, Structure and reproduction of Lichens and its economic importance.	**12**
III	Phycology **–** Distribution of Algae, Classification of algae; thallus organization in algae; reproduction in algae; Brief account of Chlorophyta, Bacillariophyta; Phaeophyta; Rhodophyta; Cyanophyta, Algal ecology and algal biotechnology, Economic importance of Algae.	**12**
IV	Virology: Nature and general features of viruses, forms and structure of viruses, morphology and ultrastructure of viruses, capsid and its arrangements, types of envelops and its composition, classification of viruses, general features of viroids, virusoids and prions and diseases caused by them; Isolation, purification and cultivation of viruses	**12**
Total		**48**

Text Books:

1. Pelczar MJ, Chan ECS and Krieg NR. (2010). *Microbiology*. 8th edition. McGraw Hill Book Company.
2. Barasanti L and Guaaltieri P. (2006). Algae: Anatomy Biochemistry and Biotechnology. Taylor and Francis Group,New York
3. Dube HC. (1981). An Introduction to Fungi. Vikas Publishing House Pvt. Ltd.
4. Raham LE, Graham JM and Wilcox LW. (2009). Algae.2nd edition. Benjamin Cumming, New York.
5. Vashishta BR and Sinha AK. (2008). Fungi. S. Chand and Company Ltd.
6. Webster J. (1980). Introduction to Fungi.2nd edition. Cambridge University Pres
7. Dimmock, NJ, Easton, AL, Leppard, KN (2007). Introduction to Modern Virology.6th edition BlackwellPublishing Ltd.
8. Carter J and Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons.
9. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). Principles of Virology, Molecular biology, Pathogenesis and Control.2nd edition. ASM press Washington DC.

References:

1. Wagner EK, Hewlett MJ. (2004). Basic Virology.2nd edition.Blackwell Publishing.
2. Mathews. (2004). Plant Virology. Hull R. Academic Press, New York.
3. Nayudu MV. (2008). Plant Viruses. Tata McGraw Hill, India.
4. Bos L. (1999) Plant viruses-A text book of plant virology by. Backhuys Publishers.
5. Versteeg J. (1985). A Color Atlas of Virology.Wolfe Medical Publication.

6. Levy JA, Conrat HF, Owens RA. (2000). Virology.3rd edition.Prentice Hall publication, New Jersey.

Paper III: Microbial Genetics		**Subject code: MIB154C103**
L-T-P-C-4-0-0-4	**Credit units: 4**	**Scheme of evaluation: (T)**

Course Objective:

- This course is design to make the students understand the concept of genetics and the principles underlying the processes which control the expression of the genes in prokaryotes and also design to understand the mechanism involve in the transfer of different genes among inter and intra species that leads to change in phenotype.

Course Outcome:

- CO-1: Memorize the basic concepts of DNA and Genetic material.
- CO-2: Understanding of DNA structure, chromosome organization in microbes.
- CO-3: apply the knowledge of DNA and chromosome in genetic issue detection in human and plant.
- CO-4:Analysis of the genetic disease associated with microbes in humans, animals, and plants.
- CO-5:Determine the future prospect to cure genetic disorder .

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Introduction to genetics: definition and scope of Genetics. Structure of nucleic acid, Organization of genetic material in microbes. DNA replication in bacteria, Rolling circle replication, theta mode of replication, Genome organization in Prokaryotes, Eukaryotes.	**12**
II	Molecular nature of the mutation, spontaneous and induced mutation. Physical mutagens. Chemical mutagens and biological mutagens. Different types of mutations and chromosome aberrations. Auxotrophic mutants and Prototroph, minimal media, Advantages and applications of mutations.	**12**
III	Gene transfer mechanism- Vertical and horizontal gene transfer (Bacterial transformation (development of competence, mechanism of transformation, detection of transformants), Bacteria conjugation-effective contact and pilli in conjugation, F-factor, the conjugal transfer process; high-frequency recombination (Hfr) strains; the order of chromosome transfer; formation of F prime (F'), drug resistance or Antibiotic resistance in bacteria.	**12**
IV	Genetics of Bacteriophages **-** General characteristics of the viral genome, T4 virulent Phage- Structure- life cycle. Lambda temperate phage- Structure – Decision-making mechanism for Lytic and lysogenic cycle, Lytic cycle, Lysogenic cycle Lysogenic repression. Transduction and its type.	**12**
Total		**48**

Text Books:

1. James D Watson *et al*. (2009). Molecular biology of the gene. 5th Edition, Pearson.
2. Karp, G. (2010);*Cell and Molecular Biology: Concepts and Experiments*, 6th edition, . John Wiley &Sons.Inc.
3. Stanley R Maloy. Microbial Genetics. 5th Edition, Narosa publishing house.
4. Daniel J Fairbanks. Genetics: The Continuity of Life, Wadsworth Publishing, ISBN-10: 0534252796

References:

1. Peter J Russel. Genetics. Pearsons Education India, ISBN-10: 9332571627.
2. William Klug, Michael Cummings, Charlotte A Spencer, Michael A Palladino. Concept of Genetics, 10th edition, Pearsons.

Practical I		Subject code: MIB154C115
L-T-P-C-0-0-8-4	Credit units: 4	Scheme of evaluation: (P)

Course Objective:

- The objective of the course is to familiarize the student with basic practical knowledge in microbiology and biochemistry

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	1: Preparation of buffer, chemical solutions, stock solution. 2: Microscope principle, operation, and study of various components of the microscope. 3: Sterilization process for glassware, culture media, and preparation of culture plates. pure culture preparation and subculturing technique.	24
II	4:Determining of bacterial growth curve and microbial growth measurement by direct cell count method, Effect of pH, temperature, and chemicals on bacterial growth. 5: Serial dilution method and bacterial colony counting. 6: Staining technique-simple, Gram's staining, spore staining, Acid-fast staining. Staining of Fungus. 7: Determination of bacterial motility (Bacterial twitching and swimming motility test, motility observation by hanging drop method).	24
III	8:Isolation and identification of *Aspergillus, Penicillium, Fusarium, Alternaria, Nostoc, Anabaena, Oscillatoria, Microcystis.* 9: Principles of colorimetry, its calibration, and estimation of O.D,	24
IV	10: Study of factors affecting enzyme activity-substrate, temperature, pH. Estimation of protein and sugars from the sample. 11: Separation of amino acids by paper chromatography. Isolation of lipid from a given sample and its separation by TLC.	24
Total		96

SYLLABUS (2nd SEMESTER)

Paper I: Immunology	Subject code: MIB154C201	
L-T-P-C-4-0-0-4	Credit units: 4	Scheme of evaluation: (T)

Course Objective:

- This course is designed to provide knowledge about the immune response in the body along with the basic structure of antigens and antibodies. Further, the syllabus also includes the application of antigens and antibodies in the different serological tests.

Course Outcome:

- CO-1: Remember the basic concepts about the innate and adaptive immune system.
- CO-2: Understanding of the antigen, antibody structure, and working mechanism of the Immune system.
- CO-3: apply the knowledge of antigen, antibody, RIA and other techniques in HLA typing and related research.
- CO-4:Analysis of autoimmune disease and other related issues.
- CO-5:Determine the future prospect to solve immunity-related issues.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	History and scope of immunology: types of immunity – innate and acquired, passive and active. Physiology of immune response- Humoral and cell mediated immunity, Lymphoid organs. Immunohaematology of blood groups, ABO and RH compatibility.	12
II	Antigens and Antibodies: structure and properties (types, iso and allo). haptens, adjuvants; antigen specificity; Immunoglobulins (antibodies) – structure, heterogeneity – types and subtypes, properties (physico-chemical and biological). Antigen – Antibody reactions; agglutination, haemagglutination, precipitation, Complement fixation, major histocompatibility complex(MHC-I &II).	12
III	Immunofluorescence; enzyme linked immunosorbent assay (ELISA), radioimmunoassay.Hybridoma technology – monoclonal antibodies and its uses. Complement pathways. Hypersensitivity-anaphylaxis, cytotoxic reaction. Cytokines. Organization and expression of Ig genes and rearrangements.	12
IV	Hypersensitivity, Autoimmunity, Transplantation immunology and tumorimmunology.HLA tissue typing, major histocompatibility complex. Immunotoxins; vaccines and its types, toxoidsnational immunization programmes, newer generation vaccines	12
Total		48

Text Books:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. Nelson D L, Cox M. M. Lehningers. (2004). Principle of Biochemistry. 4th ed. Freeman and company, New York, USA.
3. Berg, J. M., Tymoczko, J. L. and Stryer.(2006). *Biochemistry*, 6th Edition, W.H Freeman and Co.
4. Janis Kuby. (2013). Immunology. 7th Edition, WH Freeman.

References:

1. Kathleen park Talaro (2017). Foundations in Microbiology. 10th Edition, McGraw Hill. Science
2. White David (2000). Physiology and Biochemistry of Prokaryotes. 2nd ed. Oxford University Press, New York.

Paper II: Molecular biology and Recombinant DNA technology		**Subject code: MIB154C202**
L-T-P-C-4-0-0-4	**Credit units: 4**	**Scheme of evaluation: (T)**

Course Objective:

- This course provides detail information regarding nucleic acid, DNA replication, transcription, and translation. The course also discusses details about different cloning vectors.

Course outcome:

- CO-1: Remember the basic concept of genome organization and omics approaches.
- CO-2: Understanding of the replication, Transcription, and mechanism in the cell.
- CO-3: apply the knowledge of genome organization in mutation and virulence gene study.
- CO-4:Analysis of genetic material to correlate gene mutation and its impact on function.
- CO-5:Determine the future prospect to solve genetic disorders.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**O**rganization of DNA in eukaryotic cell; palindromic DNA; Types of RNA-rRNA; mRNA (the 5' cap, non-coding region, initiation codon, coding region, termination codon; Poly (A) region, post transcriptional modification,differences between prokaryotic and eukaryotic mRNA; tRNA (structure of tRNA-clover leaf model); superhelicity in DNA.Dispersive, conservative and semi-conservative models; Watson and Crick's model of DNA replication (experimental evidence); Enzyme involved in DNA replication (DNA polymerase I, Pol II, Pol III, DNA ligase); Mechanism of DNA replication; Models of DNA replication, inhibitors of DNA replication. Exonuclease and endonuclease.	**12**
II	Gene diversity; split genes, overlapping gene; molecular nature of mutation, spontaneous and induced mutation; DNA damage and repair – types of damage (deamination, oxidative damage, alkylation, pyrimidine dimmers); repair pathways – methylation – directed mismatch repair, nucleotide excision repair, base excision repair, recombination repair, SOS repair.	**12**
III	Gene Regulation and expression- Gene regulation – negative regulation – *E. coli lac* operon (structural, operator, promoter and repressor genes), Positive regulation – *E. coli trp*-operon. Central dogma; RNA polymerase; Site of transcription. Transcription – chain initiation, chain elongation, chain termination, RNA turnover; translation – charging of tRNA, initiation of polypeptide synthesis, elongation of the polypeptide chain, translocation, termination of the polypeptide chain;	**12**
IV	Cloning vectors **–** Plasmids, phages and cosmids, phagemids, Ti plasmids, other viral vectors (M13 and retroviruses); Cloning strategies, cloning and selection of individual genes; Gene libraries– cDNA and genomic libraries.	**12**

	Expression vectors, promoter probe vectors, vectors used for construction of library – artificial chromosomes; BAC vectors, YAC vectors. Working principle of PCR, requirements, types of PCR, application of PCR, Sequencing of DNA and protein in brief. Recombinant products – human growth hormone (insulin somatotropin), vaccines (hepatitis B virus vaccine, FMD vaccine), interferons.	
Total		**48**

Text Books:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. James D Watson *et al*. (2009). Molecular biology of the gene. (4th Edition), Pearson

References:

1. Gerard J Tortora, Berdell R Funke, Christine L Case. . Microbiology: An Introduction. Dorling Kindersley (india) Pvt Ltd.
2. Karp, G.(2010). *Cell and Molecular Biology: Concepts and Experiments*, 6th edition,.John Wiley &Sons.Inc.

Paper III: Applied microbiology and Enzyme technology **Subject code: MIB154C203**

L-T-P-C-4-0-0-4 **Credit units: 4** **Scheme of evaluation: (T)**

Course Objective:

- The course is designed to give an idea about the diversity of microbes and their identification.
- The syllabus is also design to understand the role of microbe in waste treatments especially degradation of xenobiotics compound. Further the course is design to give the basic idea about the microbial biotechnology and the application of different microbes in the industries.
- The course is also designed to allow students to understand about different microbial enzymes produce by microbes, their purification technique and its application in different fields. Further, students will also learn about the products (antibiotics, biofuel etc.) that can be produced from microbes.

Course outcome:

- CO-1: Remember the basic concept of microbiology related to the application in various fields.
- CO-2: Understanding the synthesis mechanism of Biopolymers and bioplastics, Bioprocess technology, beer, wing etc.
- CO-3: apply the knowledge of microbes to produce enzymes at a commercial scale.
- CO-4: Analysis of microbial potential for the benefit of society, environment, and industries.
- CO-5: Determine the future prospect to solve issues related to mankind and the environment.

Detailed Syllabus:

Modules	Topics / Course content	Periods

I	Introduction to Microbial Diversity, identification of unknown microbes: Strategy and methods, newer approaches for exploring unculturable bacteria from environmental samples like sewage. Microorganism for waste treatment, treatment of wastes - Sewage disposal, compost making, methane generation. Microbiology of degradation of xenobiotics in environment: hydrocarbons, oil pollution, surfactants, pesticides.	**12**
II	General concepts of microbial biotechnology. Microorganisms as factories for the production of novel compounds, Nature of microbial polysaccharides, mechanism of synthesis; Biopolymers and bioplastics, Bioprocess technology, beer brewing, cheese manufacture, mold–modified foods, Wine, Vinegar, The fermentation process, procedure and equipments, Ideal bioreactors, Batch, fed batch, CSTR, PFR, Multiphase bioreactors, packed bed, bubble column fluidized trickle bed, immobilization. Aseptic, septic and anaerobic fermenters.	**12**
III	Enzymes from microbial sources, large scale production of enzymes, recovery of enzymes, enzyme purification methods - enzyme precipitation, separation by chromatography, enzyme immobilization. Application of enzymes (food industries and pharmaceutical). Enzymes in diagnostic assays. Enzyme electrodes, immunoenzyme techniques.	**12**
IV	Commercial products of microbes: Antibiotics, biopolymers, biosensors, biopesticides, Production of biofuels. Microbial toxins: Types, biochemical and molecular basis of toxin production, implications. Genetically engineered microbes, anti-HIV, anticancer, antifungal, antiplasmodial, anti-inflammatory compounds.	**12**
Total		**48**

Text Books:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. Barnett, H. L. and Hunter, B. B. (1960). Illustrated Genera of Imperfect Fungi.Burgess Publishing Co., Minnesota.
3. Breed and Buchanan ((2003). Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5)
4. Cook T. (2002) Microbial Biodiversity: Saving Bacteria to save ourselves, Harvard Science Review, 26-28.
5. Nelson D L, Cox M. M. Lehningers. (2004). Principle of Biochemistry. 4th ed. Freeman and company, New York, USA.

References:

1. Keller M. and Zengler K. (2004) Tapping in to Microbial Diversity. Nature Reviews 2, 141-150.
2. Pace N. (1997) A Molecular View of Microbial Diversity and the Biosphere, Science, 276, 734-740.
3. White David (2000). Physiology and Biochemistry of Prokaryotes. 2nd ed. Oxford University Press, New York

Practical II		Subject code: MIB154C214
L-T-P-C- 0-0-8-4	Credit units: 4	Scheme of evaluation: (P)

Course Objective:

- The objective of the course is to familiarize the student with basic practical knowledge in immunology and molecular biology

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	1:Determination of blood groups and Rh factor and Demonstration of agglutination reaction with reference to widal test and VDRL test. 2:Demonstration of haemagglutination with reference to *Treponema pallidum* Haemagglutination test. 3:Demonstration of ODD (Ouchtlerlony Double Diffusion)-an immunological technique used in the detection, identification, and quantification of antibodies and antigens.	24
II	4: Separation and characterization of serum by serum electrophoresis method. 6:Separation and characterization of lymphocytes from blood, Demonstration of Antigen-antibody reaction by ELISA.	24
III	7:Demonstration of replica plating technique, Determination of expression of beta-galactosidase in *E. coli.* 8: Isolation of antibiotic-resistant *E. coli* by gradient plate method. 9:Primer Designing for Bacterial DNA amplification and PCR(polymerase chain reaction). 10: Plasmid DNA isolation from bacteria.	24
IV	11. Separation of DNA by agarose gel electrophoresis. 12: Restriction digestion of bacterial DNA. 13: Separation of protein by SDS PAGE.	24
Total		96

SYLLABUS (3rdSEMESTER)

Paper I: Parasitology, Medical and Veterinary Microbiology		**Subject code: MIB154C301**
L-T-P-C-3-0-0-3	**Credit units: 4**	**Scheme of evaluation: (TP)**

Course Objective:

The course is developed with the following objectives:

- To enable the students, to develop a proper understanding of different pathogenic microbes.
- To understand the mode of transmission and life cycle of human and animal pathogens.
- To enable understanding of the mode of action of anti-microbial agents.
- To impart the basic skills for the diagnosis and identification of pathogenic microbes.

Course outcome:

- CO-1: Remember the basic concept of pathogenesis and transmission and life cycle.
- CO-2: Understanding of normal microflora of human body; role of resident flora. Host-parasite relationships, Infection type.
- CO-3: apply the knowledge of antimicrobial agents and antibiotics as chemotherapeutic agents.
- CO-4: Analysis of the Emerging communicable diseases (Plague, Anthrax) and their control.
- CO-5: Determine the future prospect of different therapeutic agents.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Introduction to medical parasitology-classification. Pathogenesis, transmission, life cycle, lab diagnosis, treatment of Protozoa-*Entamoeba, Toxoplasma, Cryptosporidium, Leishmania,Trypanosoma, Plasmodium, Giardia, Trichomonas*and *Balantidium*. Introduction to *Mycobacteria, Brucella, Listeria, Pasturella*and Erysepelas. Spirochetes, *Rickettsiae, Chlamydia, Mycoplasma* and *Ureoplasma.*	**12**
II	Discovery of pathogenic micro-organisms; normal microflora of human body; role of resident flora. Host-parasite relationships, Infection, type and source. Disease cycle (sources of diseases, reservoirs, transmission of pathogens); Intoxications (exotoxins and endotoxins and their mechanism of action). Antimicrobial agents and antibiotics: Antiseptics, chemotherapeutic agents, effect of antibiotics on protein, nucleic acid, cellwall and cytoplasmic membrane.	**12**
III	Morphology, classification, cultural characteristics, pathogenicity and laboratory diagnosis of Staphylococci, Streptococci, Pneumococci, Neisseriae (Gonococci and Meningococci), *Haemophilus, Bordetella, Corynebacterium, Clostridium.*	**12**

IV	Study of Enterobacteriaceae (*E. coli, Klebsiella, Salmonella, Shigella, Proteus*), Vibrios and Nonfermenting Gram negative bacilli. Emerging communicable diseases (Plague, Anthrax) - symptom, identification, monitoring and surveillance and quarantine administration.	**12**
Total		**48**

Textbooks:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. Text Book Of Medical Mycology by JagdishChander, Mehta Publishers, New Delhi
3. Sherris Medical Microbiology : An Introduction to Infectious Diseases by Kenneth Ryan, McGraw-Hill Medical.
4. Jawetz, Melnick, &Adelberg's Medical Microbiology (Lange basic), McGraw-Hill Medical
5. Medical Microbiology by Patrick R. Murray, Michael A. Pfaller, & Ken S. Rosenthal, Elsevier
6. Text book of microbiology by Ananthanarayan and Paniker. Medical Microbiology by Cedric Mims, John Playfair and Ivan roitt. Mosby-wolfe

References:

1. Jawetz, Melnick, &Adelberg's. (2013). Medical Microbiology. 26th Edition. McGraw-Hill.
2. Dey, N.C., Dey, T.K. and Sinha, D., 1999. Medical Bacteriology including Medical Mycology and AIDS. 17th edition, New Central Book agency. Kolkatta.
3. Finegold, S.M. (2000) Diagnostic Microbiology, 10th Edn. C.V. Mosby Company, St. Louis
4. Chatterjee, 1986. Medical Parasitology. Tata McGraw Hill, New Delhi.
5. Karyakarte, R.P. and Damle, A.S., 2005. Medical Parasitolog. Revised edition. Published by Books and Allied (P) Ltd., Kolkatta.
6. JeyaramPaniker, 2004. Text book of Medical Parasitology. 5th edition, JAYPEE brothers, Medical Publishers (P) Ltd, New Delhi.
7. Veterinary Microbiology and Microbial Disease" by P J Quinn and B K Markey

SYLLABUS (3rdSEMESTER)

Paper II: Food Microbiology		**Subject code: MIB154C302**
L-T-P-C-3-0-0-3	**Credit units: 4**	**Scheme of evaluation: (TP)**

Course Objective:

The course is developed with the following objectives:

- To enable the students to develop a proper understanding of different food-born microbes.
- To understand the principles of food preservation.
- To enable understanding of food born infection and intoxication.
- To impart the basic skills for laboratory testing and quality control of food.

Course outcome:

- CO-1: Remember the Micro-organisms and their importance in food microbiology – molds, yeast, bacteria.

- ❖ CO-2: Understanding of the organisms, and different factors those influence microbial growth in food.
- ❖ CO-3: apply the knowledge of microbes in Food fermentation **–** Bread, vinegar, fermented vegetables, fermented dairy products.
- ❖ CO-4: Analysis of the microbial potential for fermentation and product development.
- ❖ CO-5: Evaluate their understanding of expanding their future prospect for pursuing an entrepreneurial venture

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Micro-organisms and their importance in food microbiology – molds, yeast, bacteria, general features, classification; principles of food preservation; asepsis – control of micro-organisms (anaerobic conditions, high temperature, low temperature, drying); factors influencing microbial growth in food – extrinsic and intrinsic factors; chemical preservation and food additives; canning process for heat treatment. Contamination and Spoilage **–** Cereals, Sugar products, vegetables, fruits, meat and meat products; milk and milk products, fish and sea food, poultry spoilage of canned food; detection of spoilage and characterization.	**12**
II	Food-borne infections and intoxications **–** bacterial: *Brucella, Bacillus, Clostridium, Escherichia, Shigella, Staphylococcus, Vibrio, Yersinia* and non-bacterial intoxication (withexamples of infective and toxic types) – Protozoa, algae, fungi and viruses; food borne outbreaks– laboratory testing procedures, preventive measures, GMP and Hazard Analysis and Critical Control Point. Food control agencies and its regulations; Employee's health standards, waste treatment, disposal and quality control.	**12**
III	Food fermentation **–** Bread, vinegar, fermented vegetables, fermented dairy products; experimental and industrial production methods; spoilage and defects of fermented dairy products; oriental fermented foods – its quality standard and control.	**12**
IV	Microbial cells as food (Single cell protein), mushroom cultivation; fermented beverages –beer and wine; steroid conversion – industrial enzymes, production of amylases, proteinases, cellulases, amino acid production – glutamic acid and lysine; pickles, olives, soy sauce,genetically modified (GM) foods.	**12**
Total		**48**

Textbooks:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. Food Microbiology by William C Frazier. Tata Mgraw Hill
3. Food Microbiology by dams and Moss. Springer Verlag
4. Basic food microbiology by Banwart. Cbs Publishers & Distributors Pvt Ltd.
5. Principles of Microbiology by Ronald M. Atlas (1995), Amy Mc Cullen
6. Fundamental Principles of Bacteriology A J Salle

References:

1. Adams MR & MO Moss (2005). Food Microbiology, New Age International (P) Limited. Publishers; 1st Edition, New Delhi.
2. James M Jay (2004). Modern Food Microbiology, CBS Publishers & Distributors; 4th Edition, New Delhi.

3. William Frazier and Dennis Westhoff (2008) - Food Microbiology McGraw Hill Education; 4 edition.

Practical III		**Subject code: MIB154C313**
L-T-P-C-0-0-4-2	**Credit units: 3**	**Scheme of evaluation: (T/P/TP)**

Course Objective:

- The objective of the course is to familiarize the student with basic practical knowledge in Parasitology, Medical, Veterinary and food Microbiology.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	1.Collection, transport and preservation of different samples from animal sources. 2.Isolation, identification and characterization of microorganisms from animal sources. of microorganisms. 3.Study of antibiogram, Study of LD50 against disinfectants.	**24**
II	. 4.Collection of milk samples from infected milking cow shed areas and application of COB (Clot on boiling) Test 5:MR (Milk Ring) Test to study the level of adulteration of milk.	**24**
III	6.Identification of *Candida* by microscopical examination (Staining and germ tube formation) and cultural characteristics. 7.Rapid detection tests in Microbiology: i) Dip stick test for detection of Malarial parasite ii) Dot EIA for detection of Typhoid fever. iii) Comb assay for detection of *Mycobacterium tuberculosis*	**24**
IV	8.Screening of antibiotics producing microbes from soil. 9.Production and assay enzymes: a). Amylase b). Protease c). Lipase	**24**
Total		**96**

SYLLABUS (4th SEMESTER)

Paper I: Soil and Environmental Microbiology		**Subject code: MIB154C401**
L-T-P-C-3-0-0-3	**Credit units: 4**	**Scheme of evaluation: (TP)**

Course Objective:

The course is developed with the following objectives:

- To enable the students to develop a proper understanding of soil and environment microbes.
- To understand the role of microbes in the environment.
- To enable understanding of the application of microbes such as a biofertilizer
- To impart the basic knowledge of environmental microbes and their application.

Course outcome:

- CO-1: Remember the agriculturally important and environment-friendly microbe.
- CO-2: Understanding of various soil types, Rhizosphere, and rhizoplane. Nitrogen fixation: A symbiotic and symbiotic nitrogen fixation system.
- CO-3: apply the knowledge for the Production of biofertilizers and biopesticides
- CO-4: Analysis of the role of microbes in terrestrial and aquatic ecosystems.
- CO-5:Determine the future prospect of different microbial consortia for agriculture and environmental issue.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Aero-microbiology **-** droplet nuclei, aerosol, assessment of air quality, brief account of airborne microbes – bacteria, fungi, and viruses, their diseases and preventive measures; Phylloplane and Phyllospheremicroflora. Role of microbes in environment **–** Organic matter decomposition, factors affecting litter decomposition; Biogeochemical cycling of C, N, P and S; Microbial biomass and soil fertility; Biodegradation of hydrocarbons and xenobiotics, Microbial leaching of iron and copper.	**12**
II	Soil Microbiology **–** Classification of soil-physical and chemical characteristics, soil as a habitat for micro-organisms, microflora of various soil types, Rhizosphere and rhizoplane. Nitrogen fixation: Asymbiotic and symbiotic nitrogen fixation systems – root nodulation symbiotic bacteria (process of root nodule formation), Leghemoglobulin. Microbial interactionssymbiosis, mutualism, commensalisms, amensalism, competition, antibiosis; Actinorrhiza; Mycorrhizal fungi and its effect on plants.	**12**

III	Production of biofertilizers and biopesticides– Quality control, BIS norms of biofertilizers; Biofertilizers (rhizobial inoculants, mass production and method of application); Biopesticides (viral, bacterial and fungal biopesticides); Biopolymers – Polyhydroxybutyrate (PHB), xantham gum.	**12**
IV	Aquatic Microbiology – Water ecosystems – types, fresh water (pond, lakes), marine habitats (estuaries, deep sea, hydrothermal vents); Eutrophication, food chain; potability of water, microbial assessment for water quality, water purification, physical, chemical, microbiological characteristics of sewage. Characterization of solid and liquid wastes, physical, chemical and biological (aerobic, anaerobic – primary, secondary, tertiary) treatment; Solid waste treatment; Liquid waste treatment – trickling, activated sludge, oxidation ponds. Formation of biofilm. Biomagnifications.	**12**
Total		**48**

Textbooks:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. Microbiology: Principles and Explorations by Jacquelyn Black
3. Soil Microbiology by SubbaRao. India Book House Pvt Ltd
4. Environmental Microbiology by Raina M. Maier, Ian L. Pepper, Charles P. Gerba. Academic Press
5. Fundamental Principles Of Bacteriology A J Salle

References:

1. SubbaRao NS (2004). Soil Microbiology.Fourth edition, Oxford and IBH Publishing Co.Pvt. Ltd., New Delhi.
2. Mishra RR (2004). Soil Microbiology.First edition, CBS Publishers and distributors, New Delhi.
3. Rangaswami G and Mahadevan A (2002). Disease of Crop Plants in India.Fourth edition, PHI Learning (P) Ltd., New Delhi.
4. Robert, L Tate (1995). Soil Microbiology.First edition, John Wiley and Sons, Inc. New York.
5. R,M, Atlus and Richard Bartha (2000). Microbial Ecology, Fourth edition, An imprint of Addison Wesley Longman, Inc, New York.

SYLLABUS (4th SEMESTER)

Paper II: Industrial Microbiology and Fermentation Technology		**Subject code: MIB154C402**
L-T-P-C-3-0-0-3	**Credit units: 4**	**Scheme of evaluation: (TP)**

Course Objective:

The course is developed with the following objectives:

- To enable the students, to develop a proper understanding of industrially useful microbes.
- To understand the suitability of microbes and their economic aspect.
- To enable understanding of the growth kinetics and fermentation technology.

- To impart the basic skills for batch culture, fermentation, and secondary metabolite processing.

Course outcome:

- CO-1: Remember the basic concept of the suitability of microbes in industrial processes and their source types.
- CO-2: Understanding of Batch culture in fermentation, growth kinetics of micro-organisms
- CO-3: apply the knowledge for Continuous culture and scale-up –productivity and product formation,
- CO-4: Analysis of the selection, improvement, and maintenance of industrial important strain.
- CO-5: Determine the future prospect of microbial product development at the commercial level.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Brief History of Industrial Microbiology, suitability of microbes in industrial processes and their sources types of fermentation and bioreactors, Recent development in industrial microbiology, the structure of fermentor, and Economic aspects of fermentation processes. Isolation, selection, improvement and maintenance of industrial important strain. Metabolic pathways and metabolic control mechanisms; primary metabolites (alcohols, vitamins, enzymes and organic acids) and secondary metabolites (antibiotics and toxins); substrates for industrial fermentation	12
II	Batch culture in fermentation, growth kinetics of micro-organisms, classification of fermentation process; growth and nutrient, growth and product formation, heat evolution, the effect of environment (temperature, pH, high nutrient concentration), media formulation and sterilization, the kinetics of thermal death of micro-organisms.	12
III	Continuous culture and scale-up – Continuous culture system, productivity, product formation, power requirement oxygen transfer kinetics, foam, and antifoam-instrument control, physical and chemical environment sensors.	12
IV	Downstream processing objectives and criteria, foam separation Precipitation methods filtration devices industrial scale centrifugation and cell disruption methods. liquid –liquid extraction solvent I recovery chromatography. Two phase aqueous extraction, super criticalfluid extraction, ultrafiltration drying devices crystallization and whole broth processing, IPR and bioethics.	12
Total		**48**

Textbooks:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. Industrial Microbiology: An Introduction. Michael J. Waites, Neil L. Morgan, Gary Higton. Wiley-blackwell
3. Principles of Fermentation Technology. Stanbury Pf, Whitaker A, Hall Sj. Elsevier India P Ltd
4. Stanbury, P.F., Whittaker, A and Hall, S.J., (1995) Principles of fermentation technology, Elsevier; 3rd edition.
5. Crueger and Crueger, A., Biotechnology: A text book of Industrial Microbiology, Sinavos association, InoSundeland; 2nd edition.
6. Cassida, J.E., (1968). Industrial Microbiology, New Age International (2007).

7. Presscott and Dunn, S., (1982) Industrial Microbiology. The AVI Publishing Company Inc., USA; 4th edition.

References:

1. Peppler, H. J. and Pearlman, D. (1979). Microbial Technology, Vol 1 and 2, Academic press.
2. Demain, A. L. and Soloman INA, (1986). Manual of Industrial Microbiology and Biotechnology, American society for Microbiology, Washington DC.
3. Chisti, Y., Fermentation, Biocatalysis and bioseparation, Encyclopedia of Bioprocess Technology, Vol. 5, John Wiley and Sons, N. Y.
4. Belter, P.A., Cussler, E.L. and Hu, W.S., Bioseparation: Downstream processing for Biotechnology, John Wiley and Sons, N.Y.
5. Agarwal AK &PradeepParihar (2006). Industrial Microbiology. Published by Student Edition, Behind Nasrani Cinema, Chopasani Road, Jodhpur.
6. Patel A H (2005). Industrial Microbiology.Laxmi Publications, New Delhi; Second edition.

Practical IV		**Subject code: MIB154C413**
L-T-P-C-0-0-4-2	**Credit units: 3**	**Scheme of evaluation: (T/P/TP)**

Course Objective:

- The objective of the course is to familiarize the student with basic practical knowledge in Environmental, Soil and Industrial Microbiology

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	1.Isolation and enumeration of bacteria and fungi from air samples by exposure plate method. 2.Isolation of micro-organism from rhizosphere and rhizoplane regions. 3.Isolation of *Rhizobia* from root nodule using Yeast Extract Agar Medium (YEMA). 4.Study of anatogonism of micro-organism by dual culture inoculation method (Bacterium Vs Bacterium; Bacterium Vs fungus; Fungus Vs Fungus).	**24**
II	5.Isolation of bacteria from acidic and sodic (alkaline) soil. 6.Demonstration of salt tolerance level in bacteria. 7.Isolation of drought tolerant bacteria from soil	**24**

III	8.Demonstration of working of different types of fermenters and its components. 9.Production of wine from grapes using yeast.	**24**
IV	11.Estimation of alcohol contents in fermented products. 12.Production citric acid (using *Aspergillusniger*) and estimation by titerimetric method.	**24**
Total		**96**

Elective: DSE 1 (Discipline specific)- Semester -1st

DSE Paper: Microbial biochemistry **Subject code: MIB154D101**

L-T-P-C-4-0-0-4 **Credit units: 4** **Scheme of evaluation: (T)**

Course Objective:

This course focuses on the concepts of biochemistry and important microbial macromolecules and their role in metabolism. On completion of the course a student will be well versed with the knowledge of different metabolic pathways in bacteria and eukaryotes.

Course outcome:

- CO-1: Remember the basic information about the Chemistry of Life and biomolecules.
- CO-2: Understanding the structure of biomolecules such as proteins, enzymes, lipids etc.
- CO-3: apply the knowledge for the synthesis and application of biomolecules in industries and the agriculture sector
- CO-4: Analysis of the role of the different biomolecules to maintain crucial life functions.
- CO-5: Determine the future prospect of synthesis of biomolecules at the commercial level.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Chemistry of Life and biomolecules: Types of bonds: ionic bonding, Ion-dipole. covalent, H-bonds, Van der Wall's interaction, Hydrophobic and hydrophilic interactions. Water as a biological solvent (pH and concept of buffer), Structure of Special Microbial Molecules: Peptidoglycan, bacteriorhodopsin, biphytanyl chains and lipids in archaeal cell membranes and their significance in adaptation in extreme conditions.	**12**
II	Proteins: Introduction to Amino acids chemistry and classification and properties; Brief account of Peptide bond, primary, secondary, tertiary and quaternary structures; Protein isolation, purification, characterization and	**12**

	functional analysis, Carbohydrate chemistry, classification of carbohydrates; stereochemistry, functions and storage of polysaccharides.	
III	Lipid Chemistry: Classification, properties and structure of lipids with emphasis on membrane lipids; brief account of archaebacterial and Mycobacterium lipids; Brief account of application of membrane lipids in classification of bacteria.	**12**
IV	Enzymes and their function, metabolic pathways and Fermentations: Glycolytic pathway, Pentose phosphate pathway (HMP), Entner- Doudroff pathway, Tricarboxylic acid cycle, Electron transport chain, generation and maintenance of proton motive force PMF, Fermentation- Lactic acid fermentation, LDH- Alcoholic fermentation ADH, de novo biosynthesis of purines and pyrimidines, Ribonucleotidereductase and its role in nucleic acid metabolism.	**12**
Total		**48**

Text Books:

5. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
6. Nelson D L, Cox M. M. Lehningers. (2004). Principle of Biochemistry. 4th ed. Freeman and company, New York, USA.

Berg, J. M., Tymoczko, J. L. and Stryer.(2006). *Biochemistry*, 6th Edition, W.H Freeman and Co.

Reference Books:

1. White David (2000). Physiology and Biochemistry of Prokaryotes. 2nd ed. Oxford University Press, New York.

Elective: DSE 2 (Discipline specific)- Semester -2nd

DSE: Microbial diseases and its Diagnosis **Subject code: MIB154D201**

L-T-P-C-4-0-0-4 **Credit units: 4** **Scheme of evaluation: (T)**

Course Objective:

This course is design with an objective to provide the basic information related to bacterial, viral, fungal and protozoan diseases and their diagnosis. Further, this course also provides up to date information regarding different serological and molecular based methods to detect the pathogens involve in causing disease

Course outcome:

- CO-1: Remember the basic information about Bacterial, Viral, Fungal, and Protozoan Diseases.
- CO-2: Understanding the Method of collecting clinical samples and precautions required
- CO-3: Apply the knowledge for disease diagnosis as well as an understanding of its severity.
- CO-4: Analysis of the association of pathogen and environmental factors in disease development.
- CO-5: Determine the development of a kit for the quick detection of pathogens.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Impotant Microbial Diseases** Bacterial, Viral, Fungal and Protozoan Diseases of various human body systems,Disease associated clinical samples for diagnosis.	12
II	**Collection of Clinical Samples** Method of collecting clinical samples (oral cavity, throat, skin, Blood, CSF, urine and faeces) and precautions required. Method of transport of clinical samples to laboratory and storage.	12
III	**Direct Microscopic Examination and Culture.** Examination of sample by staining-Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsastained thin blood film for malaria Preparation and use of culture media-Blood agar,Chocolate agar,Lowenstein-Jensen medium,MacConkey agar, Mannitol Salt Agar. Distinct colony properties of various bacterial pathogens.	12
IV	**Serological and Molecular Methods** Serological Methods-Agglutination, ELISA, immunofluorescence, Nucleic acid based methods - PCR, Nucleic acid probes, Automation in microbial diagnosis. Importance, Determination of resistance/sensitivity of bacteria using disc diffusion method; Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method.	12

Total	48

Textbooks:

1. Ananthanarayan R and Paniker CKJ (2009)Textbook of Microbiology, 8th edition, Universities Press Private Ltd.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, MelnickandAdelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Randhawa, VS, Mehta G and Sharma KB (2009) Practicals and Viva in Medical Microbiology2nd edition, Elsevier India Pvt Ltd

Reference Books:

1. Tille P (2013) Bailey's and Scott's Diagnostic Microbiology, 13th edition, Mosby
2. Collee JG, Fraser, AG, Marmion, BP, Simmons A (2007) Mackie and Mccartney Practical Medical Microbiology, 14th edition, Elsevier.

Elective: DSE 3 (Discipline specific)- Semester -3rd

DSE: Bioinstrumentation and computational biology **Subject code: MIB154D301**

L-T-P-C-4-0-0-4 **Credit units: 4** **Scheme of evaluation: (T)**

Course Objective:

The course is developed with the following objectives: To enable the students to develop a proper understanding of different instruments used in microbiological and molecular research. Further, this course will also introduce students to the rapidly evolving field of bioinformatics and biostatistics.

Course outcome:

- CO-1: Remember the basic concept of various biotechniques.
- CO-2: Understanding the working principles of biotechniques and data analysis.
- CO-3: Apply the techniques for a better understanding of life functions.
- CO-4: Analysis of the structure of the protein, DNA, RNA, and other related functions.
- CO-5: Determine the scope of testing lab development for clinical and nonclinical research.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Electrochemistry: pH and Buffers Potentiometric and Conductometric titration. Principal and application of Light, phase contrast, Fluorescence Scanning and Transmission electron microscopy, confocal microscopy, cytophotometry and flow cytometry, Preparation samples for microscopy.	12
II	Principle Methodology and applications of gel filtration, ion exchange and affinity chromatography, Thin layer and gas chromatography, High performance liquid chromatography, FPLC, Centrifugation: Basic principal and application, differential – density gradient and ultra centrifugation.	12
III	Principle of biophysical method for analyzing biopolymer structure, X ray diffraction Fluorescence, UV ORD/CD Visible IR, NMR and ESR spectroscopy, Atomic absorption and plasma emission spectroscopy, MS and MALDI –TOF, Electrophoresis, Principle and application of Native, SDS Agarose and 2D gel Electrophoresis. Blotting techniques – Southern blotting, Northern blotting, Western blotting	12
IV	Biostatistics and bioinformatics – Mean, mode, median; Standard deviation and standard error; analysis of variance (ANOVA); correlation and regression analysis; Computer application - Computer basics, operating system – Windows, Hardware, Software; Internet – local area network, wide area network and computer application in microbiology. Overview of bioinformatics-NCBI, EMBL, PDB; homology algorithms (BLAST) and FASTA.	12
Total		**48**

Textbooks:

1. Biochemistry by Lubert Stryer
2. Biostatistics A.nd Microbiology: A Survival Manual by Daryl S. Paulson. Springer Verlag
3. Sharma BK, Instrument method of chemical analysis
4. DA Skoog , Instrument method of analysis
5. Plummer, An introduction to practical Biochemistry
6. Chatwal and Anand, Instrumentation

Reference Books:

1. Boyer, Modren experimental Biology
2. Principles and Techniques Of Biochemistry And Molecular Biology, Keith Wilson, John Walker. Cambridge University Press India Pvt. Ltd.

Elective: DSE 4 (Discipline specific)- Semester -3rd

DSE: Antibiotic resistance in bacteria **Subject code: MIB154D302**

L-T-P-C-4-0-0-4 **Credit units: 4** **Scheme of evaluation: (T)**

L-T-P-C-3-0-0-3 **Credit units: 3** **Scheme of evaluation: (T/P/TP)**

Course Objective:

This course is designed with the objective to provide students about different antibiotic agents used in healthcare along with their mode of action. This course also includes the mechanisms bacteria use to develop antimicrobial resistance and the factors that can lead to it. The course also designs to acquaint students with the effects of multidrug-resistant organisms in hospitals and different prevention and control strategies.

Course outcome:

- CO-1: Remember the basic concept of antibiotics.
- CO-2: Understanding the working principles of antibiotics.
- CO-3: Apply the techniques for a better understanding of antibiotic resistance development.
- CO-4: Analysis of the mechanism of resistance development against multiple antibiotics.
- CO-5: Determine the scope of alternatives of antibiotics for MDR.

Detailed Syllabus:

Modules	Topics (if applicable) & Course Contents	Periods
I.	History of antibiotic use, Penicillin Discovery and it's mode of Action, Antimicrobial agents-types and their mode of action. Evolution and molecular mechanisms of antimicrobial resistance, multi-drug resistance, superbugs and its effect on healthcare	**12**
II.	Mobile elements (plasmids, transposons, integrons) and their association with antibiotic resistance, Bacterial gene exchange (conjugation, transformation, transduction).	**12**
III.	Factors contributing the emergence of antimicrobial resistance Global emergence of antimicrobial resistance, Antimicrobial susceptibility testing,	**12**
IV	Antibiotic uses in animal foods and its impact on the environment. Misuse of antibiotics and threat to global health, Preventive and control strategies to control antimicrobial resistance.	**12**
TOTAL		**48**

Textbooks:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
2. Stefan Schwarz &Lina Maria Cavaco, Jianzhong Shen (2018). Antimicrobial Resistance in Bacteria from Livestock and Companion Animals, ASM Press
3. Scott H. Podolsky (2015) The Antibiotic Era: Reform, Resistance, and the Pursuit of a Rational Therapeutics, Johns Hopkins University Press
4. Richard GW, Kim L, Abigai AS, Harry Taber. Bacterial resistance to antimicrobials.2nd edition. CRC press.
5. Carlos F. Amabile-Cuevas. Antibiotics and Antibiotics resistance in the environment.1st edition.CRC press

Reference Books:

1. Ola Sköld (2011). Antibiotics and Antibiotic Resistance, John Wiley & Sons, Inc.
2. José-Luis Capelo-Martínez Gilberto Igrejas (2019). Antibiotic Drug Resistance John Wiley & Sons, Inc.

Elective: DSE 5 (Discipline specific)- Semester -3rd

DSE: Inheritance Biology **Subject code: MIB154D303**

L-T-P-C-4-0-0-4 **Credit units: 4** **Scheme of evaluation: (T)**

Course Objective:

The course is developed with an objective to understand the fundamental principles of Mendelian inheritance, including multiple allelism, lethal alleles, gene interactions, and sex-linked transmission. The course is also designed to enable the students to apply the principles of inheritance as formulated by Mendel and understand basic aspects of the flow of genetic information from DNA to proteins. Further, this course will enable students to understand the structure and its functional role in encoding genetic material.

Course outcome:

- CO-1: Remember the basic concept of genetics.
- CO-2: Understanding the transmission of character from one generation to the next generation.
- CO-3: Apply the mendelian law and another concept to recognize the genetic disorder
- CO-4: Analysis Patterns of inheritance of character generation to generation
- CO-5: Determine the scope to fix the genetic disoder.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Rules of Inheritance: Milestones in genetics, Mendelian genetics- Examples In pea plants, Drosophila and human, Patterns of inheritance, concept of gene.	**12**
II	Chromosomes as genetic material: Inheritance, Types, structure, Mitosis, Meiosis, polytene chromosome. DNA as the genetic material: - Structure, replication, gene expression-transcription, translation, and recombination.	**12**
III	Genome – Prokaryotic and Eukaryotic genome organization, Organelle genomes and Jumping genes, Genetic basis of heritable change – Mutation and its effects, chromosomal variations, Chromosomal syndromes	**12**
IV	Animal development – Embryogenesis, Genes involved in early development in Drosophila, Basic body axis formation, Evolution of body plan	**12**

Total	48

Textbooks:

1. Brooker, R. J. 1999. Genetics: Analysis and Principles. Benjamin Cummings, Longman, INC.

2. Gardner E. J. M. J. Simmons and D.P. Snustad 1991 Principles of Genetics. John Wiley & Sons. INC. New York.

3. Klug, W. S. and M. R. Cummings 1994 Concepts of Genetics MacMillan Colley Publishing and Company NY.

4. Strickberger M. W. 1996. Genetics. Mac Millan Publishing Co. NewYork

5. Tamarin,. R H. 1999. Principles of Genetics. McGraw-Hill.

Reference Books:

1. Griffiths,AJF, Wessler SR, Lewontin RC, Gelbart WM and JH Miller 2005, Introduction to genetic analysis W.H. Freeman and Company, New York.

2. Simmons S 2006, Principles of genetics, 4th Edition, John Wiley & Sons (Asia) Pte Ltd. New Jersey.

Elective: DSE 6 (Discipline specific)- Semester -4th

DSE: Plant-microbe interaction and plant disease **Subject code: MIB154D302**

L-T-P-C-4-0-0-4 **Credit units: 4** **Scheme of evaluation: (T)**

Course Objective:

The course is developed with the following objectives: To enable the students to develop a proper understanding of the interaction taking place among the microorganism along with another organism. This course also includes the microbes present in the soil environment and their impacts on different plants. Further, this course also includes about the plant pathogens and the social impact of plant diseases.

Course outcome:

- CO-1: Remember the basic concept of Plant -Microbe Interaction.
- CO-2: Understanding the Rhizosphere effect; Phyllosphere effect; Spermosphere effect .PTI. ETI.
- CO-3: Apply the plant-microbe interaction for better plant health.
- CO-4: Analysis of symptom and disease development in plant
- CO-5: Determine the scope of PMI for plant health and development..

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Introduction to Plant-Microbial interactions:** Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation; Microbe-Plant interaction: Symbiotic and non-symbiotic interactions;	12
II	**Concept of interactions:**Rhizosphere; Non – rhizosphere; R : S ratio; Rhizosphere effect; Phyllosphere effect; Spermosphere effect; Plant growth promoting rhizobacteria; epiphytic and endophyticmicrobiomes and their significance; bioactive compound from endophytic fungi.	12
III	**Microbial Interactions and Plant Health:**Basal Resistance or PAMP-Triggered Immunity (PTI); Pathogen-Induced Resistance or Effector-TriggeredImmunity (ETI); Effectors; Resistance Proteins; Avr/R Protein Interaction;Indirect Interaction: Guard Hypothesis	12
IV	**Microbesas Plant Pathogens** : Concept of plant disease- definitions of disease, disease cycle & pathogenicity, symptoms associated with microbial plant diseases, types of plant pathogens, economic losses and social impact of plant diseases. Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds	12
Total		48

Textbooks:

1. Agrios GN. (2006). Plant Pathology.5th edition. Academic press, San Diego,

2. Singh RS. (1998). Plant Diseases Management.7th edition.Oxford& IBH, New Delhi.

3. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 8th edition. McGraw Hill Higher Education.

4. Pelczar MJ, Chan ECS and Krieg NR. (2010). Microbiology. 8th edition. McGraw Hill Book Company.

Reference books:

1. Singh DP, Singh HB, Prabha R (2017). Plant-Microbe Interactions in Agro-Ecological Perspectives. Vol. 1. Springer.
2. Boland GJ and Kuykendall LD (1998). Plant-microbe Interactions and Biological Control Books in Soils, Plants, and the Environment. CRC Press.

Elective: DSE 7 (Discipline specific)- Semester -4th

DSE: Microbes in extreme environment **Subject code: MIB154D402**

L-T-P-C-4-0-0-4 **Credit units: 4** **Scheme of evaluation: (T)**

Course Objective:

Extreme environments are numerous and diverse on Earth. Despite harsh environmental conditions, microbes have been found thriving from the deepest seafloors to the highest mountains, from the coldest polar regions to the hottest and most arid deserts or steaming hot springs. The course will encompass foundational material for the study of life in extreme environments. In this course, we will examine microbial adaptations to their environment, how the adaptive responses affect microorganisms' evolution and how microorganisms modify their environment. We will consider physical extremes, such as temperature, pH, salinity and radiation. Additionally, we will explore the wide application potential of this area of research in the fields of medicine, biotechnology, chemical and pharmaceutical industry, or cosmetics.

Course outcome:

- CO-1: Remember the basic concept of microbial diversity.
- CO-2: Understanding the adaptations: thermophiles, psychrophiles, halophiles, acidophiles, alkaliphile.
- CO-3: Apply the microbe to reduce metal toxicity and another issue.
- CO-4: Analysis of microbe potential to solve environmental problems.
- CO-5: Determine the scope of microbe to develop product at commercial level.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Concept of extremophiles, microbial diversity in extreme environment, features of Archaea compared to bacteria, identification of microbes in extreme environment.	**12**
II	Extremophilic microbes and their adaptations: thermophiles, psychrophiles, halophiles, acidophiles, alkaliphile.	**12**
III	Microbes in toxic environments: acid mine drainage, waste containing cyanides, xenobiotics, pesticides, heavy metals and radio isotopic materials.	**12**
IV	Potential applications of extremophiles, extremozymes and case studies.	**12**
Total		**48**

Textbooks :

1. Johri, B.N(2000) Extremophiles .Springer , New York

2. Colwd , D.(1999) Microbial Diversity. Academic Press.

3. Kushner,D.J(2007) Microbial Life in Extreme Environments, Academic Press.

4. Edward,C(1990) Microbiology of Extreme Environments. Open University Press.

Reference Books :

1. Da Costa, M.S, Duarte,J.C & Williams,R.A.D(1989) Microbiology of Extreme Environments and its potential for Biotechnology. Elsiever Applied Science, London.

2. Heinrich,M.R (1976)Extreme Environment: Mechanism of Microbial Adaptation. Academic Press.

3. Thomas, D(1988) Thermophiles: General, Molecular and Applied Microbiology. Wiley Inter science Publication.

4. Perry,J.J.,Staley,J(1997)Microbiology: Dynamics and Diversity .Saunders College Publishing

Elective: DSE 8 (Discipline specific)- Semester -4th

DSE: Metagenomics **Subject code: MIB154D403**

L-T-P-C-4-0-0-4 **Credit units: 4** **Scheme of evaluation: (T)**

Course Objective:

This course is designed to provide some basic idea about non culturable microorganism, whole genome sequencing and their study through the metagenomics approach.

Course outcome:

- CO-1: Remember the basic concept of metagenomics.
- CO-2: Understanding the metagenomics approach to identify microbes in the environment.
- CO-3: Apply the metagenomics approach to screen beneficial microbes.
- CO-4: Analysis of microbe potential to improve humans. Plant health and environmental problems.
- CO-5: Determine the scope of nonculturable microbes to develop products at the commercial level

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Introduction to Genomics, Comparative account of the organization of Viral, Prokaryotic, eukaryotic, and organellar genomes, Chromatin arrangement & nucleosome formation	**12**
II	Gene sequencing, first generation, second generation, and third-generation sequencing, Sanger sequencing, Maxam-gilbert sequencing, Pyrosequencing, 16S & 18S sequencing. Metagenomics, whole-genome sequencing (NGS)	**12**
III	Metagenomics and microbe identification, schematic overview of metagenomics. omics approaches, different aspects of metagenomics	**12**
IV	C value paradox & genome size, cot curves; Operons, pseudogene, gene families, gene cluster, superfamilies. Euchromatin & heterochromatin; unique and repetitive DNA.	**12**
Total		**48**

Textbooks:

1. Molecular biology of Genes by James Watson

2. Molecular biology by David Freifelder

3. Molecular Biology of the Cell- Bruce Alberts et al.

References:

1. Manuel Fuentes, Joshua LaBaer (2014). Proteomics: Targeted Technology, Innovations and Applications. Book: 978-1-908230-46-1. ebook: 978-1-908230-62-1. Caister Academic Press.

2. Patrick Arbuthnot and Marc S. Weinberg (2014). Applied RNAi: From Fundamental Research to Therapeutic Applications. Book: 978-1-908230-43-0. ebook: 978-1- 908230-67. Caister Academic Press.

3. Jianping Xu (2014). Next-generation Sequencing: Current Technologies and Applications. Edited by: Published: 2014 Book: 978-1-908230-33-1. Ebook: 978-1- 908230-95-9. Caister Academic Press.

4. S. B. Primrose (2002). Principles of Genome Analysis. A Guide to Mapping and Sequencing DNA from Different Organisms. Blackwell publishing.

5. Mount D (2004). Bioinformatics: Sequence and Genome Analysis by. Cold Spring Harbor Laboratory Press, New York.

7. Andreas D. Baxevanis, B. F. Francis Ouellette (2005). Bioinformatics- a practical guide to the analysis of Genes and Proteins. John Wiley & Sons, UK.