**M.Sc. Microbiology Program**
**Department of Microbiology**
**School of Lifesciences**
**Central University of Tamilnadu**

## A. Vision

*Vision Statement of the Department*

| |
|---|
| To disseminate knowledge across the theoretical and practical aspects of applied microbiology that is imperative for the development of scientific research in the country. |

## B. Mission

*Mission Statements of the Department*

| | |
|---|---|
| **M1** | To impart knowledge and training across the different fields of microbiology in order to equip students for academics/industry. |
| **M2** | To enhance awareness of current research across various fields of microbiology and to bring student's knowledge to the latest state-of-the-art in their area of interest. |
| **M3** | To integrate theoretical and experimental learnings in order to encourage critical scientific thinking. |

## C. Program Educational Outcome (PEO)

*After five years of successful completion of the program, the student will be able to*

| | |
|---|---|
| **PEO1** | Understand the basic concepts of all the dimensions in Microbiology |
| **PEO2** | Get an advanced outlook on the recent findings in all fields of Microbiology |
| **PEO3** | Develop critical and experimental thinking |
| **PEO4** | Become an insightful individual with an in depth understanding of various research directions and methods |
| **PEO5** | Demonstrate precision in practical and experimental procedures |

## D. PEO to Mission Statement Mapping

| | **PEO1** | **PEO2** | **PEO3** | **PEO4** | **PEO5** |
|---|---|---|---|---|---|
| **M1** | 3 | 3 | 3 | 3 | 3 |
| **M2** | 3 | 3 | 3 | 3 | 3 |
| **M3** | 2 | 3 | 3 | 3 | 2 |

## D. Graduate Attributes of M.Sc. Microbiology Program

1. **Disciplinary Knowledge:** Content and pedagogical knowledge synchronised with the curriculum frameworks and policies
2. **Communication Skills:** Possess clarity in conveying the ideas
3. **Critical Thinking:** Capacity to apply analytical thought in the teaching and learning process
4. **Problem Solving:** Participate in the educational problem solving and applying the knowledge in the day-to-day professional endeavours.
5. **Cooperation:** Appreciate collaboration and cooperation among stakeholders of education.
6. **ICT Skills:** Selecting and integrating appropriate ICT skills for professional development.
7. **Ethics:** Doing what is right to society
8. **Self-Directed Learning:** Developing autonomy and self-regulation in teaching-learning and professional development.
9. **Reasoning:** Ability to interpret and draw the conclusion from qualitative/quantitative data with open-mindedness
10. **Creativity:** Ability to produce new ideas

11. **Societal and Environmental Concern:** Performing an act or solving a problem with respect to societal and environmental concern
12. **Lifelong Learning:** Understands the need for learning and practices it throughout life

**E. Program Outcomes (PO)**

*On the successful completion of the program, the student will be able to*

| | |
|---|---|
| **PO1** | Understand basic and advanced microbiological concepts |
| **PO2** | In depth knowledge into other fields of biological sciences |
| **PO3** | Imbibe critical scientific thinking |
| **PO4** | Design and develop experimental protocols |
| **PO5** | Demonstrate efficacy in skilled experiments |
| **PO6** | Preparedness to engage in both academic and industrial sectors |

**F. PO to PEO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **PEO1** | 3 | 3 | 3 | 3 | 3 | 3 |
| **PEO2** | 3 | 3 | 3 | 2 | 2 | 3 |
| **PEO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **PEO4** | 3 | 3 | 3 | 2 | 2 | 3 |
| **PEO5** | 3 | 2 | 3 | 3 | 3 | 2 |

**SEMESTER - I**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB101** | General Microbiology | 2 | 1 | 0 | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Explain the contribution of major scientists in the field of microbiology | Understand |
| **CO 2** | Explain various types of microscopies and principle involved | Apply |
| **CO 3** | Deals with the morphology and characteristic features of various microorganisms | Analyze |
| **CO 4** | Explains various extremophilic microbes and their mode of survival | Create |
| **CO 5** | Deals with various types of media and different sterilization techniques | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | **Scope and development**<br>Scope of microbiology, ancient microbiology - Refutation of a biogenesis: Discovery of penicillin: Discovery of vaccination: One-gene one-enzyme hypothesis, Contribution of scientists – Leeuwen hoeck, Edward Jenner, Alexander Fleming, Joseph Lister, Robert Koch, Louis Pasteur, Hargobind Khorrana. Modern Microbiology: Landmark | 12 |

<table>
<tr><td></td><td>achievements in 20th century. Microbial taxonomy - Definition and systematics, Nomenclatural rules and identification. Haeckel's three kingdom classification, Whittaker's five kingdom approach - Woese domain system. Major characteristics used in taxonomy: Morphological, physiological and metabolic, genetic and molecular taxonomy. Second edition of Bergey's manual of systematic bacteriology – characteristic features of each volume with important phyla of each.</td><td></td></tr>
<tr><td>II</td><td>Microscopy<br>Microscopy: Principle and application of light, dark-field, phase contrast, differential interference contrast (DIC), fluorescence, scanning and transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, confocal microscopy, cytophotometry and flow cytometry. Preparation of microbial, animal and plant samples for microscopy.</td><td>12</td></tr>
<tr><td>III</td><td>Prokaryotic and Eukaryotic cells<br>Differences between prokaryotic and eukaryotic cell. Biology of bacteria - cell structure, size, shape, arrangement membrane, cell wall, cytoplasmic inclusions, mesosomes, flagella and motility, slime, glycocalyx, capsule, pili, chemotaxis, endospore - biology of cyanobacteria, structure, physiology and classification – biology of yeast – reproduction - virus (bacteriophages) structure, life cycle (lytic and lysogenic) – biology of algae – mycoplasma – prions.</td><td>12</td></tr>
<tr><td>IV</td><td>Extremophiles<br>Diversity of microorganisms of arctic, antarctic and hydrothermal vents – Archaeal biology - acidophile, alkaliphile, anaerobe, cryptoendolith, halophile, hyperthermophile, hypolith, lithoautotroph, metal-tolerant microbes, oligotroph, osmophile, piezophile, polyextremophile, psychrophile/cryophile, radio-resistant, thermophile, thermoacidophile, xerophile – mechanism of extremophiles.</td><td>12</td></tr>
<tr><td>V</td><td>Cultivation and control of microbes<br>Types of growth media (natural, synthetic, complex, enriched, selective-definition with examples), pure culture methods (streak plate, spread plate, pour plate, stab culture, slant culture). Anaerobic (thioglycollate, anaerobic chamber, Robertson's media, microaerophilic), liquid shake culture of aerobic bacteria, Control of microbes - sterilisation, disinfection, antiseptic, tyndalization, pasteurization: physical - dry heat, moist heat, UV light, ionizing radiation, filtration, HEPA filter, chemical methods.</td><td>12</td></tr>
<tr><td>V</td><td>Practical (Any two)
<table>
<tr><th>S.No.</th><th>Apparatus and Tools</th><th>Concept</th></tr>
<tr><td>1</td><td>-</td><td>Intelligence</td></tr>
<tr><td>2</td><td>-</td><td>Personality</td></tr>
<tr><td>3</td><td>-</td><td>Self-Concept</td></tr>
</table></td><td></td></tr>
<tr><td></td><td>Tasks and Assignments:<br>Assignment sets, experiments and/ or seminars on advanced topics will be assigned</td><td></td></tr>
</table>

| | | |
|---|---|---|
| | **References:**<br>1. Christopher J. Woolverton, Linda Sherwood, Joanne Willey Prescott LM Harley JP and Klein DA (2016). Microbiology (10th edition) McGraw-Hill Education.<br>2. Schaechter M and Leaderberg J (2009). The Desk encyclopedia of Microbiology (3rd edition) Elseiver Academic press, California.<br>3. John Webster (2007). Introduction to Fungi. (3rd edition). Cambridge University Press, Cambridge.<br>4. Madigan MT Martinko. JM and Parker J Brock TD (2017). Biology of Microorganisms. (15th edition). Pearson.<br>5. Holt, J.S., Kreig, N.R., Sneath, P.H.A and Williams, S.T. Bergey's Manual of Determinative Bacteriology (9th Edition), Williams and Wilkins, Baltimore.<br>6. Mara D. and Horan N. (2013). The Handbook of Water and Waste-Water Microbiology. (3rd edition) Academic CRC Press | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 2 |
| **CO5** | 1 | 1 | 1 | 1 | 2 | 3 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | - | - | 2 | 2 | - |
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A**<br>**(Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B**<br>**(Short Answer - 5 x 4 = 20 marks)** | 10 | 10 | - | - | - |
| **Part – C**<br>**(Essay- 3 x 10 = 30 marks)** | - | - | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| 2 | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| 2 | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |

| | | | |
|---|---|---|---|
| 1 | _____boiled the beef broth for an hour and sealed in a flask. No microbes observed during incubation.<br>**A. Lazzaro Spallanzani; B.** Louis Pasteur; C. Anton von Leeuwenhock; D. Robert koch | Recognize | Remember |
| 2 | _____ gave the concept of Germ theory of disease, which means germs are responsible for the disease not the not the inert matter.<br>A. Lazzaro Spallanzani; B. **Louis Pasteur; C.** Anton von Leeuwenhock; D. Robert koch | Recall | Remember |
| 3 | _____ developed vaccine against rabbis from the brains and spinal cord of rabbit.<br>A. Lazzaro Spallanzani; B. **Louis Pasteur; C.** Anton von Leeuwenhock; D. Robert koch | Recognize | Remember |
| 4 | Living, unstained cells and organisms can be observed best using _____<br>A. Light microscopy; B. Electron microscopy; C. **Phase contrast microscopy; D.** Atomic force microscopy | Recognize | Remember |
| 5 | The lowest temperature that kills all microorganisms in a liquid suspension in 10 minutes is known as the _____<br>**A. thermal death point; B.** D value; C. F value; D. Z value | Recognize | Remember |
| 6 | The time required to kill 90% of the microorganisms in a sample at a specific temperature is the _____<br>A. thermal death point; B. **D value; C.** F value; D. Z value | Recognize | Remember |
| 7 | The time in minutes at a specific temperature needed to kill a population of cells is the _____<br>A. thermal death point; B. D value; C. **F value; D.** Z value | Recall | Remember |
| 8 | _____ is used to prevent infection by killing or inhabiting pathogen growth on animal tissue.<br>**A. Antiseptic; B.** Germicide; C. Bacteriostatic; D. fungicidal | Recall | Remember |
| 9 | Microorganisms belonging to the same _____ would be expected to have the most characteristics in common with each other.<br>A. genus; B. **species; C.** family; D. order | Identify | Remember |
| 10 | _____is the arrangement of organisms into groups or taxa.<br>A. phylogeny; B. **systematic; C.** taxonomy; D. classification | Identify | Remember |
| | **PART – B Short Answer** | | |

| | | | |
|---|---|---|---|
| | **The answer should not exceed 200 words 5 x 10 = 50** | | |
| 11 | a. Write the scope for microbiology.<br>**b.** Explain the refutation of a biogenesis.<br>**c.** Write the contribution of scientists – Edward Jenner, Francesco redi, Joseph Lister and Paul ehrlich. | Explain | Understand |
| 12 | a. Differentiate between prokaryotic and eukaryotic cell.<br>b. Classify bacteria based on size, shape and arrangement with example. | Differentiate Define | Understand |
| 13 | a. Explain the various internal cell organelles of bacteria with function of each.<br>b. Write the classification of algae with characteristic features of each division.<br>c. Differentiate between brightfield and darkfield microscopy. | Cite Examples | Understand |
| 14 | Explain in detail the nutritional classification of bacteria with example of each? | Illustrate | Apply |
| 15 | a. Write a short on:<br>a. Cryophiles; b. Piezophile; c. Auxotrophs; d. Mycoplasma; e. Prions<br>b. Write the classification for bacteriophages | Describe | skill |

**SEMESTER - I**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB 102** | Cell and Molecular Biology | 2 | 2 | | 4 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Explain the structure and function of different cell organelles, and the mode of replication, transcription, and translation of nucleic acids | Understand |
| **CO 2** | Evaluate and apply knowledge of concepts in cellular biology. | Apply |
| **CO 3** | Examine the cyclic events of cell division and types of cell division. | Analyze |
| **CO 4** | Interpret and explain key experiments in cell and molecular biology | Create |
| **CO 5** | Decipher the cell signalling pathways using modern techniques | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | The molecules of life, the architecture of cells; Cell theory, Emergence of modern cell biology, Structure of prokaryotic and eukaryotic cells- cell wall, cell membrane, cell organelles -organization and functions, Cell cycle events - Molecular cell biology - protein structure and function, Hierarchical structure of proteins - folding, modification and degradation, functional design of proteins - membrane proteins - purification, detection and characterization**.** | 12 |
| **II** | Biosynthesis of macromolecules - Biomembranes and subcellular organization of prokaryotic and eukaryotic cells - cell architecture - Cell signalling – types, Chemical signals and cellular receptors, G Protein-linked receptors, Protein kinase-associated receptors, Growth factors as messengers, Cell signals and Apoptosis, Cytoskeleton: microfilaments-intermediate filaments-microtubules**.** | 12 |
| **III** | Prokaryotic and eukaryotic DNA replication, mechanisms of DNA replication, fidelity of replication, enzymes and proteins involved in DNA replication. Types of gene mutations. Suppression, Transposable Genetic Elements, Ames' test. DNA damage and repair mechanisms, DNA repair and aging, DNA repair modulation. | 12 |
| **IV** | Prokaryotic transcription: RNA polymerase, holoenzyme and apoenzyme, sigma factors, details of initiation, elongation, termination. Eukaryotic transcription: Types of RNA polymerases. Promoter of RNA polymerase II. Enhancers. General and inducible transcription factors. Posttranslational modification: mRNA processing, processing, capping, cleavage and polyadenylation, splicing of nuclear pre-mRNA, mRNA stability. | 12 |
| **V** | Gene code: characteristics, deciphering the code. Protein biosynthesis: Prokaryotic and eukaryotic translation, the translational machinery, mechanism of initiation, elongation and termination. Regulation of expression in eukaryotes: Britten-Davidson model. DNA binding and activation domains of transcription factors. Packaging of chromosomes and its relation to transcription regulation. Regulation of translation by 3' and 5' UTR motifs. | 12 |
| VI | Gene Regulation & Expression: Operon concept, Repression of the lac operon, Regulation of tryptophan biosynthesis operon by attenuation, catabolite repression instability of bacterial RNA, positive and negative regulation, inducers and co-repressors. Negative regulation - E. coli lac operon; Regulation of the heat-shock regulation by an alternate sigma factor, Two component regulatory systems. | 12 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ A write-up on the underlying mechanism of autophagy and ubiquitin proteasome mediated protein degradation in neurodegenerative diseases models<br>✓ Seminar on mitochondrial dysfunction in Alzheimer's disease and Parkinson's disease | |

| | | |
|---|---|---|
| | ✓ A mini project on gene expression and regulation using E.Coli as model organism<br>✓ Internal exams<br><br>References<br>Alberts Bruce (2014) Molecular Biology of Cell (6th edition), Garland Science<br>Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter.<br>Benjamin Lewin. Gene VIII. Pearson Education Inc. NJ, 2004.<br>Darnell, Lodish and Baltimore. Molecular Cell Biology, 6th Ed. Garland Science<br>Russel Peter. Essential Genetics. 2nd Ed, Blackwell Science<br>Watson. J. D, Baker. T. A, Bell. S. P, Gann. A, Levine. M, Losick. R. Molecular Biology of Gene. (7th edition) Pearson<br>Weaver. R. F. Molecular Biology. 5th Ed. McGraw-Hill Education | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 2 |
| **CO5** | 1 | 1 | 1 | 1 | 2 | 3 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | 1 | 1 | 2 | 2 | - |
| **Test** | 4 | 4 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Short Answer - 5 x 4 = 20 marks)** | 10 | 10 | - | - | - |
| **Part – C (Essay- 3 x 10 = 30 marks)** | - | - | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| 2 | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| 2 | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | From the following which statement is incorrect<br>a)Bacteria have a single circular molecule of DNA, and | Recognize | Remember |

| | | | |
|---|---|---|---|
| | typically only a single replication origin per circular chromosome.<br>b)Archaea have a single circular molecule of DNA and several origins of replication along this circular chromosome.<br>c**)Archaea have a single circular molecule of DNA and only one origin of replication along this circular chromosome.**<br>d) Eukaryotes often have multiple origins of replication on each linear chromosome that initiate at different times. | | |
| 2 | The role of σ subunit in the prokaryotic RNA polymerase enzyme is<br>a) DNA binding<br>b) Chain initiation and recognition<br>c) Chain initiation and interaction with regulatory protein<br>**d) Promotor recognition** | Recall | Remember |
| 3 | In this type, mutation turns abnormal phenotype into wild type phenotype<br>a) Transversion mutation<br>**b) Back mutation**<br>c) Frameshift mutation<br>d) Forward mutation | Recognize | Remember |
| 4 | 4. Which of these properties do not agree with trp operon attenuator?<br>a) It brings about the repression of trp operon<br>**b) It consists of one stem-loop system**<br>c) It has two codons for tryptophan in sequence<br>d) Ribosome stalls at the attenuator | Recognize | Remember |
| 5 | What is the regulation of a lac operon by a repressor known as?<br>a) Neutral regulation b) Positive regulation<br>c) Mixed regulation **d) Negative regulation** | | Remember |
| 6 | Genetic Abnormalities in the neurofilament is associated with the following disease<br>a) Parkinson's disease.<br>**b) Amyotrophic Lateral disease**<br>c) Huntington's disease<br>d) Alzheimer's disease | Recognize | Remember |
| 7 | Which of the following organelle is involved in xenobiotic detoxification?<br>a) Golgi<br>b) Lysosome<br>**c) Smooth Endoplasmic Reticulum (SER)**<br>d) Rough Endoplasmic Reticulum (RER) | Recall | Remember |
| 8 | The receptors for a group of signaling molecules known as growth factors are often<br>a) Ligand-gated ion channels<br>b) G-protein-linked receptors<br>c) Cyclic AMP<br>**d) Receptor tyrosine kinases** | Recall | Remember |

| | | | |
|---|---|---|---|
| 9 | Topoisomerases are a major component of<br>a) Transcription Factors<br>b) House Keeping Proteins<br>c) Histone Proteins<br>**d) Non-histone Proteins** | Identify | Remember |
| 10 | Which of the following is not a part of 5' untranslated region?<br>a) Introns in the UTRs<br>b) Secondary structure<br>**c) Poly A tail**<br>d) G4 structures | Identify | Remember |
| | **PART – B Essay Answer**<br>**The answer should not exceed 1000 words 5 x 10 = 50** | | |
| 11 | Detail the following with an example<br>a) Intragenic mutation suppression<br>b) bypass suppression<br>c) transposable elements | Explain | Understand |
| 12 | a) What are the different steps involved in RNA processing?<br>b) Termination steps in prokaryotic transcription. | Differentiate<br>Define | Understand |
| 13 | a) Explain the blue white colony screening and how it can help in the identification of recombinant bacteria? | Cite Examples | Understand |
| 14 | a) Classify the different classes of sphingolipids with examples<br>b) Describe the techniques used for the qualitative and quantitative analysis of lipids | Illustrate | Apply |
| 15 | a) Explain the underlying mechanism of the mTOR-dependent and independent mechanism of autophagy.<br>b) Detail the sequential involvement of various ATG complexes in the formation of phagophore and autophagosome | Describe | Analyse |
| 16 | Explain with well-labelled diagrams the Prokaryotic Translation – Chain Initiation and Prokaryotic Translation – Chain Elongation steps. | Explain<br>Discuss | Understand |
| 17 | Explain in detail the three levels of chromatin organization with suitable diagrams | Illustrate | Apply |

**SEMESTER - I**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB103** | Microbial Biochemistry | 2 | 1 | | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Understand the chemistry of life and major biomolecules' roles in our lives, how they are bonded with our metabolism | Understand |
| **CO 2** | To study how the energy flows through living systems and concepts of energy change | Apply |

| | | |
|---|---|---|
| **CO 3** | Understand the concepts of protein structure determinations and nucleic acid structures. | Analyze |
| **CO 4** | Understand the structures and isomers of carbohydrates and metabolism of lipids and their uses | Create |
| **CO 5** | To study the metabolic pathways and fermentation | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | **Chemistry of Life** and Special Microbial Molecules: Bonds: ionic bonding, Ion-dipole. Covalent bond, H-bonds, Van der Wall's interaction, Hydrophobic and hydrophilic interactions. Water as a biological solvent and its role in biological processes pH, Henderson-Hasselbalch equation, the concept of buffer, strength of buffer, range of buffer, important biological buffers. Structure of Microbial Molecules: Peptidoglycan, bacteriorhodopsin, biphytanyl chains and lipids in archaeal cell membranes and their significance in adaptation in extreme conditions. | 9 |
| **II** | **Bioenergetics:** Laws of thermodynamics, entropy, enthalpy, free energy, free energy and equilibrium constant, Gibbs free energy equation, determination of free energy of hydrolytic and biological oxidation reduction reactions, under standard and non-standard conditions, high energy compounds, coupled reactions, determination of feasibility of reactions. ATP and other different groups of high energy phosphate compounds. | 9 |
| **III** | **Proteins & Nucleic acids:** Structural features of amino acids & classification, peptide linkage: partial double bond nature, determination of primary structure of polypeptide, structural classification of proteins, primary, secondary, tertiary, quaternary structures of proteins. Ramchandran plot. Structure of purines, pyrimidines, nucleosides and nucleotides. Physiochemical properties of nucleic acids - Denaturation of nucleic acids. Hyperchromic effect and Tm. Chargaff's rule, Secondary structure of DNA - Watson and Crick model. Secondary structure of tRNA - clover leaf model | 9 |
| **IV** | **Carbohydrates & Lipids:** Monosaccharides, disaccharides, oligosaccharides and polysaccharides, concepts of epimer, isomer. Lipids: Saturated and unsaturated fatty acids, fatty acid oxidation. Biosynthesis of fatty acids, triacylglycerols and phospholipids | 9 |
| **V** | **Metabolic Pathways and Fermentations:** Glycolytic pathway, Pentose phosphate pathway (HMP), Entner-Doudroff pathway, Tricarboxylic acid cycle, PDH Multi-enzyme complex Amphibolic pathway, anaplerotic reactions. ETC, generation and maintenance of proton motive force PMF, chemi-osmotic theory, Q cycle, Ubiquinone, Cyt C. Substrate level and oxidative phosphorylation, inhibitors and un-couplers of electron transport chain and function of ATPase (bacterial and mitochondrial), shuttle systems. Fermentation - Lactic acid fermentation, LDH - Alcoholic fermentation ADH - Catabolism of glycogen. Amino acid catabolism- Urea cycle: deamination and transamination reactions. de novo biosynthesis of purines and pyrimidines, ribonucleotide reductase and its role in nucleic acid metabolism | 9 |
| | **Tasks and Assignments:** | |

| | | |
|---|---|---|
| | 1. Each student is required to submit the following:<br>2. Demonstrate the different chemical bonding among bio, micro and macro molecules of ife.<br>3. Determine and analyze the protein structure based on their protein sequences.<br>4. Mechanism of energy transfer within the cells, and demonstrate the prokaryotic and eukaryotic energy production pathways.<br><br>**References:**<br>1. D.L. Nelson, Michael M. Cox Lehninger's Principle of Biochemistry. 6th ed. W. H. Freeman, 2012<br>2. J.M. Willey, Lansing M. Prescott Microbiology. 7th Ed. McGraw-Hill Higher Education, 2008<br>3. Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, Jr., Lubert Stryer Biochemistry. 8th Ed. W. H. Freeman, 2015.<br>4. White David. Physiology and Biochemistry of Prokaryotes. 3rd Ed. Oxford University Press, New York, 2007 | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 | 2 |
| **CO2** | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 1 | 1 | 2 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | - | - | 2 | 2 | - |
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A<br>(Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B<br>(Essay - 10 x 5 = 50 marks)** | 10 | 10 | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| 2 | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| 2 | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | The most common type of protein structure is<br>a. Beta sheets b) alpha helix c) beta turns d) all the above | Recognize | Remember |

| | | | |
|---|---|---|---|
| 2 | The common point of rotation in the peptide bond is<br>a) Beta carbon c) C-N bond<br>b) C-C bond d) alpha carbon | Recall | Remember |
| 3 | The molecular weight of T-RNA is<br>a. 25-30 KD b. 30-35 KD c. 20-25 KD d. 15-20 KD | Recognize | Remember |
| 4 | From the following which is not a structural protein<br>a. Keratin b. tubulin c. myosin d. actin | Recognize | Remember |
| 5 | A _____ refers to one of three possible ways of reading a nucleotide sequence.<br>a. Open reading frame b. reading frame c. codons d. protein-coding sequences | Recognize | Remember |
| 6 | Helix breaker is<br>a. Cytosine b. alanine c. proline d. glycine | Recognize | Remember |
| 7 | From the following which is not a ketose<br>a. Xylulose b. ribulose c. Dihydroxyacetone d. arabinose | Recall | Remember |
| 8 | Photosynthesis is an _____ reaction<br>a. Exergonic b. endergonic c. equilibrium reaction d. none of the above | Recall | Remember |
| 9 | ATP is consisted of following type of bonds<br>a. Acyl phosphatic bond b. thioester bond c. Phospho anhydride bond d. enol phosphatic bond | Identify | Remember |
| 10 | The following enzyme is not involved in pyruvate dehydrogenase complex<br>a. pyruvate dehydrogenase<br>b. dihydrolipoyl reductase<br>c. dihydrolipoyl transacetylase<br>d. dihydrolipoyl dehydrogenase | Identify | Remember |
| | **PART – B ESSAY Answer**<br>**The answer should not exceed 200 words 10x 5 = 50** | | |
| 11 | How do you asses the spontaneity of a reaction in comparison with Gibbs free energy, enthalpy and entropy? | Describe | Analyse |
| 12 | What are stereoisomers, enantiomers, epimers and enantiomers? Give suitable examples. | Explain Discuss | Understand |
| 13 | What are different high energy compounds involved in metabolic pathways? | Assess | Skill |
| 14 | a. What is anaerobic cellular respiration and what are the products formed out of that?<br>b. Summarise the amount of ATP production from aerobic respiration processes. | Describe | Analyse |
| 15 | What are different forms of secondary structures are possible in a protein molecule and their use? | Explain Discuss | Understand |

| | | | |
|---|---|---|---|
| 16 | Detail the T-RNA structure and function. | Assess | Skill |

**SEMESTER - I**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB104** | Immunobiology | 3 | 0 | 0 | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Understand the basics of immunology | Understand |
| **CO 2** | Explain the antigen recognition by the B-cell and T-cell receptors and antibody structure | Apply |
| **CO 3** | Explain the immune signaling and apoptosis | Analyze |
| **CO 4** | Learn adaptive immune responses | Create |
| **CO 5** | Understand the role of immune system in human health and diseases | Apply |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Introduction to Immunobiology and Innate Immunity: Principles of innate and adaptive immunity, Effector mechanisms – The first-lines of defense, complement system, Pattern recognition, induced innate responses to infection. | 16 |
| **II** | Recognition of Antigen: Antigen recognition by B-cell and T-cell receptors, Structure of antibody molecule, the interaction of antibody molecule with specific antigen, Antigen recognition by T cells, Generation of lymphocyte antigen receptors, primary Ig rearrangement, T-cell receptor gene rearrangement, structural variation in Ig constant regions, secondary diversification of antibody repertoire, antigen presentation to T lymphocytes, generation of T-cell receptor ligands, the MHC and its functions. | 16 |
| **III** | Development of Mature Lymphocyte Receptor Repertoires: signaling through immune system receptors, general principles of signal transduction and propagation, antigen receptor signaling and lymphocyte activation, Other receptors and signaling pathways: cytokine and cytokine receptors, apoptosis receptors, Development of B lymphocytes and T lymphocytes, Positive and negative selection, Survival and maturation of lymphocytes in lymphoid tissues. | 16 |
| **IV** | Adaptive Immune Response: T cell-mediated immunity, entry of naïve T cells and APCs into peripheral lymphoid organs, priming of naïve T cells by DCs, General properties of effector T cells and their cytokines, T cell-mediated cytotoxicity, macrophage activation by Th1 cells, Th2 cells, Th17 cells & Tregs. Humoral Immune Response: B cell activation by helper T cells, Distribution and functions of Ig classes, Destruction of antibody-coated pathogens via Fc receptors, Dynamics of adaptive immunity, The mucosal immune system and organization, Mucosal responses to infection and regulation. | 16 |

| | | |
|---|---|---|
| **V** | Immune System in Health and Disease: Failures of host defense mechanisms: Evasion and subversion of immune defenses, Immunodeficiency diseases, Allergy and other hypersensitivity disorders and mechanisms, Autoimmunity and transplantation: The making and breaking of selftolerance, autoimmune diseases and mechanisms, genetic and environmental basis of autoimmunity, responses to alloantigens, transplant rejection, manipulation of immune responses, treatment of adverse responses, anti-tumor responses and vaccination. Immunodiagnostics: Serological reactions: Immunoprecipitation, flocculation, agglutination, ELISA, RIA, complement fixation, western blotting, flow cytometry, cytokine arrays. | 16 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ Assignments<br>✓ Research seminars<br>**References:**<br>1. Janeway Immunobiology. 9th Edition. Publisher-Garland Science, 2016<br>2. Abul K Abbas, Andrew H Lichtman & Shiv Pillai, Cellular & Molecular Immunology, 8th Edition 2014, Elsevier<br>3. Roitt's Essential Immunology, 13th Edition, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt 2016, Wiley-Blackwell.<br>4. William E. Paul. Fundamental Immunology. 7th Edition. Lippincott Williams and Wilkins, 2012. | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 2 | 4 | 3 | 3 | 2 | 3 |
| **CO3** | 1 | 3 | 3 | 3 | 3 | 4 |
| **CO4** | 2 | 3 | 1 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 1 | 3 | 2 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | - | - | 2 | 2 | - |
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part –B (Essay- 5 x 10 = 50 marks)** | 10 | 10 | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| 2 | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| 2 | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | ----------can bind to DNA.<br>a. DAPI<br>b. CDDO<br>c. Metotrexate<br>d. DMSO | Recognize | Remember |
| 2 | --------- Protein can be used as an internal control in blotting experiments.<br>a. Bcl-2<br>b. Nrf2<br>c. Bax<br>d. B-actin | Recall | Remember |
| 3 | Bid is a substrate of ----------.<br>a. Caspase 2<br>b. Caspase 3<br>c. Caspase 8<br>d. Caspase | Recognize | Remember |
| 4 | The _____ marginal zone is a unique compartment that separates the lymphoid white pulp from the surrounding red pulp.<br>a. Spleenic<br>b. Tonsil<br>c. Peyer's patch<br>d. Appendix | Recognize | Remember |
| 5 | The TLR9 recognises:<br>a. CpG motifs.<br>b. Gram +ve peptidoglycan.<br>c. Mycobacterial lipoarabinomannan.<br>d. dsRNA. | Recognize | Remember |
| 6 | Which of the following pairs is mismatched?<br>a. Plasma cell: mediation of phagocytosis and killing of microorganisms in the plasma<br>b. Dendritic cell: activation of adaptive immune responses<br>c. Neutrophil: formation of pus<br>**d.** Regulatory T cell: inhibition of T-cell activity. | Recognize | Remember |
| 7 | Peptides produced by processing of cytosolic proteins largely:<br>a. Enter the endoplasmic reticulum by diffusion.<br>b. Are presented at the cell surface with MHC class II to CD4 T-helpers.<br>c. Are presented at the cell surface with MHC class II to CD8 cytotoxic T-cells.<br>d. Are presented at the cell surface with MHC class I to CD8 cytotoxic T-cells. | Recall | Remember |

| | | | |
|---|---|---|---|
| 8 | The initial complement component that is bound by complement-fixing antibodies is:<br>a. C1q<br>b. C1s<br>c. C3b<br>d. C5a | Recall | Remember |
| 9 | Homing of effector T cells to inflamed tissue is facilitated by the upregulation of _____ on the surface of the effector T cell.<br>a. VLA-4<br>b. L-selectin<br>c. CD28<br>d. VCAM-1 | Identify | Remember |
| 10 | Antigen recognition by T cells in the absence of co-stimulation results in<br>a. upregulation of B7<br>b. expression of the high-affinity IL-2 receptor<br>c. T-cell anergy<br>d. T-cell apoptosis | Identify | Remember |
| | | | |
| **PART – B Essay Answer<br>The answer only 5 questions and answer should not exceed 400 words 5 x 10 = 50** | | | |
| 11 | Discuss the following.<br>a.Cytokine array<br>b.Tissue microarray | Describe | Analyse |
| 12 | How will you find out the binding element of the transcription factor NFκB by an experimental method? Explain with a suitable diagram. | Explain Discuss | Understand |
| 13 | Explain the receptor-mediated apoptotic pathways in detail. | Assess | Skill |
| 14 | Describe the macromolecular structure of the MHC ligand that presents microbial peptides to naïve CD8+ and CD4+ T cells. Discuss the cellular mechanisms underlying the processing and presentation of MHC-I and II to antigens in endosomal and ER compartments. | Explain Discuss | Understand |
| 15 | Write short notes on<br>a. Immunoproteosome<br>b. Idotypic antibody<br>c. MHC restriction<br>d. Treg cells | Explain Discuss | Understand |
| 16 | What is hybridoma technology? Discuss the principles and procedures involved in the mass generation of monoclonal antibodies in R&D labs and their clinico-diagnostic applications | Describe | Analyse |
| 17 | Describe the mechanisms involved in the expansion of different subsets of T helper cell phenotypes following activation by antigen-presenting cells. Discuss the | Describe | Analyse |

| | | | |
|---|---|---|---|
| | significance of Th1, Th2, Th17 and Tregs in cell-mediated immune responses. | | |

**SEMESTER - I**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB105** | Microbial Physiology | 2 | 1 | 0 | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Explain the nutritional patterns and their classifications in various microbes. | Understand |
| **CO 2** | Explain various types of metabolic processes and their diversity in microbes. | Apply |
| **CO 3** | Deals with photosynthesis and inorganic metabolic processes present in microorganisms. | Analyze |
| **CO 4** | Explains the anaerobic respiration and associated processes happening in various microbes. | Create |
| **CO 5** | Deals with various types of metabolic regulations along with their regulatory pathways present in microbes. | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | **Microbial nutrition**<br>Microbial nutrient requirements, macro-nutrients, micro-elements, growth factors, sources of nutrients, nutritional classification of bacteria: phototroph, chemotroph, autotroph, heterotroph, photoautotroph, photoheterotroph, chemoautotroph, chemoheterotroph – nutritional patterns of pathogens – saprophytes – auxotroph. | 12 |
| **II** | **Metabolic Diversity**<br>Heterotrophic metabolism on substrates other than glucose. Hydrolysis of polymers - Starch hydrolysis, Cellulose hydrolysis, Oxidation of aliphatic hydrocarbons - Amino acid utilization: Oxidative deamination, Transamination - Oxidation of aromatic compounds -Methanotrophy; Characteristics of methanotrophs, Dissimilation of methane by methanotrophs -Carbon assimilation by methylotrophs - Energy efficiency in C1 metabolism | 12 |
| **III** | **Photosynthesis & Inorganic Metabolism**<br>Characteristics and Metabolism of Autotrophs, Photosynthetic Bacteria and Cyanobacteria Autotrophic CO2 Fixation and Mechanisms of Photosynthesis, Photosystem I and II in cyanobacteria – Methanogenesis - Nitrification: Nitrifying Bacteria, Ammonia oxidation, Nitrite oxidation, anaerobic nitrification - Sulfur bacteria and the oxidation of sulfur compounds | 12 |
| **IV** | **Anaerobic Respiration**<br>Denitrification: Biochemistry of denitrification, - Regulation of denitrification - Metal reduction: Fe (III) and Mn (IV) reduction, Microbial reduction of other metals, Metal reduction and the environment | 12 |

<table>
<tr><td></td><td>- Sulfidogenesis: Biochemistry of sulfidogenesis, Reduction of sulfate and sulfur, - sulphur reducing bacteria.</td><td></td></tr>
<tr><td>V</td><td>Metabolic Regulation<br>Regulation through modulation of enzyme activity: fine regulation, Feedback inhibition Enzyme activity modulation through structural changes, Phosphorylation Adenylylation, Acetylation, Other chemical modifications, Regulation through physical modification and dissociation/association, Allosteric regulation and Feedback control- Regulation of E. coli aspartate carbamoyltransferase.</td><td>12</td></tr>
<tr><td>V</td><td>Practical (Any two)
<table>
<tr><th>S.No.</th><th>Apparatus and Tools</th><th>Concept</th></tr>
<tr><td>1</td><td>-</td><td>Intelligence</td></tr>
<tr><td>2</td><td>-</td><td>Personality</td></tr>
<tr><td>3</td><td>-</td><td>Self-Concept</td></tr>
</table></td><td></td></tr>
<tr><td></td><td>Tasks and Assignments:<br>Assignment sets, experiments and/ or seminars on advanced topics will be assigned<br><br>References:<br>1. Alcomo, I.E. 2011. Fundamentals of Microbiology. 9th Edition, Jones and Bartlett Publishers, Sudbury. Massachusetts.<br>2. Gerard J. Tortora, Berdell R. Funke, Christine L. Case. Microbiology-An Introduction.11th edition Pearson, 2013<br>3. David White., 2007 The Physiology and Biochemistry of Prokaryotes, 3rd edn, Oxford University Press<br>4. Perry, J.J., Staley, J.T. and Lory, S. 2007. Microbial Life. 2nd edition Sinauer Associates, Publishers, Sunderland, Massachusetts.<br>5. Schaechter, M. Ingraham, J.L. and Neidhardt, F.C. 2006. Microbe. ASM Press, Washington. D.C.</td><td></td></tr>
</table>

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 2 |
| **CO5** | 1 | 1 | 1 | 1 | 2 | 3 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |

| | | | | | |
|---|---|---|---|---|---|
| **Seminar** | - | - | 2 | 2 | - |
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Short Answer - 5 x 4 = 20 marks)** | 10 | 10 | - | - | - |
| **Part – C (Essay- 3 x 10 = 30 marks)** | - | - | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| **2** | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2** | **Presentation**<br><br>**50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | Assume you inoculated 100 facultative anaerobic cells onto nutrient agar and incubated the plate aerobically. You then inoculated 100 cells of the same species onto nutrient agar and incubated the second plate anaerobically. After incubation for 24 hours, you should have?<br>a) more colonies on the aerobic plate.<br>b) more colonies on the anaerobic plate.<br>c) the same number of colonies on both plates.<br>d) nothing will grow in both the plates | Recognize | Remember |
| 2 | Which one of the following temperatures would most likely kill a mesophile?<br>a) -20°C<br>b) 12°C<br>c) 20°C<br>d) 47°C | Recall | Remember |
| 3 | An organism that has peroxidase and superoxide dismutase but lacks catalase is most likely an<br>a) aerobe.<br>b) aerotolerant anaerobe.<br>c) obligate anaerobe<br>d) facultative anaerobes | Recognize | Remember |
| 4 | A soup container was forgotten in the refrigerator and shows contamination. The contaminants are probably which of the following?<br>a) thermophiles<br>b) acidophiles<br>c) mesophiles<br>d) psychrophiles | Recognize | Remember |
| 5 | Growth of bacteria or microorganisms refer to<br>_____<br>a) an increase in the size of an individual organism<br>b) an increase in the mass of an individual organism<br>c) any changes in the population | Recognize | Remember |

| | | | |
|---|---|---|---|
| | d) an increase in number of cells | | |
| 6 | Which of the following factors are responsible for the stability of thermophiles at high temperatures?<br>a) Increased leakage of cell components<br>b) Presence of large no. of polar amino acids and alpha-helix protein<br>c) Presence of thermo ribosomes<br>d) Presence of Inositol diphosphate and thermal stability of ribosomes | Recognize | Remember |
| 7 | The Reactive Oxygen Species(ROS) produced by some bacteria are degraded by which of the following enzymes?<br>a) Peroxidase<br>b) Lyase<br>c) Catalase<br>d) Superoxide dismutase, Catalase and Peroxidase | Recall | Remember |
| 8 | Which of the following acts as a chemical reductant in bacterial photosynthesis?<br>a) Oxygen<br>b) Water<br>c) Hydrogen sulphide<br>d) Ammonia | Recall | Remember |
| 9 | Bacteria that grow in mine drainage at pH 1–2 are probably which of the following?<br>a) Alkaliphiles<br>b) Acidophiles<br>c) Neutrophiles<br>d) Obligate anaerobes | Identify | Remember |
| 10 | Which of the following environments would harbor psychrophiles?<br>a) Mountain lake with a water temperature of 12 °C<br>b) Contaminated plates left in a 35 °C incubator<br>c) Yogurt cultured at room temperature of 25 °C<br>d) Salt pond in the desert with a daytime temperature of 34 °C | Identify | Remember |
| | **PART – B ESSAY Answer**<br>**The answer should not exceed 200 words 10x 5 = 50** | | |
| 11 | Define microbial nutrition and describe in detail the different types of transport systems used by microbial cells to transport nutrients? | Describe | Analyse |
| 12 | Describe the microbial metabolism of starch hydrolysis? write the step involved in isolating the starch hydrolysing bacteria in the lab?. | Explain Discuss | Understand |
| 13 | What are methanotrophs? Describe how Carbon assimilation is performed by methylotrophs? | Assess | Skill |
| 14 | Describe in detail the metabolic process of lactose and maltose utilization by the *E. coli* cells? | Describe | Analyse |

| | | | |
|---|---|---|---|
| 15 | Describe the mechanism of uptake and oxidation of aliphatic hydrocarbons by microorganism? | Explain Discuss | Understand |
| 16 | Aspartate transcarbamoylase (ATCase) is the first step in the pyrimidine synthesis. Explain how rising ATP and CTP concentrations have antagonistic effects on the allosteric regulation of this enzyme. | Assess | Skill |

**SEMESTER - II**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **PMB 101** | Practical Microbiology I | | 0 | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Principles and methods of sterilization, culturing and staining of microbes | Understand |
| **CO 2** | Evaluate and apply knowledge of modern techniques in the identification of microbes | Apply |
| **CO 3** | Examine the cell cycle in various squash preparations to identify mitotic and meiotic stages | Analyze |
| **CO 4** | Classifications of bacterial and fungal staining procedures | Create |
| **CO 5** | Isolation and purification of microbes and maintaining the pure culture in lyophilized condition | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Principles and methods of sterilization, Direct microscopic observations of bacterial shape – cocci, rods, chains, fungal spores, mycelium, yeast budding, Preparation of Media: Nutrient broth, Nutrient agar, plates, slants, soft agar, Pure culture technique: Streak plate, spread plate and pour plate methods, Measurement of size of microbes – micrometry, Bacterial motility by hanging drop method, Enumeration of bacterial/yeast cells-viable count (plate count) Total count (Haemocytometer), Isolation and purification of cyanobacteria, actinomycetes, fungi and protozoans, Staining methods: Simple, Negative, acid fast, Gram staining, spore, Capsule, Metachromatic granular staining, Lactophenol cotton blue staining and flagellar staining - Fungal slide culture. | 20 |
| **II** | Preparation of permanent slides, Observation of prokaryotic and eukaryotic cells and cell types, Study of cell organelles adopting preparations/models, Squash preparation of giant chromosome of salivary gland of chironomous larva, Squash preparation of onion root tip, testis and anther lobes, Preparation of buccal smear, Red blood cell as osmometer, Subcellular fractionation and biochemical/enzymological analysis, Metaphase chromosome preparations and preliminary banding techniques | 20 |
| | **Tasks :** | |

| | | |
|---|---|---|
| | Each student will be evaluated by the following:<br>✓ Lab performance 20%<br>✓ Lab report 30%<br>✓ Examination 50% | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 2 |
| **CO5** | 1 | 1 | 1 | 1 | 2 | 3 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | 1 | 1 | 2 | 2 | - |
| **Test** | 4 | 4 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A<br>(Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B<br>(Essay - 5 x 10 = 50 marks)** | 10 | 10 | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content<br>50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | evidence and facts mostly specific. | | | | |
| **2** | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| **Sl. No.** | **Criteria** | **100%** | **75%** | **50%** | **25%** | **0%** | **Relation to COs** |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| **2** | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| **Sl. No.** | **Model Questions** | **Specification** | **Level** |
|---|---|---|---|
| | **PART – B Essay Answer**<br>**The answer should not exceed 1000 words 2 x 25 = 50** | | |
| 1 | Identify the slides containing below<br>a) Smear preparation<br>b) Squash preparation<br>c) Permanent fungal specimen | Identify | Describe |
| 2 | Project viva voce | Explain | Understand |

**SEMESTER - I**

| **Course Code** | **Course Name** | **L** | **T** | **P** | **Credits** |
|---|---|---|---|---|---|
| **PMB 102** | Practical Microbiology II | | | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Make standard buffers and determine pH of a solution | skills |
| **CO 2** | Perform qualitative and quantitative tests for carbohydrates, proteins, and estimation of RNA/DNA | skills |
| **CO 3** | Learn the quantification of blood cells, ELISA, western blotting techniques | analyze |
| **CO 4** | observe animal handling | analyze |
| **CO 5** | Observe different injection methods in animal | skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Preparation of standard buffers and determination of pH of a solution, Qualitative tests for Carbohydrates- Tests for sugars: Fructose, lactose, maltose, glucose and starch, Qualitative tests for amino acids, Quantitative estimation of glucose by DNS method, Quantitative estimation of protein by Biuret method, Quantitative estimation of protein by Lowry's method, Determination of Iodine value, Estimation of carbohydrates by anthrone method, Estimation of amino acids by ninhydrin method, Estimation of DNA/RNA. | 15 |
| **II** | Virtual demonstration (as per UGC guidelines) of handling of laboratory animals, Different ways of injecting antigens to mouse (IP, SC, IV, retro-orbital), Isolation of organs and tissues of immune system from mouse, Quantification of blood cells using haemocytometer, extraction of human PBMCs by Ficoll-Hypaque overlay method, flow cytometry and data analysis, WIDAL test for enteric fever, Immunoelectrophoresis, ELISA, Western blotting, VDRL test for syphilis | 15 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ Participate in the subject-oriented quiz.<br>✓ Visit industry to learn techniques and advancements.<br>✓ Maintaining record note books<br><br>**References:**<br>1. **Practical Handbook of Microbiology, edited by** Emanuel Goldman (Editor), Lorrence H Green (Editor).<br>**2.** Practical Immunology, 4th Edition, edited by Frank C. Hay, Olwyn M. R. Westwood. By Carlos F. Barbas, Dennis R. Burton, Jamie K. Scott, Gregg J. Silverman | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 |
| **CO2** | 3 | 2 | 2 | 2 | 2 |
| **CO3** | 1 | 3 | 2 | 2 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **CO4** | 2 | 2 | 1 | 2 | 2 |
| **CO5** | 1 | 2 | 2 | 1 | 1 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 10 | 10 | 10 | 10 | 10 | 50 |
| **External** | 10 | 10 | 10 | 10 | 10 | 50 |
| **Total** | 17 | 17 | 15 | 17 | 17 | **100** |

**e. Mapping Course Outcome with Internal Assessment (50 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Practical** | 3 | 3 | 3 | 3 | 3 |
| **Seminar** | - | - | | | - |
| **Test** | 4 | 4 | 4 | 4 | 4 |
| **Attendance** | 3 | 3 | 3 | 3 | 3 |
| **Total** | 10 | 10 | 10 | 10 | 10 |

**f. Mapping Course Outcome with External Assessment (50 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Essay - 10 x 5 = 50 marks)** | 8 | 8 | 8 | 8 | 8 | 8 |
| **Total** | **10** | **10** | **10** | **10** | **10** | **10** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| **2** | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| 2 | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Demonstration 20 x 2 = 40** | | |
| 1 | Estimate the amount of protein in the given sample by Bradford Assay. | Recognize | Remember |
| 2 | Estimate the glucose in the given sample by DNS method | Recognize | Remember |
| | **PART – B Spotter The answer should not exceed 200 words 5 x 2 = 10** | | |
| 11 | List the advantages of using Zebrafish as a model organism. | Recognize | Analyze |
| 12 | Identify the image and elaborate it. | Recognize | Analyze |

**SEMESTER - II**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB201** | Bacteriology and Mycology | 2 | 2 | | 4 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | To offer comprehensive knowledge on bacterial systematics and bacterial ultrastructure | Understand |
| **CO 2** | To get in depth knowledge in Microbial growth parameters and conditions | Understand |
| **CO 3** | To get in-depth knowledge in bacterial genetics | Apply |
| **CO 4** | To obtain overall understanding about the fungal taxonomy and principles of classification | Understand |
| **CO 5** | In depth knowledge about fungal genetics and their applications | Analyse |

| | | |
|---|---|---|
| **CO6** | Significance and applications of research on fungi | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Bacterial classification based on Bergey's Manual of Determinative Bacteriology – Gram negative, Gram positive, the mycoplasmas and archea; Classification based on serology, biochemistry, 16s rRNA, G+C content and molecular tools. Bacterial ultrastructure and organelles. Staining of bacteria and organelles. | 10 |
| **II** | Microbial Growth: Culture conditions - bacterial culture media- chemically defined, complex, differential and selective media - for aerobes and anaerobes; Bacterial growth curve; Effect of physical and chemical factors on growth. Measuring bacterial growth- Spectrophotometric method, microscopic counting, serial dilution and viable cell count. Bacterial reproduction. Fungal nutrition and metabolism – nutritional requirement, saprophytic, parasitic, obligatory and facultative. Culture media and natural substrates of fungi. Biotrophic semibiotrophic and necrotrophic mode of growth. Fungal-microbe interaction, fungal – plant interactions – symbiotic and antagonistic interactions. | 10 |
| **III** | Bacterial Genetics: Organization of genetic material in bacteria, Gene transfer mechanisms: Conjugation, Transformation and Transduction. Recombination in bacteria. Natural transformation systems- Streptococcus pneumoniae and Haemophilus influenzae. Transfection and forced competence. Bacterial Conjugation- Properties of the F plasmid, F+ x F - mating, F' x F conjugation. Transduction- Generalized and specialized transduction, Drug resistance in bacteria. | 10 |
| **IV** | Fungal taxonomy – Criteria. Traditional, chemo and molecular taxonomy. Fungal ecology, distribution of yeasts and fungi. General characteristics, structure and organization of fungi – Fungal body and cell, Colony, communication and signalling. Cell differentiation and reproduction. Fungal reproduction - Vegetative, asexual and sexual. Adaptive & Developmental Changes: Myxobacterial developmental cycle: Life Cycle of myxobacteria, Aggregation and fruiting body formation, Intercellular signalling in myxobacteria Fungal-microbe interaction, fungal – plant interactions – symbiotic and antagonistic interactions. Endophytic fungi -symbiotic and opportunistic associations, co evolution and loss of reproductive structures, Secondary metabolite production, toxins – importance, toxicity to herbivores and insects. | 10 |
| **V** | Fungal Genetics: Features and consequences of heterothallism, homothallism, mating types, Vegetative incompatibility, Polyploidy and aneuploidy. Neurospora- Tetrad analysis and linkage detection - 2 point and 3-point crosses – Induction of Mutations - Mitotic recombination in Neurospora – Transposable elements - Gene conversion. Yeast plasmids, Mating type genetics of yeast. | 10 |

| | | |
|---|---|---|
| **VI** | Significance of Fungi: Agricultural production and plant productivity, toxigenic fungi and mycotoxins, plant pathogens, fungi in biocontrol; Fungi in biotechnology and industrial production; Fungal metabolites and economic significance – mycotoxins, medicinal uses, food additives, alcohol, vinegar, enzymes, biopesticides. Edible fungi – mushrooms, Mushroom poisoning. Beneficial contribution of mycorrhizal associations – endo and ecto mycorrhiza. | 10 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ Each student should discuss one publication in the field of microbial classification and identification<br>✓ Each student should take an assignment to write about a component of bacterial ultrastructure.<br>✓ Participate in the subject-oriented quiz.<br>✓ Prepare a protocols for Fungal isolation, classification and identification<br>✓ **References:**<br>Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton – Microbiology-10th<br>edition; publisher: Mcgraw-Hill College 2016.<br>2. Jacquelyn G. Black, Laura J. Black- Microbiology: Principles and Explorations, 9th edition;<br>Publisher: Wiley 2014<br>3. Gerard J. Tortora, Berdell R. Funke, Christine L. Case- Microbiology: An Introduction -12th<br>4. edition: publisher: Pearson 2015.<br>5. Mehrotra RS and KR Aneja. An Introduction to Mycology, New Age Publishers<br>6. Steven L. Stephenson (2010), The Kingdom Fungi: The Biology of Mushrooms, molds and<br>lichens. | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 | 2 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 3 |
| **CO5** | 2 | 2 | 3 | 1 | 1 | 2 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 | Total |
|---|---|---|---|---|---|---|---|
| **Internal** | 7 | 7 | 5 | 7 | 7 | 7 | 40 |
| **External** | 10 | 10 | 10 | 10 | 10 | 10 | 60 |
| **Total** | 17 | 17 | 15 | 17 | 17 | 17 | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 | 2 |
| **Seminar** | - | - | 2 | 2 | - | |
| **Test** | 4 | 4 | 4 | 4 | 4 | 2 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 | 1 |
| **Total** | 7 | 7 | 7 | 7 | 7 | 5 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Essay - 10 x 5 = 50 marks)** | 8 | 8 | 8 | 8 | 8 | 8 |
| **Total** | **10** | **10** | **10** | **10** | **10** | **10** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| **2** | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding**<br><br>**50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| **2** | **Presentation**<br><br>**50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | Which mycotoxin is useful to treat post-partum complications<br>a. Aflatoxin<br>b. Ergotamine<br>c. Ochratoxin<br>d. Fumonisins | Recognize | Remember |
| 2 | Which of the following statements is true?<br>a. A dikaryotic ascus that forms in the ascocarp underg karyogamy,<br>meiosis, and mitosis to form eight ascospores.<br>b. A diploid ascus that forms in the ascocarp underg karyogamy, meiosis, and mitosis to form eight ascospo<br>c. A haploid zygote that forms in the ascocarp underg karyogamy, meiosis, and mitosis to form eight ascospo<br>d. A dikaryotic ascus that forms in the ascocarp underg plasmogamy, meiosis, and mitosis to form ei ascospores. | Recall | Remember |
| 3 | The so-called simple septa of some fungi have a central pore nearby associated organelles called<br>a. Woronin bodies<br>b. Dolipore<br>c. Crozier<br>d. Sterigma | Recognize | Remember |
| 4 | *Neurospora crassa* was used by Beadle and Tatum<br>a. to produce citric acid and thus break the Italian lemon monopoly<br>b. because it was easy to produce both asexual and sexua spores for experiments<br>c. to identify mutants that were unable to synthesize sing nutritional compounds<br>d. to develop the one gene-one enzyme hypothesis | Recognize | Remember |

| | | | |
|---|---|---|---|
| 5 | The fertile region of ascocarp is referred to as;<br>a. Trama<br>b. Hymenium<br>c. Hypothecium<br>d. Stipe | Recognize | Remember |
| 6 | F factor has several of the following elements that assist in plasmid integration.<br>a. Episomes<br>b. IS elements<br>c. Tra A<br>d. Col factor | Recognize | Remember |
| 7 | What is a concatemer?<br>a) A process of unidirectional nucleic acid replication<br>b) The site where homologous sections of DNA are associated<br>c) A cell with temporarily diploid nature of genome<br>d) A long continuous DNA molecule that contains multi copies of same DNA sequence | Recall | Remember |
| 8 | One of the following is not a cause for increase in drug resistance<br>a. Using narrow spectrum antibiotics<br>b. Self-administration of drugs<br>c. Wrong diagnosis<br>d. Profit oriented pharma companies | Recall | Remember |
| 9 | Which of the following statements is false?<br>a) Plasmids have their own origin of replication<br>b) An "Exogenote" can be defined as a piece of recipient cell's DNA<br>c) Some of the R plasmids can be transmitted between different species<br>d) The chromosome exchanges during Meiosis result fro crossing over | Identify | Remember |
| 10 | Which of the following proteins helps form Holliday junction and promotes branch migration?<br>A. Ruv ABC<br>B. Rec G<br>C. Rec A<br>D. Rec BCD | Identify | Remember |
| | **PART – B ESSAY Answer**<br>**The answer should not exceed 200 words 10x 5 = 50** | | |
| 11 | Describe the general characteristic, classification, and life cy of Basidiomycete fungi and elaborate on the medicinal proper of two mushrooms. | Describe | Analyse |
| 12 | Explain the life cycle of Neurospora spp in terms of homo, het and pseudothallism? ascospores. How does the term tetrad re to the terms ascus and octad? How the products of mei segregation can be identified by tetrad analysis? (Show it o diagram of the life cycle.) | Explain Discuss | Understand |

| | | | |
|---|---|---|---|
| 13 | Describe the procedures for isolating endophytic fungi from plant tissue, and explain the morphological and taxonom methods adopted to classify and identify them. How to derive answer for a hypothesis that endophytic fungi switch t lifestyle to saprobe using Phomopisis and Collectotrichi species. | Assess | Skill |
| 14 | What are the different phage-mediated vectors used in molecular biology? Explain with examples | Describe | Analyse |
| 15 | What is transduction? Explain in detail the two forms of transduction events that are observed in bacteria | Explain Discuss | Understand |
| 16 | Write short notes on the following?<br>A. Competence in bacterial cells<br>B. Natural transformation system - *Streptococ pneumoniae*<br>C. Mode of action of anti-bacterial drugs | Assess | Skill |
| 17 | Explain in detail the Lederberg and Tatum experiment Bernard Davis U tube experiment. | Asses | Analyse |

**SEMESTER - II**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB 202** | Virology | 3 | 0 | 0 | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Provides an insight into the ultra-structure, replication and molecular biology of viruses | Understand |
| **CO 2** | Evaluate and compare methods used for laboratory diagnosis of viral infections | Apply |
| **CO 3** | Comprehensibly analyse and report outcomes of virological research | Analyze |
| **CO 4** | Demonstrate knowledge of the emerging and reemerging of selected RNA and DNA viruses | Create |
| **CO 5** | Formulate vaccine strategies and decipher the mechanisms of antiviral drugs | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Definitive properties of viruses: Morphology, Ultra structure, Chemical composition - proteins, nucleic acids, and enzymes. Classification and nomenclature; Group I, Group II, Group III, Group IV, Group V, Group VI, Group VII. Sub-viral particles: Discovery, Structure, Classification, replication and diseases caused | 10 |

| | | |
|---|---|---|
| **II** | General aspects of plant and animal viral diseases. Introduction to viral vaccines, preparation of vaccines, new vaccine technology; antiviral drugs, antiviral gene therapy, antiviral libraries, antiretrovirals—mechanism of action and drug resistance. Modern approaches for virus control: Antisense RNA, siRNA, ribozymes, in silico approaches for drug designing. T-phages, Cyanophages, Baculovirus. Mechanism of host cell damage- Host cell 'shut off', apoptosis, necrosis, alteration of signaling pathways. | 10 |
| **III** | Viral Genetics: General characteristics of viral genome, T4 virulent Phage - Structure-life cycle. Lambda temperate phage- Structure - Lytic and lysogenic cycle, Lysogenic repression. Genetic mapping of viruses, Recombination in viruses; Genetics of bacteriophage | 8 |
| **IV** | Diagnostic Virology: Biological activity of viruses, Physical, chemical, structural components, visualization, detection and enumeration: physical, biological, immunological and molecular methods. Isolation, purification, and cultivation: Embryonated eggs, laboratory animals and cell cultures. Serological methods, PCR-based assays and immunohistochemistry. Infectivity assays for phages and plant viruses, viral products expressed in infected cells. Cell culture, worm and animal models for studying viral infections for drug and vaccine development. | 8 |
| **V** | Emerging virus and challenges: Mechanism of host cell damage- Host cell 'shut off', apoptosis, necrosis, alteration of signaling pathways. Viruses and the future: Promises and problems. Emerging diseases, sources and causes of emergent virus diseases. Prospectus using medical technology to eliminate specific viral and other infectious diseases. Silver lining: viruses as therapeutic agents, viruses for gene delivery, viruses to destroy other viruses. Importance of studying modern virology. | 10 |
| | **Tasks and Assignments:**<br>• Each student is required to submit the following:<br>• Assignments on the underlying mechanism of entry, fusion and replication of viruses of their own choice.<br>• Model making of viruses's structure and their genetic material an deliver a seminar on the same topic.<br>• Midterm Internal exams<br><br>References<br><br>Bailey & Scott's Diagnostic Microbiology, 13th Edition, Patricia M. Tille, Elsevier, 2014.<br>Basic Virology. Edward K. Wagner, Martinez J. Hewlett, David C. Bloom, David Camerini.<br>Fields Virology. Vol 1 and 2. B.N. Fields, D.M. Knipe, P.M. Howley, R.M. Chanock, J.L. Melnick, T.P. Monath, B. Roizman, and S.E. Straus, eds.), 3rd Edition. Lippincott-Raven, Philadelphia, PA.<br>Virology: Principles and Applications John Carter, Venetia Saunders.<br>Virology Methods Manual. Brian W.J. Mahy (Editor), Hillar O. Kangro (Editor). Elsevier Science & Technology Books. | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 2 |
| **CO5** | 1 | 1 | 1 | 1 | 2 | 3 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | 1 | 1 | 2 | 2 | - |
| **Test** | 4 | 4 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Essay - 5 x 10 = 50 marks)** | 10 | 10 | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2** | **Organiza-tion**<br><br>**50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding**<br><br>**50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| **2** | **Presentation**<br><br>**50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | 1. What is significant about Foot- and-mouth disease virus?<br>**a) It was the first filterable animal virus**<br>b) Human adults are frequently infected by this virus<br>c) It is an enveloped virus<br>d) d) It belongs to Rhabdoviridae | Recall | Remember |
| 2 | 2The flu virus has developed a high rate of resistance to which of the following drugs?<br>a) Rimantidine<br>b) Zanamivir<br>c) Ribavirin<br>**d) Amantadine** | Recall | Remember |
| 3 | Why do class 3 viruses transcribe a mRNA rather than simply disassociate and use the positive RNA as mRNA?<br>a) Virions carry RNA transcriptase enzyme into the cell<br>b) The virion RNA is translated into a single large polyprotein<br>**c) More energy efficient than denaturing the dsRNA**<br>d) (D) dsDNA is unstable | Recognize | Remember |

| | | | |
|---|---|---|---|
| 4 | Regarding HIV binding to it's target cells:<br>a) It binds to CD4 coreceptor only before fusion with host cell membrane.<br>b) It binds to CD4 as well as CCR5 chemokine coreceptors.<br>c) It binds to CD4 and CXCR4 chemokine coreceptors for fusion.<br>**d) It binds to CD4 and either of CCR5 or CXCR4 coreceptors for fusion with host cell membrane.** | Recognize | Remember |
| 5 | Which of the following experimental requirements makes the siRNA approach unsuitable for determining the consequence of silencing a gene of interest in an established cell line<br>**a) Expression of the gene of interest is integral to cell viability**<br>b) End point RT-PCR and western blots are the only available validation assays<br>c) Lipofectamine is the only available delivery method<br>d) (D) The cell line proliferation rate is relatively slow | Recall | Remember |
| 6 | ----------is a variation of the plaque assay, but instead of relying on cell lysis in order to detect plaque formation, it employs immunostaining techniques.<br>a) The Endpoint dilution assay<br>**b) The focus forming assay**<br>c) The MTT assay<br>d) The ELISA | Recognize | Remember |
| 7 | If there is a capsomere at each of the 12 vertices of a simple capsid; how this capsomere is termed when it is surrounded by five other capsomeres<br>**a) Penton**<br>b) Polyhedra<br>c) Icosahedral<br>d) d) Helical | Recognize | Remember |
| 8 | When the genomes of negative-sense RNA viruses are purified and introduced into cells that are permissive to the original intact virus, what will occur?<br>a) **No infection because virus transcriptase is not present**<br>b) Infection occurs because viral transcriptase is present<br>c) Higher rate of viral replication using RNA polymerases<br>d) Attenuation | Recognize | Remember |
| 9 | The term used to define when one of the influenza genes or RNA strands is substituted with a gene or strand from another influenza virus from a different animal host.<br>a) Antigenic drift<br>b) **Antigenic shift**<br>c) Mutagenic shift<br>d) Antigenic mutation | Identify | Remember |
| 10 | Measles caused by?<br>a) Poxviruses | Identify | Remember |

| | | | |
|---|---|---|---|
| | b) Influenza<br>c) **Morbilliviruses**<br>d) Mortalliviruses | | |
| | **PART – B Essay Answer**<br>**The answer should not exceed 1000 words 5 x 10 = 50** | | |
| 11 | a) Describe the structural forms used in the building of icosahedron viral particles<br>b) Explain the organization of the Adeno, Herpes and Tobacco mosaic virus in terms of triangulation units, helical turn, number of capsomers, etc.) | Explain | Understand |
| 12 | Cells produce mRNA by transcription of their DNA genomes. By contrast, single-stranded RNA genome viruses have three different strategies with respect to viral mRNA production. Briefly describe the production of mRNA for each of the following viruses.<br>(a) Poliovirus<br>(b) SARS-CoV-2<br>(c) Influenza | Differentiate Define | Understand |
| 13 | a) Describe various human receptor molecules involved in the attachment of viruses<br>b) Explain the underlying mechanisms of viral-receptor interaction of Poliovirus an Influenza A virus | Cite Examples | Understand |
| 14 | a) Explain two modes of the viral internalization process after the viral glycoprotein and receptor engagement<br>b) how different viral capsids or virons are imported into the nucleus with examples | Illustrate | Apply |
| 15 | Write short notes on the following:<br>a) Plaque assay<br>b) Leaky scanning<br>c) Viral Hemagglutination<br>d) Hershey-Chase Experiment | Describe | Analyse |
| 16 | Explain the type of gene therapy, and various viral vectors with suitable examples | Explain Discuss | Understand |
| 17 | Explain the following:<br>a) siRNA<br>b) shRNA<br>c) antisense RNA | Illustrate | Apply |

**SEMESTER - II**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB203** | Food & Industrial Microbiology | 2 | 2 | 0 | 4 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Explains various techniques involved in detecting food borne pathogens | Understand |

| | | |
|---|---|---|
| **CO 2** | Explains microbial growth kinetics and strain improvement techniques | Understand |
| **CO 3** | Deals with fermentation technology | Understand |
| **CO 4** | Deals with various fermented microbial products and its production | Understand |
| **CO 5** | Explains various food spoilage and preservation techniques | Understand |
| **CO 6** | Deals with Food safety and quality management systems | Understand |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | **Food Microbiology & Food-Borne Pathogens**<br>Importance and significance of microorganisms. Factors – Intrinsic and extrinsic factors affecting their growth in food. Food-borne diseases; detection and enumeration of their products in food- Culture-dependent methods- Sample collection, processing, analysis, surface testing, Direct microscopy, enumeration and isolation; Animal and cell culture models; Culture independent methods – Metagenomics, biosensor-, Immunologic- and nucleic acid-based detection – PCR, Molecular typing and differentiation; Analytical methods for detection of microbial toxins and metabolites. | 12 |
| **II** | **Basics of Industrial Microbiology**<br>Historical account of microbes in industrial microbiology; sources and characters of industrially important microbes; their isolation, purification and maintenance; Screening of useful strains; primary and secondary screening; Strain improvement through random mutation and genetic engineering; types of fermentation and fermenters. Microbial growth kinetics in batch, continuous and fed-batch fermentation. Microbial production of metabolites. | 12 |
| **III** | **Fermentation technology**<br>Concept and scope of microbial fermentation technology , inoculum, screening and selection, fermentation medium, fermentation processes, dual and multiple fermentation, continuous fermentation, batch fermentation; bioreactors, types, designs and functional characteristics; scaleup of fermentation; strain improvement fermentation economics; fermentation processes, downstream processing and product recovery. | 12 |
| **IV** | **Fermented Microbial Products**<br>Milk, fermentation and dairy products. Food fermentationsManufacture of fermented foods- Meat and fishery products, plant products- Sauerkraut and fermented olives, breads, beverages. Microbial cells as food- SCP, mushroom cultivation. Source and applications of microbial enzymes, antioxidants, bio-surfactants, polysaccharides, flavors and colors. Probiotics and advantages, genetically modified foods. Microbiology and production of alcoholic beverages, organic acids, amino acids, and vitamins. Microbial Enzymes: Immobilization of microbial enzymes and whole cells; Industrial enzymes production; and their applications. Enzymes involved in microbial biocatalyst/transformations. Beverages– Role of microorganisms in food and dairy industry. Fermented beverages-beer, wine and other alcoholic beverages. Microbial preparation of Tempeh, sauerkraut, Miso, yogurt. Probiotics. Single cell protein. Mushroom cultivation, Acetic acid; Lactic | 12 |

<table>
<tr><td></td><td>acid; Gluconic acid. Microbial production and commercial applications of Amylases, Proteases, Lipases. Biotransformation of steroids.</td><td></td></tr>
<tr><td>V</td><td>Food Spoilage & Food Preservation<br>Organisms involved, characteristic features, dynamics and significance of spoilage of different groups of foods - Cereal and cereal products, vegetables and fruits, meat, poultry and sea foods, milk and milk products, packed and canned foods. Spoilage and defects of fermented foods. Food preservation- use of temperatures- Significance of psychrophilic microbes in cold-stored and frozen foods, Drying, Chemical, Modified atmosphere, Radiation, other food protection methods and microbial resistance.</td><td>12</td></tr>
<tr><td>VI</td><td>Food Safety & Quality Management Systems<br>General principles of food safety risk management, food packing and types of packing, Recent concerns on food safety- Safe food alternatives (Organic foods), Good agricultural practices (GAP), food park concept Through Private/ corporate sector, Food indicators of water and food safety and quality- Microbiological criteria of foods and their significance. The HACCP and ISO systems for food safety. Biofuels & Biopolymers: Biofuels (ethanol and methane) from organic residues; fuels from algae; Mushroom cultivation; other microbial products - Biopolymers and EPS, Bioplastics, Biosurfactants, effluent treatment, SCP.</td><td>12</td></tr>
<tr><td></td><td>Practical (Any two)
<table>
<tr><th>S.No.</th><th>Apparatus and Tools</th><th>Concept</th></tr>
<tr><td>1</td><td>-</td><td>Intelligence</td></tr>
<tr><td>2</td><td>-</td><td>Personality</td></tr>
<tr><td>3</td><td>-</td><td>Self-Concept</td></tr>
</table></td><td></td></tr>
<tr><td></td><td>Tasks and Assignments:<br><br>Assignment sets, experiments and/or seminars on advanced topics will be assigned<br><br>References:<br>
1. James M. Jay., Loessner, M. J., and Golden D. A., 2005, Modern Food Microbiology, 7th edition.<br>
2. Arun K. Bhunia, 2008, Foodborne Microbial Pathogens- Mechanisms and Pathogenesis, Food<br>
3. Science text Series, Springer International, New York, USA.<br>
4. Doyle, M. P. & Beuchat, L. R., 2007, Food Microbiology- Fundamentals and Frontiers, ASM<br>
5. Marriott, N. G. and Gravani R. B. 2006. Principles of Food Sanitation, Food Science text Series, Springer International, New York, USA. Nduka Okafor (2007). Modern Industrial Microbiology and Biotechnology. 1st Edition: Science Publishers.<br>
7. Richard H. Baltz, Julian E. Davies, and Arnold L. Demain (2010). Manual of Industrial Microbiology and Biotechnology. 3rd Edition, ASM Press.<br>
8. Modern Industrial Microbiology & Biotechnology by N. Okafer, Scientific Publishers, Enfield, USA, 2007.</td><td></td></tr>
</table>

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 2 |
| **CO5** | 1 | 1 | 1 | 1 | 2 | 3 |
| **CO6** | 1 | 1 | 1 | 1 | 2 | 3 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | - | - | 2 | 2 | - |
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Short Answer - 5 x 4 = 20 marks)** | 10 | 10 | - | - | - |
| **Part – C (Essay- 3 x 10 = 30 marks)** | - | - | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2** | **Organiza-tion**<br><br>**50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding**<br><br>**50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| **2** | **Presentation**<br><br>**50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | Ropiness of bread is due to the growth of _____<br>**A. Bacillus subtilis; B.** Endomycosis fibuligera; C. Serratia marcescens; D. Rhizopus stolonifera | Recognize | Remember |
| 2 | Custard rot egg is due to the presence of<br>**A. Proteus vulgaris; B.** P. roteus; C. Pseudomonas fluorescens; D. Acinetobacter | Recall | Remember |
| 3 | Food additive commonly used in meat processing<br>A. Benzoate; B. Sorbate; C. **Nitrites; D.** Propionic acid | Recognize | Remember |
| 4 | In sauerkraut production the initial colonization occurred by the invasion of<br>*A. Lactobacillus plantaurm; B.* ***Leuconostoc mesenteroids;*** ***C.*** *Lactobacillus brevis; D. Lactobacillus acidophilus* | Recognize | Remember |
| 5 | The average protein content in the mushrooms is<br>A. 50-70 %; B. **35-45 %; C.** 20-40 %; D. 10-30 % | Recognize | Remember |
| 6 | Secondary packaging is used for | Recognize | Remember |

| | | | |
|---|---|---|---|
| | A. Containment; B. protection; C. **Manual movement of products; D.** Convenience | | |
| 7 | The FSSAI stands for<br>**A. Food safety and standards authority of India; B.** Food security and standards authority of India; C. Food safety and security authority of India; D. Food standards and service authority of India | Recall | Remember |
| 8 | Among, which of the following are categories as food infection?<br>A. Botulism; B. **Salmonellois; C.** Staphylococcal intoxication; D. None of these | Recall | Remember |
| 9 | Why botulism is a problem mainly in canned foods and not in a fresh food?<br>A. Canned food is not sterilized, so bacteria such as C. botulinum can survive; B. Fresh food contains its own microbiota, which prevents the growth of pathogens such as C. botulinum; C. The canning process reduces the pH of food, and C. botulinum is an acidophile; D. **botulinum is an obligate anaerobe and canning process removes $O_2$.** | Identify | Remember |
| 10 | Gram-positive, rod-shaped bacterium, *Corynebacterium glutamicumis* is used for the production of?<br>A. Amylases; B. Alcohol; C. **Glutamic acid; D.** Acetic acid | Identify | Remember |
| | **PART – B ESSAY Answer**<br>**The answer should not exceed 200 words 10x 5 = 50** | | |
| 11 | A. What are the aerobic and anaerobic changes taking place due to microbial spoilage in meat.<br>B. Write the mechanism of microbial inactivation by radiation.<br>C. Microbial changes taking place in food during spoilage. | Describe | Analyse |
| 12 | Explain in detail the microbial spoilage of canned foods. | Explain Discuss | Understand |
| 13 | Short note on: a. Principles of food preservation; b. Thermal death point; c. Blanching; d. Freeze drying; e. Radicidation | Assess | Skill |
| 14 | What are the functions of packaging? and detail the biodegradable packaging. | Describe | Analyse |
| 15 | Define Food-borne diseases with examples explain how detection and enumeration of food born disease is performed in food products? | Assess | Skill |

**SEMESTER - II**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB204** | Agricultural Microbiology and Plant Pathology | 2 | 2 | 0 | 4 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|

| | | |
|---|---|---|
| **CO 1** | Explains various factors contributing to the soil environment including their structure, profile, microbial composition/interaction, and various bio-geo chemical cycles. | Understand |
| **CO 2** | Explains the scope of utilizing microbes as biofertilizers. | Apply |
| **CO 3** | Deals with various plant diseases caused by various microbes along with their principle, symptoms, and control methods. | Analyze |
| **CO 4** | Deals with the epidemiology and forecasting principles of plant diseases. | Create |
| **CO 5** | Explains various principles and methods of plant disease control. | Skill |
| **CO 6** | Deals with the plant-microbe interactions at molecular level. | Apply |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | **Soil Environment**<br>Microorganisms, soil structure, profile, physico-chemical conditions, Microbial composition, sampling techniques, microorganisms in organic decomposition. Bio-geochemical cycles – Carbon, sulphur, iron, phosphorus cycles & nitrogen cycles – Nitrogen fixation, nitrification, de-nitrification, Rhizospheric microorganisms, Siderophores. PGPM-Plant growth promoting microorganisms. Plant-microbe interactions. Mechanisms of plant growth promotion. | 12 |
| **II** | **Biofertilizers**<br>Introduction, biofertilizers using N2-fixing microbes – phosphate solubilization- Rhizobium, Azatobacter, Azospirillum, Azolla; Anabaena symbiosis, blue green algae and mycorrhizal associations – endo and ecto mycorrhizae. Cultivation, mass production and inoculation of Rhizobium, Azotobacter, Azospirillum, Azolla and cyanobacteria as rice biofertilizer, Carrier based inoculants, methods of application, QC, agronomic importance. Application methods. Importance of neem cakes and oil on paddy field. | 12 |
| **III** | **Major plant disease symptoms caused by fungi, bacteria, and viruses**<br>Development and stages of disease development, pathogen dissemination, Relationship between disease cycles and epidemics, pathogenicity genes, Genes controlling: Degradation of cuticle and cell wall, production of secondary metabolites-fungal toxins; Resistance (R) genes of plants, Plant diseases – Principles, symptoms and control: Fungal – General characteristics and different fungal diseases in plants like root rot, leaf spot, blight etc, Life cycle of the rice blast fungus Magnaporthe oryzae, Bacterial – Blight of rice and blast of rice, citrus canker, Xanthomonas. Viral and mycoplasmal – Bud necrosis of groundnut, citrus mosaic, little leaf of brinjal, tomato leaf curl. Disease forecasting and detection. | 12 |
| **IV** | **Epidemiology and Forecasting of Plant Diseases**<br>Epidemic concept and historical development, pathometry and crop growth stages, epidemic growth and analysis. Common and natural logrithms, function fitting area under disease progress curve and correction factors, inoculum dynamics, population biology of pathogens, temporal spatial variability in plant pathogens. Survey, surveillance and vigilance, crop loss assessment and models. Principles and pre-requisites of forecasting, systems and factors affecting various components of | 12 |

<table>
<tr><td></td><td>forecasting, some early forecasting, procedures based on weather and inoculum potential, modeling disease growth and disease prediction.</td><td></td></tr>
<tr><td>V</td><td>Principles of plant disease control<br>Protection - Diseases of field, vegetable, orchard and plantation crops and their control; causes and classification of plant diseases; principles of biological control of diseases. Methods to exclude pathogens from host-Quarantines and Inspections, Crop certification, Evasion or avoidance of pathogen, use of pathogen-free propagating material, pathogen-free seeds and vegetative propagating materials. Plant immunization; Direct protection; Integrated control, Biopesticides – Bacillus thuringiensis, B. sphaericus, B. popilliae, Pseudomonas syringae. Biocontrol- Microbial control - Trichoderma. Biological control – Use of Baculovirus, NPV virus, protozoa & fungi in biological control. Endophytic fungi - symbiotic and opportunistic associations, co-evolution and loss of reproductive structures, Secondary metabolite production, toxins – importance, toxicity to herbivores and insects. Use of endophytic fungi as biocontrol agents against plant diseases, insect herbivores.</td><td>12</td></tr>
<tr><td>VI</td><td>Molecular plant microbe-interactions<br>Cell signalling, Quorum sensing, and Biofilm formation. Invasion of plant tissue: Resistance mechanisms against attack by plant pathogens. Molecular detection of pathogens. Integrated pest management-concepts and components; host plant resistance-biological control of insect pests; Recycling of agricultural wastes – microbiology of biogas, bioethanol and value added products. Mushroom cultivation and vermicomposting.</td><td>12</td></tr>
<tr><td></td><td>Practical (Any two)<br><table><tr><th>S.No.</th><th>Apparatus and Tools</th><th>Concept</th></tr><tr><td>1</td><td>-</td><td>Intelligence</td></tr><tr><td>2</td><td>-</td><td>Personality</td></tr><tr><td>3</td><td>-</td><td>Self-Concept</td></tr></table></td><td></td></tr>
<tr><td></td><td>Tasks and Assignments:<br>Each student is required to submit the following:<br>➢ Determine and analyze Major plant disease symptoms caused by fungi, bacteria, and viruses<br>➢ Demonstrate the pathometry and crop growth stages analysis.<br>➢ Perform molecular detection of common pathogens.<br><br>References:<br>1. Dirk J, Elas V, Trevors JT, Wellington, EMH Modern Soil Microbiology, CRC Press; 2 edition (21 December 2006).<br>2. Microbes For Sustainable Agriculture by K.V.B.R. Tilak, K.K. Pal, Rinku Dey I K International Publishing House Pvt. Ltd (12 January 2009)<br>3. George N. Agrios. 2005. Plant Pathology, 5th Edition, Academic Press.<br>4. Schumann, G.L. 2006. Essential Plant Pathology. APS Press.<br>5. Sharma, P.D. 2006. Plant Pathology.</td><td></td></tr>
</table>

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 2 |
| **CO5** | 1 | 1 | 1 | 1 | 2 | 3 |
| **CO6** | 1 | 1 | 1 | 1 | 2 | 3 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | - | - | 2 | 2 | - |
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Short Answer - 5 x 4 = 20 marks)** | 10 | 10 | - | - | - |
| **Part – C (Essay- 3 x 10 = 30 marks)** | - | - | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | specific. | | | | |
| **2** | **Organiza-tion**<br><br>**50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| **Sl. No.** | **Criteria** | **100%** | **75%** | **50%** | **25%** | **0%** | **Relation to COs** |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding**<br><br>**50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| **2** | **Presentation**<br><br>**50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| **Sl. No.** | **Model Questions** | **Specification** | **Level** |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | Which of the following soil horizons show the highest density of microbial population?<br>a) Horizon<br>b) A Horizon<br>c) B Horizon<br>d) C Horizon | Recognize | Remember |
| 2 | Cankers and galls are common disease signs for which of the following disease-causing plant pathogens?<br>a) Fungi<br>b) Bacteria<br>c) Virus<br>d) Protozoa<br>e) Actinomycetes | Recall | Remember |

| | | | |
|---|---|---|---|
| 3 | Which of the following qualities does not describe properties of high-performance soil?<br>a) Contains strong soil microbiome<br>b) Contains optimal active and passive carbon<br>c) Contains approximately 40% of mineral matter<br>d) Contains approximately 40% of organic matter<br>e) Contains approximately 15% of water | Recognize | Remember |
| 4 | **In which of the following plant diseases, leaves get** shrunken **and chlorophyll gets degraded?**<br>a) Rhizoctonia<br>b) Citrus Canker<br>c) Tundu disease of wheat<br>d) Mosaic disease of tobacco | Recognize | Remember |
| 5 | The obligate parasitic fungi absorb the nutrients from the host cells through?<br>a) Haustoria<br>b) Prosthecae<br>c) Flagella<br>d) Pili | Recognize | Remember |
| 6 | Which of the following microorganism was responsible for Bengal famine of 1943?<br>a) Helminthosporium oryzae<br>b) Puccinia triticina<br>c) Hemileia vastatrix<br>d) Plasmopara viticola | Recognize | Remember |
| 7 | **The process of using a natural predator to control the spread of any plant pathogen is called as**<br>a) Genetic engineering<br>b) Biological control<br>c) Confusing pathogen technique<br>d) Artificial pest control | Recall | Remember |
| 8 | **In which disease of plant white mildew appears typically on underside of leaves?**<br>a) Cylindrocladium<br>b) Angular leaf Spot<br>c) Downy Mildew<br>d) Black arm of Cotton | Recall | Remember |
| 9 | Management of plant viruses is possible through?<br>a) Pathogen derived resistance<br>b) RNA silencing<br>c) Resistance gene<br>d) All the above | Identify | Remember |
| 10 | Aflatoxin is produced by?<br>a) Albugo candida<br>b) Asperfillus flavus<br>c) Trichoderma harzianum<br>d) Ceratocystis ulmi | Identify | Remember |
| | **PART – B ESSAY Answer**<br>**The answer should not exceed 200 words 10x5 = 50** | | |
| 11 | Describe in detail the principles of biological control of plant | Describe | Analyse |

| | | | |
|---|---|---|---|
| | diseases? | | |
| 12 | Write short notes on:<br>a) Anabaena symbiosis<br>b) Mycorrhizal associations | Explain<br>Discuss | Understand |
| 13 | Compare and contrast the ways that the environment influences diseases in which the pathogen infects the plant shoots and the diseases in which the pathogen infects roots. | Assess | Skill |
| 14 | Write a note on plant quarantine and inspection | Describe | Analyse |
| 15 | Explain with diagrams:<br>a) Nitrogen cycle<br>b) Carbon cycle | Explain<br>Discuss | Understand |
| 16 | How and to what extent can plant diseases be controlled by legislation and regulation? | Assess | Skill |

**SEMESTER - II**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB205** | Recombinant DNA and Protein Technology | 2 | 2 | | 4 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Understand the genetic codes and basic molecular biologies such as enzymes and vectors | Understand |
| **CO 2** | Understand the advanced molecular biology tools including cloning, and genomic library creation. | understand |
| **CO 3** | Study and apply the techniques for gene transfer | apply |
| **CO 4** | Understand the protein motif, domains ,etc. | Understand |
| **CO 5** | Understand and analyze the protein purification methods | analyse |
| **CO6** | Learning protein databases, tools and proteomics | skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | **Basic molecular biology**: History of nucleic acid, role of genes inside the cell, genetic code, genetic elements that control gene expression. Enzymes in recombinant DNA technology- DNA polymerase, reverse transcriptase, restriction endonucleases, polynucleotide kinase, terminal deoxynucleotidyl transferase, DNase, methylase, phosphatases, ligases RNase and their mode of action. Vectors in recombinant DNA technology Introduction to cloning vectors, biology and features of vectors, types of vector - plasmids, cosmids, phages, BAC and YAC and viruses | 10 |
| **II** | **Gene isolation, cloning** and expression, oligonucleotide synthesis, DNA sequencing methods, new generation sequencing (NGS), whole genome sequencing, site-directed mutagenesis, Gene mapping-restriction mapping, RFLP, RAPD, AFLP. Gene silencing, sequencing methods, probes and target sequences, Southern blotting, Northern blotting, in situ hybridization, nucleic acid mutagenesis in vivo and in vitro, Construction | 10 |

| | | |
|---|---|---|
| | of DNA Library: Construction of genomic and cDNA libraries, Screening libraries with gene probes, colony hybridization, plaque hybridization, screening by gain of function, immunological screening. Engineering microbes for the production of antibiotics, enzymes, Insulin, growth hormones, monoclonal antibodies etc. | |
| **III** | **Gene Transfer Techniques:** Gene transfer techniques in microbes, animals and plants - transformation, electroporation, microprojectile system, liposome-mediated gene transfer, DNA/calcium phosphate co-precipitate method, gene-gun, transfection with phage vectors etc. Agrobacterium based gene transfer in plants - Ti plasmid: structure and functions, Ti plasmid based vectors. Transgenic organisms from mice to rice, human genetic engineering and gene therapy, gene therapy methods. | 10 |
| **IV** | **Protein technology:** Primary, secondary, tertiary and quaternary structures; Motifs, super secondary structures and fold types; forces that stabilize protein fold, folding pathways, mutagenesis studies; Directed protein evolution, phage display, cell surface display, cell free display systems; Alternative scaffolds, combinatorial enzyme engineering; Protein engineering, Protein post translational modification; Mapping Protein-protein Interaction; Topology and Network motifs. | 10 |
| **V** | **Strategies for protein engineering**; Therapeutic protein engineering; site-directed mutagenesis, Protein expression systems and protein expression (pET vectors), eukaryotic and prokaryotic protein expression, secreted protein, purification, biophysical characterization, His-tag based purification, protein purification technique | 10 |
| **VI** | **Identification of protein targets and biomarkers**; Protein arrays; Structural genomics and structural proteomics, Two dimensional gel electrophoresis, DIGE, Protein identification using computational tools. Proteomes, - Protein digestion and separation techniques. Role of Mass spectrometry in protein identification - MALDI TOF - Tandem MS and SALSA - peptide mass fingerprinting, affinity methods, yeast hybrid systems and protein arrays | 10 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ Each student should discuss one protein database and analyze the algorithm, applications, and features.<br>✓ Each student should take an assignment to determine the protein domain and motif in a functional protein.<br>✓ Participate in the subject-oriented quiz.<br>✓ Prepare a protocols for gene consensus sequence and respective cloning into a suitable vector.<br>**References:**<br>Sandy Primose (2006). Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers.<br>2. Brown T.A. (2010). Gene Cloning and DNA analysis. 6th Edition, Wiley-Blackwell.<br>3. David E Newton. (2010). DNA technology. ABC-CLIO, LLC | |

| | | |
|---|---|---|
| | 4. Beiquan Mou and Ralph Scorza. (2011). Transgenic Horticultural Crops: Challenges and oppurtunities. CRC press.<br>5. Pete Shanks. (2005). Human Genetic engineering. Avalon publishing groups. | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 | 2 |
| **CO2** | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 1 | 1 | 2 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 | Total |
|---|---|---|---|---|---|---|---|
| **Internal** | 7 | 7 | 5 | 7 | 7 | 7 | 40 |
| **External** | 10 | 10 | 10 | 10 | 10 | 10 | 60 |
| **Total** | 17 | 17 | 15 | 17 | 17 | 17 | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 | 2 |
| **Seminar** | - | - | 2 | 2 | - | |
| **Test** | 4 | 4 | 4 | 4 | 4 | 2 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 | 1 |
| **Total** | 7 | 7 | 7 | 7 | 7 | 5 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| **Part – A<br>(Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 | 2 |
| **Part – B<br>(Essay - 10 x 5 = 50 marks)** | 8 | 8 | 8 | 8 | 8 | 8 |
| **Total** | **10** | **10** | **10** | **10** | **10** | **10** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | facts mostly specific. | | | | |
| **2** | **Organiza-tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| **Sl. No.** | **Criteria** | **100%** | **75%** | **50%** | **25%** | **0%** | **Relation to COs** |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| **2** | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| **Sl. No.** | **Model Questions** | **Specification** | **Level** |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | The 5'-3' Exonuclease activity of DNA polymerase present in<br>a) Central domain<br>**b) N-Terminal**<br>c) C-Terminal<br>d) None of the above | Recognize | Remember |
| 2 | The host-controlled variation in bacterial viruses is<br>**a)** Heritable<br>**b) Non heritable**<br>**c)** Depends on the nutrient media where it grows<br>**d)** All the above | Recall | Remember |
| 3 | The following will not induce star activity of restriction enzyme<br>a. High glycerol concentration [> 5% v/v]<br>b. Low ionic strength [< 25 mM]<br>c. Presence of alcohol | Recognize | Remember |

| | | | |
|---|---|---|---|
| | d. **Use of Mg++ as the divalent cation**. | | |
| 4 | Including the elements of cloning vector, the expression vector may have these extra feature(s)<br>a) Selectable marker and a reporter gene<br>b) Transcription and translation initiation site<br>c) Promotor and ribosomal binding site<br>**d) Both c & b** | Recognize | Remember |
| 5 | The temperature at which one half of the DNA duplex will dissociate to become single stranded is called as<br>a) Denaturation temperature<br>b) Threshold temperature<br>**c) Melting temperature**<br>d) temperature cycle | Recognize | Remember |
| 6 | Approximate size of the Ti plasmid is<br>**a) 200 kb**<br>b) 20 kb<br>c) 24 kb<br>d) 100 kb | Recognize | Remember |
| 7 | Snake venom is an example of<br>a) Endonuclease<br>**b) Exonuclease**<br>c) Phosphotransferase<br>d) SI nuclease | Recall | Remember |
| 8 | RNase A is specific for<br>**a) Pyrimidine nucleoside linkages**<br>b) Purine nucleoside linkages<br>c) All the above<br>d) None of the above | Recall | Remember |
| 9 | In the biphasic switch mechanism, during the lysogenic cycle this regulator is switched on<br>a) Cro<br>**b) CI**<br>c) CII<br>d) CRI | Identify | Remember |
| 10 | In the phagemid-based vector system, the missing genes to make a complete phage will be provided by<br>a) Helper plasmid<br>b) Cosmids<br>c) Phasmids<br>**Helper phage** | Identify | Remember |
| | **PART – B ESSAY Answer**<br>**The answer should not exceed 200 words 10x 5 = 50** | | |
| 11 | 11. What are the components that make the Ti plasmid complete? Detail any of the derived vectors of Ti plasmid. | Describe | Analyse |
| 12 | 12. Explain the following a) digital droplet PCR principles and advantages<br>b) LAMP assay | Explain Discuss | Understand |
| 13 | Detail a) Probe hybridization assay<br>b) Illumina sequencing. | Assess | Skill |

| | | | |
|---|---|---|---|
| 14 | What are the different phage-mediated vectors used in molecular biology? Explain with examples | Describe | Analyse |
| 15 | If you are asked to develop a cDNA library from the immunized animals B cells. How will you perform it? | Explain Discuss | Understand |
| 16 | Briefly explain the four major classes of proteins based on their shape and solubility. | Assess | Skill |
| 17 | Write short notes on<br>a) Rossmann fold (5 marks)<br>b) Any two forces that determine protein structure marks) | Asses | Analyse |

**SEMESTER - II**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **PMB201** | Practical Microbiology | 0 | 0 | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Deals with various basic microbiology techniques of culturing and detection | Understand |
| **CO 2** | Deals with isolation and identification of various fungi | Understand |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | **Part 1**<br>Introduction to good laboratory practices and preparation of different minimal, complex and differential media, Isolation of bacteria from air, water, soil, Endospore staining, Flagella staining and Capsule staining, Bacterial culture techniques-Liquid broth culture & Pure culture techniques-serial dilution technique, Pour plate, spread plate, streak plate techniques, Measurement of bacterial population by turbidimetry and colony counting by serial dilution of samples, Bacterial growth curve, Antibiotic sensitivity tests-disc method, Preservation of pure cultures: slant preparation, water stock, glycerol stock, Biochemical tests for bacterial identification, Detection of bacterial pathogens by PCR method. | |
| **II** | **Part II**<br>Methods of isolation and identification of fungi by traditional methods, Preparation of pure culture and preservation of culture, Isolation and identification of endophytic fungi from plants, Observation and identification of mycorrhiza, Isolation and identification of fungi from seeds, Study of soil fungi from varied geographical origins, Isolation of antibacterial/ antimycotic compounds from fungi, Staining and observation of plant pathogenic fungi, Study of asexual reproduction in Saccharomyces, staining of human fungal pathogens using LPCB and culture. | |
| | **Practical (Any two)**<br>**S.No.** \| **Apparatus and Tools** \| **Concept** | 16 |

| | | | | |
|---|---|---|---|---|
| | 1 | Detection of bacterial pathogens by PCR | Understanding | |
| | 2 | Identification of mycorrhiza | Understanding | |
| | 3 | Bacterial growth measurement | Understanding | |
| | **Tasks and Assignments:**<br>Assignment sets, experiments and/or seminars on advanced topics will be assigned<br><br>**References:**<br>Microbiology, A laboratory manual by James Cappuccino and Natalie Aherman 10th edition<br>Koneman's Color atlas and textbook of diagnostic microbiology, 7th edition by Gary W. Procop, Deirdre L. Church, Geraldine S Hall and William M, Janda | | | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 |

**d. Evaluation Scheme**

| | CO1 | CO2 | Total |
|---|---|---|---|
| **Internal** | 20 | 20 | 40 |
| **External** | 30 | 30 | 60 |
| **Total** | **50** | **50** | **100** |

**e. Mapping Course Outcome with Internal Assessment (50 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Practical** | 3 | 3 | 3 | 3 | 3 |
| **Seminar** | - | - | | | - |
| **Test** | 4 | 4 | 4 | 4 | 4 |
| **Attendance** | 3 | 3 | 3 | 3 | 3 |
| **Total** | 10 | 10 | 10 | 10 | 10 |

**f. Mapping Course Outcome with External Assessment (50 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| **Part – A**<br>**(Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 | 2 |
| **Part – B**<br>**(Essay - 10 x 5 = 50 marks)** | 8 | 8 | 8 | 8 | 8 | 8 |
| **Total** | **10** | **10** | **10** | **10** | **10** | **10** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| 2 | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| 2 | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Demosntration**<br>**Multiple choice 20 x 2 = 40** | | |
| 1 | Demonstration of Bacteria isolation from seawage | Recognize | Remember |
| 2 | PCR | Recognize | Remember |

| | PART – B Spotter<br>The answer should not exceed 200 words 5 x 2 = 10 | | |
|---|---|---|---|
| 11 | Identify the image and elaborate it. | Recognize | Analyze |
| 12 | Identify the image and elaborate it. | Recognize | Analyze |

**SEMESTER - II**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **PMB 202** | Practical Microbiology IV | | | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Learn and perform the isolation of different microorganisms and characterize them | skills |
| **CO 2** | Learn and perform immunological assays | skills |
| **CO 3** | Microscopic examination of samples for ova, cysts, parasites | analyze |
| **CO 4** | Learn and perform molecular biological experiments such as isolation of different nucleic acids, cloning etc. | analyze |
| **CO 5** | Learn and perform polymerase chain reactions | skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Part I: Isolation of bacteriophages from sewage, Estimation of virus yields - plaque assay, Routes of inoculations in embryonated eggs, Haemagglutination test, Hemagglutination inhibition assay, Biocontrol assay on insect larvae using NPV, ELISA test, Study of virus infected plant material, One step growth curve of bacteriophage by Burst size determination, Demonstration of identification of arthropod vectors of viral transmission. Microscopic examination of parasites of medical importance (ova, cysts, blood smear examination), stool concentration, staining and observation. | 15 |
| **II** | Part II: Isolation of Genomic DNA and quantification, Isolation of Plasmid and quantification, Preparation of Vector and Insert by restriction digestion, Preparation of competent cells using CaCl2, Ligation reaction of restriction digested Vector and Insert, Transformation of recombinant DNA, PCR amplification of gene of interest, Isolation of RNA and quantification, Reverse transcriptase PCR, Restriction Fragment Length Polymorphism (RFLP) analysis, RAPD and phylogenetic tree, Quantitative Real Time – PCR (Demonstration) | 15 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ Each student should discuss complete details of one of the display techniques.<br>✓ Students should demonstrate the screening techniques for the effective selection of high-affinity biomolecules.<br>✓ Participate in the subject-oriented quiz. | |

| | | |
|---|---|---|
| | ✓ Visit industry to learn techniques and advancements.<br>**References:**<br>Phage Display In Biotechnology and Drug Discovery, Second Edition: edited by Sachdev S. Sidhu, Clarence Ronald Geyer.<br><br>Bacteriophage Applications - Historical Perspective and Future Potential: **Authors:** Nicastro**, J.,** Wong**, S.,** Khazaei**, Z.,** Lam**, P.,** Blay**, J.,** Slavcev**, R.A.y**<br><br>Phage Display: A Laboratory Manual, Page 532<br>By Carlos F. Barbas, Dennis R. Burton, Jamie K. Scott, Gregg J. Silverman | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 |
| **CO2** | 3 | 3 | 3 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 1 | 1 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 10 | 10 | 10 | 10 | 10 | 50 |
| **External** | 10 | 10 | 10 | 10 | 10 | 50 |
| **Total** | 17 | 17 | 15 | 17 | 17 | **100** |

**e. Mapping Course Outcome with Internal Assessment (50 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Practical** | 3 | 3 | 3 | 3 | 3 |
| **Seminar** | - | - | | | - |
| **Test** | 4 | 4 | 4 | 4 | 4 |
| **Attendance** | 3 | 3 | 3 | 3 | 3 |
| **Total** | 10 | 10 | 10 | 10 | 10 |

**f. Mapping Course Outcome with External Assessment (50 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| **Part – A**<br>**(Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 | 2 |
| **Part – B**<br>**(Essay - 10 x 5 = 50 marks)** | 8 | 8 | 8 | 8 | 8 | 8 |
| **Total** | **10** | **10** | **10** | **10** | **10** | **10** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| 2 | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| 2 | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Demonstration**<br>**Multiple choice 20 x 2 = 40** | | |
| 1 | Demonstration of phage isolation from sewage | Recognize | Remember |
| 2 | Amplification of given gene sequence | Recognize | Remember |
| | **PART – B Spotter**<br>**The answer should not exceed 200 words 5 x 2 = 10** | | |

| | | | |
|---|---|---|---|
| 11 | Identify the image and elaborate it. | Recognize | Analyze |
| 12 | Identify the image and elaborate it. | Recognize | Analyze |

**SEMESTER – III**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB301** | Bioinformatics, Biostatistics, and Intellectual Property Rights | 2 | 2 | 0 | 4 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Explains various basic concepts in bioinformatics providing an overview on the same. | Understand |
| **CO 2** | Learn sequence alignment and algorithms. | Apply |
| **CO 3** | Deals with various data types and their presentation. | Analyze |
| **CO 4** | To deals with various statistical tests and software for data analysis. | Create |
| **CO 5** | Explains Intellectual property rights, their basics, and forms | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | **Overview of Bioinformatics**<br>Overview of databases in bioinformatics Biological databases:<br>Sequence and Structure databases – Protein Sequence databases – SWISS-PROT, PIR - Nucleic Acid Sequence Databases – GenBank, EMBL, DDBJ –pattern and motif searches databases – PROSITE, BLOCKS, PRINTS, PFAM – structure databases – PDB – structural classification – SCOP, CATH, PRINTS, BLOCKS, PRINTS, PRODOM, PFAM. | 12 |
| **II** | **Sequence Alignment Algorithms**<br>Pairwise alignment - Local and Global alignment concepts –<br>Databases searches for homologous sequences - FASTA and BLAST - Multiple sequence alignment – Progressive Alignment - Clustal W, methods for phylogenetic tree construction. | 12 |
| **III** | **Qualitative and quantitative data**<br>Cross-sectional and time series data, discrete and continuous data, nominal, ordinal, ratio, and interval scales; Presentation of data: Frequency distribution and cumulative frequency distribution, Measures of variability z-score and standard normal distribution, diagrammatic and graphical presentation of data, construction of bar, pie diagrams, histograms, frequency polygon, and frequency curve. | 12 |
| **IV** | **Introduction to the t-statistic**<br>the independent samples t-test, the dependent (paired) samples t-test, One-way ANOVA, simple linear regression analysis, Chi-Square and other non-parametric tests, introduction to multivariate analysis.: Software for Data Analysis: Introduction to the software, required data | 12 |

<table>
<tr><td></td><td>format, tables, descriptive measures, graphs and charts, presentation of tables/charts.</td><td></td></tr>
<tr><td>V</td><td>Introduction to IPR<br>IPR, forms of IPR and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible, and Intangible property. WTO: agency controlling trade among nations, WTO with reference to biotechnological affairs, TRIPs. WIPO, EPO. Concept related to patents novelty, non-obviousness, utility, anticipation, prior art etc. Type of patents. Indian patent act and foreign patents. Patentability, Patent application, Revocation of patent, Infringement and Litigation with case studies on patent, Commercialization and Licensing.</td><td>12</td></tr>
<tr><td></td><td>Practical (Any two)<table><tr><th>S.No.</th><th>Apparatus and Tools</th><th>Concept</th></tr><tr><td>1</td><td>-</td><td>Intelligence</td></tr><tr><td>2</td><td>-</td><td>Personality</td></tr><tr><td>3</td><td>-</td><td>Self-Concept</td></tr></table></td><td></td></tr>
<tr><td></td><td>Tasks and Assignments:<br>Each student is required to submit the following:<br>➢ Demonstrate the use of Sequence and Structure databases.<br>➢ Perform Pairwise alignment - Local and Global alignment concepts using different type of sequences.<br>➢ Determine and analyze Cross-sectional and time series data, discrete and continuous data.<br>References:<br>1. Arthur. M. Lesk, Introduction to Bioinformatics, 4th Edition, 2014, Oxford University Press. K. Najarian, S.Najarian, S. Gharibzadeh, C. N. Eichelberger, Systems Biology and : A Computational Approach 1st Edition, 2009, CRC Press. ISBN: 978- 1420046502<br>2. Gupta SC, Kapoor VK (2014). Fundamentals of Mathematical Statistics, S Chand and sons, India.<br>3. Gupta SP (2009). Statistical Methods, 28th edition, S Chand and Sons, India.<br>4. Bioethics and Biosafety by M.K. Sateesh, IK International Publishing, 2010.<br>5. Law Relating to Intellectual Property Rights, VK Ahuja, 2nd Edition, Lexis Nexis (2013) ISBN: 9788180389894.<br>6. Law and Strategy of biotechnological patents by Sibley. Butterworth publication. (2007) ISBN: 075069440, 9780750694445.</td><td></td></tr>
</table>

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 2 |
| **CO5** | 1 | 1 | 1 | 1 | 2 | 3 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | - | - | 2 | 2 | - |
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Short Answer - 5 x 4 = 20 marks)** | 10 | 10 | - | - | - |
| **Part – C (Essay- 3 x 10 = 30 marks)** | - | - | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| **2** | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| 2 | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | It is the most common measure of central tendency and least affected by the sample fluctuations<br>a) Median<br>b) Mean<br>c) Mode<br>d) All the above | Recognize | Remember |
| 2 | From the following which is not an intangible property<br>a) Customer lists<br>b) Trade secrets<br>c) Business licenses<br>d) Art objects | Recall | Remember |
| 3 | _____ cover eight areas for IPRs legislation including patent, copyright and geographical indications<br>a) WTO<br>b) PCT<br>c) TRIPS<br>d) WIPO | Recognize | Remember |
| 4 | From the following which diagrammatic representation shows the behavior of a variable over time.<br>a) Bar chart<br>b) Frequency polygons<br>c) line diagram<br>d) Pie diagram | Recognize | Remember |

| | | | |
|---|---|---|---|
| 5 | Which of the following is an example of Homology and similarity tool?<br>a) BLAST<br>b) RasMol<br>c) EMBOSS<br>d) PROSPECT | Recognize | Remember |
| 6 | In the pairwise sequence alignment method, what does the gap score represents?<br>a) Match<br>b) Mismatch<br>c) Insertion/Deletion<br>d) Homology | Recognize | Remember |
| 7 | Which of the following is used as a repository for the 3-dimensional structure data for large biological molecules?<br>a) NCBI<br>b) EMBL<br>c) Swiss-Prot<br>d) PDB | Recall | Remember |
| 8 | BLOSUM matrices are used for?<br>a) Multiple sequence alignment<br>b) Pair wise sequence alignment<br>c) Phylogenetic analysis<br>d) All of the above | Recall | Remember |
| 9 | Sequence alignment helps scientists<br>a) To trace out evolutionary relationships<br>b) To infer the functions of newly synthesized genes<br>c) To predict new members of gene families<br>d) All of these | Identify | Remember |
| 10 | When you are comparing two or more than two sequences of same or different organisms, what is the type of the alignment?<br>a) Global<br>b) Pairwise sequence<br>c) Local<br>d) Multiple sequence | Identify | Remember |
| | **PART – B ESSAY Answer**<br>**The answer should not exceed 200 words 10x 5 = 50** | | |
| 11 | Calculate the linear correlation coefficient for the following data. X = 4, 8 ,12, 16 and Y = 5, 10, 15, 20? | Describe | Analyse |
| 12 | What are the functions of WIPO and TRIPS? | Explain Discuss | Understand |
| 13 | Detail the obviousness in deciding novelty? | Assess | Skill |
| 14 | Explain the uses and importance of Protein Information resources sequence database? | Describe | Analyse |

| | | | |
|---|---|---|---|
| 15 | What are the initiatives taken by Government of India towards protection of IPR? | Explain Discuss | Understand |
| 16 | Describe in detail the multiple sequence alignment, its type and uses in analyzing the sequences? | Assess | Skill |

**SEMESTER - III**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB302** | Marine Microbiology | 2 | 1 | | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | To understand microbial processes of marine environment. | Understand |
| **CO 2** | To get in depth knowledge in marine microbe dynamics | Apply |
| **CO 3** | To obtain knowledge about microbial applications in space research | Analyze |
| **CO 4** | To gain an insight of microbes that can grow in extreme environments | Create |
| **CO 5** | In study the microbes of importance in seafood industry | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Introduction to Microbial Oceanography – marine ecosystem: benthic & littoral zone, saltpan, mangroves and estuarine microbes, microbial loop - marine microbial communities - phytoplankton, protozoa, bacteria, fungi, and virus. Microbial endosymbionts – epiphytes – coral microbial association, sponge-microbial association. | 12 |
| **II** | Dynamics of Marine Microbes - Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming - Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization phosphorus cycle; Decomposition of organic matter; Bioleaching and biodeteroriation of natural and synthetic materials. | 12 |
| **III** | Seeing microbes from space: Geo-satellite, Monitoring, Remote sensing, Modeling and Scaling. Several satellite-borne sensors, including the Sea-Viewing Wide Field-of-View Sensor (SeaWiFS), Moderate-Resolution Imaging Spectroradiometer (MODIS-Terra, MODIS Aqua), Medium Resolution Imaging Spectrometer (MERIS), and the Ocean Colour Monitor (OCM) Case study : Viewing Mapping Vibrio species and Trichodesmium . cholerae. | 12 |
| **IV** | Microbes of extreme environments – mechanism of extremophiles – halophiles –halorhodopsin – deep sea microbes – microbes of hydrothermal vents - thermophilic, alkalophilic, asmophilic and barophilic, psychrophilic microorganisms – hyperthermophiles and halophiles –importance in biotechnology, geo-satellite, monitoring and remote sensing | 12 |

| | | |
|---|---|---|
| **V** | Seafood microbiology - normal genera associated with fish, food spoilage, fish & human pathogens; zoonotics – Brief account on aquaculture pathogens - Vibriosis – shrimp diseases – WSSV– MBV etc. Rapid diagnosis of contamination in sea foods and aquaculture products. | 12 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ Each student should discuss one publication in the field of marine microbiology<br>✓ Each student should take an assignment to write about an application of marine microbiology<br>✓ Participate in the subject-oriented quiz.<br>✓ Prepare a presentation about diseases and zoonotics with seafood<br>✓ **References:**<br>Colin Munn, Marine Microbiology: Ecology & Applications 2nd Edition. Garland Science,<br>Taylor & Francis, 2009. ISBN: 978-0815365174.<br>2. David L. Kirchman, Microbial Ecology of the Oceans, 2nd Edition, John WIley & Sons, 2008.<br>ISBN: 978-0470043448.<br>3. M.T. Madigan and J.M. Martinko, Biology of Microorganisms, 11th Edition, Pearson<br>Prentice Hall, USA, 2006.<br>4. Bhakuni, D.S. and Rawat, D.S. (2005). Bioactive marine natural products. Anamaya<br>Publishers, New Delhi.<br>5. Joseph Selvin and A. S. Ninawe (2009). Shrimp Disease Management. ANE Publishers. | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 | 2 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 3 |
| **CO5** | 2 | 2 | 3 | 1 | 1 | 2 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | - | - | 2 | 2 | - |

| | | | | | |
|---|---|---|---|---|---|
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Short Answer - 5 x 4 = 20 marks)** | 10 | 10 | - | - | - |
| **Part – C (Essay- 3 x 10 = 30 marks)** | - | - | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| **2** | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2** | **Presentation**<br><br>**50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | 1. _____ leached from mangrove litter, controls bacterial population and reduces harmful activities of virulent pathogens.<br>a. Organic acids<br>b. Tannins<br>c. Methane<br>d. All of the above | Recognize | Remember |
| 2 | Blind roots to overcome respiration problem in anaerobic soil conditions<br>a. Prop roots<br>b. Pneumatophores<br>c. Stilt roots<br>d. Adventitious roots | Recall | Remember |
| 3 | Zone beyond the continental shelf and occurs at depth of 150-4000 m<br>a. Abyssal zone<br>b. Bathyal zone<br>c. Hadal zone<br>d. Intertidal zone | Recognize | Remember |
| 4 | _____is the most common and diverse bacterial phyla in sponges<br>**a. Chloroflexi**<br>b. Dendrilla<br>c. Gamma- proteobacteria<br>d. none of the above | Recognize | Remember |
| 5 | Enzyme isolated from halophilic bacteria of mangrove sediments<br>a. Permease<br>b. L-asparaginase<br>c. Arylsulfayase<br>d. all of the above | Recognize | Remember |
| 6 | . _____ are dominant at and below the chemocline<br>a. Sulfate reducing bacteria<br>b. Methanogenic bacteria<br>c. Cyanobacteria<br>d. Green Sulphur bacteria | Recognize | Remember |

| | | | |
|---|---|---|---|
| 7 | High GC content contributes to the thermostability of the genome.<br>a) True<br>b) False<br>c) Depends on organism<br>d) Not applicable for thermophiles | Recall | Remember |
| 8 | Protein adaptations of thermophiles include which of the following?<br>a. More compact core containing disulfide bonds<br>b. Less hydrogen bonds<br>c. Greater average hydrophilicity for interior residues<br>d. All the above | Recall | Remember |
| 9 | Presence of lipid quinones enhances which of the following properties of membranes?<br>a) Fluidity<br>b) Stability<br>c) Permeability<br>d) All the above | Identify | Remember |
| 10 | S-layer glycoprotein requires which of the following for stability?<br>A. Presence of tetraether lipids<br>B. Presence of monolayer membrane<br>C. High salt concentrations<br>D. None of the above | Identify | Remember |
| | **PART – B ESSAY Answer**<br>**The answer should not exceed 200 words 10x 5 = 50** | | |
| 11 | Explain the microbial diversity in mangrove ecosystem. | Describe | Analyse |
| 12 | Explain in detail the microbial diversity in estuaries. | Explain Discuss | Understand |
| 13 | Explain the spatial distribution of microorganisms in marine ecosystem | Assess | Skill |
| 14 | Explain the interaction between sponge-specific microbial symbionts. | Describe | Analyse |
| 15 | Explain in detail (with diagrams) the "salt-in" and "salt-out" strategy employed by halophiles for survival in saline environments. | Explain Discuss | Understand |
| 16 | List out 4 genome adaptations of thermophiles | Assess | Skill |
| 17 | Write an essay on halorhodopsin | Asses | Analyse |

**SEMESTER - III**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB303** | Environmental Microbiology | 2 | 1 | | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | To understand the activities of the microorganisms at large in nature/ environment | Understand |
| **CO 2** | To evaluate the roles of microorganisms in ecosystems | Apply |
| **CO 3** | To gain an insight of plant microbe interactions | Analyze |
| **CO 4** | To understand the precise natural habitats and activities of microorganisms | Create |
| **CO 5** | In study the microbes application in waste management | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Microbial Ecology: Interaction between abiotic and biotic factors in an ecosystem, ecological niche, limiting factor, concept of community, fluctuation and succession. Ecological pyramid, energy flow, food chain, food webs and their dynamism, stability and complexity of ecosystem. Interactions between microbes and organisms at trophic levels: commensalism, mutualism, parasitism and predation with examples. Microbial Communities: Microenvironment and niche, communities in soil, water, air. Biofilms, microbial mats and their significance. | 12 |
| **II** | Aquatic Microbiology: The aquatic environment - major environmental conditions influencing microflora. Distribution of microorganisms in the aquatic environments – freshwater environment, estuaries and marine environment. Microbiology of drinking water, water pollution, purification of water for human consumption. Assessment of microbial status in water and waste water. Wastewater characteristics, Effluent treatment processes (like trickling filter, activated sludge, oxidative pond, anaerobic digestion and chemical disinfection). | 12 |
| **III** | Plant-Microbe Interactions: Introduction, concepts and scope of agricultural microbiology, Interrelationships between plants and microorganisms, Rhizosphere and phyllosphere microorganisms and their interactions with plants. Plant pathogens (bacterial and fungal), mechanisms of plant pathogenicity, symptoms of plant diseases, transmission of plant diseases. Signalling events in pathogenesis and resistance to pathogens. Molecular basis of plant disease control along with cultural practices, chemical and biological control. Microbial control of insects. Beneficial association between plant and microorganisms (association of plants with cyanobacteria, actinomycetes and fungus). | 12 |
| **IV** | Cyanobacteriology: Origins of life and photosynthesis, Diversity of cyanobacteria, Molecular ecology and environmental genomics of cyanobacteria, comparative genomics of marine cyanobacteria, stress response-regulatory system, Molecular biology of cyanelles and chloroplast, supramolecular membrane organization; phycobilisome and phycobiliprotein structures, Use of cyanobacteria in the study of the structure and function of photosystem II and cytochrome complex; photosystem I, F-type ATPase in Cyanobacteria, Biochemistry and molecular regulation of CO2 metabolism and genetic analysis of | 12 |

| | | |
|---|---|---|
| | cyanobacteria, Heterocyst metabolism and development, Differentiation of hormogonia and relationships with other biological processes. | |
| **V** | Microbiology of wastewater and solid waste treatment: - biological, aerobic, anaerobic, primary, secondary and tertiary treatments. Activated sludge and Anaerobic digestion process. Treatment of industrial effluents by microorganisms. Composting. Microbiology of degradation of xenobiotics. Bioremediation: Factors affecting the bioremediation process, Bioremediation of toxic waste sites; Role of microbes; Microbial degradation of environmental pollutants-industrial solvents, pesticides, petroleum hydrocarbons, xenobiotics; bioremediation practices and technologies. Biofertilizers, Biofuel production from organic wastes, Bioenergy, Bioleaching. | 12 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ Each student should discuss one publication in the field of environmental microbiology<br>✓ Each student should take an assignment to write about an application of microbes in waste management<br>✓ Participate in the subject-oriented quiz.<br>✓ Prepare a presentation about plant microbe interactions<br>✓ **References:**<br>1. Prabhakaran, G. 2004. Introduction to Soil and Agricultural Microbiology, Himalaya Publishing House.<br>2. George N. Agrios. 2005. Plant Pathology. 5th Edition. Academic Press.<br>3. Raina M. Maier, Ian A. Pepper and Charles Gerba (2009) Environmental Microbiology (2nd edition). Academic Press.<br>4. Antonia Herrero & Enrique Flores. The Cyanobacteria: Molecular Biology, Genomics and Evolution, Caister Academic Press, 2008.<br>5. T. A. Sarma. Handbook of Cyanobacteria, CRC press, 2012.<br>6. Samit Ray. Cyanobacteria, New Age International Pvt. Ltd Publishers, 2006.<br>7. Percy M. Gault & Harris J. Marler. Handbook on Cyanobacteria: Biochemistry, Biotechnology and Applications (Bacteriology Research Developments), Nova Science Publishers, Inc. 2009. | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 | 2 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO4** | 2 | 2 | 1 | 3 | 2 | 3 |
| **CO5** | 2 | 2 | 3 | 1 | 1 | 2 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | - | - | 2 | 2 | - |
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| **Category** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Short Answer - 5 x 4 = 20 marks)** | 10 | 10 | - | - | - |
| **Part – C (Essay- 3 x 10 = 30 marks)** | - | - | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| **Sl. No.** | **Criteria** | **100%** | **75%** | **50%** | **25%** | **0%** | **Relation to COs** |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| **2** | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| **Sl. No.** | **Criteria** | **100%** | **75%** | **50%** | **25%** | **0%** | **Relation to COs** |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding**<br><br>**50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| **2** | **Presentation**<br><br>**50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | The concept of microbial loop was first introduced in<br>A. Aquatic ecosystem<br>**B. Marine ecosystem**<br>C. Terrestrial ecosystem<br>D. Air ecosystem | Recognize | Remember |
| 2 | The types of interaction in which Bdellovibrio penetrates the cell wall and multiplies between the wall and the plasma membrane, a periplasmic mode of attack, followed by lysis of the prey and release of progeny<br>A. Parasitism<br>**B. Predation**<br>C. Ammensalism<br>D. Competition | Recall | Remember |
| 3 | Protozoan from the termit's gut breakdown cellulose and enables termites to use wood as food source, is a type of _____ interaction<br>**A. Mutualism**<br>B. Synergism<br>C. Commensalism<br>D. Cometablosm | Recognize | Remember |
| 4 | Competitive exclusion principle was described by<br>**A. Gause**<br>B. Wommack<br>C. Colwell<br>D. None of the above | Recognize | Remember |
| 5 | Which of the following is a part of constitutive host defense in plants?<br>A. Cork layer<br>B. Tyloses<br>C. Secretions like gums | Recognize | Remember |

| | | | |
|---|---|---|---|
| | **D. Shape of stomata** | | |
| 6 | Translocation of effectors of pathogen into the plant cell is done by which of the following secretion systems in bacteria?<br>A. Type I<br>B. Type II<br>**C. Type III**<br>D. All the above | Recognize | Remember |
| 7 | Which of the following statements is not applicable to Systemic acquired resistance (SAR)?<br>A. SAR prepares plant for a second attack by pathogen<br>**B. SAR brings about local cell death and sealing off of the pathogen**<br>C. Both Salicilic acid and Jasmonic acid are involved in SAR<br>D. SAR once acquired lasts for a period of several days | Recall | Remember |
| 8 | Which of the following Bacteria is responsible for causing disease in plants-spanning a very large number of families and hundreds of species?<br>A. Erwinia amylovora<br>**B. Ralstonia solanacearum**<br>C. Xanthomonas oryzae<br>D. Botrytis cinerea | Recall | Remember |
| 9 | Biological oxidation processes usually referred as biological treatment, are the most common form of<br>A. Primary treatment<br>**B. Secondary treatment**<br>C. Tertiary treatment<br>D. All of these | Identify | Remember |
| 10 | Which one of the following is not a biofertiliser??<br>A. Azotobacter<br>B. Clostridium<br>C. **Bacillus thuringiensis**<br>D. Azolla | Identify | Remember |
| | **PART – B ESSAY Answer**<br>**The answer should not exceed 200 words 10x 5 = 50** | | |
| 11 | Define ecosystem and what are different types of ecosystems? | Describe | Analyse |
| 12 | What is non-host resistance? Using well labelled diagrams, briefly explain the two types of non-host resistance in plants. | Explain Discuss | Understand |
| 13 | What are trickling filters, describe their role and importance in waste water treatment? | Assess | Skill |
| 14 | Describe bioremediation? Name the important factors affecting the bioremediation process. | Describe | Analyse |
| 15 | What is the major mechanism of pathogen removal during activated sludge treatment? | Explain Discuss | Understand |

**SEMESTER - III**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB304** | Pharmaceutical Microbiology | 3 | 0 | 0 | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Understand the basics antibiotics and synthetic antimicrobial agents | Understand |
| **CO 2** | Explain mode of action of antibiotics and chemotherapeutics, various techniques in pharmaceutical microbiology | Apply |
| **CO 3** | Understand about vaccines, sterilization and sterility testing, application of microbial enzymes | Analyze |
| **CO 4** | learn about regulatory practices in the pharmaceutical industries | Create |
| **CO 5** | understand good laboratory practices and good manufacturing practices | Apply |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Antibiotics and synthetic antimicrobial agents: production of antibiotics and synthetic antimicrobial agents, (Aminoglycosides, β lactams, tetracyclines, ansamycins, macrolide antibiotics), Antifungal antibiotics, antitumor substances. Peptide antibiotics, Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents. Chemical disinfectants, antiseptics and preservatives. Commercial production of steroids, alkaloids, interferon, human proteins-insulin, somatostatin, vaccines and anti-cancer agents | 16 |
| **II** | Antibiotics and chemotherapeutics: Mode of action, Antibiotic sensitivity assays- disc method; replica plating technique; Antibiotic resistance in bacteria- factors of development of resistance, Quorum sensing, Biofilms, anti-fungal drugs and their mode of action, anti-fungal sensitivity testing, antifungal resistance. Molecular principles of drug targeting, Drug delivery system in gene therapy, Bacterial resistance to antibiotics, Mode of action of bacterial killing by quinolinones, Bacterial resistance to quionolinones, 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) | 16 |
| **III** | Microbial production and Spoilage of pharmaceutical Products Microbial contamination and spoilage of pharmaceutical products (sterile injectables, non-injectables, ophthalmic preparations and implants) and their sterilization. Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization) Chemical and biological indicators Manufacturing procedures and in process control of pharmaceuticals. New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines. Vaccine clinical trials. Immobilization procedures for | 16 |

| | | |
|---|---|---|
| | pharmaceutical applications (liposomes). Macromolecular, cellular and synthetic drug carriers. Biosensors in pharmaceuticals. Application of microbial enzymes in pharmaceuticals. | |
| **IV** | Regulatory practices, biosensors and applications in Pharmaceuticals Financing R&D capital and market outlook. IP, BP, USP. Government regulatory practices and policies, FDA perspective. Reimbursement of drugs and biologicals, legislative perspective. Rational drug design. | 16 |
| **V** | Quality Assurance and Validation Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry. Regulatory aspects of quality control. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory) Safety microbiology laboratory. | 16 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ Assignments<br>✓ Research seminars<br>**References:**<br>1. Janeway Immunobiology. 9th Edition. Publisher-Garland Science, 2016<br>2. Abul K Abbas, Andrew H Lichtman & Shiv Pillai, Cellular & Molecular Immunology, 8th Edition 2014, Elsevier<br>3. Roitt's Essential Immunology, 13th Edition, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt 2016, Wiley-Blackwell.<br>4. William E. Paul. Fundamental Immunology. 7th Edition. Lippincott Williams and Wilkins, 2012. | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 3 | 2 | 3 |
| **CO2** | 2 | 4 | 3 | 3 | 2 | 3 |
| **CO3** | 1 | 2 | 2 | 3 | 3 | 4 |
| **CO4** | 2 | 3 | 1 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 1 | 3 | 2 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | **20** | **20** | **20** | **20** | **20** | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | - | - | 2 | 2 | - |

| | | | | | |
|---|---|---|---|---|---|
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 |
| | | | | | |
| **Part – B (Essay- 5 x 10 = 50 marks)** | 10 | 10 | 10 | 10 | 10 |
| **Total** | **12** | **12** | **12** | **12** | **12** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| **2** | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2** | **Presentation**<br><br>**50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | What is virus attenuation in practical terms for successful vaccine discovery?<br>a. Passage of live virus from cell to cell and a search for less virulent mutants<br>b. As (a) but using low temperature (33ºC) to select cold adapted mutants<br>c. Direct random mutagenesis to create a less virulent mutant<br>d. Recovery of a naturally occurring 'wild' virus which is naturally less virulent | Recognize | Remember |
| 2 | 2. Which of the following is incorrect about a microarray?<br>a. It is a slide attached with a high-density array of immobilized DNA oligomers representing the entire genome of the species under study<br>b. Array of immobilized DNA oligomers cannot be cDNAs<br>c. Each oligomer is spotted on the slide and serves as a probe for binding to a unique complementary cDNA<br>d. It is the most commonly used global gene expression profiling method | Recall | Remember |
| 3 | 3. ---------- equipment is used for aseptic production.<br>a. Bionic limbs<br>b. Molecular computer<br>c. Blow/fill/seal<br>d. None of the above | Recognize | Remember |
| 4 | 4. All of the following are LIVE vaccines Except:<br>a. MMR<br>b. Yellow fever<br>c. BCG<br>d. Hepatitis A | Recognize | Remember |
| 5 | 5. The time in minutes at a specific temperature needed to kill a population of cells is the:<br>a. F value<br>b. Decimal reduction time<br>c. D value | Recognize | Remember |

| | | | |
|---|---|---|---|
| | d. Z value | | |
| 6 | 6. Which of the following antifungal drugs is most effective in the treatment of invasive aspergillosis?<br>a. Ketocozole<br>b. fluconazole<br>c. Voriconazole<br>d. Clotrimazole | Recognize | Remember |
| 7 | All of the following are LIVE vaccines except:<br>a. MMR<br>b. Yellow fever<br>c. BCG<br>d. Hepatitis A | Recall | Remember |
| 8 | The time in minutes at a specific temperature needed to kill a specific pathogen of cells is the<br>a. F value<br>b. Decimal reduction time<br>c. D value<br>d. Z value | Recall | Remember |
| 9 | The chemical used most often to inactivate the biological toxin in a toxoid vaccine is:<br>a. Thiomerosal<br>b. Formaldehyde<br>c. Neomycin<br>d. Acetic acid | Identify | Remember |
| 10 | Pneumoccocal polysaccharide vaccines:<br>a. Contain purified capsular polysaccharide<br>b. Do nto prevent exacerabation of chronic bronchitis<br>c. Can provide limited cross protection against non-vaccine serotypes<br>d. Provide long-lasting immunity ie. More than 10 years | Identify | Remember |
| | | | |
| **PART – B Essay Answer<br>The answer only 5 questions and answer should not exceed 400 words 5 x 10 = 50** | | | |
| 11 | Detail the history and development of whole live attenuated, inactivated, toxoid, cellculture based, recombinant subunit, DNA/mRNA and vectored vaccines. What are the currently approved vaccines for COVID-19 in India. | Describe | Analyse |
| 12 | For Staphylococcus aureus in turkey stuffing, D60 = 15.4 min and z = 6.8°C How long would it take to reduce a population of S. aureus in turkey stuffing from 105 cells to 100 cells at 55°C, 60°C, and 65°C? | Explain Discuss | Understand |
| 13 | Illustrate and explain the design of a typical fermenter for culturing filamentous fungi for the industrial production of β-lactam antibiotics. Detail the extraction, purification and GMP of Penicillin V and Cephaolposrin | Assess | Skill |
| 14 | Describe Biosensors. Propose a strategy to detect viruses using biosensors. | Explain Discuss | Understand |

| | | | |
|---|---|---|---|
| 15 | What are the various types of rational drug designing methods? | Explain Discuss | Understand |
| 16 | Classify antifungal drugs on their mechanism of action and detail the mode of action of azole and echinocandins | Describe | Analyse |
| 17 | Details the history and development of whole live attenuated, inactivated, toxoid, cell culture based, recombinant subunit, DNA/mRNA and vectored vaccines. What are the currently approved vaccines for COVID-10 in India? | Describe | Analyse |

**SEMESTER - III**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **CMB 305** | Medical Microbiology | 2 | 1 | | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Understand the basic principles of medical Microbiology such as how bacteria responds to human and how human responds to microbes. To study on commensal, pathogenic and especially gut microbiome. | Understand |
| **CO 2** | Understand the morphology, epidemiology, bio-chemical, genetic characteristics of pathogenic microorganisms | understand |
| **CO 3** | To study on different viruses and fungi their pathogenesis and epidemiology. | apply |
| **CO 4** | To study on antimicrobial compounds to fungi, bacteria, viruses and parasites. | Understand |
| **CO 5** | Understand the treatment, prevention of pathogenic diseases | analyse |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | **Basic Principles of Medical Microbiology**: Bacterial morphology and bacterial structures, Commensal and pathogenic microbial flora in humans, Sterilization. Disinfection and antisepsis, Basic concepts of immune responses to infectious agents, antimicrobial vaccines, General principles of laboratory diagnosis, microscopic principles and applications, molecular diagnosis, serologic diagnosis. | 9 |
| **II** | **Medical Bacteriology**: Staphylococcus and related organisms, Streptococcus, Enterococcus and other Gram Positive cocci, Bacillus, Listeria and Erysipelothrix, Corynebacterium and other Gram positive rods, Nocardia and related bacteria, Mycobacterium, Neisseria and related genera, Enterobacteriaceae, Vibrio and Aeromonas, Campylobacter and Helicobacter, Pseudomonas and related organisms, Haemophilus and related bacteria, Bordetella, Brucella and Francisella, Legionella, Anaerobic spore-forming Gram positive bacilli, Anaerobic nonspore-forming Gram positive bacteria, Anaerobic Gram negative bacteria, Treponema, Borrelia and Leptospira, Mycoplasma and Ureaplasma, Rickettsia and Orientia, Ehrlichia, Anaplasma and Coxiella, Chlamydiaceae, Role of bacteria in disease. | 9 |

| | | |
|---|---|---|
| **III** | **Medical Virology**: Mechanisms of viral pathogenesis, Antiviral agents, Laboratory diagnosis of viral diseases, Poxviruses, human herpesviruses, Adenoviruses, Papillomaviruses, Polyomaviruses, Parvoviruses, Picornaviruses, Coronaviruses and Noraviruses, Paramyxoviruses, Orthomyxoviruses, Rhabdoviruses, Filoviruses, Bornaviruses, Reoviruses, Togaviruses, Flaviviruses, Bunyaviridae, Arenaviridae, Retroviruses, hepatitis viruses, Unconventional agents and prions, Role of viruses in disease. | 9 |
| **IV** | Unit 4: Medical Mycology: Pathogenesis of fungal diseases, antifungal agents, Laboratory diagnosis of fungal diseases, Superficial and cutaneous mycoses, Subcutaneous mycoses, Systemic mycoses caused by endemic dimorphic fungal pathogens, Opportunistic mycoses, Fungal and fungal-like infections of unusual etiology, Mycotoxins and mycotoxicoses, Role of fungi in disease. | 9 |
| **V** | Unit 5: Medical Parasitology: Pathogenesis of parasitic diseases, anti-parasitic agents, laboratory diagnosis of parasitic diseases, intestinal and urogenital protozoa, blood, and tissue protozoa, nematodes, trematodes, cestodes, arthropods, Role of parasites in disease. | 9 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ Each student should discuss complete details of one bacterium in the assignment including their morphological, biochemical, and genomic characterization.<br>✓ Each student should take an assignment to assess the pathology and epidemiology of any microorganisms in the syllabus.<br>✓ Participate in the subject-oriented quiz.<br>✓ Visit to a diagnostic lab.<br>**References:**<br>1. David Greenwood, Richard Slack, John Peutherer, Mike Barer, Medical Microbiology 17th Ed., Churchill Livingstone, 2007.<br>2. Murray P.R., Pfaller M.A., Tenover F.C., & Yolken R.H. 2007. Clinical Microbiology, ASM Press.<br>3. Bauman, R.W. 2009. Microbiology: with Diseases by Body System; Benjamin Cummings.<br>4. Sherris, John C, Medical Microbiology: An Introduction to Infectious Diseases, 2nd Edition, Elsevier.<br>5. David Wilks, Mark Farrington and David Rubenstein 2010. Infectious Diseases Manual: Blackwell Science.<br>6. George F. Brooks, Karen C. Carroll, Janet S.Butel, Stephen A. Morse. 2007. Jawetz, Melnick & Adelberg's Medical Microbiology. 24th Ed. McGraw-Hill Professional.<br>7. Nester E. W., Anderson D. G. & Nester M. T. 2006. Microbiology: A Human Perspective, McGraw Hill.<br>8. Harvey, R.A., Champe, P.C. & Fisher, B.D. 2007. Lippincott's Illustrated Reviews: Microbiology. Lippincott Williams and Wilkins, New Delhi/New York | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 |
| **CO2** | 3 | 3 | 3 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 1 | 1 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 8 | 8 | 8 | 8 | 8 | 40 |
| **External** | 12 | 12 | 12 | 12 | 12 | 60 |
| **Total** | 17 | 17 | 15 | 17 | 17 | **100** |

**e. Mapping Course Outcome with Internal Assessment (40 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Assignments** | 2 | 2 | - | - | 2 |
| **Seminar** | - | - | 2 | 2 | - |
| **Test** | 5 | 5 | 5 | 5 | 5 |
| **Attendance** | 1 | 1 | 1 | 1 | 1 |
| **Total** | 8 | 8 | 8 | 8 | 8 |

**f. Mapping Course Outcome with External Assessment (60 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Essay - 10 x 5 = 50 marks)** | 8 | 8 | 8 | 8 | 8 | 8 |
| **Total** | **10** | **10** | **10** | **10** | **10** | **10** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2** | **Organiza-tion**<br><br>**50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| **Sl. No.** | **Criteria** | **100%** | **75%** | **50%** | **25%** | **0%** | **Relation to COs** |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding**<br><br>**50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| **2** | **Presentation**<br><br>**50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| **Sl. No.** | **Model Questions** | **Specification** | **Level** |
|---|---|---|---|
| | **Part – A: Objective Type**<br>**Multiple choice 10 x 1 = 10** | | |
| 1 | From the following which is true for *Heamophilus influenza*<br>a) Gram (+), non-spore forming and motile<br>b) Gram (-), non-spore forming and non-motile<br>c) Gram (+), spore forming and non-motile<br>d) Gram (-), non-spore forming and motile | Recognize | Remember |
| 2 | The sub-terminal spore formation caused by the *Clostridium* _____ (sp)<br>*a) Clostridium tetani*<br>***b) Clostridium Perfringens***<br>*c) Clostridium bifermentans*<br>*Clostridium tertium* | Recall | Remember |
| 3 | *Staphylococcal* endotoxins are heat stable<br>***a) Yes***<br>*b) No* | Recognize | Remember |
| 4 | A high cell wall content of high-molecular-weight lipids present in this bacterium<br>*a) Streptococcus*<br>*b) Staphylococcus* | Recognize | Remember |

| | | | |
|---|---|---|---|
| | *c) Pseudomonas*<br>***d) Mycobacterium*** | | |
| 5 | *The bacterial plasma membrane is composed primarily of protein and phospholipid in the ration of*<br>*a) **3:1** b) 2:2 c) 1:3 d) 3:2* | Recognize | Remember |
| 6 | A disease constantly present at some rate of occurrence in a particular location<br>a) Epidemic b) **Endemic** c) d) out break d) disease prevalence | Recognize | Remember |
| 7 | A bacterium with the tendency ti attack the stomach lining is<br>*a) Campylobacter*<br>*b) Corynebacterium*<br>*c) Helicobacter pylori*<br>d) *Pseudomonas* | Recall | Remember |
| 8 | Although vaccines are available for different diseases the infection still occurs due to<br>a) Vaccines are too expensive<br>b) Unavailability to the public<br>c) Neglected<br>d) All the above | Recall | Remember |
| 9 | Adjuvants are mostly used in<br>a) Live vaccine c) inactive vaccine<br>b) Attenuated vaccine d) DNA vaccine | Identify | Remember |
| 10 | The toxin which is stable at 100 ° C for 30 min, resists hydrolysis by gastric enzymes is<br>a) Cytotoxin c) enterotoxin<br>b) Exotoxin d) all the above | Identify | Remember |
| | **PART – B ESSAY Answer**<br>**The answer should not exceed 200 words 10x 5 = 50** | | |
| 11 | What can I expect if I have an *E. coli* infection? B) Pathogenicity of A. baumannii | Describe | Analyze |
| 12 | Detail the fecal microbiota and treatment of Diarrhoea | Explain Discuss | Understand |
| 13 | What vaccination(s) needed adjuvants and explain components of Alum. | Assess | Skill |
| 14 | Detail the physiological, biochemical and epidemiological characteristics of *Pseudomonas aeruginosa.* | Describe | Analyse |
| 15 | How does the microbiome affect immunity and contribute to disease? | Explain Discuss | Understand |
| 16 | Explain: what is the serological diagnosis? and how the host responds to a microbial infection? | Assess | Skill |
| 17 | Detail the pathogenesis, symptoms and culturing conditions of following diseases<br>a) Rocky mounted spotted fever<br>b) Ehrlichiosis | Asses | Analyse |

**SEMESTER - III**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **PMB 205** | Practical Microbiology V | | | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | To study the normal micro-biota of mouth and skin; | skills |
| **CO 2** | Identification and Biochemical tests of gastrointestinal bacterial infection | skills |
| **CO 3** | Collection and microbiological examination of sputum for pus cells and bacteria. | analyze |
| **CO 4** | Examination of microbial load in various food sources | analyze |
| **CO 5** | Milk quality determination and detection of number of bacteria in milk | skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Study of normal micro-biota of mouth and skin; isolation, identification and preservation, Identification and Biochemical tests of respiratory tract bacterial pathogen (using avirulent strain of MTCC Culture of – Streptococci/Klebsiella pneumoniae. Identification and Biochemical tests of gastrointestinal bacterial infection (using avirulent strain of MTCC Culture) – Salmonella/Shigella sps.<br>Laboratory examination and identification and biochemical tests of pus (using avirulent strain of MTCC culture) for Staphylococcus aureus, Streptococcus pyogenes and Pseudomonas aeruginosa. Laboratory examination of sputum: Collection and microbiological examination of sputum for pus cells and bacteria. Ziehl-Neelsen staining to detect Mycobacteria (using avirulent strain). | 15 |
| **II** | Examination of microbial load in soft drinks, ice creams, packaged and canned foods. Isolation and identification of food poisoning bacteria from contaminated foods, dairy products. Isolation and identification of food spoilage fungi from foods. Isolation, extraction and detection of aflatoxin from<br>foods. Production and estimation of lactic acid by Lactobacillus sp./ Streptococcus sp. Role of microbes in fermented foods- Bread making, Sauerkraut. Detection of number of bacteria in milk by standard plate count (SPC). Determination of quality of milk sample by methylene blue reduction test. Assessment of water quality by multiple tube fermentation test. | 15 |
| | **Tasks and Assignments:**<br>Each student is required to submit the following:<br>✓ Each student should discuss complete details of one of the display techniques.<br>✓ Students should demonstrate the screening techniques for the effective isolation of normal microbiota from various sources | |

| | | |
|---|---|---|
| | ✓ Participate in the subject-oriented quiz.<br>✓ Visit industry to learn techniques and advancements. | |

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 |
| **CO2** | 3 | 3 | 3 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 1 | 1 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 10 | 10 | 10 | 10 | 10 | 50 |
| **External** | 10 | 10 | 10 | 10 | 10 | 50 |
| **Total** | 17 | 17 | 15 | 17 | 17 | **100** |

**e. Mapping Course Outcome with Internal Assessment (50 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Practical** | 3 | 3 | 3 | 3 | 3 |
| **Seminar** | - | - | | | - |
| **Test** | 4 | 4 | 4 | 4 | 4 |
| **Attendance** | 3 | 3 | 3 | 3 | 3 |
| **Total** | 10 | 10 | 10 | 10 | 10 |

**f. Mapping Course Outcome with External Assessment (50 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| **Part – A (Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 | 2 |
| **Part – B (Essay - 10 x 5 = 50 marks)** | 8 | 8 | 8 | 8 | 8 | 8 |
| **Total** | **10** | **10** | **10** | **10** | **10** | **10** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2** | **Organiza-tion**<br><br>**50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| **1** | **Knowledge and Understanding**<br><br>**50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| **2** | **Presentation**<br><br>**50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Demosntration**<br>**Multiple choice 20 x 2 = 40** | | |
| 1 | Identification and Biochemical tests of respiratory tract bacterial pathogen | Recognize | Remember |
| 2 | Ziehl-Neelsen staining to detect Mycobacteria | Recognize | Remember |
| | **PART – B Spotter**<br>**The answer should not exceed 200 words 5 x 2 = 10** | | |
| 11 | Isolation and identification of food spoilage fungi from foods. | Recognize | Analyze |
| 12 | Assessment of water quality by multiple tube fermentation test. | Recognize | Analyze |

**SEMESTER - III**

| Course Code | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|
| **PMB306** | Practical Microbiology VI | 0 | 0 | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Deals with various bioassays and fermentation studies | Understand |
| **CO 2** | Deals with isolation of soil microbes and microbial organic waste management techniques | Analyze |
| **CO 3** | Deals with DNA isolation techniques, cloning, expression, and PCR. | Skill |

**b. Syllabus**

<table>
<tr><th>Units</th><th>Content</th><th>Hrs.</th></tr>
<tr><td>I</td><td>Part 1<br>Bioassay of nicotinic acid, Production of ethanol by yeast, Isolation of amylase producing microorganisms from soil, Isolation of protease producing microorganisms from soil, Isolation of lipase producing microorganisms from soil, Production and extraction of thuricides, Laboratory production of biofertilizers, Production and quantification of citric acid, Demonstration: Reactor Studies: Batch, fed-batch, and continuous flow reactor analysis and residence time distribution, Demonstration: Down-stream processing lab, Determination of specific growth rate in submerged fermentations, Production of wine from grape juice, Preparation of fermented food: curd, cheese and alcohols, Isolation and characterization of plant growth promoting bacteria.</td><td>10</td></tr>
<tr><td>II</td><td>Part II<br>Isolation and identification of nitrogen-fixing bacteria from soil, Splash liberation of fungal spores from diseased tissue, Seed health testing by using Standard Blotter Method, Estimation of phenols from healthy and diseased plant tissues, Degradation of cellulose by fungi (Chaetomium), Associative and antagonistic relationships among soil microorganisms, Microbial management of organic wastes, Microbial degradation of oil, Isolation of hydrocarbon and heavy metal tolerant microorganisms, Production and analysis of Polyhydroxy butyrates (PHB).</td><td>10</td></tr>
<tr><td>III</td><td>Part III<br>Isolation HMW DNA, DNA cloning and expression in E. coli cells, end repairing and cloning in fosmid/BAC, restriction analysis, polymerase chain reaction-Gradient, RT-PCR (demo), 16S typing, Mega software, Entrez Human genome map viewer.</td><td>10</td></tr>
<tr><td></td><td>Practical (Any two)
<table>
<tr><th>S.No.</th><th>Apparatus and Tools</th><th>Concept</th></tr>
<tr><td>1</td><td>Detection of bacterial pathogens by PCR</td><td>Understanding</td></tr>
<tr><td>2</td><td>Identification of mycorrhiza</td><td>Understanding</td></tr>
<tr><td>3</td><td>Bacterial growth measurement</td><td>Understanding</td></tr>
</table></td><td></td></tr>
<tr><td></td><td>Tasks and Assignments:<br>Each student is required to submit the following:<br>✓ Each student should discuss complete details of Production of various compounds from naturally collected yeast.</td><td></td></tr>
</table>

| | | |
|---|---|---|
| | ✓ Students should demonstrate the isolation and identification of nitrogen-fixing bacteria from soil.<br>✓ Participate in the subject-oriented quiz.<br>✓ Visit industry to learn techniques and advancements.<br><br>**References:**<br><br>Microbiology, A laboratory manual by James Cappuccino and Natalie Aherman 10th edition<br>Koneman's Color atlas and textbook of diagnostic microbiology, 7th edition by Gary W. Procop, Deirdre L. Church, Geraldine S Hall and William M, Janda | |

**d Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 |
| **CO2** | 3 | 3 | 3 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 1 | 1 |

**d. Evaluation Scheme**

| | CO1 | CO2 | CO3 | CO4 | CO5 | Total |
|---|---|---|---|---|---|---|
| **Internal** | 10 | 10 | 10 | 10 | 10 | 50 |
| **External** | 10 | 10 | 10 | 10 | 10 | 50 |
| **Total** | 17 | 17 | 15 | 17 | 17 | **100** |

**e. Mapping Course Outcome with Internal Assessment (50 Marks)**

| | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| **Practical** | 3 | 3 | 3 | 3 | 3 |
| **Seminar** | - | - | | | - |
| **Test** | 4 | 4 | 4 | 4 | 4 |
| **Attendance** | 3 | 3 | 3 | 3 | 3 |
| **Total** | 10 | 10 | 10 | 10 | 10 |

**f. Mapping Course Outcome with External Assessment (50 Marks)**

| Category | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| **Part – A**<br>**(Objective - 10 x 1 = 10 marks)** | 2 | 2 | 2 | 2 | 2 | 2 |
| **Part – B**<br>**(Essay - 10 x 5 = 50 marks)** | 8 | 8 | 8 | 8 | 8 | 8 |
| **Total** | **10** | **10** | **10** | **10** | **10** | **10** |

**g. Rubric for Assignments**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO5 |
| 2 | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO5 |

**h. Rubric for Seminar**

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms, and concepts | Detailed knowledge of facts, terms, and concepts | Considerable knowledge of facts, terms, and concepts | Minimal knowledge of facts, terms, and concepts | Not Attended | CO3, CO4 |
| 2 | **Presentation 50%** | Well Communicated with logical sequences, examples, and references | Communicated with sequences | Just Communicated | No coherent communication | Not Attended | CO3, CO4 |

**i. Model Question Paper**

| Sl. No. | Model Questions | Specification | Level |
|---|---|---|---|
| | **Part – A: Demosntration**<br>**Multiple choice 20 x 2 = 40** | | |
| 1 | Demonstration of isolation and identification of nitrogen-fixing bacteria from soil. | Recognize | Remember |
| 2 | Estimation of phenols from healthy and diseased plant tissues | Recognize | Remember |

| | PART – B Spotter<br>The answer should not exceed 200 words 5 x 2 = 10 | | |
|---|---|---|---|
| 11 | Identify the growth pattern and elaborate it. | Recognize | Analyze |
| 12 | Explain DNA cloning and expression in E. coli cells. | Recognize | Analyze |