PONDICHERRY UNIVERSITY
PUDUCHERRY 605 014

CURRICULUM AND SYLLABUS of

M.Sc. Microbiology

(2019 ONWARDS)

Department of Microbiology

School of Life Sciences

About the course

The Department of Microbiology is committed to excellence in education, research and extension. This Department is being strengthened with various research units and periodical update / modernization of the curricula. The Department of Microbiology at the Pondicherry University, School of Life Sciences, brings together a variety of researchers as faculty of this programme who are specialized in their domains and united by the common goal of understanding the "Microbes".

Microbes are playing important role in the bioprocess of all living things and maintain homeostasis of the universe. Without microbes, one cannot imagine such a biologically balanced and diverse universe; rather our earth would have placed as a barren planet. As the microbial activities are so diverse, the microbiology programme is a multidisciplinary subject, which will have the roots of life science, environmental science, and engineering. Traditional microbiology is considered to be an important area of study in biology since it has enormous potential and vast scope in fermentation, bioremediation and biomedical technology. But the recent developments from human microbiome project, metagenomics and microbial genome projects has expanded its scope and potential in the next generation drug design, molecular pathogenesis, phylogeography, production of smart biomolecules, etc. Modern Microbiology has expanded its roots in genome technology, nanobiotechnology, green energy (biofuel) technology, bioelectronics etc. Considering recent innovations and rapid growth of microbiological approaches and applications in human and environmental sustainability, the M.Sc. Microbiology curricula is designed to enlighten the students in basics of Microbiology to recent developments. The first semester curricula would cover basic concepts including biomolecules and metabolism, cell and molecular biology and techniques in microbiology. In the second semester, the students will study core microbiology including Microbiome biology, mycology, virology etc, subsequently they will study applied and modern microbiology including environmental, food, agriculture, aquatic microbiology, microbial genomics and metagenomics. A unique feature of the curricula includes both theory and practical course for each papers and dissertation work in the fourth semester.

Entrance Examination

M.Sc. Microbiology programme: The selection of student is based on All India entrance examination. The question paper will consists of objective types of questions of multiple choices. The questions will be of testing the basic knowledge of the students in cell and molecular biology, biochemistry, genetic engineering, and general and applied Microbiology.

Teaching and Learning Methods

Lectures, tutorials and seminars form the main methods of course delivery enhanced by individual and group project work, laboratory work, computing workshops and industrial visits.

Assessment Methods

Assessment will be through Choice Based Credit System (CBCS) through session by continuous assessment (class tests, assignments, seminars, laboratory works and project work and report) and end semester examinations. A thesis written for the project/dissertation will be evaluated by an expert followed by viva-voce.

Minimum credit requirement = 72; All teaching, learning and evaluations will follow Choice Based Credit System (CBCS) as per the Pondicherry University guideline's.

EVALUATION

Breakup of Internal/ External End Semester Exams:

All subjects in a PG programme shall carry an Internal Assessment component to the extent of 40 marks and End Semester for 60 marks.

Break up of Internal Assessment Marks

Each teacher shall organize a continuous assessment of each of the courses assigned to him/her. The internal assessment marks shall be given as per the following breakup:

Internal Assessment Tests / Term Papers / Quizzes (two) **2 x 15 = 30**

Seminars/ Assignments/ Case Demos/ Presentations/ Write ups/ Viva, etc. **1x 10 = 10**

Internal Total **40**

Internal Assessments

A schedule of Internal Assessment tests shall be prepared at the very beginning of the semester. Internal Assessment marks shall be displayed within a week from the date of conduct of examination and all corrected answer papers shall be given back to students with comments, if any. It is mandatory for all students to participate in all the Internal Assessment tests and in various course-work related activities for award of the above marks.

End- semester examinations

An End Semester examination shall be conducted for all courses offered in the department. The duration of the end semester examination shall be for 3 hours. A schedule of End Semester examinations be prepared and displayed by the department at least one- month ahead of the conduct of the examination. Each teacher shall prepare a model question paper, a Panel of External examiners and submit the same to the Head of the Department by 6th week of the Semester. The question paper should cover all the units of syllabus. Head of the Department shall coordinate the question paper setting.

Letter Grades

The department shall display the provisional grades within 15 days. If a student wishes to look at the evaluated answer scripts he/ she can approach the concerned teacher within a week of declaration of the provisional results.

Letter Grades

Performances of students in each paper are expressed in terms of marks as well as in Letter Grades. In case of fractions the marks shall be rounded off to nearest integer. The class interval for the purpose of awarding the grades can be arrived at by dividing the difference between the highest mark secured and the minimum pass mark by 6 as there are six passing grades. The formula is given below:

$K = (X-50)/6$

Where, K = class interval, X= the highest mark in the subject.

The grades may be awarded as given in the following table.

Range of Marks in %	Letter Grade	Points for Calculation of GPA/ CGPA
X to (X-K)	A+	10
(X-K-1) to (X-2K)	A	9
(X-2K-1) to (X-3K)	A-	8
(X-3K-1) to (X-4K)	B+	7
(X-4K-1) to (X-5K)	B	6
(X-5K-1) to (X-6K)	C	5
Below 50	F	0

K should not be rounded off to less than two decimal places. The numbers given in Range of Marks column, (X-K), (X-2K), (X-3K), etc., can be rounded off to the nearest whole number. In courses where the number of students who have secured 50 marks and above is less than 10 then grading may be given based on the Table.

Range of Marks in %	Letter Grade	Points for Calculation of GPA/ CGPA
81-100	A+	10
71-80	A	9
66-70	A-	8
61-65	B+	7
56-60	B	6
50-55	C	5
Below 50	F	0

The GPA and CGPA will be calculated as weighted average of points secured by the student in all the papers registered by him /her. The weights are the number of credits for each paper. For example, a student getting in A grade in 4 credit course, A- grade in 2 credit course, A+ grade in a 3 credit course and F grade in a 3 credit course will have a GPA as (9x4 + 8x2 +10x3 + 0x3)/ (4+2+3+3)=(36+16+30+0)/12=82/12 = 6.83 out of 10.0; GPA = 6.83. The CGPA shall also be calculated in similar lines taking all subjects taken by the students in all semesters. Students with a CGPA of 9.0 and above and did not fail in any of the courses taken by him/ her shall be awarded Distinction.

A CGPA of 6.0 and above shall be placed in First class.

Student who has secured less than 50% marks in any paper gets F Grade and he is treated as failed in that paper.

M.Sc. Microbiology, Department of Microbiology, School of Life Sciences

Programme objectives

1. The M.Sc. microbiology course is a multidisciplinary subject, which develop skills and knowledge base of students. M.Sc. Microbiology students able to apply their knowledge in microbial identification, diagnosis of infectious diseases and microbial processes expanded its roots across the disciplines particularly in genome technology, nanobiotechnology, green energy (biofuel) technology, bioelectronics and synthetic biology.
2. Classify microbes using molecular phylogenetics and modern taxonomy.
3. Scope and application in fermentation, bioremediation and biomedical technology.
4. Implications in the recent developments from human microbiome project, metagenomics and microbial genome projects has expanded its scope and potential in the next generation drug design, molecular pathogenesis, phylogeography, and production of smart biomolecules.

Programme outcomes

1. Students can apply their knowledge (Microbiological approaches and applications) in human and environmental sustainability.
2. Techniques and approaches in the exploration of uncultured microbial majority and Microbiome Biology.
3. The students able to apply microbiological techniques in inter-disciplinary subjects include nanotechnology, Biotechnology, bioelectronics and allied biosciences
4. Microbiology students can understand implications of global projects include Human Microbiome Project and Earth Microbiology Project.

CURRICULUM AND SYLLABI FOR M.Sc. MICROBIOLOGY- COURSE STRUCTURE
(2019-20 onwards)

SL. NO.	COURSE NAME	COURSE CODE	TYPE OF COURSE	NUMBER CREDITS
I Semester- Theory Courses				
1	General Microbiology	MICB-411	HC	3
2	Microbial Genetics	MICB-412	HC	3
3	Biochemistry	MICB-413	HC	3
4	Immunology	MICB-414	HC	3
I Semester- Lab Courses				
1	General Microbiology Lab	MICB-415	HC	1
2	Microbial Genetics Lab	MICB-416	HC	1
3	Biochemistry Lab	MICB-417	HC	1
4	Immunology Lab	MICB-418	HC	1
II Semester- Theory Courses				
1	Mycology	MICB-421	HC	3
2	Virology	MICB-422	HC	3
3	Techniques in Microbiology	MICB-423	HC	3
4	Cell and Molecular Biology	MICB-424	HC	3
5	Microbiome Biology	MICB-425	HC	3
II Semester- Lab Courses				
1	Mycology Lab	MICB-426	HC	1
2	Virology Lab	MICB-427	HC	1
3	Instrumentation Techniques Lab	MICB-428	HC	1
4	Molecular Biology Lab	MICB-429	HC	1
III Semester- Theory Courses				
1	Medical Microbiology	MICB-511	HC	3
2	Food Microbiology	MICB-512	HC	3
3	Applied & Industrial Microbiology	MICB-513	HC	3
4	rDNA Technology	MICB-514	HC	3
5	Microbial genomics	MICB-515	HC	3
III Semester- Lab Courses				
1	Medical Microbiology Lab	MICB-516	HC	1
2	Food Microbiology Lab	MICB-517	HC	1
3	Applied & Industrial Microbiology Lab	MICB-518	HC	1
4	Microbial genomics Lab	MICB-519	HC	1
IV Semester				
1	**Project/ Dissertation**	MICB-521	HC	6
Total Number of credits				**60**

SOFT CORE-COURSE- COURSE STRUCTURE (2019-20 onwards)

SL. NO.	COURSE NAME	COURSE CODE	TYPE OF COURSE	NUMBER CREDITS
1	Industrial visit and Reporting	MICB-431	SC	2
2	Self-study Review	MICB-432	SC	2
3	Research Methodology – Scientific writing and publication ethics	MICB-433	SC	2
4	Research Methodology – Biostatistics	MICB-434	SC	2
5	Entrepreneurship and Microbial Industries	MICB-435	SC	3
6	Public Health Microbiology	MICB-436	SC	3
7	Biomolecules	MICB-437	SC	3
8	Microbial Physiology	MICB-438	SC	3
9	Microbial Technology	MICB-541	SC	3
10	Marine Microbiology	MICB-542	SC	3
11	Microbial Nanotechnology	MICB-543	SC	3
12	Agricultural Microbiology	MICB-544	SC	3
13	Fermentation Technology	MICB-545	SC	3
14	Genome Technology	MICB-546	SC	3
15	Drug Design and Discovery	MICB-547	SC	3
16	Bioethics, Biosafety and IPR	MICB-548	SC	3

GENERAL MICROBIOLOGY

Course Code: MICB-411
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objectives: *This course aims to introduce the history and development of Microbiology.*

Pre-Requisite: Bachelor degree in Life Sciences

Unit 1 **10 h**

Introduction to Microbiology – Scope of microbiology - Ancient Microbiology - Refutation of a biogenesis: discovery of penicillin: discovery of vaccination: proposal of one gene one enzyme hypothesis - Major contribution of scientists– Leeuwenhoeck, Edward Jenner, Alexander - Flemming, Joseph Lister, Robert Koch, Louis Pasteur, Hargobind Khorana. Modern Microbiology - Landmark 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. Bergey's Classification of bacteria. Concepts of Microbiome, synthetic biology.

Unit 2 **10 h**

Biology of Microorganisms: Differences between prokaryotic and eukaryotic cell. Biology of bacteria - cell structure, size, shape, arrangement membrane, cell wall, cytoplasmic inclusions, mesosomes, flagella and motility, slime, capsule, pili, chemotaxis, endospore - biology of fungi, structure, physiology and classification – biology of yeast – reproduction - virus (bacteriophages) structure, life cycle (lytic and lysogenic) – biology of algae – Mycoplasma – prions.

Unit-3 **8 h**

Microbial nutrition: Microbial nutrient requirements – macro-nutrients, micro-elements – growth factors - sources of nutrients – nutritional classification of bacteria - Phototroph, Chemotroph, Autotroph (lithotroph), Heterotroph (organotroph), Photoautotroph, Photoheterotroph, Chemoautotroph, Chemoheterotroph - Nutritional patterns of pathogens – Saprophytes - Auxotroph.

Unit-4 **10 h**

Extremophiles: 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, Radioresistant (*Deinococcus radiodurans*), Thermophile, Thermoacidophile, Xerophile – mechanism of extremophiles.

Unit 5 **10 h**

Cultivation and control of microbes: Types of growth media (natural, synthetic, complex, enriched, selective- definition with example), pure culture methods (streak plate, spread plate, pour plate, stab culture, slant culture). Automation in Microbiology. Anaerobic (thioglycolate, anaerobic chamber, Robertson's media, microaerophilic), liquid shake culture of aerobic bacteria Control of microbes- Sterilisation, disinfection, antiseptic, tyndallisation, pasteurization: Physical- dry heat, moist heat, UV light, ionizing radiation, filtration, HEPA filter, Chemical methods.

Recommended Text Books:

1. Tortora Gerard J., Funke, Berdell R. Case, Christine L. (2016). Microbiology: An Introduction, 12th Edition. Pearson, Boston.
2. Madigan M. T., Martinko J. M., Bender K. S., Buckley D. H., Stahl D. A. (2015). Brock biology of microorganisms, Fourteenth edition. Pearson, Boston.
3. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton, Lansing M. Prescott (2017). Prescott's microbiology, 10th edition. Mcgraw-Hill Education, New York.
4. John W. Foster. (2016). Microbiology: Human Experience, 16th edition. W.W. Norton & Co.

Suggested Readings:

1. Jacquelyn G. Black, Laura J. Black. (2015). Microbiology: Principles and explorations, 9th edition. Wiley, Hoboken, New Jersey.
2. Ananthanarayanan R., Jayaram Paniker C.K. (2017). Textbook of Microbiology, 10th edition. Orient Lomgman.

Course Outcome: *The contents of this course will help students understand history, biology of microorganisms, growth and control of microbes. A unit is exclusively focused on archaea which is one of the domains of Carl Woese's classification. Thus the beginners are rightly exposed to foundation of Microbiology which would lead them towards progressive advancement of the subject.*

MICROBIAL GENETICS

Course Code: MICB-412
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objectives: *The aim of the course is to provide a basic knowledge about the use of microbes in genetic studies.*

Pre-Requisite: Bachelor degree in Life Sciences

Unit- 1 **8 h**

History and Development- Definition and scope of Genetics. Premendelian genetic concepts – Preformationism, Epigenesis, Inheritance of acquired characters, traits, Germplasm theory. Hereditary and Environment, Genotype and Phenotype.

Unit- 2 **8 h**

Microbial Genetics: Branches of Genetics, Microbes as tools for genetic studies, Basic and Applied Research, Genetic maps, Genes at the molecular level.

Unit- 3 **10 h**

Viral Genetics- General characteristics of viral genome, T_4 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.

Unit- 4 **12 h**

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, Transduction- Generalized and specialized transduction, Drug resistance in bacteria.

Unit- 5 **10 h**

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*, Gene conversion. Yeast plasmids, Mating type genetics of yeast.

Recommended Text Books:

1. Snyder L. and Champness W. (2007). Molecular Genetics of Bacteria. 3rd edition, ASM Press, Washington, D.C.
2. Baumberg. S. (2002). Prokaryotic gene expression. Oxford University Press, UK.
3. Hartl D. L. (2009). Essential Genetics- A genomics perspective, 5th edition, Jones and Barlett Publishers, Boston.
4. Dale J. W. and Park S. F. (2010). Molecular Genetics of Bacteria, Wiley Blackwell Publishers, Boston.
5. Trun N. and Trempy J. (2003). Fundamental Bacterial Genetics. 1st Edition, Wiley-Blackwell Publishers.
6. Maloy S. R., Cronan J.E., Freifelder D. (1994). Microbial Genetics. Jones and Barlett Publishers, Boston.

Suggested Reading:

1. Watson J. D., Baker. T. A, Bell. S. P, Gann. A, Levine. M, Losick. R. (2003). Molecular Biology of Gene. 5th Edn. The Benjamin / Cummings Pub. Co. Inc
2. Streips U.N. and Yasbin R. E. (2002). Modern Microbial Genetics. Second Edition Wiley-Liss, Inc.

Course Outcome: *Microbial Genetics is an important tool in dissecting the genetic structure of an organism. The basic principles presented in this paper is of major importance in constructing new organisms for practical applications leading to research in Genetic recombination and genetic engineering.*

MICROBIAL BIOCHEMISTRY

Course Code: MICB 413
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objective*: It is an interdisciplinary course designed to introduce the essential fundamentals of biochemistry. This course focuses on the concepts of biochemistry and important microbial macromolecules and their metabolism.*
Pre-Requisite: Bachelor degree in Life Sciences

Unit- 1 **10h**

Chemistry of Life and Special Microbial Molecules:
Bonds: ionic bonding, Ion-dipole, dipole-dipole interactions, electronegativity, covalent, H-bonds, Van der Walls interaction, London forces, hydrophobic interactions, Water as a biological solvent and its role in biological processes. pH, Henderson-Hasselbalch equation, concept of buffer, strength of buffer, range of buffer, important biological buffers. pH indicator dyes.
Structure of Special Microbial Molecules: Bacteriorhodopsin, biphytanyl chains and lipids in archaeal cell membranes and other important adaptations in extremophiles: thermophiles and halophiles.

Unit- 2 **10h**

Bioenergetics: Laws of thermodynamics, concepts of entropy, enthalpy, free energy, spontaneous reactions and equilibrium constant, Gibbs free energy equation, determination of free energy of hydrolytic and biological oxidation reduction reactions, Nernst equation 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. Calculations of ΔG, ΔH. ATP : Energy currency of the cell.

Unit- 3 **10 h**

Macromolecules I- Proteins and Nucleic Acids: Proteins: Structural features of amino acids, classification of amino acids based on polarity and charge, peptide linkage: partial double bond nature, determination of primary structure of polypeptide (N-terminal, C-terminal determination, method of sequencing of peptides), Sequence determination of the peptide based on chemical and enzymatic reactions. structural classification of proteins, primary, secondary, tertiary, quaternary structures of proteins. Ramchandran plot.
Nature of Nucleic Acids: Structure of purines, pyrimidines, nucleosides and nucleotides. Capping of RNA. Hyperchromic effect and Tm. Chargaff's rule, Secondary structure of DNA - Watson and Crick model. Secondary structure of tRNA - clover leaf model. *de novo* biosynthesis of purines and pyrimidines

Unit- 4 **8 h**

Macromolecules II- Carbohydrates and their Metabolic pathways and Fermentations: Carbohydrates: Monosaccharides, disaccharides: conventions of naming a disaccharide, oligosaccharides and polysaccharides, concepts of epimer, isomer, anomer, Glycolytic pathway, Pentose phosphate pathway (HMP), Entner- Doudoroff pathway, **Fermentation-** Lactic acid fermentation, LDH- Alcoholic fermentation ADH - Catabolism of Glycogen.

Unit- 5 **10 h**

Macromolecules III- Lipids and Metabolism Lipids: Saturated and unsaturated fatty acids nomenclature, short hand notations, Fatty acid oxidation: β oxidation, α-oxidation. Biosynthesis of saturated fatty acids, structure of yeast fatty acid synthase, triacylglycerols and phospholipids. Tricarboxylic acid cycle, PDH Multi-enzyme complex Amphibolic pathway, anaplerotic reactions. Electron transport chain, generation and maintenance of proton motive force PMF, chemiosmotic theory, Q cycle, Ubiquinone, Cyt C. Substrate level and oxidative phosphorylation, inhibitors and un-couplers of electron transport chain and function of ATP synthase, Shuttle systems.

Recommended Text Books:

1. Nelson D. L. and Cox, M. (2008) M. Lehninger's Principle of Biochemistry. 5th edition. W. H. Freeman and company, U.S.A.
2. Voet D. and Voet J.G. (2011) Biochemistry 4th Edition. John Wiley and Sons
3. Berg J.M., Tymoczko J.L., and Stryer L. (2012) Biochemistry 7th Edition. W.H. Freeman,U.S.A.
4.

Suggested Reading:

1. Segel, I.H. (1975) Biochemical Calculations : How to solve mathematical problems in general biochemistry. Second Edn. John Wiley & Sons , U.S.A.
2. Wood W.B., Wilson J.H., Benbow R.M., Hood L.E. (1981) Biochemistry: A problems approach. Second Edn. Benjamin / Cummings publishing group, U.S.A.

Course Outcome: *On completion of the course a student will be well versed with the knowledge of bioenergetics, energy calculations at physiological conditions and central metabolic pathways in bacteria and eukaryotes.*

IMMUNOLOGY

Course Code: MICB- 414
Total Number of Lecture hours: 40
Total Number of Credits: 03

Course Objective: *This course attempts to teach host defense system, essential concepts of immune system, host-microbial interaction, immune-diagnosis and emerging advancement of immunology.*

Pre-Requisite: Bachelor degree in Life Sciences

Unit- 1 **8 h**

Basics of Immunology: Historic perspective, Discovery of humoral and cellular immunity, Types of Immunity (Innate &Acquired immunity), Innate immunity components-physical, physiological defenses; – complement, acute phase proteins. Acquired immunity: (specific) natural, artificial, active and passive immunity. Inflammatory response, Hematopoiesis, Cells (T cell, B cell, macrophages, neutrophils, Natural killer cells, mast cells, basophils, and eosinophils etc) & organs of Immune system (Thymus, Bone marrow, lymph node, spleen, MALT, GALT, BALT).

Unit- 2 **8 h**

Antigens and Antibodies: Immunogenicity versus Antigenicity, Nature of antigens; Antibody-structure and functions-subtypes; structural basis of Antibody diversity; Theories of Antibody formation., Genetic basis of antibody diversity-somatic hyper mutation recombination, class switching and clonal selection, Recent advances in the production of monoclonal antibodies and their applications, Antibody engineering.

Unit- 3 **8 h**

T Cell & B cell Biology: MHC restriction-antigen presentation (Organisation & inheritance of MHC, MHC molecules & genes), Role of Antigen presenting cells (APCs),Antigen processing & presentation pathways, T cells subsets, T cell maturation, activation and differentiation, B cells subsets, B cell generation, activation and differentiation

Unit- 4 **8 h**

Immunity in Health & Diseases: Infection-Immunity& signal transduction pathways (antibacterial, antiviral and anti fungal immune responses), Immune system Disorders (Hypersensitivity Type-I to TypeIV), Immunodeficiency diseases (Primary and secondary immunodeficiencies), Auto immune diseases (organ specific and systemic), Prevention & therapy (Vaccine, cell therapy, cytokine and antibody therapy).

Unit- 5 **8 h**

Immunotechniques and Immunodiagnosis: Immune cell culture**,** ELISA, Immunoprecipitation & Immuno Blotting, CHIP assay, Nanopro Immunoassay, Flowcytometry, Immunofluorescence, Antibody Array, cytokine RT-PCR array, whole animal imaging.

Recommended Text Books:

1. Kuby Immunology- 7th edition. (2013). Publisher W. H. Freeman & Company.

Suggested Reading:

1.I.Roitt. (2005). Essential Immunology.10th ed. Blackwell Science.

2. Janways Immunobiology. 7th edition. (2007). Publisher-Garland Science.

3. William E. Paul. Fundamental Immunology. 6 th Edition. Lippincott Williams and Wilkins. (2008). Publisher: Philadelphia.

Course Outcome: *Through this course students will acquire knowledge from basics to recent advancement in Immunology. This course will be helpful for students to choose their career in Immunology research and biopharmaceutical industries.*

GENERAL MICROBIOLOGY LAB

Course Code: MICB-415 **Total Number of Credits: 01**

1. Principles and methods of sterilization.
2. Direct microscopic observations of bacterial shape – cocci, rods, chains, fungal spores, mycelium, yeast budding.
3. Preparation of Media: Nutrient broth, Nutrient agar, plates, slants, soft agar.
4. Pure culture technique: Streak plate, spread plate and pour plate methods.
5. Measurement of size of microbes – micrometry.
6. Motility determination – Hanging drop method.
7. Enumeration of bacterial / yeast cells-viable count (Plate count) Total count (Haemocytometer count).
8. Isolation and purification of cyanobacteria, actinomycetes, fungi and protozoans.
9. Staining methods: Simple, Negative, acid fast, Gram staining , spore, Capsule, Metachromatic granular staining, Lactophenol cotton blue staining - Fungal slide culture.

Methodology book: Benson, Harold J.Brown, Alfred E. (2010) Benson's microbiological applications: laboratory manual in general microbiology, complete version New York: McGraw-Hill Higher Education.

MICROBIAL GENETICS LAB

Course Code: MICB-416 **Total Number of Credits: 01**

1. Transformation methods
2. Conjugation
3. Transduction
4. Karyotyping
5. Probability and Pedigree Analysis
6. RFLP
7. Replica plate technique
8. Ames test
9. Gradient plate technique – spontaneous mutations

Methodology book: Surajit Das amd Hirak Nandan Dash, 2015, Microbial Biotechnology-A Laboratory Manual for Bacterial Systems, Springer India

MICROBIAL BIOCHEMISTRY LAB

Course Code: MICB-417 **Total Number of Credits: 01**

1. Preparation of standard buffers and determination of pH of a solution.
2. Qualitative tests for Carbohydrates- Tests for sugars: Fructose, lactose, maltose, glucose and starch.
3. Qualitative tests for amino acids.
4. Quantitative estimation of glucose by DNS method
5. Quantitative estimation of protein by Biuret method.
6. Quantitative estimation of protein by Lowry's method.
7. Determination of Iodine value.
8. Estimation of carbohydrates by anthrone method.
9. Estimation of amino acids by ninhydrin method.
10. Estimation of DNA

Methodology book:

1. Joshi A. Rashmi. 2002. A Textbook of Practical Biochemistry, B. Jain**.**

2. S.P. Singh,2009,Practical Manual of Biochemistry

IMMUNOLOGY LAB

Course Code: MICB-418 **Total Number of Credits: 01**

1. Handling of laboratory animals (Demonstration using softwares & Videos)
2. Detection of antigen pattern by Ouchterlony Double Immunodiffusion
3. Quantification of antigen by Radial Immunodiffusion.
4. Quantification of cells by Hemocytometer
5. Widal test
6. Quantification of antigen by Immunoelectrophoresis
7. Quantification of antigen/antibody concentration by ELISA
8. Flow cytometry (demonstration)
9. Blood grouping
10. VDRL test

Methodology book:

1. Robert Burns. 2005. Immunochemcial protocol. Springer. 3 rd Edition
2. Johh. E. Coligan et al. 2002. Current protocol in Immunology. Loose leaf

MYCOLOGY

Course Code: MICB-421
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objectives*: The aim of this course is to provide knowledge about the basic and applied aspects of fungi in agriculture, food production and industry.*

Pre-requisite: Bachelor's degree in Life Sciences

Unit-1 **10 h**

Historical perspectives – history and significance of mycology in the scientific development. General characteristics of fungi - Structure and organization of fungi – The fungal body and cells, Colony, communication and signaling. Cell differentiation and reproduction. Reproduction in fungi - Vegetative, asexual and sexual reproduction in fungi with special reference to their significance.

Unit-2 **10 h**

Taxonomy – Criteria for classification. Traditional, Chemo and molecular taxonomy and their significance. Myxomycetes, Ascomycetes, Basidiomycetes and imperfect fungi. Ecology (Fungal Lifestyle)- the way they make their living, Distribution of yeasts and fungi.

Unit-3 **8 h**

Nutrition and metabolism in fungi – nutritional requirement of fungi, saprophytic, parasitic, obligatory and facultative. Culture media for fungi, Natural substrates of fungi. Biotrophic semi-biotrophic and necrotrophic mode of growth. Fungal-microbe interaction, fungal - plant interactions – symbiotic and antagonistic interactions.

Unit-4 **10 h**

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. Mycorrhizal associations – endo and ecto mycorrhiza.

Unit- 5 **10 h**

Significance of fungi in human and livestock health - symbiotic fungi, toxigenic fungi and mycotoxins, pathogenic fungi; Significance of yeasts and fungi in agricultural production – symbiotic fungi, fungi in improving plant productivity, toxigenic fungi and mycotoxins, plant pathogenic fungi, fungi in biocontrol; Significance of fungi in

biotechnology and industrial production; Fungal metabolites and their economic significance – mycotoxins, medicinal uses of fungi (antibiotics), food additives, alcohol, vinegar, enzymes, biopesticides. Fungi as food – mushrooms, Mushroom poisoning.

Recommeneded Text Books:

5. Alexopoulos C. J. and Mims C. W. and Blackwell M. (2010). Introductory Mycology, John Wiley and Sons Inc.
6. Carlile M. J., Watkinson S. C. and Gooday G.W. (2001). The Fungi, 2nd Editon, Academic Press.
7. Webster J. and Weber R. W. S. (2007). Introduction to Fungi, 3rd Edition, Cambridge University Press.
8. Agrios G. N. (2005). Plant Pathology, 5th Edition, Elsevier.
9. Sharma P. D. (2005). Fungi and Allied Organisms. Alpha Science International Publishers.

Suggested Reading:

1. Bennett J. W. and Klich M. (2003). Mycotoxins. Clin. Microbiol. Rev. 16:497-516.
2. Ainsworth G.C. (2009). Introduction to the History of Mycology, 2nd Edition, Cambridge University Press

Course Outcome: *This paper deals with recognizing fungi as model systems in biological sciences, applications of modern research techniques, agricultural and industrial concerns, and increased awareness of various ecological and phylogenetic issues by understanding their distribution, occurrence, structure, and classification. All have helped to an explosion of knowledge relating to fungi with a traditional base.*

VIROLOGY

Course Code: MICB-422
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objectives: *Virology syllabus is structured from basic virology to the advanced techniques in virology. This paper provides an insight into the history, ultra structure and diagnosis of virus.*

Pre-requisite: Bachelor's degree in Life Sciences

Unit-1 **10 h**

Concept and scope of virology: Foundations of virology: Virus prehistory, discovery of viruses. Definitive properties of viruses: Morphology, Ultra structure, Chemical composition - proteins, nucleic acids, and enzymes. Classification and nomenclature of viruses; Trends in virology; Evolutionary importance of viruses. Epidemiology of Virus infection. Principles of diagnosis in virology.

Unit-2 **10 h**

Diagnostic virology: Biological activity of viruses, Physical, chemical and structural components of viruses, Visualization and enumeration of virus particles, Detection of viruses: physical, biological, immunological and molecular methods. Cultivation of viruses in embryonated eggs, laboratory animals and cell cultures. Serological methods – haemaglutination and HAI, complement fixation, immunofluorescence methods, ELISA and RIA: Physical, chemical and molecular methods- protein, radioactive tracers, electron microscopy, nucleic acid - PCR based assays, flowcytometry and immunohistochemistry. Infectivity assays for phages and plant viruses. Characterization of viral product expressed in the infected cells. Isolation and purification of viruses.

Unit-3 **10 h**

Study of virus: Morphology, ultra structure, chemical composition and replication of: Group I – T2 Bacteriophage, Group II – Banana bunchy top virus, Group III – Reovirus, Group IV-TMV, Group V – Rhabdovirus, Group VI – HIV, Group VII – HBV. Sub-viral particles: Discovery, Structure, Classification, replication and diseases caused by Satellite virus, Virusoids, Viroids and Prions. Cellular interactions—clathrin coated pits, lipid rafts, caveolae, endocytosis and virus uncoating mechanisms. Oncogenesis: oncogenic viruses, viral transformation by activation of cellular signal transduction pathways, viral transformation via cell cycle control pathways.

Unit-4 **9 h**

Applied virology: General aspects of plant and animal viral diseases. Introduction to viral vaccines, preparation of vaccines, new vaccine technology; antiviral drugs,Monoclonal Antibodies, antiviral gene therapy, antiviral libraries, antiretrovirals—mechanism of action and drug resistance. Modern approaches of virus control: Antisense RNA, siRNA, ribozymes, in silico approaches for drug designing. T-phages, Cyanophages, Baculovirus. Silver lining: viruses as therapeutic agents, viruses for gene delivery, viruses to destroy other viruses. Importance of studying modern virology.

Unit- 5 **9 h**

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 (Ebola, Nepha, Hendra, SARS etc).

Recommended Text Books:

1. Knipe D.M. and Howley P.M. (2013). Fields Virology, 6th Edition 2 Vol. Wolters Kluwer Health/Lippincott Williams & Wilkins, Philadelphia.
2. Martinez J. Hewlett (2018). Basic Virology, 4th Edition. Wiley, USA.
3. Carter J. and Saunders V. (2013). Virology: Principles and Applications, 2nd Edition. Willy, USA.
4. Flint S.J., Racaniello V.R., Enquist L.W., Rancaniello V.R., Skalka. A.M. (2015) Principles of Virology, 4th Edition, 2 Vol. American Society for Microbiology, USA.
5. Black J.G. and Black L.J. (2017) Microbiology-Principles and Explorations, 10th Edition. John Wiley & Sons Inc. New York, USA.
6. Dimmock, N.J., Easton, A.J., and Leppard, K.N. (2016). Introduction to Modern Virology. 7th Edition. Blackwell publishing, USA.

Suggested Reading:

1. Jane Flint S. (2015). Principles of virology. 2, Pathogenesis and control. ASM Press, Washington, DC.

Course Outcome: *This course imparts the knowledge on various groups of virus and their detail study. The main features of this syllabus apart from the recent advances in the virology like antivirals & their mode of action, Antisense RNA, siRNA, ribozymes and in silico approaches for drug designing. Emerging virus and challenges also included in the course structure for better understanding of the upto date developments in the field of virology.*

TECHNIQUES IN MICROBIOLOGY

Course code: MICB-423
Total number of Lecture hours: 48
Total number of Credits: 03

***Course Objective*:** *This course aims to introduce various techniques and instrumentation methods required for the study of microorganisms.*

Pre-requisite: Bachelor's degree in Life Sciences

Unit- 1 **10 h**

Microscopy- Magnification, resolving power, Principles and applications, simple, compound, dark, bright field, phase-contrast and fluorescent microscopes. Confocal laser scanning microscopy.
Electron microscopy: SEM and TEM, Mechanism of image formation and contrast generation in SEM, Sample preparation methods for TEM

Unit- 2 **10 h**

Spectroscopy - Electromagnetic spectrum, Beer Lambert's Law. UV/VIS Spectrophotometry, single beam, dual beam, Infrared spectroscopy, FTIR, Atomic absorption spectroscopy, Electron Spin Resonance Spectroscopy techniques, Spin label and H and C NMR spectroscopy. Mass spectroscopy Fluorescent spectroscopy, Quenching, principle, instrumentation and application of MALDI-ToF.

Unit- 3

8 h

Centrifugation Techniques: Principles, Swedberg unit, sedimentation coefficient, factors affecting sedimentation rate, clearing factor, rotors , their types and maintenance, determination of molecular weight by centrifugation, types of centrifuges, density gradient centrifugation, ultracentrifuges.
Other techniques: Flow cytometry. Next-generation sequencing methods: Illumina (Solexa) sequencing, 454 Pyrosequencing, SMRT, SOLiD, Oxford Nanopore.

Unit- 4 **10 h**

Chromatography - Introduction and types of chromatography, paper, thin layer, gas (LC-MS, GC-MS), Rf value, Qualitative and preparative techniques, Gel permeation, ion-exchange, HP-TLC, HPLC, FPLC and affinity chromatography and instrumentation. Applications of Chromatographic techniques in Microbiology.

Unit- 5

10 h

Electrophoresis and Blotting techniques – factors affecting gel electrophoresis, PAGE (native and SDS), discontinuous, Agarose gel electrophoresis, Pulse Field Gel Electrophoresis, Blotting techniques- Southern blot, Western blot and Northern blotting,

Radioactivity techniques - Nature and types of radiations. Detection and measurement of radioactivity, Geiger Muller counter, Liquid Scintillation counter, Safety measures in handling radioisotopes. Radio Immuno Assay, non- radio-labelling.

Recommended Text Books:

1. Wilson K. & Walker. J. (2010). Principles and Techniques in Practical Biochemistry. 7th ed. Cambridge Univ. Press, UK
2. Freifelder D. M. (1982) Physical Biochemistry- Application to Biochemistry and Molecular Biology, 2nd edition., W.H. Freeman, U.S.A.
3. Dryer, R. L. and Lata G. F. (1989) Experimental Biochemistry. Oxford University Press, UK
4. Boyer, R. (2000) Modern Experimental Biochemistry:, Third edition, Benjamin Cummings, San Francisco
5. Mikkelsen, S. R. and Corto´n, E. (2004) Bioanalytical Chemistry. John Wiley & Sons, U.S.A.
6. Pattabhi, V. and Gautham, N. (2002) Biophysics. Second Edition. Kluwer Academic Publishers, Narosa Publishing House, India
7. Slater, R. J. (2002) Radioisotopes in Biology: A Practical Approach. Oxford University Press, UK

Suggested Reading:

1. Evans, J. N.S. (1995). Biomolecular NMR Spectroscopy. Oxford University Press, UK.
2. Wahid, P.A. (2001) An Introduction to Isotopes and Radiations: Allied Publishers Ltd., India
3. Rouessac, F and Rouessac, A. (2007) Chemical Analysis: Modern instrumentation methods and techniques. Second edition., John Wiley and Sons, U.S.A.
4. Simpson, R.J., Adams, P. D. and Golemis, E.A. (2009) Basic methods in Protein purification and analysis; Laboratory Manual. Cold Spring Harbor Laboratory Press, U.S.A.

Course Outcome: *This course provides understating on techniques and methods of microscopy, spectroscopy, chromatography, radioactivity, centrifugation and electrophoresis.*

CELL AND MOLECULAR BIOLOGY

Course code: MICB-424
Total number of Lecture hours: 40
Total number of Credits: 03

Course Objective: *This course is designed to teach the students basics, molecular mechanism and latest advancement in cell and molecular biology.*

Pre-Requisite: Bachelor degree in Life Sciences

Unit 1 **8 h**

The dynamic cell: Molecules of life - the architecture of cells - Cell Theory, Emergence of modern cell biology, Structure of Prokaryotic and Eukaryotic cells, Cell wall, Membrane, Extracellular matrix, Cell organelles-organization and functions, Cytoskeleton: microfilaments-intermediate filaments-microtubules, cell cycle events.

Unit 2 **8 h**

DNA Replication:DNA structure, Chromatin Organization, Prokaryotic and Eukaryotic DNA replication, mechanisms of DNA replication, fidelity of replication, enzymes and accessory proteins involved in DNA replication.

Unit 3 **8 h**

Gene mutations: Types of mutations. Suppression, Transposable Genetic Elements, Ames test. **DNA damage and repair mechanisms**, Global response to DNA damage, DNA repair and aging, Medicine and DNA repair modulation.

Unit 4 **8 h**

Transcription: 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). Post-transcriptional modification: mRNA processing, Processing, Capping, Cleavage and polyadenylation, splicing of nuclear pre-mRNA, mRNA stability.

Unit 5 **8 h**

Translation: Genetic code (Characteristics, deciphering the code). Prokaryotic and eukaryotic translation, translational machinery, mechanism of initiation, elongation and termination. Post translational modification, Control of gene expression in eukaryotes (Activation & repression).

Recommended Text Books:

1. Watson. J. D, Baker. T. A, Bell. S. P, Gann. A, Levine. M, Losick. R. Molecular Biology of Gene. 5th The Benjamin / Cummings Pub. Co. Inc, 2003
2. Weaver. R. F. Molecular Biology. 3rd ed. Mc Graw Hill publilcation , 2005
3. Alberts Bruce (2008) *Molecular Biology of Cell,* 5th Ed. Garland Pub.
4. Russel Peter. Essential Genetics. 2nd Edn, Blackwell Science Pub.
5. Friefelder D. (1995). Molecular Biology, 2nd Edn. Narosa Publishing House

Suggested Reading:

1. Darnell, Lodish and Baltimore. Molecular Cell Biology, 5th Ed. Scientific American Publishing Inc, 2000
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular biology of the Cell. 4th ed. Garland publishing Inc, 2002
3. Benjamin Lewin. Gene VIII. Pearson Education Inc. NJ, 2004

Course Outcome: *Through this course students will acquire knowledge from basics to recent development in cell biology, DNA replication, transcription and translation*

MICROBIOME BIOLOGY

Course code: MICB-425
Total number of Lecture hours: 40
Total number of Credits: 03

Course Objective: *The microbiome represents the trillions of microbes (unseen microbial majority) associated with animal and human gut, environment and various niches. From the human microbiome project, it was revealed that the gut microbiota plays a significant role in human disease biology and treatments.*

Pre-requisite: Bachelor's degree in Life Sciences

Unit 1: **8 h**

Microbiome – definition – uncultured majority – Candidatus, Status and phyla radiatus – definition, History of microbiome perspective, environmental genomics-microbiomes of oceans, lakhs and terrestrial ecosystems, Microbiome ecology, the fungal and viral microbiomes, Microbiome evolution. Earth Microbiome project.

Unit 2: **8 h**

Approaches in Micobiome analysis, Metagenomics (open and closed formats), Meta-transcriptomics, Pan-genomics, Epigenomics, Microfluidics technology to study the human microbiome, single cell genomics, Advance culturing techniques to study microbiomes. Metagenomics: – definition – principles – methods - whole genome shotgun cloning – metagenomic library production – high throughput screening - metagenomics of archealogical samples – Sargasso sea project – microbial phylogeography.

Unit 3: **8 h**

Human microbiome: biodiversity and major genera of human-microbiome, human-microbiome system as a "holobiont" or "superorganism", microbiome distributions in healthy individuals; composition of specific body sites' microbiome (nose, skin, oral, urogenital, etc.) - fecal transplants- designer probiotics, Symbiosis- Dysbiosis -Rebiosis, Dynamics microbiome changes from birth to death; pregnancy and the microbiome; personnel microbiome concepts.

Unit 4: **8 h**

Microbiome and disease biology: gut-brain conversation, obesity and gut microbiome, infectious diseases and gut microbiome, non-infectious diseases and gut microbiome, phylogeography of epidemics, microbiome's role in diseases such as Inflammatory bowel disease (IBD), colitis, obesity, diabetes; effects of diet on microbiome; interactions with the immune system and resistance to pathogens; Drug delivery using microbes engineered to

secrete peptides, Microbes as neuromodulators, Microbes as cancer therapeutics, impacts of antibiotics on the development of resistomes.

Unit 5: **8 h**

Biofilm biology: biofilm – definition, cell-cell communication, extracellular polymeric substances (EPS), Formation stages – Development, Dispersal, Habitats - dental plaque, diversity and eDNA, biofilm Infectious diseases - *Pseudomonas aeruginosa* and *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Streptococcus mutans*, *Candida*. Uses in medicine, industry, Food industry, aquaculture. Eukaryotic biofilms, biofilm as model of microbiome.

Text Books

Angela E. Douglas (2018). Fundamentals of Microbiome Science – how microbes shape animal biology, Princeton University Press, New Jersey, United States.

Rob DeSalle and Susan L. Perkins (2015). Welcome to the microbiome. getting to know the trillions of bacteria and other microbes in, on, and around you. Yale University Press.

Suggested Readings

Rodney Dietert (2016). The Human Superorganism: how the microbiome is revolutionizing the pursuit of a healthy life. Dutton Books.

Justin Sonnenburg and Erica Sonnenburg (2014). The good gut: taking control of your weight, your mood, and your long-term health. Penguin Press.

Emeran Mayer (2016). The Mind-Gut Connection: How the Astonishing Dialogue Taking Place in Our Bodies Impacts Health, Weight, and Mood. eBook, Harper Wave Books.

Martin J. Blaser (2014). Missing Microbes: How the Overuse of Antibiotics Is Fuelling Our Modern Plagues. Harper Collins Publishers. Toronto.

Diana Marco (2014). Metagenomics of the Microbial Nitrogen Cycle: Theory, Methods and Applications Book: 978-1-908230-48-5. ebook: 978-1-908230-60-7, Caister Academic Press.

Pilar Francino, M (2012). Horizontal Gene Transfer in Book: 978-1-908230-10-2. ebook: 978-1-908230-72-0, Caister Academic Press.

Course Outcome: *Understanding the microbiomes will pave the way for transforming microbiology to microbiome biology as to evolve techniques and approaches to exploit the benefits of microbiomes in general.*

MYCOLOGY LAB

Course Code: MICB-426 **Total Number of Credits: 01**

1. Methods of isolation and identification of fungi by traditional methods.
2. Preparation of pure culture and preservation of culture.
3. Isolation and identification of endophytic fungi from plants.
4. Isolation and Observation of mycorrhiza.
5. Isolation and identification of fungi from seeds.
6. Study of soil fungi from varied geographical origins.
7. Isolation of antibacterial/ antimycotic compounds from fungi.
8. Staining and observation of plant pathogenic fungi.
9. Study of asexual reproduction in *Saccharomyces*.

Methodology book: Aneja K R (2001), Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation , New Age International Ltd.

VIROLOGY LAB

Course Code: MICB-427 **Total Number of Credits: 01**

1. Isolation of bacteriophages from sewage
2. Estimation of virus yields - plaque assay
3. Routes of inoculations in embryonated eggs
4. Haemagglutination test
5. Hemagglutination inhibition assay
6. Biocontrol assay on insect larvae using NPV
7. ELISA test
8. Study of virus infected plant material.
9. One step growth curve of bacteriophage by Burst size determination
10. Demonstration of identification of arthropod vectors of viral transmission.

Methodology book: Florence G. Burleson, Thomas M. Chambers, and Danny L. Wiedbrauk, (1992). Virology: A Laboratory Manual. The Academic Press, USA.

INSTRUMENTATION TECHNIQUES LAB

Course Code: MICB-428 **Total Number of Credits: 01**

1. Kohler Illumination and handling of Microscope: stereo microscope
2. Observation of unstained sample using compound microscope
3. Preparation of sample for light microscopy, staining and sectioning, use of oil immersion lens
4. UV-Visible spectrophotometry: Absorption spectrum, Hyper/ hypo chromic effect.
5. Paper Chromatography of amino acids
6. Thin Layer Chromatography
7. High Performance Thin Layer Chromatography (HPTLC) (Demo)
8. Ion exchange chromatography.
9. SDS Gel electrophoresis.
10. Agarose Gel electrophoresis
11. Fourier Transform Infrared Spectroscopy (FTIR) (Demo)
12. Scanning Electron Microscope
13. High Performance Liquid Chromatography (HPLC)/ Flow cytometry (Demo)
14. Visit Central Instrumentation facility (CIF) of the university

Methodology book: by Prakash Singh Bisen and, Anjana Sharma , (2012). Introduction to Instrumentaion Techniques in life Sciences.CRC Press.

MOLECULAR BIOLOGY LAB

Course Code: MICB-429 **Total Number of Credits: 01**

1. Cell Viability Assay
2. Observation of human cheek epithelial cells
3. Observation of mitochondria in human cheek epithelial cells
4. Cell cycle Analysis
5. Isolation of genomic DNA from bacteria
6. Isolation of plasmid from bacteria
7. Isolation of RNA from bacteria
8. Primer Designing
9. Amplification of gene of interest by Polymerase chain reaction

Methodology book:

1. Ralph Rapley (2008). Molecular Biomethods Handbook . Humana press
2. http://www.iscb.org.in/docs_pdf/ISCBProtocol.pdf

MEDICAL MICROBIOLOGY

Course Code: MICB-511
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objective ***:*** *This course deals with importance of the microorganisms in human health. The basic concepts and medical terms will be explained along Students will study important diseases by body system with reference to the etiology, pathogenesis, treatment, diagnosis and prevention.*

Pre-Requisite: Bachelor degree in Life Sciences

Unit- 1 **6 h**

Important developments in medical microbiology. Normal microbiota of human body and their significance, opportunistic infections: situations/ conditions that create opportunities for infection Nosocomial infections and their control. CDC Blood and body fluid guidelines. General concepts and guidelines for clinical specimen collection, transport, processing and handling. biosafety levels. Koch's postulates, Molecular Koch's postulates

Unit- 2 **12 h**

Basic concepts in Microbiology: Concept of epidemic, endemic and pandemic, acute, chronic, morbidity, mortality, prevalence, incidence, Reservoirs, Carriers. Stages of Disease Progression. Modes of transmission; contact : horizontal, vertical, vector, vehicle transmission, portals of entry. Mechanisms of microbial resistance to host cellular and humoral defenses. *Molecular basis of microbial pathogenicity*. Pathogenicity Islands, bacterial toxins: Exotoxins, Endotoxins, Superantigens. *Antimicrobial Agents: Mechanisms of drug resistance,* Multi-drug Resistance: Target modification, Antibiotic inactivation, Bypass pathway, Drug efflux,

Unit-3 **10 h**

Diseases of skin: Etiology, Pathogenesis, Laboratory diagnosis, prophylaxis and treatment of skin diseases caused by: *Staphylococcus aureus; Streptococcus pyogenes, Pseudomonas aeruginosa*; Varicella Zoaster Virus, Measles Virus; Cutaneous Mycoses, *Leishmania major/ tropicana.* **Diseases of Gastrointestinal tract (GIT) system:** Etiology, Pathogenesis, Laboratory diagnosis, prophylaxis and treatment of GIT diseases caused by: *Salmonella typhi, Shigella dysenteriae, Escherichia coli:* ETEC, EHEC, EPEC, EAEC; viral Hepatitis: Hepatitis A, Hepatitis B, Hepatitis C; *Entamoeba histolytica*,

Unit- 4 **10 h**

Diseases of Nervous System: Etiology, Pathogenesis, Laboratory diagnosis, prophylaxis and treatment of *Clostridium tetani, Clostridium botulinum, Mycobacterium leprae,* Rabies virus,

Neisseria meningitidis **Diseases of Reticuloendothelial System:** Etiology, Pathogenesis, Laboratory diagnosis, prophylaxis and treatment of *Brucella, Plasmodium,* Bacterial Septicemia

Unit-5 **10h**

Diseases of Respiratory System: Etiology, Pathogenesis, Laboratory diagnosis, prophylaxis and treatment of *Corynebacterium diphtheriae, Bordetella pertussis, Mycobacterium tuberculosis, Mycoplasma pneumoniae, Chlamydia pneumoniae, Streptococcus pneumoniae, Klebsiella pneumoniae, Chlamydia psitacci, Hemophilus influenza,* Common Cold Viruses, Influenza Virus A and B, *Pneumocystis carinii* **Diseases of Urogenital System**: Pathogenesis, Laboratory diagnosis, prophylaxis and treatment of HIV, *Neisseria gonorrheae, Chlamydia trachomatis*

Text Books:

1. Brooks, G.F., Carroll, K. C., Butel, J. S. and Morse, S. A. (2007) Jawetz, Melnick, & Adelberg's Medical Microbiology, Twenty-Fourth Edition. McGraw-Hill Companies, UK
2. Murray P.R., Pfaller M.A., Tenover F.C., and Yolken R.H. (2007). Medical Microbiology 6th Edn., ASM Press, U.S.A.
3. Bauman, R.W. (2005). 4th Edition. Microbiology: with diseases by body system; Pearson Education, Inc., U.S.A.
4. Ryan K. J. and Ryan C.G. (2004) Sherris Medical Microbiology: an Introduction to infectious diseases. 2nd edition. McGraw-Hill, U.S.A.
5. Nester E. W., Anderson D. G. and Nester M. T. 2006. Microbiology: A Human Perspective, McGraw-Hill, U.S.A.

Suggested Readings:

1. Brogden, K. A., Minion, C., Roth, J.A., Bolin, C.A. and Stanton, T. B. (2000) Virulence Mechanisms of Bacterial Pathogens 2nd Edition. ASM Press, U.S.A.
2. Salyers, A. A. and Whitt, D.D. (2002) Bacterial Pathogenesis: A molecular Approach –2nd Edn. ASM Press, U.S.A.

Course Outcome: *Students will have clear understanding of microbial diseases, host-pathogen dynamics and challenges involved in keeping drug resistant microbes under control.*

FOOD MICROBIOLOGY

Course Code: MICB- 512
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objective: *The aim of this course is to highlight the importance of food and the risks associated with consumption of foods due to microbial contamination.*

Pre-Requisite: Bachelor degree in Life Sciences

Unit- 1 **12 h**

Historical Perspective and Scope of Microbiology in relation to food- Importance and significance of microorganisms in food. Factors – Intrinsic and Extrinsic parameters - affecting the growth of microorganisms in food. Food borne diseases- Bacterial food borne diseases- (Staphylococcal intoxification, Botulism, Salmonellosis, Shigellosis, EPEC Diarrhoea, *Clostridium perfringens* gastroenteritis, *Bacillus cereus* gastroenteritis; Food-borne fungi- Mycotoxins- Aflatoxicosis, Deoxynivalenol, Mycotoxicosis, Ergotism. Food Borne Viral Pathogens- (Norwalk virus, Reovirus, Rotavirus, Adenovirus, Parvovirus, Hepatitis A Virus) Food Borne Animal Parasites- Protozoa – Giardiasis, Amebiasis, Toxoplasmosis, Crypotosporidiosis. Cysticercosis/ Taeniasis; Roundworm – Trichinosis, Anisakiasis.

Unit- 2 **10 h**

Detection of foodborne pathogens- Detection and Enumeration of micro organisms and their products in food- Culture dependent methods- Sample collection and processing, analysis, surface testing, Direct microscopic observation, enumeration and isolation methods; Animal and Cell Culture Models to study food-borne pathogen interaction; Culture independent techniques – Metagenomics, Biosensor based detection of food pathogens, Nucleic-acid based methods- PCR; Immunological methods to detect food-borne pathogens; Molecular Typing and Differentiation of Food-borne Bacterial Pathogens.

Unit- 3 **10 h**

Food spoilage and Food preservation- 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- High temperature, Low temperature- Significance of psychrophilic microbes in cold-stored and frozen foods, Drying, Chemical, Modified atmosphere, Radiation, other food protection methods and Microbial Resistance.

Unit- 4 **10 h**

Microbiology of Food fermentations- Milk Fermentation, Fermented and Non-fermented Dairy Products. Food fermentations- Manufacture of fermented foods- Meat and fishery products, plant products- Sauerkraut and fermented olives, breads, beverages. Microbial cells as food- SCP, mushroom cultivation. Probiotics and their advantages, Genetically modified foods.

Unit- 5 **6 h**

Food safety and Quality Management Systems- General principles of food safety risk management, Recent concerns on food safety- Safe food alternatives (Organic foods), Good agricultural Practices (GAP), Food Indicators of water and food safety and quality- Microbiological criteria of foods and their Significance. The HACCP and ISO systems for food safety.

Recommended Text Books:

1. Adams M. R. and Moss M. O. (1996). Food Microbiology, New Age International (Rt) Ltd., New Delhi.
2. Frazier W.C. and Westhoff D.C. (1995). Food Microbiology, Tata McGraw Hill Publishing Ltd., New Delhi.
3. Jay J. M., Loessner M. J. and Golden D. A. (2005). Modern Food Microbiology, Seventh edition.
4. Verma L. K. and Joshi V. K. (2000). Post Harvest Technology of Fruits and Vegetables, Tata McGraw Hill Publication.
5. Doyle M. P. and Beuchat L. R. (2007). Food Microbiology- Fundamentals and Frontiers, ASM Press.
6. Bhunia A. K. (2008). Food-borne Microbial Pathogens- Mechanisms and Pathogenesis, Food Science text Series, Springer International, New York, USA.

Suggested Reading:

1. Benwart G. J. (1987). Basic Food Microbiology, CBS Publishers & Distributors, New Delhi.
2. Deak T. and Beuchat L. R. (1996). Hand Book of Food Spoilage Yeasts, CRC Press, New York.
3. Garbutt J. (1997). Essentials of Food Microbiology, Armold – International Students edition, London.
4. Marriott N. G. and Gravani R. B. (2006). Principles of Food Sanitation, Food Science text Series, Springer International, New York, USA.

Course Outcome: *The Food Microbiology paper would enable students to learn about the epidemiology of food-borne diseases and the pathogens. Also, the study would equip them to study various methods of pathogen detection available along with understanding the beneficial and harmful effects of microbes in the food industry. Food Safety standards are also highlighted.*

APPLIED & INDUSTRIAL MICROBIOLOGY

Course Code: MICB-513
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objectives: *The syllabus of applied and industrial microbiology is oriented towards the industrial application of microorganisms and recent microbial products.*

Pre-Requisite: Bachelor degree in Life Sciences

Unit- 1 **10 h**

Basics of Industrial Microbiology: Historical account of microbes in industrial microbiology; sources and characters of industrially important microbes; their isolation, purification and maintenance; Screening of useful strains; primary screening 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 process.

Unit- 2 **10 h**

Microbial production of metabolites: Microbial production of Primary and secondary metabolites. Metabolic engineering, Pathways involved in secondary metabolite production, Commercial production of antibiotics with special reference to penicillin, streptomycin and their derivatives. Microbial transformations: steroids and alkaloids production. Large scale production of recombinant molecules interferon, human proteins- insulin, somatostatin, vaccines and anticancer agents.

Unit- 3 **10 h**

Fermented Microbial products: Microbiology and production of alcoholic beverages; Malt beverages, distilled beverages, wine and champagne; Pathways involved in primary metabolite production, Commercial production of organic acids like acetic, lactic, citric, and gluconic acids; Commercial production of important amino acids (glutamic acid, lysine and tryptophan), and vitamins (riboflavin and vitamin A).

Unit- 4 **9 h**

Microbial enzymes: Immobilization of microbial enzymes and whole cells and their applications in industries; Industrial enzymes production; Cellulases, Xylanases, Pectinases,

Amylases, Lipases and Proteases and their applications. Enzymes involved in microbial biocatalysis / transformations.

Unit- 5 **9 h**

Biofuels & Biopolymers: Biofuels (ethanol and methane) from organic residues; fuels from algae; Microbial fuel cells, Mushroom cultivation; other microbial products - Biopolymers and EPS, Bioplastics, Biosurfactants.

Recommended Text Books:

1. Nduka Okafor, Benedict C. Okeke (2017). *Modern Industrial Microbiology and Biotechnology*. 2nd Edition: CRC Press Publishers.
2. Waites, M.J., Morgan, N.L., Rockey, J.S. and Higton, G. (2002). *Industrial Microbiology: An Introduction.* Blackwell Science Publishers.

Suggested Reading:

1. W. Crueger & A. Crueger (2017). Cruegers Biotechnology: A Text Book of Industrial Microbiology. Edited by K.R. Aneja. Panima Publishing Corporation.
2. Reed. G. (1999). Prescott and Dunn's Industrial Microbiology. CBS Publishers.
3. Demain, A. L. (2001). Industrial Microbiology and Biotechnology IInd Edition. ASM Press, Washington.
4. P.F. Stanbury, W. Whitaker & S.J. Hall (2016). Principles of Fermentation Technology. 3rd edition. Elsevier publication.
3. Richard H. Baltz, Julian E. Davies, and Arnold L. Demain (2010). Manual of Industrial Microbiology and Biotechnology. 3rd Edition, ASM Press.
4. Daniel Forciniti (2008). Industrial Bioseparations: Principles and Practice. 1st Edition, Wiley-Blackwell.
5. Nduka Okafor, Benedict C. Okeke (2017). *Modern Industrial Microbiology and Biotechnology*. 2nd Edition: CRC Press Publishers.

Course Outcome: *After studying this paper, students will know the applied and industrial aspects of microbiology such as screening of microorganisms, strain improvement, microbial metabolites, fermented microbial products, microbial enzymes, Biofuels using microbes and microbial production of Biopolymers. The recent applications of the microbes for the human welfare are well structured in this paper.*

RECOMBINANT DNA TECHNOLOGY

Course Code: MICB-514
Total Number of Lecture hours: 40
Total Number of Credits: 03

Course Objective**:** *This course aims to teach gene cloning and strategies of rDNA technology. This course provides an insight into the vectors, techniques, legal and ethical issues in rDNA technology.*

Pre-Requisite: Bachelor degree in Life Sciences

Unit-1 **8 h**

Introduction- 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

Unit- 2 **14 h**

Nucleic acid amplification and hybridization Techniques - Polymerase chain reaction (PCR) and its applications, variations in PCR and applications, methods of nucleic acid detection, methods of nucleic acid hybridization, sequencing methods, probes and target sequences, Southern blotting, Northern blotting, *in situ* hybridization, nucleic acid mutagenesis *in vivo* and *in vitro*, CRISPR-Cas systems for editing and targeting genome.

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Unit-3 **5 h**

Construction 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.

Unit- 4 **5 h**

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, genegun, transfection with phage vectors etc. *Agrobacterium* based gene transfer in plants - Ti plasmid: structure and functions, Ti plasmid based vectors.

Unit-5 **8 h**

Applications and legal issues- Applications of recombinant DNA technology in Agriculture, Veterinary, Industry, Forensic science and Medicine. Gene mapping-restriction mapping,

RFLP, RAPD, AFLP. Engineering microbes for the production of antibiotics, enzymes, Insulin, growth hormones, monoclonal antibodies etc. Transgenic organisms from mice to rice, Human genetic engineering and Gene therapy- methods of gene therapy, gene therapy in treatment of diseases, Stem cell therapy, Future of stem cell therapy. Science and the constitution- ethical, legal and environmental issues

Recommended Text Books:

1. Sandy Primose (2006). Principles of Gene Manipulation and Genomics. 7th Ed., Blackwell Publishers.

2. Brown T.A. (2010). Gene Cloning and DNA analysis. 6th Edition, Wiley-Blackwell.

Suggested Reading:

1. David E Newton. (2010). DNA technology. ABC-CLIO, LLC

2. BeiquanMou and Ralph Scorza. (2011). Transgenic Horticultural Crops: Challenges and Oppurtunities. CRC press.

3. Thomas F. Budinger and Miriam D. Budinger. (2006). Ethics of Emerging Technologies: Scientific Facts and Moral Challenges. John Wiley and Sons Inc.

4. Pete Shanks. (2005). Human Genetic engineering. Avalon publishing groups.

5. Glick BR and Pasternak JJ (2003). Molecular Biotechnology, 2nd EditioN, ASM press.

6. Peter J Russels (1997). Genetics. 5th Ed. Benjamin-Cummings Publishing Co.

7. David Frifielder, Stanley R.Maloy. (1994). Molecular Biology and Microbial genetics. 2nd Edition, Jones and Brlett Publishers.

Course Outcome: *Through this course students will acquire knowledge from basics to recent advancement in rDNA technology.*

MICROBIAL GENOMICS

Course Code: MICB-515
Total Number of Lecture hours: 40
Total Number of Credits: 03

Course objective*: This course aims to understand advancement of Microorganisms using culture-independent approaches.*

Prerequisite: Bachelor's degree in Life Sciences

Unit- 1 **8 h**

Taxonomy and phylogeny: Basic concepts in systematics, taxonomy and phylogeny; Polyphasic taxonomy, molecular evolution; nature of data used in Taxonomy and Phylogeny, Definition and description of phylogenetic trees and various types of trees, Phylogenetic analysis algorithms such as maximum Parsimony, UPGMA, transformed distance, Bayesian algorithm, Neighbor- Joining.

Unit- 2 **8 h**

Whole genome library: Need of genome library, methodology, Enzymes used in genome library construction, Vectors for library construction, Genomic libraries in high-capacity vectors, cDNA cloning, Shotgun cloning, Whole genome shotgun sequencing: DNA sequencing theory pair end sequencing, Contributions of Craig Venter, Early history of genome sequencing. Hierarchical Shotgun sequencing, ePCR, Next-generation sequencing methods and full genome sequencing platforms.

Unit- 3 **6 h**

Genome projects: An overview of genome projects: human, plant, animal and microbial genomes. Genomes of model organisms – *Haemophilus, E. coli, Saccharomyces cerevisiae, Streptomyces* (industrial strain), virus and cyanobacteria. Functional analysis of genomes - microarrays and transcriptomes, gene chips and gene expression analysis, methods in proteomics and metabolomics.

Unit- 4 **8 h**

Structural and functional genomics- definition, historical prospective and strategies. Genome Structure: genome sizes – microbial and organelle genome – genome physical mapping and sequencing – tools in genome analysis; Structural and functional annotations of

genes and genomes.Human Genome Map repositories. Evolutionary genomics – Comparative genomics.

Unit- 5 **10 h**

Synthetic biology and bioengineering

Introduction to synthetic biology - Metabolomics and synthetic microbiology, predictive model building (metabolomes) - Secondary metabolism and synthetic biology - synthetic bacterium, Mycoplasma laboratorium, Repressilators, Biobrics, iGEM, Genome engineering, yeast cell factories (artimisinin).

Recommended Text Books:

1. Sandy B. Primrose, Richard Twyman (2004), Genomics : Applications in Human Biology. Wiley and Sons.
2. Diana Marco (2011). Metagenomics: Current Innovations and Future Trends. Book: 978-1-904455-87-5. Horizon Scientific Press.

Suggested Reading:

1. Muhammad Jamal (2017). The CRISPR/Cas System: Emerging Technology and Application. Caister Academic Press.
2. Manuel Fuentes, Joshua LaBaer (2014). Proteomics: Targeted Technology, Innovations and Applications. Book: 978-1-908230-46-1. ebook: 978-1-908230-62-1. Caister Academic Press.
3. Patrick Arbuthnot and Marc S. Weinberg (2014). Applied RNAi: From Fundamental Research to Therapeutic Applications. Book: 978-1-908230-43-0. ebook: 978-1-908230-67. Caister Academic Press.
4. Jianping Xu (2014). Next-generation Sequencing: Current Technologies and Applications. Edited by: Published: 2014 Book: 978-1-908230-33-1. Ebook: 978-1-908230-95-9. Caister Academic Press.
5. S. B. Primrose (2002). Principles of Genome Analysis. A Guide to Mapping and Sequencing DNA from Different Organisms. Blackwell publishing.
6. Mount D (2004). Bioinformatics: Sequence and Genome Analysis by. Cold Spring Harbor Laboratory Press, New York.
7. Andreas D. Baxevanis, B. F. Francis Ouellette (2005). Bioinformatics- a practical guide to the analysis of Genes and Proteins. John Wiley & Sons, UK.

8. Tom Strachan and Andrew P Read (2011). Human Molecular Genetics, 4th edition, Garland Science.
9. Sudbery P and Sudbery I (2009). Human Molecular Genetics. Prentice Hall.
10. Guido Grandi (2004), Genomics, proteomics and Vaccines. Wiley and Sons.

Course outcome: *Microbial Genomics, and Bioinformatics are new dimensions of approaches in exploring the microbial world. Without these new dimensions, a Microbiology student could not apply his knowledge in research and development activities. Therefore, this course could enable the students to perform analysis and interpretation of microbial phylogeny.*

MEDICAL MICROBIOLOGY LAB

Course Code: MICB-516 **Total Number of Credits: 01**

1. Study of normal micro-biota of mouth; isolation, identification and preservation of microorganisms
2. Study of normal micro-biota of skin; isolation identification and preservation of microorganisms
3. Identification and Biochemical tests of respiratory tract bacterial pathogen (using avirulent strain of MTCC Culture of – *Streptococci/ Klebsiella pneumoniae.*
4. Identification and Biochemical tests of gastrointestinal bacterial infection (using avirulent strain of MTCC Culture of) – *Salmonella / Shigella sps.*
5. Laboratory examination and identification and biochemical tests of pus specimens (using avirulent strain of MTCC Culture) for *Staphylococcus aureus, Streptococcus pyogenes and Pseudomonas aeruginosa.*
6. Laboratory examination and identification and biochemical tests of urine specimens (using avirulent strain of MTCC Culture) for *E.coli and Candida albicans.*
7. Laboratory examination of sputum: Collection of sputum. Microbiological examination of sputum for pus cells and predominant bacteria. Ziehl-Neelsen staining to detect the presence of *Mycobacterium*. (using avirulent strain of MTCC Culture).
8. Visit to Clinical laboratory for one day orientation and demonstration on clinical specimen collection and processing.

Methodology book: C.P. Prince Pages : 300 pages Publisher : Jaypee Brothers Medical Publishers 2008-12-01 Language : English ISBN-10 : 8184486375 ISBN-13 : 9788184486377

FOOD MICROBIOLOGY LAB

Course Code: MICB-517 **Total Number of Credits: 01**

1. Examination of microbial load in soft drinks, ice creams, packaged and canned foods.
2. Isolation and identification of food –borne pathogenic bacteria from contaminated foods, dairy products.
3. Isolation and identification of food spoilage fungi from foods (Eg: Cereals, Spices).
4. Production and estimation of lactic acid by *Lactobacillus* species
5. Detection of number of bacteria in milk by standard plate count (SPC).
6. Determination of quality of milk sample by methylene blue reductase test.
7. Bacteriological Examination of water quality.
8. Determination of water quality using Membrane Filter Technique.

Methodology book: Harley and Prescott (1996), Laboratory Exercises in Microbiology, McGraw Hill Higher Education, 3rd Edition

APPLIED & INDUSTRIAL MICROBIOLOGY LAB

Course Code: MICB-518 **Total Number of Credits: 01**

1. Bioassay of nicotinic acid
2. Production of Ethanol by Yeast.
3. Isolation of amylase producing microorganisms from soil
4. Isolation of protease producing microorganisms from soil
5. Isolation of lipase producing microorganisms from soil
6. Production and extraction of thuricides.
7. Laboratory scale production of biofertilizers.
8. Production, quantification and extraction of Citric acid
9. Demonstration: Reactor Studies: Batch, fed-batch, and continuous flow reactor analysis and residence time distribution.
10. Demonstration: Down-stream Processing Lab
11. Determination of the specific growth rate a bacterium in submerged fermentations.
12. Production of wine from grape juice.
13. Preparation of fermented food products-curd, cheese and alcohols.
14. Isolation and characterization of plant growth promoting bacteria.

Methodology book: Bull, Alan T. and Junker, Beth and Katz, Leonard and Lynd, Lee R. and Masurekar, Prakash and Reeves, Christopher D. and Zhao, Huimin, eds. (2010). *Manual of Industrial Microbiology and Biotechnology, 3rd Edition.* ASM Press.

MICROBIAL GENOMICS LAB

Course Code: MICB-519 **Total Number of Credits: 01**

1. Polymerase chain reaction-Gradient
2. Cloning of GFP protein
3. RT-PCR
4. 16S typing
5. Primary databases : Nucleic Acid & Protein : Genbank, EMBL, DDBJ
6. Multiple sequence alignment- Global and local alignment
7. Molecular Phylogenetic methods- Parsimony, Distance, Molecular Phylogeny, Bayesian - MEGA
8. Evaluation of Methods and Phylogenetic tree- Bootstrapping
9. Using Phylogenetic Trees to Study Speciation and Extinction, Gene duplication, Recombination
10. Comparative genomic analysis tools
11. Bioinformatic programs to protein mutations.

Methodology book: Maria S. Poptsova (2014). Genome Analysis: Current Procedures and Applications. Book: 978-1-908230-29-4. ebook: 978-1-908230-68-3. Caister Academic Press.

Project/Dissertation

Course Code: MICB-521
Total Number of Credits: 03

Industrial Visit and Reporting

Course Code: MICB-431
Total Number of Credits: 02

SELF-STUDY REVIEW

Course Code: MICB-432
Total Number of Lecture hours: 32
Total Number of Credits: 02

A self study review is a course aims to prepare Masters students for their dissertation works. This course is based on a literature review of scholarly reports available on a selected topic for dissertation work. The review shall consolidate the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic.

Sl No	Details	Activity plans
1	Duration	Two months
2	Topic	Related with dissertation work
3	Guide	Dissertation guides
4	Nature of work	Review of literature, analysis and reporting
5	Evolution	Submission of Report – 50 marks Presentation and viva-voce – 50 marks

RESEARCH METHODOLOGY – SCIENTIFIC WRITING AND PUBLICATION ETHICS

Course Code: MICB-433
Total Number of Lecture hours: 32
Total Number of Credits: 02

Course objective: *Research methodology is the specific procedures or techniques used to identify, select, process, and analyze information about a topic (libguides.wits.ac.za).*

Prerequisite: Masters students in Life Sciences

Unit-I **8 h**

Academic document preparation - Books - types and varieties, Chapter in an edited volume, Book reports, Conference papers, Dissertation, Research Article, Research Paper, Technical reports, Thesis, Data announcements, poster presentations.

Unit-II **8 h**

Impact of Research: Impact Factor, calculation methods, various citation index methods, H-index, i10-index, STR, Web of Science, Scopus index, Source Normalized Impact per Paper, Citescore, 5-Year Impact factor, SCImago Journal Rank (SJR). Clarivate analytics.

Unit-III **8 h**

Art of Scientific writing: Interpretation of Data and Paper Writing - Layout of a Research Paper, Writing a Research Report: Format and style. Review of literature and its implications, Major findings, Conclusions and outcomes. Reference formats, Leading Science Journals, Impact factor of Journals.

Unit-IV **8 h**

Publication Ethics: Ethics of scientific exhibits (visuals, graphs, charts, etc) – copy right and power point presentations, Ethical issues related to publishing, Plagiarism and Self Plagiarism – Turnitin (demo), COPE guidelines.

Recommended book:

S. Melville, W. Goddard. (1996) Research Methodology: An Introduction for Science and Engineering Students. Juta & Co Ltd, Land.

Suggested Readings

Joseph E. Harmon, Alan G. Gross (2007), On Early English Scientific Writing. The scientific literature, ISBN 9780226316567. The University of Chicago Press.

Day, Robert; Sakaduski, Nancy (2011). Scientific English: A Guide for Scientists and Other Professionals, Third Edition. ABC-CLIO. ISBN 978-0-313-39173-6. Greenwood.

Wendy Laura Belcher (2009). Writing Your Journal Article in 12 Weeks: A Guide to Academic Publishing.

Course outcome: *This course enables the students to apply their knowledge in publication ethics, impact factor and citation index and plagiarism which ultimately prepare the students become an innovative scientific researcher.*

RESEARCH METHODOLOGY – BIOSTATISTICS

Course Code: MICB-434
Total Number of Lecture hours: 32
Total Number of Credits: 02

Course objective: *Research methodology aims the students to learn specific procedures or techniques used to identify, select, process, and analyze information about a topic.*

Prerequisite: Masters students in Life Sciences

Unit -I **6 h**

Fundamentals of Biostatistics; sampling, Data collection and recording, Measures of Central Tendency - arithmetic mean, mode, median for ungrouped and grouped data.

Unit-II **4 h**

Measures of Dispersion: variance, standard deviation and standard error.

Unit -III **7 h**

Probability Rules and Theoretical Distributions: Basic probability rules, expectation, conditional probability; Probability distributions Bionomial, Poisson, Normal and Log-normal distributions; Fitting of probability distributions to environmental data

Unit -IV

7 h

Test of Significance: Null hypothesis and uses of t-test, F-test, X^2-tests; Correlation and Regression: Bi-variate data and scatter diagram; Simple (linear) correlation and regression; Coefficient of correlation and regression and their properties.

Unit -V **6 h**

Analysis of Variance: ANOVA - Computer applications in environmental modeling. Computer based modeling for population and population studies.

Recommended book:

Zar, Jerrold H. (1998). Biostatistical Analysis. Prentice Hall, N.J.

Suggested Reading

1. Walpole, R. and R. Myres (1993). Statistics for Engineers and scientists, 5th edn. Mac Millan, N.Y.
2. Wayne, R. Ott (1995). Environmental Statistics and Data analysis. CRC Press.
3. Manly (2001) statistics for environmental science and management, chapman and Hall/CRC

Course outcome: *In this course the students would learn data processing and validation methods in publications to prepare the students become an innovative scientific researcher.*

ENTREPRENEURSHIP AND MICROBIAL INDUSTRIES

Course Code: MICB-435
Total Number of Lecture hours: 40
Total Number of Credits: 03
Course objective: *This soft course was designed for students from all the science discipline. The course focuses on basics of Entrepreneurship, organisation and bioscience based investment.*

Pre-Requisite: Any MSc/ MSc integrated student can register for this course.

Unit-I **8 h**
Entrepreneurship- (Economical & social facts) – Entrepreneur- Identifying new opportunity – communicating ideas to business plan-Entrepreneurial exit strategy

Unit-II **8 h**

Entrepreneurial organization – Developing company – Firm development strategy - Firm development instruments – Legal and tax aspects of venture – lean start-up methodology

Unit-III **8 h**
Entrepreneur & company founder – starting own company – survival – steps to run the firm – public communication – pros/cons of being founder – current scenario of start-up industries

Unit-IV **8 h**
Bioscience based investment – business of science – scientific analyst – role of scientific analyst – decision to invest – marketing stocks – corporate financing

Unit-V **8 h**
Entrepreneurship in Biosciences – Developing project from idea to business plan – proof of concept – product development – biological products/drugs/device approval process-preclinical trials etc – intellectual property management and ways to protect new discoveries – Design and writing patent-commercialisation of Bio products

Text Books:

1. Craig Shimasaki. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Elsevier.

Suggested Reading:

1. Holger Palzelt (Editor), Thomas Brenner. (2008). Handbook of Bioentrepreneurship. Springer.

2. Khanka S.S. (2007). Entrepreneurial Development. Chand & company Ltd.

3. Cynthia Robbins-Roth. (1998). Alternative Careers in Science. Academic press.

***Course outcome*:** *After this course student will learn how to be an entrepreneur in biosciences.*

PUBLIC HEALTH MICROBIOLOGY

Course Code: MICB-436
Total Number of Lecture hours: 40
Total Number of Credits: 03

Course Objective:*This course aims to teach basics of public health, general concept of microbiology, causes, symptoms and prevention of infectious diseases.*

Pre-Requisite: Any MSc/ MSc integrated student can register for this course

Unit-I **8 h**

Introduction to Public health: Public health definition and approach. Public health Organizations and functions – (World health organization (WHO), Center for Disease control and Prevention (CDC), Occupational Safety and Health Administration (OSHA) and Public health organizations in India), Importance of public health Microbiology, Public health Diseases (Non communicable and communicable)

Unit-II **8 h**

Air and water borne diseases: bacterial, Viral and Fungal diseases. Analysis of microbial load in air and water, air sanitation, water treatment, control of Air and water borne diseases

Unit-III **8 h**

Food borne diseases: Food Hygiene, Food spoilage, Food poisoning and food borne infection. Types of food borne diseases (Typhoid, Cholera, Diarrhea, Food poisoning), control of food borne diseases.

Unit-IV **8 h**

Nosocomial Infection: Causes, Control, Prevention and surveillance. Disposal of infective hospital and laboratory materials – monitoring of sanitation in community. **Sexually transmitted Infections** (STI): HIV/AIDS, Hepatitis B, Syphilis, Genital herpes–diagnosis of hospital acquired infection

Unit-V **8 h**

Prevention and treatment of infectious diseases: Good hygiene and practices, Vaccines – types of vaccine, Vaccine schedule (India and United states), Modern development in Vaccine production, Antimicrobial agents (Antibacterial, antifungal, antiprotozoal, antiviral and antiretroviral drugs).

Text books

1. Mary Jane Schneider. (2017). Introduction to Public Health. 5th edition.

2. W. John Spicer. (2007). Clinical Microbiology and Infectious Diseases. Elsivier,

Suggested Reading:

1. Brownson, R.C., Baker, E.A., Leet T.L. and Follespie K.N. (2003). Evidence Based Public Health, Oxford University Press
2. Murray P.R., Pfaller M.A., Tenover F.C., and Yolken R.H. (2007). *Clinical Microbiology*, ASM Press.
3. Brownson, R.C., Baker, E.A., Leet T.L. and Follespie K.N. (2003) Evidence Based Public Health, Oxford University Press
4. Murray P.R., Pfaller M.A., Tenover F.C., and Yolken R.H. 2007. *Clinical Microbiology*, ASM Press.

Course Outcome: *Through this course students will be gain knowledge on microbial disease, their cause and transmission. The outcome of course will be helpful for students to practise safe and healthy life style.*

BIOMOLECULES

Course Code: MICB-437
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objective: *This course deals with important macromolecules in biological system viz. Carbohydrates, Proteins, Lipids, Nucleic Acids. It also deals with the major and minor bioelements like vitamins and metal ions. This syllabus will prepare students to study more advanced topics.*

Pre-Requisite: Any MSc/ MSc integrated student can register for this course

Unit-1 CARBOHYDRATES 10 h

Definition – classification - Structures and Properties of Simple Sugars - The Variety of Monosaccharides - conformation. Concept of epimer, isomer, enantiomer. Disaccharides scientific nomenclature, Polysaccharides - Conformations of Polysaccharide Chains. Homopolysaccharides - Heteropolysaccharides. Unbranched and Branched, Polysaccharides of Bacterial surfaces

Unit-2 LIPIDS AND STEROLS 10 h

Lipid Composition of Microorganisms - Naming of fatty acids, degree of unsaturation, essential and non-essential fatty acids, common types of membrane lipids: Phospholipids, Cholesterol, Glycolipids, Archaeal Lipids, ganglioside, cerebroside, sphingomyelin, triacylglycerols, arachidonic acid, prostaglandins, - properties, amphipathic molecules, micelle formation, liposomes, lateral diffusion, transverse diffusion, membrane fluidity, hydropathy plot, artificial membranes, lipid raft.

Unit-3 PROTEINS 10 h

The building blocks of proteins: amino acids, peptides, polypeptides - Amino acids: Classification of amino acids – molecular mass, properties of amino acids, Ramchandran Plot. Three dimensional structure of protein. Classification - Fibrous and globular proteins. Structural organization of proteins- Primary structure, Secondary structure- α-Helix, β- pleats and β – turn. Hierarchy of structural organization.

Unit-4 NUCLEIC ACIDS 10 h

Structure and Chemistry of Nucleotides - Names and Abbreviations. Acid–Base Chemistry and Tautomerism. Absorption of Ultraviolet Light. Base Pairs - Double Helices - The B Form of DNA. Other Double-Helical Forms of DNA - Ribonucleic Acids (RNA) - types - RNA Loops and Turns.

Unit-5 VITAMINS AND BIOELEMENTS 8 h

Vitamins: Classification, sources and properties - coenzymes - Bioelements: Major and minor bioelements, Trace and ultra-trace elements, their sources and some of their functions in microorganisms.

Recommended Text Books:

1. Nelson D. L. and Cox, M. (2008) M. Lehninger's Principle of Biochemistry. 5th edition. W. H. Freeman and company, U.S.A.
2. Metzler, D. E. (2003) Biochemistry: the chemical reactions of living cells. Second edition. Academic Press, U.S.A.
3. Frieden, E. (1984) Biochemistry of the essential ultra-trace elements. Plenium press, U.S.A.
4. Simmonds, R. J. (1992) Chemistry of Biomolecules: An Introduction. Royal society of Chemistry, UK

Suggested Reading:

1. Berg J. M., Tymoczko J. L.and Stryer L. (2006) Biochemistry. 6th edition. W.H. Freeman, U.S.A.
2. White D. (2000) Physiology and Biochemistry of Prokaryotes. 2nd edition. Oxford University Press, New York, U.S.A.

***Course Outcome*:** *Students will study the fundamental concepts of these biomolecules, their structures, types and biological importance*

MICROBIAL PHYSIOLOGY

Course Code: MICB-438
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objective: *Microorganisms have tremendous metabolic diversity hence it's intriguing to learn how these small creatures deal with different environmental conditions and either adopt themselves to it or convert it to favorable conditions by involving different physiological processes. It will elaborate the anaerobic respiration by variety of groups of microbes and non-genetic regulation at metabolic pathways.*

Pre-Requisite: Any MSc/ MSc integrated student can register for this course

Unit-1 **10 h**

METABOLIC DIVERSITY *Heterotrophic metabolism on substrates other than glucose* Hydrolysis of polymers - Starch hydrolysis, Cellulose hydrolysis, Oxidation of aliphatic hydrocarbons - Amino acid utilization: Oxidative deamination, Transamination - Methanotrophy; Characteristics of methanotrophs, Dissimilation of methane by methanotrophs

Unit-2 **10 h**

PHOTOSYNTHESIS AND INORGANIC METABOLISM

Characteristics and Metabolism of Autotrophs, Photosynthetic Bacteria and Cyanobacteria Autotrophic CO_2 Fixation and Mechanisms of Photosynthesis, Photosystem I and II in cyanobacteria - Nitrification: Nitrifying Bacteria, Ammonia oxidation, Nitrite oxidation, anaerobic nitrification - Sulfur bacteria and the oxidation of sulfur compounds

Unit-3 **10 h**

ANAEROBIC RESPIRATION

Denitrification: Biochemistry of denitrification, - Regulation of denitrification - Metal reduction: Fe(III) and Mn(IV) reduction, Metal reduction and the environment - Sulfidogenesis: Biochemistry of sulfidogenesis, Reduction of sulfate and sulfur, - sulphur reducing bacteria.

Unit-4 **8 h**

METABOLIC REGULATION:

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 a*spartate carbamoyl transferase

Unit-5 **10 h**

ADAPTIVE AND DEVELOPMENTAL CHANGES

Myxobacterial Developmental Cycle: Life Cycle of Myxobacteria, Aggregation and Fruiting Body Formation, Intercellular signaling in myxobacteria - *Caulobacter* Differentiation: Life Cycle of *Caulobacter crescentus,* The Stalk, the Holdfast, and the Flagellum: Structure. Genetics, and Regulation, Regulation and Checkpoints of the Cell Cycle of *C. crescentus* - Oxidative stress, Heat shock response, Response to changes in osmotic pressure, Chemotaxis

Recommended Text Books:

1. Moat A.G., Foster J.W. and Spector M.P.(2002). Microbial Physiology (4th edition). John Wiley and Sons, U.S.A.
2. Caldwell, D.R. (1995) Microbial Physiology and Metabolism, Wm. C. Brown Publishers, U.S.A.
3. White, D., (2003) The Physiology and Biochemistry of Prokaryotes. Second edition. Oxford University Press, UK
4. Gottschalk,G. (1985) Bacterial Metabolism, Second edition, Springer, U.S.A.

Suggested Reading:

1. Perry, J.J., Staley, J.T. and Lory, S. (2002). Microbial Life. Sinauer Associates, Publishers, Sunderland, U.S.A.
2. Schaechter, M. Ingraham, J.L. and Neidhardt, F.C. (2006). Microbe. ASM Press, U.S.A.
3. Tortora, G.J., Funke, B.R. and Case C.L. 2004. Microbiology-An Introduction. Benjamin Cummings. San Francisco. U.S.A.
4. Alcomo, I.E. (2001). Fundamentals of Microbiology. Sixth Edition, Jones and Bartlett Publishers, U.S.A.

Course Outcome: *The contents of this course will help students how microbes can grow on substrates other than glucose, their inorganic metabolism and photosynthesis and how do they respond to the changes in environment.*

MICROBIAL TECHNOLOGY

Course Code: MICB-541
Total Number of Lecture hours: 40
Total Number of Credits: 03

Course objective: *This course aims to introduce the basic and applied Microbiology. The contents of this course will help students to understand importance of microorganisms.*

Prerequisite: Masters students in Life Sciences

Unit-I **8 h**

Industrial Fermentation – role of microorganisms in food and dairy industry . Fermented beverages-beer, wine and other alcoholic beverages. Microbial preparation of Tempeh, sauerkraut, Miso, yogurt. Probiotics. Biomass production – Baker's Yeats, Single cell protein. Mushroom cultivation.

Unit-II **8 h**

Industrial Process: Antimicrobials, Organic acids and enzymes- microbial production of pencillin, Tetracycline and peptide antibiotics; Acetic acid; Lactic acid; Gluconic acid. Microbial production and commercial applications of Amylases, Proteases, Lipases. Biotransformation of steroids.

Unit-III **8 h**

Microbiology of wastewater and solid waste treatment: - biological, aerobic, anaerobic, primary, secondary and tertiary treatments. Trickling filter - Activated sludge and Anaerobic digestion process. Treatment of industrial effluents by microorganisms. Composting methods. Microbiology of degradation of xenobiotics – BHC, DDT and pesticides. Bioremediation of insecticides, pesticides and heavy metals.

Unit-IV **8 h**

Plant Growth Promoting Rhizobacteria (PGPR). Biofertilizers- *Rhizobium, Azospirillum, Azotobacter, Gluconacetobacter*, Azorhizobium, phosphobacteria - mycorrhizae - Blue Green Algae and Azolla. Biopesticides - *Bacillus thuringiensis*, NPV, *Beauveria bassiana*. Mass production of biofertilizers and biopesticides – integrated insect pest management.

Unit-V **8 h**

Green Energy: Renewable bioenergy using microorganisms – Methanogenesis, Methane production by anaerobic digestion of waste organic materials. Bioethanol and Biobutanolproduction by using microorganisms. Biohydrogen Generation, Microbial Fuel. Biodiesel from algae.

Recommended Text Books:

1. Prescott's Microbiology, Joanne M. Willey , Linda M. Sherwood , Christopher J. Woolverton 8th Edition McGraw-Hill Publishers.
2. Wulf Cruger and Anneliese Cruger., Biotechnoloogy, (A text book of industrial Microbiology), Panima Publishers, New Delhi, 2nd edition, 2003.

Suggested Readings

1. Prescott and Dunn, Industrial Microbiology, CBS Publishers, New Delhi, 4th Edition, 1987.
2. Waste Water Engineering - Treatment, Disposal and Re-use by Metcalf and Eddy, Inc.,Tata MacGraw Hill, New Delhi.
3. Pharmaceutical Microbiology – Edt. by W.B.Hugo & A. D. Russell Sixth edition. Blackwell scientific Publications.
4. Bioremediation by Baker K.H. And Herson D.S. 1994.. Mac Graw Hill Inc. N.Y.

Course outcome: *The students became trained manpower in microbial production of beverages, Antimicrobials, Organic acids and enzymes, Microbiology of wastewater and solid waste treatment, Plant Growth Promoting Rhizobacteria and Renewable bioenergy using microorganisms.*

MARINE MICROBIOLOGY

Course Code: MICB-542
Total Number of Lecture hours: 40
Total Number of Credits: 03

Course objective: *This course aims the students to learn the world's oceans and its unprecedented stresses due to human impacts such as increased nutrient runoff, over-fishing, and increased emissions of greenhouse gases that are causing pervasive changes in ocean chemistry and temperature. This paper is designed introduce the students to understand microbial processes and dynamics of marine environment.*

Prerequisite: Masters students in Life Sciences

Unit-I **8 h**

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 – Theory of hologenome (coral).

Unit-II **8 h**

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 biodeterioration of natural and synthetic materials

Unit-III **6 h**

Marine Microbial products: Microbial interaction Microbes of Biotechnological importance; Primary and secondary metabolites - enzymes, antibiotics, organic acid, toxins, biosurfactants and pigments

Unit-IV **9 h**

Microbes of extreme environments – mechanism of extremophiles – halophiles – halorhodopsin – deep sea microbes – microbes of hydrothermal vents - thermophilic, alkalophilic, osmophilic and barophilic, psychrophilic microorganisms – hyperthermophiles and halophiles – importance in biotechnology.

Unit-V **9 h**

Seafood microbiology - normal genera associated with fish, food spoilage, fish & human pathogens; zoonotics – *Vibrio parahaemolyticus,* Brief account on aquaculture pathogens - Vibriosis – fish and shrimp diseases – WSSV – MBV etc. Rapid diagnosis of contamination in seafoods and aquaculture products.

Recommended Text Books:

1. M.T. Madigan and J.M. Martinko (2006) Biology of Microorganisms, 11th Edition, Pearson Prentice Hall, USA.
2. Rheinhemer, G. (1980). Aquatic Microbiology, Johnwiley & Sons, pp. 235.

Suggested Readings:

1. Elay, A.R. (1992). Microbial food poisoning. Chapman and Hall, London, 191 pp.
2. Ford, T.E., (1993). Aquatic microbiology. An ecological approach. Blackwell scientificpublications,London, 518 pp.
3. Krichman, D.L. (2000). Microbial ecology of the oceans. Wiley – liss, New york, 542 pp
4. Bhakuni, D.S. and Rawat, D.S. (2005). Bioactive marine natural products. Anamaya Publishers, New Delhi.
5. Joseph Selvin and A. S. Ninawe (2009). Shrimp Disease Management. ANE Publishers.

Course outcome: *The basic knowledge and tools to predict how these changes will affect critical ocean ecosystems upon which society relies for many important functions.*

MICROBIAL NANOTECHNOLOGY

Course Code: MICB-543
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objectives: *The aim of the course is to provide basic knowledge about Nanobiotechnology, implications and the various applications in biomedicine*

Prerequisite: Masters students in Life Sciences

Unit-I **9 h**

Introduction to Nanotechnology: Characteristic scale for quantum phenomena, nanoparticles, nano-clusters, nanocomposite, nanotubes, nanowires and emergence of bionanotechnology. Characterization of nanoparticles – UV-Vis spectroscopy, Electron Microscopy – HRTEM, SEM, AFM, EDS, XRD.

Unit-II **9 h**

Microbial nanotechnology –Microbial synthesis of Nanoparticles. Synthesis of nanodrugs – metal nanoparticles and drug delivery vechicles – Nanoshells – Tectodentrimers Nanoparticle drug systems – Diagnostic applications of nanotechnology**.**

Unit-III **9 h**

Preparation of nanobiomaterials – Polymeric scaffolds collagen, Elastins: Mucopolysaccharides, proteoglycans, cellulose and derivates; Dextrans; Alginates;Pectins; Chitin. Nanoparticles – types, functions – Silver, Gold and Titanium. Physical and chemical properties of nanoparticles.

Unit-IV **12 h**

Nanoscale applications in biology and medicine: Nanotechnologies for biology and medicine - Micro- and nano- fluidics - Scanning probe microscopy in biology and medicine - Self-assembly of biological molecules. Nanobiotics, Application of Nanoparticles in theranostics, Drug delivery – protein mediated and nanoparticle mediated. Hybridconjugates of gold nanoparticles – DNA oligomers – use of DNA molecules in nanomechanics and Computing.Nanoparticles as carrier for genetic material. Genetically Modified Organisms (GMO) and applications.

Unit-V **9 h**

Implications of nanotechnology: Health and safety implications from nanoparticles: Health issues – Environmental issues – Need for regulation – Societal implications: Possible military applications – Potential benefits and risks for developing countries – Intellectual property issues – Criticism of Nanotechnology – Studies on the implications of Nanotechnology.

Recommended Text Books:

1. Pradeep T. (2012). Textbook of Nanoscience and Nanotechnology. McGraw Hill Education (India) Private Limited.
2. Murty B.S., Shankar P., Baldev Raj, Rath B. B., James Murday. (2013). Textbook of Nanoscience and Nanotechnology. Springer, Berlin, Heidelberg.
3. Risal Singh, Shipra Mital Gupta. (2016). Introduction to Nanotechnology: Understanding the Essentials, 1st edition. Oxford University Press.
4. Rakesh K. Tekade. (2019). Biomaterials and Bio-Nanotechnology, 1st edition. Academic Press.
5. David E. Reisner. (2011). Bionanotechnology II: Global Prospects. CRC Press.
6. Yubing Xie. (2017). The Nanobiotechnology Handbook, 1st edition. CRC Press.

Course Outcome*: Microbes play an important role in the synthesis of nanoparticles. This syllabus would enlighten the students to understand basic concepts and application of nanotechnology. The most important objectives that are frequently found in nanobiology involve applying nanotools to relevant medical/ biological problems and refining these applications. Developing new tools for the medical and biological fields is another primary objective in nanotechnology.*

AGRICULTURAL MICROBIOLOGY

Course Code: MICB-544
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objective: *This course designed to introduce the essential fundamentals of Agriculture Microbiology.*

Prerequisite: Masters students in Life Science

Unit-I **10 h**

Soil Environment- Microorganisms, soil structure, soil profile, Physico-chemical conditions, Microbial composition, sampling techniques, role of Microorganisms in organic matter decomposition (cellulose, Hemicellulose, Lignins). Bio-geo chemical cycles – Carbon cycle, Nitrogen cycle – Nitrogen fixation, nitrification, de-nitrification, sulphur, iron and phosphorus cycles. PGPR-Rhizosphere – Rhizosphere Microorganisms, Siderophores. PGPM-Plant growth promoting microorganisms. plant-microbe beneficial interactions. Mechanisms of plant growth promotion.

UNIT-II **10 h**

Major plant disease symptoms caused by fungi, bacteria and viruses. Plant diseases – Principles, symptoms and control measures of the following diseases: Fungal – Tikka, red rot of sugarcane, *Fusarium* wilts (red gram and cotton), *Sclerotium rolfsii* and *Macrophomina phaseolina* (collar rot disease, charcoal rot). Bacterial – Blight of rice, citrus canker, *Xanthomonas* (black rot). Viral and mycoplasmal – Bud necrosis of groundnut, citrus mosaic, little leaf of brinjal, tomato leaf curl. Principles of plant disease control. Protection - Diseases of field, vegetable, orchard and plantation crops of India and their control; causes and classification of plant diseases; principles of plant disease control biological control of diseases.

UNIT-III **10 h**

Biofertilizers – Introduction, biofertilizers using nitrogen fixing microbes – phosphate solubilization- *Rhizobium, Azotobacter, Azospirillum, Azolla*; *Anabaena* Symbiosis, blue green algae and Ecto- and Endomychorizae. Cultivation, mass production and inoculation of *Rhizobium, Azotobacter, Azospirillum, Azolla* and cyanobacteria, Carrier-based inoculants, methods of application, quality control, agronomic importance. Application methods for different biofertilizers – Vermicomposting.

UNIT-IV **9 h**

Biopesticides – Principles of biological control – antagonism, parasitism, *Bacillus thuringiensis, B. sphaericus, B. popilliae, Pseudomonas syringae*. Biocontrol- nematophagy - Microbial control of plant pathogens- *Trichoderma*. Useful genes from microorganisms for

agriculture (herbicide resistant, Bt, viral). Biological Control – Use of Baculovirus, NPV virus, protozoa & fungi in biological control.

UNIT-V **9 h**

Molecular plant microbe-interactions: 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 and biochemistry of biogas, bioethanol and other value added products.

Recommended Text Books:

1. Dirk J, Elas V, Trevors JT, Wellington, EMH (1997) Modern Soil Microbiology, Marcel Dekker INC, New York.
2. Agricultural Microbiology by G.Rangaswamy and Bagyaraj, Prentice Hall India.
3. Bio-fertilizers in Agriculture and Forestry, 1995, by N.S. Subba Rao.
4. Microbes For Sustainable Agriculture by K.V.B.R. Tilak, K.K. Pal, Rinku Dey
5. Soil Microbiology and Plant Growth, 1995, by N.S. Subba Rao.
6. Plant Growth and Health Promoting Bacteria by Dinesh K. Maheshwari
7. Plant-microbe interactions, Volume 1 by Gary Stacey and Noel T. Keen
8. Biological control of crop diseases Volume 89 of Books in soils, plants, and the environment by S. S. Gnanamanickam
9. Plant-microbe interactions and biological control Volume 63 of Books in soils, plants, and the environment by Greg J. Boland, L. David Kuykendall

Course outcome: *This course focuses on the concepts of Agricultural Microbiology such as Soil Environment, Major plant diseases caused by fungi, bacteria and viruses, biopesticides & biofertilizers and plant microbe-interactions*

FERMENTATION TECHNOLOGY

Course Code: MICB-545
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objective*: This course aims to introduce technological advancement of fermentation and bioprocess for industrial applications.*

Prerequisite: Masters students in Life Sciences

Unit-I **10 h**

Introduction to fermentation technology: Interaction between chemical engineering, Microbiology and Biochemistry. History of fermentation. Introduction to fermentation processes, Microbial culture selection for fermentation processes - Fermentation Pathways for Industrial Products: Biochemical pathways of metabolic reactions for utilization of carbon sources and formation of different metabolites by micro organisms; possibility of control of the reactions for the increased formation of useful metabolites. Strain Development - Various techniques of modifying the strains for increased production of industrial products.

Unit-II **10 h**

Fermentation process: Growth of cultures in the fermenter Importance of media in fermentation, media formulation and modification. Kinetics of growth in batch culture, continuous culture with respect to substrate utilization, specific growth rate, steady state in a chemostat, fed-batch fermentation, yield of biomass, product, calculation for productivity, substrate utilization kinetics. Fermentation process: Inoculum development. Storage of cultures for repeated fermentations, scaling up of process from shake flask to industrial fermentation - cell and enzyme immobilization.

Unit-III **9 h**

Bioreactors: Design of a basic fermenter, bioreactor configuration, design features, individual parts, baffles, impellers, foam separators, sparger, culture vessel, sterilization of media - cooling and heating devices, probes for online monitoring, computer control of fermentation process-PID, measurement and control of process. Reactors for specialized applications: Continuous Stirred Tank Bioreactor, Airlift Bioreactor, Fluidized Bed Bioreactor, Packed Bed Bioreactor, Photobioreactor and Membrane Bioreactor.

Unit-IV **9 h**

Downstream Processing: Introduction, removal of microbial cells and other solid matters, Filtration: Theory, Batch filters (plate and frame filters, pressure leaf filters), Continuous filters (rotary vacuum, Cross flow filtration); Centrifugation, Cell aggregation and flocculation, Types of centrifuges (basket centrifuges, tubular bowl centrifuge etc); Cell disruption: Physical mechanical methods and chemical methods - solvent extraction of product; evaporation chromatographic systems for separation and crystallization; drying techniques

Unit-V **10 h**

Bioprocess economics - Bioproduct regulation - General fermentation economics. Intellectual Property Rights (IPR), Patents, Trademarks, Copyrights, Secrets, Patenting of biological materials, international cooperation, obligations with patent applications, implication of patenting, current issues, hybridoma technology etc. Patenting of higher plants and animals, transgenic organisms and isolated genes, patenting of genes and DNA sequences.

Recommended Text Books:

1. Stanbury, P.F., Whitekar A. and S.J. Hall. (1995). Principles of Fermentation Technology. Pergaman. McNeul and Harvey.
2. McNeil B. and L. M. Harvey (1990). Fermentations - A practical approach. IRL Press.
3. Sven-Olof Enfors (2000). Bioprocess Technology: Fundamentals and Applications. Royal Institute of Technology
4. Creuger A. and Creuger W. (1984). Biotechnology- A textbook of Industrial Microbiology Oxford University Press
5. Vogel, H.C. and C.L. Todaro, (2005). *Fermentation and Biochemical Engineering Handbook : Principles, Process Design and Equipment*. 2nd Edition, Standard Publishers.

Suggested Reading:

1. Biely, J.E. and Ollis D.F (1986). Bio Chemical Engineering Fundamentals Megraw Hills.
2. Moo-Young M (2011). Comprehensive Biotechnology, Elsevier.
3. Brian Currell, R. C. Van Dam Mieras (1997). Biotechnological Innovations in Chemical Synthesis. BIOTOL. Publishers / Butterworth.
4. Christoph Wittmann, James C. Liao, Sang Yup Lee, Jens Nielsen, Gregory (2017). Industrial Biotechnology: Microorganisms. Wiley-VCH.

Course Outcome: *Microorganisms are capable of growing on a wide range of substrates and can produce a remarkable spectrum of products. This course will enlighten the students on basics of fermentation, metabolic engineering, fermenter design and downstream processing. The economics and IPR of industrial products are introduced to understand commercialization of microbial products.*

GENOME TECHNOLOGY

Course Code: MICB-546
Total Number of Lecture hours: 40
Total Number of Credits: 03

Course objective: *The Genome Technology course aimed to transform advanced developments in genomic science to the students.*

Prerequisite: Masters students in Life Sciences

Unit-I **8 h**

An introduction to genetic technology -Enzymes used in genetic engineering- Restriction endonucleases, DNA polymerases, Reverse transcriptase, Ligases, Polynucleotide kinase, Alkaline phosphatase, Nucleases, Klenow fragment, Terminal deoxynucleotidyl transferase, RNase. Vectors for cloning- Plasmids, Bacteriophage , Filamentous phage vectors, Cosmids, Phagemids, PACs, YACs. Ligation of DNA fragments with vectors - Homopolymer tailing, Ligation of cohesive termini, Blunt-end ligation, Linker molecules.

Unit-II **8 h**

Introducing genes into bacterial systems- Natural gene transfer methods-Transformation, transduction, calcium chloride mediated transformation, Transfection with phage vectors. Introducing genes into eukaryotes- Gene transfer by viral transduction, Calcium phosphate mediated transformation; Liposome mediated transformation, Microinjection, Electroporation.

Unit-III **6 h**

Producing genomic libraries, Genomic libraries in high-capacity vectors, cDNA cloning, Shotgun cloning, Cloning in *E.coli*, Identifying the recombinant DNA and its products- Genome Engineering, genome editing and CRISPR-CAS tools.

Unit-IV **9 h**

Prokaryotic expression systems Gene expression based on bacteriophage T7 RNA polymerase, Eukaryotic expression systems- Fused genes, Unfused genes, Secreted proteins, Gene expression by transcription factors- Nfkb, PPAR, Antisense RNA technology- SiRNA, miRNA.

Unit-V **9 h**

Techniques in genetic technology- Hybridization technique, Southern**,** Northern-Western blotting techniques, Site directed mutagenesis, Restriction mapping, DNA profiling in forensic science, Chromosome walking, Chromosome jumping, DNA sequencing, PCR. Basic concepts of Intellectual property rights.

Recommended Text Books:

1. Sandy B. Primrose, Richard Twyman (2004), Genomics : Applications in Human Biology. Wiley and Sons.
2. Mount D (2004). Bioinformatics: Sequence and Genome Analysis by. Cold Spring Harbor Laboratory Press, New York.

Suggested Reading:

1. Diana Marco (2014). Metagenomics of the Microbial Nitrogen Cycle: Theory, Methods and Applications Book: 978-1-908230-48-5. ebook: 978-1-908230-60-7, Caister Academic Press.
2. Pilar Francino, M (2012). Horizontal Gene Transfer in Book: 978-1-908230-10-2. ebook: 978-1-908230-72-0, Caister Academic Press.
3. Muhammad Jamal (2017). The CRISPR/Cas System: Emerging Technology and Application. Caister Academic Press.
4. Manuel Fuentes, Joshua LaBaer (2014). Proteomics: Targeted Technology, Innovations and Applications. Book: 978-1-908230-46-1. ebook: 978-1-908230-62-1. Caister Academic Press.
5. Patrick Arbuthnot and Marc S. Weinberg (2014). Applied RNAi: From Fundamental Research to Therapeutic Applications. Book: 978-1-908230-43-0. ebook: 978-1-908230-67. Caister Academic Press.
6. Jianping Xu (2014). Next-generation Sequencing: Current Technologies and Applications. Edited by: Published: 2014 Book: 978-1-908230-33-1. Ebook: 978-1-908230-95-9. Caister Academic Press.
7. Maria S. Poptsova (2014). Genome Analysis: Current Procedures and Applications. Book: 978-1-908230-29-4. ebook: 978-1-908230-68-3. Caister Academic Press.
8. Diana Marco (2011). Metagenomics: Current Innovations and Future Trends. Book: 978-1-904455-87-5. Horizon Scientific Press.
9. S. B. Primrose (2002). Principles of Genome Analysis. A Guide to Mapping and Sequencing DNA from Different Organisms. Blackwell publishing.

Course outcome*: This course would develop the students became knowledgeable/skilled in new methods, technologies and instruments that enable rapid, low-cost determination of DNA sequence, SNP genotyping, functional genomics and synthetic biology.*

DRUG DESIGN AND DISCOVERY

Course Code: MICB-547
Total Number of Lecture hours: 48
Total Number of Credits: 03

Course Objectives*: Drug Design and Discovery course introduce the basic principles of modern drug design, discovery and development. The course deals with the different source of drug with specific focus on microbial source, drug development and manufacturing process.*

Prerequisite: Masters students in Life Sciences

Unit-I **9 h**

Introduction- History of drug design, Current approaches and philosophies in drug design, Molecular mechanisms of diseases and drug action with examples. Pharmaceutical products, Pharmaceuticals of microbial origin (macrolides, ansamycins, Peptide and other antibiotics) animal origin (sex hormones androgens, Oestrogens, Progesterone and progestogens etc), plant origin (Alkaloids Atropine and scopolamine Morphine and cocaine Additional plant alkaloids)

Unit-II **10 h**

Sources of Drugs- Microbial drugs, Plants as a source of drugs, E. coli as a source of recombinant therapeutic proteins. Expression of recombinant proteins in yeasts, animal cell culture systems. Additional production systems: Fungal production systems, Transgenic animals, Transgenic plants and Insect cell-based systems. Rational drug design and Combinatorial approaches to drug discovery, Antibody Drug Conjugates.

Unit-III **10 h**

Drug development process- Impact of genomics and related technologies upon drug discovery: Gene chips, Proteomics, Structural genomics and Pharmacogenetics, Model systems in the development of drugs, Nanoscaffolds for Drug Delivery.
Drug manufacturing process- Guides to good manufacturing practice, Production of final product - Cell banking systems, Upstream processing, Microbial cell fermentation, Mammalian cell culture systems, Downstream processing, Final product formulation, Freeze-drying, Labelling and packing.

Unit-IV **10 h**

Vaccines and adjuvant- Traditional vaccine preparations, attenuated, dead or inactivated bacteria, Attenuated and inactivated viral vaccines, Toxoids, antigen-based and other vaccine preparations. Impact of genetic engineering on vaccine technology. Peptide vaccines Vaccine vectors. Development of an AIDS vaccine, Difficulties associated with vaccine development, AIDS vaccines in clinical trials, Cancer vaccines, Recombinant veterinary vaccines. Adjuvant technology: Adjuvant mode of action, Mineral-based adjuvants ,Oil-based emulsion adjuvants Bacteria/bacterial products as adjuvants, Biosimilars.

Unit-V **9 h**

Nucleic acid as drugs- Gene therapy: Basic approach to gene therapy, Vectors used in gene therapy -Retroviral vectors, Additional viral-based vectors, Manufacture of viral vectors, Non-viral vectors. Gene therapy and genetic disease, cancer, Gene therapy and AIDS. Gene-based vaccines.

Recommended Text Books:

1. Kristian Stromgaar, Povl Krogsgaard-Larsen and Ulf Madsen (2017). Textbook of Drug Design and Discovery, Fifth Edition, CRC press, 2017.
2. Thomas J. Dougherty and Steven J. Projan. Microbial Genomics and Drug Discovery, Taylor and Francis, 2003.

Reference Books:

1. Kenneth M. Merz, Dagmar Ringe and Charles H. Reynolds. Drug Design: Structure- and Ligand-Based Approaches, Cambridge University press, 2010.
2. Kristian Stromgaar, Povl Krogsgaard-Larsen and Ulf Madsen (2017). Textbook of Drug Design and Discovery, Fifth Edition, CRC press, 2017.
3. David B. Weiner and William V. Williams. Biological Approaches to Rational Drug Design (Handbooks in Pharmacology and Toxicology) CRC press, 1994.
4. Gary Wlash (2004). Biopharmaceuticals, Biochemistry and Biotechnology. 2nd edition. Wiley publisher.

Course Outcome: *The course will imparts knowledge on detection, selection, and validation of new antibacterial targets, vaccines and the use of gene technology in pharmaceutical industry.*

BIOSAFETY, BIOETHICS & IPR

Course Code: MICB-548
Total Number of Lecture hours: 40
Total Number of Credits: 03

Course Objective: *This soft course teaches student about biosafety, bioethics and IPR, which are highly essential and must to learn for science students.*

Pre-Requisite: Any MSc/ MSc integrated student can register for this course.

Unit-I **8 h**

Introduction to Biosafety: Biological laboratory, Biosafety, Need for biosafety, Good laboratory practices (GLP) - Fundamental points and resources of GLP, Standard operating procedures (SOPs), Implementation of GLP.

Unit-II **8 h**

Biosafety levels: Types of biosafety levels (Biosafety level I, II, III, IV), Requirements of Biosafety levels, Operational guidelines for biosafety levels. Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals

Unit-III **8 h**

Biosafety facilities: Animal Biosafety facilities (ABSL), Plant Biosafety facilities (PBSL), Aquatic organism Biosafety facilities (AQBSL), Operational guidelines for ABSL, PBSL, AQBSL.

Unit-IV **8 h**

Bioethics: Introduction to Ethics, Ethical issues in Biosciences, Ethical committee, Guidelines for research that involve animals, Human, Microorganism, Genetic engineering, Gene therapy, organ transplantation & Stem cells.

Unit-V **8 h**

IPR: Intellectual Property (IP), types of IP, (Patents, Trademarks, Copyright & Related Rights, Industrial Design), importance of IPR, legal protection of bioscience discoveries (patentable and non patentable). Procedure for filing Indian, International and US patent.

Reference Books:

1. Lewis Vaughn. Bioethics: Principles, Issues and Cases, 2nd Edition. Oxford University Press
2. Deepa Goel, Shomini Parashar. (2013). IPR, Biosafety and Bioethics.Pearson.

Suggested Reading:

1. Handbook Good Laboratory Practices, World Health Organization, Second edition.
2. Regulations and guidelines on biosafety of recombinant DNA research and biocontainment, DBT, Government of India, 2017.

Course Outcome: *Through this course students will acquire knowledge on good laboratory practise, safety guidelines and ethics to be followed in science. This course will be helpful for student to perform best in bioscience laboratory.*