**Annexure 2**
**Detailed Syllabus for Each Course**

| | | |
|---|---|---|
| **Semester: V** | **Course No.: 351** | **Course Code: -- MIM-351(T)**<br>**Course Title: Microbial Genetics and Molecular Biology** |
| **Credits: 4** | | **Course Category: -Major** |

**Course Outcomes: On successful completion of the course the learner will be able to**

| CO# | COGNITIVE ABILITIES | COURSE OUTCOMES |
|---|---|---|
| **CO351.1** | REMEMBERING | Describe the structure, properties, and replication of genetic material |
| **CO351.2** | UNDERSTANDING | Explain transcription, genetic code, translation, and molecular modifications |
| **CO351.3** | APPLYING | Analyze mechanisms of gene regulation, mutation, and DNA repair in microbes |
| **CO351.4** | ANALYSING | Apply knowledge of gene transfer systems and mobile genetic elements in microbial genetics |
| **CO351.5** | EVALUATING | Assess experimental evidence and molecular techniques used in microbial genetics to evaluate their applications in research and biotechnology. |

| Unit No. | Unit Contents | Sessions Allotted |
|---|---|---|
| **1** | **1. Genetic Material and DNA Replication**<br>**2. Basic Concepts:** Chromosome, nucleoid, plasmid, genome, gene, genotype, phenotype, replicon<br>**3. Experimental Proof of nucleic acid as Genetic Material:** Griffith, Avery–MacLeod–McCarty, Hershey–Chase and Fraenkel-Conrat and Singer<br>**4. DNA Structure:** Elucidation of DNA, Double helix model, base pairing, structural forms (A, B, Z DNA)<br>**5. Semi-Conservative Replication:** Meselson–Stahl experiment<br>**6. Replication Mechanism:**<br>A. Initiation & strand separation<br>B. RNA primer synthesis<br>C. Leading & lagging strand synthesis<br>D. Okazaki fragment joining and primer removal<br>E. Proofreading by DNA polymerase<br>**7. Patterns of Replication:** Cairns' model, Rolling circle mechanism<br>**8. Post-Replication Modifications:** DNA methylation, supercoiling | **15** |
| **2** | **Gene Expression – Transcription, Genetic Code, Translation & Modifications**<br>**1. Central Dogma of Molecular Biology**<br>**2. Gene Structure:** Promoter, coding region, terminator, regulatory sequences<br>**3. Transcription in Prokaryotes:** | 15 |

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|---|---|---|
| | A. Initiation (role of promoter, RNA polymerase, sigma factor)<br>B. Elongation<br>C. Termination (Rho-independent and Rho-dependent)<br>**4. Post-Transcriptional Modifications:** Intron splicing (self-splicing, spliceosome-mediated) and 5′ capping, 3′ polyadenylation (in eukaryotic context)<br>**5. Genetic Code:** Triplet nature, polarity, degeneracy, wobble hypothesis, near universality<br>**6. Translation in Prokaryotes:** Initiation (initiation factors, 70S complex) Elongation (AA-tRNA binding, peptide bond formation, translocation) Termination (release factors)<br>**7. Post-Translational Modifications**: Protein folding, cleavage, phosphorylation, glycosylation, signal peptide removal | |
| **3** | **Gene Regulation in Prokaryotes:**<br>**1. Regulation of gene expression:**<br>A. Lac operon – negative inducible and positive control (catabolite repression)<br>B. Trp operon – negative repressible control, attenuation control<br>C. Other regulatory systems – arabinose operon, quorum sensing (overview)<br>**2. Mutations:**<br>A. Spontaneous (Lederberg's proof)<br>B. Induced – chemical mutagens (5-bromouracil, methyl-nitrosoguanidine, acridine orange), physical mutagens (UV radiation), biological mutagens (phage Mu)<br>C. Ames's test<br>**3. Transposable Elements:** IS elements, Tn elements, transposon mutagenesis<br>**4. Effects of Mutations:** Silent, missense, nonsense, frameshift, reversion, suppression<br>**5. Bacterial Mutants:** Morphological, conditional, biochemical, resistant<br>**6. DNA Repair Mechanisms:**<br>A. Direct repair (photoreactivation)<br>B. Base excision repair<br>C. Nucleotide excision repair<br>D. Mismatch repair<br>E. SOS repair | **15** |
| **4** | **Gene Transfer in Bacteria & Mobile Genetic Elements**<br>**1. Fundamentals:** Zygote, allele, recombination, horizontal vs. vertical gene transfer, merozygote<br>**2. Bacterial Plasmids:** Properties, functional types (F, R, Col, degradative, virulence), maintenance<br>**3. Transformation:**<br>A. Natural (DNA uptake in Gram+ & Gram– bacteria) | **15** |

| | | |
|---|---|---|
| | B. Artificial (chemical & electroporation methods)<br>**4. Transduction:**<br>A. Lytic & lysogenic phage cycles<br>B. Generalized & specialized transduction<br>**5. Conjugation:**<br>A. F+ × F– mating<br>B. Hfr conjugation<br>C. F′ conjugation<br>**6. Applications:** Horizontal Gene Transfer in Evolution, Plasmids in genetic engineering | |

**Reference Books:**


1. Prescott, Harley, and Klein's Microbiology, J. M. Willey, L. M. Sherwood, C. J. Woolverton, 11th Edition (2020), McGraw Hill Higher Education- USA
2. Principles of Microbiology, R. M. Atlas, 2nd Edition (Indian Edition) (2015), McGraw Hill Education (India) Private Limited –New Delhi


**Suggested readings:**


1. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular biology of the gene* (7th ed.). Pearson.
2. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2015). *Molecular biology of the cell* (6th ed.). Garland Science.
3. Pierce, B. A. (2024). *Genetics: A conceptual approach* (7th ed.). W. H. Freeman.
4. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H., & Stahl, D. A. (2015). *Brock biology of microorganisms* (14th ed.). Pearson.
5. Snyder, L., & Champness, W. (2007). *Molecular genetics of bacteria* (3rd ed.). ASM Press.
6. Brown, T. A. (2023). *Gene cloning and DNA analysis: An introduction* (9th ed.). Wiley.
7. Griffiths, A. J. F., Doebley, J., Peichel, C., Wassarman, D., & Carroll, S. B. (2025). *Introduction to genetic analysis* (12th ed.). W. H. Freeman.
8. Wilson, B. A., Salyers, A. A., & Whitt, D. D. (2011). *Bacterial pathogenesis: A molecular approach* (3rd ed.). ASM Press.
9. Friedberg, E. C., Walker, G. C., Siede, W., Wood, R. D., Schultz, R. A., & Ellenberger, T. (2006). *DNA repair and mutagenesis* (2nd ed.). ASM Press.
10. Brown, T. A. (2017). *Genomes* (4th ed.). Garland Science.

| | | |
|---|---|---|
| **Semester: V** | **Course No.: 352** | **Course Code: -- MIM-352 (T)**<br>**Course Title: Immunology and Clinical Microbiology** |
| **Credits: 4** | | **Course Category: -Major** |

**Course Outcomes: On successful completion of the course the learner will be able to**

| CO# | COGNITIVE ABILITIES | COURSE OUTCOMES |
|---|---|---|
| **CO352.1** | REMEMBERING | Recall fundamental concepts of Immune system, lymphoid organs, antigens and antibodies |
| **CO352.2** | UNDERSTANDING | Explain mechanisms of immune responses, antigen – antibody reactions, immune disorders and epidemiological principles |
| **CO352.3** | APPLYING | Apply laboratory techniques (microscopy, culture, serology, immunoassays) for identification and diagnosis of pathogens |
| **CO352.4** | ANALYSING | Analyze immunological data (ELISA, Western blot, hypersensitivity reactions) and epidemiological patterns of infectious diseases |
| **CO352.5** | EVALUATING | Evaluate effectiveness of vaccines, diagnostic approaches and treatment strategies in public health and clinical contexts |
| **CO352.6** | CREATING | Design experimental approaches using monoclonal antibodies, biosensors or molecular tools for immunological and clinical applications |

| Unit No. | Unit Contents | Sessions Allotted |
|---|---|---|
| **1** | **Introduction to Immunology**<br>1) **Components of the Immune System**<br>a) Cells: B-cells, T-cells, NK cells<br>b) Soluble mediators: Cytokines, Interferons, Complement system<br>2) **Antigen-Presenting Cells (APCs)**<br>a) Neutrophils, Macrophages, Dendritic cells<br>3) **Lymphoid Organs**<br>a) Primary (Central) lymphoid organs<br>b) Secondary (Peripheral) lymphoid organs<br>4) **Major Histocompatibility Complex (MHC)**<br>a) Structure of MHC in man and mouse | **15** |

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|---|---|---|
| | b) Structure & functions of MHC Class I and Class II molecules<br>5) **Types of Immunity**<br>a) Innate (species, racial, individual) vs. Acquired (active & passive, natural & artificial)<br>6) **Immune Response (IR)**<br>a) Concepts and basic functions<br>7) **Antigens**<br>a) Antigen, Immunogen, Hapten, Epitope<br>b) Physico-chemical and biological properties<br>c) Types of antigens<br>8) **Antibodies**<br>a) Concept & Basic structure<br>b) Classes: physico-chemical and biological properties<br>c) Monoclonal antibodies: Hybridoma technology & applications | |
| **2** | **Antigen-Antibody Reactions and Immune Disorders**<br>1) **Antigen-Antibody Reactions**<br>a) Mechanism: zone phenomenon, lattice formation<br>b) In vitro techniques:<br>i) Precipitation<br>ii) Agglutination<br>iii) Immunofluorescence<br>2) **Advanced Immunoassays**<br>a) ELISA (principle, types, applications)<br>b) Radioimmunoassay (RIA)<br>c) Western blot<br>3) **Immune Disorders**<br>a) Hypersensitivity (Types I–IV)<br>b) Autoimmunity & autoimmune disorders<br>4) Immunodeficiency (congenital and acquired) | **15** |
| **3** | **Epidemiology of Infectious Diseases and Vaccines**<br>1) **Epidemiology**<br>a) Concepts of epidemiology | **15** |

| | | |
|---|---|---|
| | b) Types of infection<br>c) Techniques in epidemiology<br>d) Epidemiological markers<br>e) Infectious disease cycle: Host–parasite relationship, microbial pathogenicity<br>f) Nosocomial infections: sources, transmission, control<br>2) **Vaccines**<br>a) Concept of immuno-prophylaxis<br>b) Types of vaccines<br>c) Schedule of vaccination (India)<br>3) Hazards of vaccination | |
| **4** | **Clinical Microbiology**<br>1) **Specimen Handling**<br>a) Types of specimens (blood, urine, CSF, sputum, pus, stool, swabs, biopsy tissues)<br>b) Methods of collection, storage, and transportation<br>c) Aseptic precautions in collection<br>2) **Diagnostic Methods**<br>a) **Microscopy**: Direct smears, staining (Gram, acid-fast, fluorescent, special stains)<br>b) **Culture techniques**: Primary isolation, enrichment, selective and differential media<br>c) **Biochemical identification**: Carbohydrate fermentation, IMViC, catalase, oxidase, urease, coagulase tests<br>d) **Viruses**: Cytopathic effects<br>3) **Clinical Immunology in Diagnosis**<br>a) Serological tests: agglutination, precipitation, complement fixation, Immunodiffusion, ELISA<br>4) **Pathological Indicators**<br>a) Changes in blood and CSF<br>b) Changes in body fluids and tissues<br>5) **Modern Approaches in Diagnosis**<br>a) Molecular methods: PCR, RT-PCR, sequencing-based diagnosis<br>b) Biosensors in diagnostic microbiology | **15** |

| | | |
|---|---|---|
| | c) Role of computers and automation in diagnostics | |

**Reference Books:**


1. Prescott, Harley, and Klein's Microbiology, J. M. Willey, L. M. Sherwood, C. J. Woolverton, 7th Edition (2008), McGraw Hill Higher Education- USA
2. Principles of Microbiology, R. M. Atlas, 2nd Edition (Indian Edition) (2015), McGraw Hill Education (India) Private Limited–New Delhi
3. Baker and Silverton's Introduction to Medical Laboratory Technology, Baker F J, Silverton R E, Pallister C J, 7th edition (1998), Butterworths-Heinemann, Oxford, UK


**Suggested readings:**


1. **Murphy, K., & Weaver, C. (2016).** ***Janeway's immunobiology*** **(9th ed.). Garland Science.**
2. **Roitt, P. L., Brostoff, J., & Male, D. (2017).** ***Roitt's essential immunology*** **(13th ed.). Wiley-Blackwell.**
3. **Coico, R., & Sunshine, G. (2015).** ***Immunology: A short course*** **(7th ed.). Wiley-Blackwell.**
4. **Abbas, A. K., & Lichtman, A. H. (2023).** ***Basic immunology: Functions and disorders of the immune system*** **(7th ed.). Elsevier.**
5. **Stevens, C. D. (2016).** ***Clinical immunology and serology: A laboratory perspective*** **(4th ed.). F. A. Davis.**
6. **Elgert, K. D. (2009).** ***Immunology: Understanding the immune system*** **(2nd ed.). Wiley-Blackwell.**
7. **Paul, W. E. (2013).** ***Fundamental immunology*** **(7th ed.). Lippincott Williams & Wilkins.**
8. **Gordis, L. (2013).** ***Epidemiology*** **(5th ed.). Elsevier Saunders.**
9. **Aschengrau, A., & Seage, G. R. (2014).** ***Essentials of epidemiology in public health*** **(3rd ed.). Jones & Bartlett Learning.**
10. **Merrill, R. M. (2017).** ***Introduction to epidemiology*** **(7th ed.). Jones & Bartlett Learning.**
11. **Plotkin, S. A., Orenstein, W. A., Offit, P. A., & Edwards, K. M. (2018).** ***Plotkin's vaccines*** **(7th ed.). Elsevier.**
12. **Centers for Disease Control and Prevention. (2021).** ***Epidemiology and prevention of vaccine-preventable diseases*** **(14th ed.). Public Health Foundation.**
13. **Murray, P. R., Rosenthal, K. S., & Pfaller, M. A. (2021).** ***Medical microbiology*** **(9th ed.). Elsevier.**
14. **Ochei, J., & Kolhatkar, A. (2000).** ***Medical laboratory science: Theory and practice*****. Tata McGraw-Hill.**
15. **Collier, L., Balows, A., Sussman, M., & Mahy, B. W. J. (1998).** ***Topley & Wilson's microbiology and microbial infections*** **(9th ed.). Arnold.**
16. **Gladwin, M., & Trattler, W. (2014).** ***Clinical microbiology made ridiculously simple*** **(6th ed.). MedMaster.**

**Paper Code: MIM 353 P**
**Paper Name: Microbiology Practicals**
**Credit:04 (08 hrs/week, Total:120 hrs)**

**Common Course Outcomes (COs)**
By the end of this practical course, students will be able to:

| CO# | COGNITIVE ABILITIES | Course Outcomes |
|---|---|---|
| **CO353.1** | Knowledge, Comprehension | Demonstrate knowledge of microbial genetics, diagnostic techniques, biochemical tests, and immunological assays. |
| **CO353.2** | Application | Apply laboratory techniques for isolation, cultivation, identification, and characterization of bacteria and mutants, as well as clinical sample analysis. |
| **CO353.3** | Analysis | Analyze experimental results to interpret microbial growth patterns, mutation frequency, antibiotic resistance, haematological parameters, and immunological reactions. |
| **CO353.4** | Evaluation | Evaluate the accuracy, reliability, and limitations of various microbiological, biochemical, and serological diagnostic methods. |
| **CO353.5** | Synthesis | Integrate experimental outcomes to understand microbial physiology, host–pathogen interactions, and clinical applications in diagnosis and therapy. |
| **CO353.6** | Application, Evaluation | Develop scientific skills, ethical practices, and problem-solving ability by performing experiments, recording observations, and preparing a survey-based clinical report. |

1) Study of electron micrographs of bacterial chromosome (nuclide), bacterial plasmid (super coiled and relaxed), theta model (cairn's model) of bacterial DNA replication, polysome (polyribosome), bacterial conjugation.
2) Isolation of lac- mutants of *Escherichia coli* using UV radiations as mutagen.
3) Isolation of pigment less mutant of *Serratia marcescens* using UV radiations as mutagen.
4) Isolation of streptomycin resistant mutants of *Escherichia coli* by gradient plate method.
5) Isolation of streptomycin resistant mutants of *Escherichia coli* by replica plate method.
6) Isolation of DNA
7) Use of enzyme as analytical tool: Glucose estimated by GOD-POD method
8) Isolation, cultivation and identification of Gram- negative bacteria- *Escherichia coli, Enterobacter aerogenes*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Salmonella typhi, Salmonella paratyphi A, Salmonella paratyphi B.*
9) Study of antibiogram (using multidisc)
10) Physical and chemical analysis of urine.
11) Estimation of blood urea by diacetyl monoxime method (DAM).
12) Study of agglutination reaction: Widal test by slide agglutination and double dilution method.

13) Study of precipitation reaction: Rapid plasma regain (RPR) method.
14) Detection of HBsAg using ELISA test.
15) Estimation of haemoglobin by Sahli's acid hematin method.
16) Total count of erythrocytes and leucocytes.
17) Differential count of leucocytes by Field's method.
18) Survey Report: clinical cases registered on a busy day with a local general practitioner/pathological lab.

**References:**


1. Patel, R. J., & Patel, K. R. (2009). *Experimental Microbiology* (Vols. 1–2). Aditya Prakashan.
2. Cappuccino, J. G., & Welsh, C. (2019). *Microbiology: A laboratory manual* (12th ed.). Pearson.
3. Pollack, R. A., et al. (2018). *Laboratory exercises in microbiology* (5th ed.). Wiley.
4. Dubey, R. C., & Maheshwari, D. K. (2010). *Textbook of practical microbiology* (reprint). S. Chand Publishing.
5. Mukherjee, K. L. (2017/2024). *Medical laboratory technology* (Vols. 1–3), CBS Publishers).
6. Gladwin, M., Trattler, W., & Mahan, C. S. (2016). *Clinical Microbiology Made Ridiculously Simple* (6th ed.). MedMaster Publishing.
7. Baker, F. J., Silverton, R. E., & Pallister, C. J. (1998). *Baker & Silverton's introduction to medical laboratory technology* (7th ed.). Butterworth-Heinemann / Hachette Learning.
8. Godkar, P. B., & Godkar, D. P. (2021/2024). *Textbook of Medical Laboratory Technology* (Vols. 1–2; 3rd–4th eds.). Bhalani Medical Book House.
9. Rao, C. V. (2005). *Immunology: Introductory textbook*. Narosa Publishing House .
10. Kothari, C. R., & Garg, G. (2019). *Research methodology: Methods and techniques* (4th ed.). New Age International Publishers.

| Semester – V | Course No: 356 | Course Code – MI-SEC 356A<br><br>Course Title – Introduction to fermentation technology |
|---|---|---|
| Credits – 02 | | Course Category - SEC |

**Course Outcomes (COs) – Combined for Theory and Practicals**

| CO No. | Cognitive abilities | Course outcomes |
|---|---|---|
| **CO356.1** | REMEMBERING | Describe the concepts and techniques involved in screening, isolation, and strain improvement of industrially important microorganisms. |
| **CO356.2** | UNDERSTANDING | Explain the classification of fermentation media, principles of inoculum development, and aseptic culture handling methods. |
| **CO356.3** | APPLYING | Apply knowledge of sterilization techniques, culture transfer, and scale-up processes in laboratory fermentation practices. |
| **CO356.4** | ANALYSING | Analyze the results of primary screening, enzyme/antibiotic assays, and the influence of nutritional and physical factors on microbial metabolite production. |
| **CO356.5** | EVALUATING | Evaluate and troubleshoot fermentation processes by integrating theoretical knowledge with experimental data and optimization strategies. |

| Unit No | Title of Unit and Contents | Total Number of Lectures |
|---|---|---|
| **I** | **Screening and Isolation of Industrially Important Organisms**<br>1) **Sources of industrial strains**<br>a) Natural habitat<br>b) Culture collections<br>2) **Screening approaches**<br>a) **Primary screening**<br>b) **Secondary screening**<br>3) **Criteria for industrial suitability**<br>**2)Strain Improvement**<br>a) **Traditional approaches**:<br>i) Random mutagenesis (UV, chemical mutagens: NTG, EMS)<br>ii) Selection of improved mutants (auxotrophs, resistant strains)<br>b) **Modern approaches**:<br>i) Protoplast fusion | **15** |

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| | ii) Recombinant DNA technology (gene amplification, pathway engineering)<br>iii) Adaptive evolution (serial transfers under stress conditions)<br><br>**3)Media Used for Fermentation**<br>a. Functions of media<br>b. Types of media:<br>i) Synthetic media<br>ii) Complex media<br>c. **Carbon sources**: glucose, sucrose, , starch molasses, Corn steep liquor agrocellulosic material, oils and hydrocarbons.<br>d. **Nitrogen sources**: ammonium salts, urea, peptone, yeast extract, sulphite waste liquor, Soyabean meal and oilcakes.<br>i. **Additives**: Precursors, buffers, chelators, vitamins, trace elements and antifoaming agents.<br>4) **Economics in medium design**: low cost, availability, consistency of raw materials.<br><br>**5) Sterilization of Media**<br>**a)** Batch sterilization<br>b) Continuous sterilization<br>c) Sterilization Kinetics<br>d) Sterilization challenges<br>**6) Inoculum Development** | |
| **II** | **Practical skills in fermentation technology:**<br>1. Primary screening of enzyme producing organisms (amylase / protease)<br>2. Primary screening of organic acid producing organisms<br>3. Primary screening of antibiotic producing organisms by Wilkins method<br>4. Primary screening of antibiotic producing organisms by crowded plate method<br>5. Production of amylase and its activity check – DNS/ dextrinizing method<br>6. Optimization of amylase production: OFAT: pH, Temperature, sources of carbon and nitrogen | **30** |

**References:**


1. Principles of Fermentation Technology, Stanbury P F, Whitaker A and Hall SJ, (1995), 2nd edition, Pergamon Press, London, UK
2. Industrial Microbiology: An Introduction, Waites, M J and Morgan N L, (2002), Blackwell Science
3. Industrial Microbiology, Casida LE, Jr. (1968), Wiley Eastern Ltd, New Delhi, India
4. Introduction to fermentation technology by H.A. Modi Volume I (2009), Pointer Publishers

**Suggested readings:**


1. Prescott, S. C., & Dunn, C. G. (1982). *Prescott & Dunn's industrial microbiology* (4th ed.). AVI Publishing.
2. El-Mansi, E. M. T., Bryce, C. F. A., Demain, A. L., & Allman, A. R. (2011). *Fermentation microbiology and biotechnology* (3rd ed.). CRC Press.
3. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical engineering fundamentals* (2nd ed.). McGraw-Hill.
4. Glazer, A. N., & Nikaido, H. (1995). *Microbial biotechnology: Fundamentals of applied microbiology* (2nd ed.). W. H. Freeman.
5. Crueger, W., & Crueger, A. (1990). *Biotechnology: A textbook of industrial microbiology* (2nd ed.). Panima Publishing Corporation.
6. Demain, A. L., & Davies, J. E. (Eds.). (1999). *Manual of industrial microbiology and biotechnology* (2nd ed.). ASM Press.
7. Primrose, S. B., & Twyman, R. (2013). *Principles of gene manipulation and genomics* (7th ed.). Wiley-Blackwell.
8. Shuler, M. L., & Kargi, F. (2002). *Bioprocess engineering: Basic concepts* (2nd ed.). Prentice Hall.
9. Doraiswamy, S. N., & Ghosh, L. M. (1994). *Advances in fermentation technology*. Oxford & IBH Publishing.
10. Singh, R. S., Pandey, A., & Larroche, C. (2013). *Advances in industrial biotechnology*. I. K. International Publishing House.

| Semester – V | Course No: 356B | Course Code – MI-SEC 356B<br><br>Course Title – Biostatistics |
|---|---|---|
| Credits – 02 | | Course Category - SEC |

**Course Outcomes: On successful completion of the course the learner will be able to**

| CO# | COGNITIVE ABILITIES | COURSE OUTCOMES |
|---|---|---|
| CO356.1 | REMEMBERING | Define basic biostatistical concepts including types of data (qualitative, quantitative, primary, secondary), and key terms related to frequency distribution and central tendency. |
| CO356.2 | UNDERSTANDING | Explain the structure and purpose of frequency distribution tables and describe graphical methods |
| CO356.3 | APPLYING | Apply appropriate statistical methods to calculate measures of central tendency (mean, median, mode) using microbiological data and represent data graphically |
| CO356.4 | ANALYSING | Analyze datasets to compute and interpret measures of dispersion (range, mean deviation, standard deviation, variance), identifying patterns or variability in biological data. |
| CO356.5 | EVALUATING | Evaluate the suitability of various statistical tools and interpret statistical findings to support conclusions in biological research contexts. |

| Unit No | Title of Unit and Contents | Total Number of Lectures |
|---|---|---|
| I | **Fundamentals of Biostatistics**<br>A. Types of data: Qualitative, Quantitative, Primary, Secondary<br>B. Frequency distribution table: class interval, class frequency, Relative frequency<br>C. Graphical representation of data: Line diagram, bar chart, histogram, pie chart<br>D. Measures of central tendency: Arithmetic Mean, Geometric Mean, Median, Mode<br>E. Measures of dispersion: Range, Mean deviation, Standard deviation, Variance | 15 |
| II | **Practical**<br>1. Draw Histogram on graph paper from the given frequency distribution data<br>2. Calculation of Arithmetic Mean from microbiological data<br>3. Calculation of Median from microbiological data<br>4. Calculation of Mode from microbiological data | 30 |

| | | |
|---|---|---|
| | 5. Calculation of Mean deviation from microbiological data<br>6. Calculation of standard deviation from microbiological data | |

**References:**


1. Banerjee P. K. (2004). Introduction to Biostatistics: a textbook of Biometry; revised edition-2011. S. Chand publication New Delhi
2. Daniel, W. W. (2019). Biostatistics: A Foundation for Analysis in the Health Sciences. 10th Ed., Wiley.
3. Rosner, B. (2020). Fundamentals of Biostatistics. 8th Ed., Cengage Learning.
4. Pagano, M., & Gauvreau, K. (2018). Principles of Biostatistics. CRC Press.


**Suggested readings:**

1) **Biostatistics: The Bare Essentials** – Geoffrey R. Norman & David L. Streiner
2) **Primer of Biostatistics** – Stanton A. Glantz
3) **Essentials of Biostatistics in Public Health** – Lisa M. Sullivan
4) **Introductory Biostatistics** – Chap T. Le
5) **Applied Biostatistics for the Health Sciences** – Richard J. Rossi
6) **Statistics for Biologists** – Campbell, R. C.

| Semester: VI | Course No.: 361 | Course Code: -- MIM-361(T)<br>Course Title: Microbial Metabolism and Biosynthesis |
|---|---|---|
| Credits: 4 | | Course Category: -Major |

**Course Outcomes: On successful completion of the course the learner will be able to**

| CO# | COGNITIVE ABILITIES | COURSE OUTCOMES |
|---|---|---|
| CO362.1 | REMEMBERING | Recall concepts of microbial metabolism, biosynthesis, and metabolic regulation. |
| CO362.2 | UNDERSTANDING | Explain catabolic pathways (EMP, ED, PPP, TCA, fermentation) and mechanisms of energy generation in microbes. |
| CO362.3 | APPLYING | Apply knowledge of metabolic pathways to interpret microbial energy strategies under aerobic/anaerobic/fermentative conditions. |
| CO362.4 | ANALYSING | Analyze metabolic regulation (allosteric, covalent modification, energy charge) and fuelling reactions in heterotrophs, chemolithotrophs, and phototrophs. |
| CO362.5 | EVALUATING | Evaluate biosynthetic pathways of carbohydrates, lipids, nucleotides, and nitrogen/sulphur assimilation in cellular metabolism. |
| CO362.6 | CREATING | Design experimental approaches (enzyme assays, isotope labelling, mutants, biosensors) to study metabolic and biosynthetic pathways. |

| Unit No. | Unit Contents | Sessions Allotted |
|---|---|---|
| 1 | **Introduction to Metabolism and Biosynthesis**<br>1. **Concepts of Metabolism**<br>a. Catabolism, Anabolism, Amphibolic pathways<br>b. Primary vs. Secondary metabolism<br>2. **Metabolic Regulation**<br>a. Importance and physiological role<br>b. Mechanisms of control:<br>i. Metabolic channelling<br>ii. Allosteric regulation & feedback inhibition<br>iii. Covalent modification (phosphorylation, methylation)<br>iv. Energy charge regulation, precursor activation<br>3. **Basics of Biosynthesis**<br>a. Principles and energetics of biosynthesis<br>b. Role of reducing power: $NAD^+$/$NADP^+$/FAD | 15 |

| | | |
|---|---|---|
| | c. Role of precursor metabolites<br>4. **Experimental Approaches in Biosynthesis**<br>a. Enzyme assays and sequential induction<br>b. Metabolic inhibitors & biochemical mutants<br>c. Isotope labelling & pulse-chase techniques | |
| **2** | **Fuelling Reactions in Heterotrophs**<br>1) **Glucose Catabolism**<br>a) EMP, ED & Pentose Phosphate pathways<br>2) **TCA Cycle**<br>a) Catabolic & anabolic roles<br>3) **ATP Generation Mechanisms**<br>a) Substrate-level phosphorylation<br>b) Oxidative phosphorylation:<br>i) Electron transport chain (components and organization)<br>ii) Proton motive force (PMF) and its role<br>iii) ATP synthase: structure, function, inhibitors, uncouplers<br>iv) Chemiosmotic coupling hypothesis<br>c) Anaerobic respiration: nitrate respiration and ETC variations<br>4) **Fermentation Pathways**<br>a) General features<br>b) Lactic acid fermentation<br>c) Ethanolic fermentation<br>d) Mixed acid fermentation<br>e) Butanediol fermentation<br>5) **Catabolism of other Substrates**<br>a) **Fatty acids**: β-oxidation<br>b) **Amino acids**: deamination, decarboxylation, transamination, Stickland reaction | **15** |
| **3** | **1) Fuelling Reactions in Chemolithotrophs and Phototrophs**<br>2) **Chemolithotrophic Metabolism**<br>a) Physiological groups | **15** |

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| | b) ETC in forward & reverse electron flow<br>c) ATP and reducing power generation<br>3) **Phototrophic Metabolism**<br>a) Photosynthetic pigments & apparatus in phototrophic eubacteria<br>b) Cyclic & noncyclic photophosphorylation<br>c) Photophosphorylation in Halobacteria (bacteriorhodopsin-based)<br>d) Physiological groups of phototrophs | |
| **4** | **Biosynthesis of Cellular Components**<br>1) **Feeder Pathways & Their Significance**<br>a) Anaplerotic reactions<br>b) Glyoxylate cycle<br>2) **Carbohydrate Biosynthesis**<br>a) $CO_2$ fixation pathways: Calvin cycle, reductive TCA cycle<br>b) Gluconeogenesis<br>c) Peptidoglycan biosynthesis<br>3) **Assimilation Pathways**<br>a) Ammonia assimilation<br>b) Nitrate & molecular nitrogen assimilation<br>c) Sulphur assimilation<br>4) **Lipid & Nucleic Acid Biosynthesis**<br>a) Fatty acids: saturated & unsaturated<br>b) Lipid assembly (polymerization of fatty acids)<br>c) Nucleotide biosynthesis:<br>i) Pyrimidine pathway<br>ii) Purine pathway | **15** |

**Reference Books:**


1. *General Microbiology*, Stanier, R. Y., Ingrahm, J. L., Wheelis, M. L. and Painter, P. R. 5th ed. (1995), Mac Millan Press Ltd., Hong Kong
2. *Prescott, Harley, and Klein's Microbiology*, J. M. Willey, L. M. Sherwood, C. J. Woolverton, 7th Edition (2008), McGraw Hill Higher Education – USA

3. *Principles of Microbiology*, R. M. Atlas, 2nd Edition (Indian Edition) (2015), McGraw Hill Education (India) Private Limited – New Delhi

**Suggested Reading:**

1. Cohen, G. N. (2004). *Microbial biochemistry*. Springer.
2. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2021). *Brock biology of microorganisms* (16th ed.). Pearson.
3. White, D., Drummond, J. T., & Fuqua, C. (2011). *The physiology and biochemistry of prokaryotes* (4th ed.). Oxford University Press.
4. Nelson, D. L., & Cox, M. M. (2021). *Lehninger principles of biochemistry* (8th ed.). W. H. Freeman.
5. Stryer, L., Berg, J. M., & Tymoczko, J. L. (2019). *Biochemistry* (9th ed.). Macmillan Learning.
6. Palmer, T., & Bonner, P. L. (2007). *Enzymes: Biochemistry, biotechnology, clinical chemistry* (2nd ed.). Woodhead Publishing.
7. Gottschalk, G. (1986). *Bacterial metabolism* (2nd ed.). Springer-Verlag.
8. Doelle, H. W. (2014). *Bacterial metabolism* (1st ed.). Elsevier.
9. Voet, D., Voet, J. G., & Pratt, C. W. (2016). *Fundamentals of biochemistry: Life at the molecular level* (5th ed.). John Wiley & Sons.
10. Atlas, R. M., & Bartha, R. (1998). *Microbial ecology: Fundamentals and applications* (4th ed.). Benjamin/Cummings.

| Semester: VI | Course No.: 362 | Course Code: -- MIM-362(T)<br>Course Title: Virology and Mycology |
|---|---|---|
| Credits: 4 | | Course Category: -Major |

**Course Outcomes: On successful completion of the course the learner will be able to**

| CO# | COGNITIVE ABILITIES | COURSE OUTCOMES |
|---|---|---|
| CO352.1 | REMEMBERING | Demonstrate knowledge of general characteristics, structural organization and cultivation, and |
| CO352.2 | UNDERSTANDING | Classification of viruses and fungi, including their reproduction, nutrition, and pathogenicity. |
| CO352.3 | APPLYING | Apply theoretical understanding to explain mechanisms of viral replication (bacteriophage lytic & lysogenic cycles, plant and animal viruses) and fungal growth, cultivation, and preservation methods. |
| CO352.4 | ANALYSING | Analyze viral infection outcomes (persistent, latent, oncogenic transformation, interference) and fungal diseases in plants and animals to interpret host–pathogen interactions. |
| CO352.5 | EVALUATING | Evaluate the importance of viruses (oncogenic, prions, viroids) and fungi (metabolites, industrial applications, pathogenic effects) in biotechnology, agriculture, medicine, and public health. |

| Unit No. | Unit Contents | Sessions Allotted |
|---|---|---|
| 1 | **Introduction to Viruses**<br>1) **General Characteristics of Viruses**<br>a) Properties and unique features<br>b) Structural organization (nucleic acid, capsid, envelope, symmetry)<br>2) **Cultivation of Viruses**<br>a) Animal inoculation<br>b) Embryonated eggs<br>c) In vitro culture: primary and secondary cell lines, continuous cell lines<br>d) Cultivation of bacteriophages<br>3) **Enumeration (Assay) of Viruses**: Plaque assay, pock assay, end-point dilution, hemagglutination<br>4) **Classification of Viruses**<br>a) Principles of classification<br>b) PCNV and ICNV systems<br>5) **Special Viral Types** | 15 |

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| | a) Sub-viral entities: viroids, virusoids, prions<br>b) Persistent and slow viruses | |
| **2** | **Phage Biology and Animal/Plant Viruses**<br>1) **Phage Biology**<br>a) **Bacteriophage lytic cycle (T4):** adsorption, penetration, intracellular development, assembly, release<br>b) One-step growth curve, burst size<br>c) Host-induced modifications (restriction–modification, CRISPR overview)<br>d) Single-stranded phages: ϕX174 (DNA) and MS2 (RNA)<br>e) **Bacteriophage λ – Lysogeny:** establishment, induction, excision<br>2) **Plant Viruses**<br>a) Replication of TMV (Tobacco Mosaic Virus)<br>3) **Animal Viruses**<br>a) General replication strategies<br>b) Cytopathic effects<br>4) **Oncogenic Viruses**<br>a) Types of oncogenic DNA and RNA viruses<br>b) Concepts of oncogenes and proto-oncogenes | **15** |
| **3** | **1) Fungi – Structure, Cultivation, and Classification**<br>2) **General Characteristics of Fungi**<br>a) Somatic structure<br>b) Ultrastructure of fungal cell<br>c) Hyphal modifications<br>3) **Cultivation and Preservation**<br>a) Principles of fungal nutrition<br>b) Cultivation media and methods<br>c) Slide culture technique<br>d) Prevention of bacterial contamination<br>e) Preservation techniques | **15** |

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| | 4) **Reproduction in Fungi**<br>a) Asexual and sexual reproduction<br>b) Para-sexuality<br>c) Fruiting bodies<br>5) **Classification of Fungi**<br>a) Criteria for classification (morphology, reproduction, molecular)<br>b) Recent classification systems<br>c) Outline of major classes:<br>i) **Zygomycetes**<br>ii) **Ascomycetes**<br>iii) **Basidiomycetes**<br>iv) **Deuteromycetes** | |
| **4** | **Fungal Importance and Diseases**<br>1) **Importance of Fungi**<br>a) Primary and secondary metabolites (enzymes, antibiotics, organic acids)<br>b) Economic, industrial, and medical significance<br>2) **Fungal Diseases in Plants**<br>a) Late Blight – *Phytophthora infestans*<br>b) Powdery Mildew – *Erysiphe spp.*<br>c) Rust – *Puccinia graminis*<br>d) Downy Mildew – *Plasmopara viticola*<br>e) Red Rot – *Fusarium spp.*<br>3) **Fungal Diseases in Animals (Including Humans)**<br>a) Candidiasis – *Candida albicans*<br>b) Aspergillosis – *Aspergillus fumigatus*<br>c) Ringworm (Dermatophytosis) – *Trichophyton spp.*<br>d) Cryptococcosis – *Cryptococcus neoformans*<br>e) Histoplasmosis – *Histoplasma capsulatum* | **15** |

**References:**


1. Alexopoulos C J, Mims C W, Blackwell M, (1996), ***Introductory Mycology***, 4th ed., Blackwell Publishing
2. Sharma O P, (1989), ***Textbook of Fungi***, Tata McGraw-Hill Publishing Co. Ltd
3. Dube H C, (1990), ***An Introduction to Fungi***, 2nd edn, Vikas Publishing House Pvt Ltd
4. Biswas S B, Biswas A, ***An Introduction to Viruses***, 3rd ed., (1984), Vani Educational Books, New Delhi
5. Carter J and Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons.
6. Wagner EK, Hewlett MJ. (2004). Basic Virology. 2nd edition. Blackwell Publishing.


**Suggested Readings:**


1. Knipe, D. M., & Howley, P. M. (2013). *Fields virology* (6th ed.). Lippincott Williams & Wilkins.
2. Cann, A. J. (2015). *Principles of molecular virology* (6th ed.). Academic Press. https://doi.org/10.1016/C2013-0-19138-5
3. Acheson, N. H. (2025). *Fundamentals of molecular virology* (3rd ed.). Wiley-Blackwell. ISBN-13: 9781119885863
4. Dimmock, N., Easton, A., & Leppard, K. (2001). *Introduction to modern virology* (5th ed.). Blackwell Science. ISBN-13: 9780632054075
5. White, D. O., & Fenner, F. J. (1994). *Medical virology* (4th ed.). Academic Press. ISBN-13: 9780127463605
6. Webster, J., & Weber, R. W. S. (2007). *Introduction to fungi* (3rd ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511809026
7. Mehrotra, R. S., & Aneja, K. R. (1990). *An introduction to mycology* (1st ed.). New Age International. ISBN-13: 9788122400892
8. Agrios, G. N. (2005). *Plant pathology* (5th ed.). Academic Press. ISBN-13: 9780120445653
9. Kavanagh, K. (2005). *Fungi: Biology and applications* (1st ed.). John Wiley & Sons. ISBN-13: 9780471493228
10. Sarbhoy, A. K. (Ed.). (1988). *Perspectives in mycology and plant pathology*. Malhotra Publishing House. ISBN-13: 9788185046136

**Paper Code: MIM 363 P**
**Paper Name: Microbiology Practicals**
**Credit:04 (08 hours/week, Total:120 hrs)**

**Course Outcomes (COs)**
By the end of the practical course, students will be able to:

| CO No. | Cognitive Ability | Course Outcome |
|---|---|---|
| **CO1** | Knowledge, Comprehension | Demonstrate knowledge of biochemical estimations, microbial assays, and structural features of viruses and fungi. |
| **CO2** | Application | Apply experimental techniques for quantification of biomolecules, enzyme activity, microbial cultivation, and pathogen isolation. |
| **CO3** | Analysis | Analyze experimental data to interpret biomolecular separations, cytopathic effects, plant diseases, hyphal modifications, and microbial interactions. |
| **CO4** | Evaluation | Evaluate accuracy, precision, and limitations of different biochemical, microbiological, and pathological methods used in the laboratory. |
| **CO5** | Synthesis | Integrate knowledge of biochemical assays, microbial physiology, virology, and mycology to explain host–pathogen interactions and industrial applications. |
| **CO6** | Application, Evaluation | Develop laboratory skills, scientific attitude, ethical practices, and problem-solving abilities through practical work and internship/project exposure. |

1. Estimation of reducing sugar (glucose) by Cole's method.
2. Estimation of Non reducing sugar (Sucrose) by Cole's method.
3. Estimation of glucose by Nelson-Somogy's method.
4. Estimation of streptomycin by Nitroprusside method
5. Estimation of protein by Folin-Lawry's method.
6. Estimation of Lactose by Lane-Eynon Method
7. Determination of bacterial amylase activity by iodometric method.
8. Separation of amino acids by paper chromatography.
9. Separation of amino acids by thin layer chromatography.
10. Study of Immobilization of Cell/Enzyme
11. Study of cytopathic effects of viruses using electron micrographs.
12. Study of plant diseases caused by Virus and Fungi - Mosaic, red rot, rust, smut, wilt, leaf curl, powdery mildew, downy mildew using photograph.
13. Study of common Hyphal Modifications -by Photograph.
    - Appressoria- Host penetration in plant pathogens
    - Haustoria- Nutrient absorption from host cells
    - Stolons- Vegetative spread across the surface
    - Sclerotia- Survival under adverse conditions
    - Clamp connections- equal distribution of genetically distinct nuclei in dikaryotic.
14. Study of the structure of important bacterial / animal / plant viruses (ϕ X174, lambda (λ), influenza, hepatitis B, HIV and TMV) using electron micrographs

15. Study of fungal interactions in soil by buried slide technique.
16. Cultivation of fungi by Slide culture technique
17. Isolation of bacteriophages from water/sewage sample.
18. Fungal Spore count by Neuber chamber counting method

**References:**


1. Experimental Microbiology (Volume 1 and 2) – Rakesh J Patel
2. Microbiology: A Laboratory Manual – Cappuccino & Welsh
3. Textbook of Practical Microbiology – Dubey R. C. & Maheshwari D. K.
4. Laboratory Experiments in Microbiology – Robert A. Pollack et al.
5. Industrial Microbiology – Casida L. E. Jr.
6. Introductory Mycology – Alexopoulos C. J., Mims C. W., Blackwell M.
7. Medical Microbiology – Jawetz, Melnick & Adelberg
8. Virology: Principles and Applications – Carter J. & Saunders V.
9. Biochemistry – Stryer L.
10. Fundamentals of Biostatistics – Rosner B.

**Internship 4 credits**

**(120 hours shall be completed by the students by doing internship/project/flip teaching/Case study)**

**Course Outcomes (COs) – Internship (4 Credits, 120 Hours)**

| CO Code | Bloom's Taxonomy Level | Course Outcome Statement |
|---|---|---|
| CO1 | Application | Apply theoretical knowledge to practical situations in professional/academic settings. |
| CO2 | Analysis | Analyze real-world problems and suggest feasible solutions through project/case study/teaching. |
| CO3 | Comprehension / Skill | Develop professional, technical, and communication skills required for workplace readiness. |
| CO4 | Affective / Collaboration | Work effectively in a team or independently, showing responsibility, discipline, and ethics. |
| CO5 | Synthesis / Evaluation | Create structured reports/presentations demonstrating critical thinking and problem-solving. |
| CO6 | Evaluation | Evaluate personal strengths and areas of improvement through reflective learning and feedback. |