This
M.Sc. Microbiology Syllabus
Is Effective in Sessions

2023-2025

2024-2026

2025-2027

MSc MICROBIOLOGY PROGRAM

RESTRUCTURED SYLLABUS AS PER NEW EDUCATION POLICY 2020

DATE OF SUBMISSION: 12.7.2023

DEPARTMENT OF LIFE SCIENCES & BIOTECHNOLOGY

CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY, KANPUR

Learning Outcome Based Curriculum Framework

M. Sc. Microbiology (Revised as per NEP 2020)
(Introduced from Academic Year 2004-)

1. Preamble-

Microbiology is the study of organisms, most of which are too small to be seen with the naked eye, their interactions with humans, animals, plants, and the environment, and their applications. These microorganisms have vital significance in human development as they can be exploited for several beneficial aspects while many cause devastating damage and sufferings affecting health and causing destruction. Understanding the intercellular interactions and behavioral physiology of these microorganisms through basic sciences such as genetics, cellular & molecular biology as well as their biochemical analysis has burgeoned a number of applied microbiology fields such as Agriculture Microbiology, Industrial Microbiology, Medical and Clinical Microbiology, Infectious Immunobiology, Microbial Biotechnology, Pharmaceutical Microbiology, Food & Beverage Microbiology and Environmental Microbiology. Syllabus helps in qualifying CSIR -JRF/NET, and after completion of course students peruse research in various fields and different industries. The post graduate course has been developed under the Learning Outcome Curriculum Framework under the recommendations and guidance of the University Grants Commission (UGC). Keeping in view the post graduate attributes of the subject, the learning outcomes were envisioned. The curriculum was based on the learning outcomes. It is envisaged that the students obtaining training under this curriculum will develop the necessary skill sets, technical knowledge and ethics taught under this program, keeping in view the postgraduate attributes.

MSc Microbiology program is a two-year duration with 4 semester system. There are 4 compulsory theory courses and one practical course offered in each semester.

Assessment is in the form of continuous assessment mode with internal and external examination. Within the semester, assessment tasks associated with each unit of the coursework learning of the knowledge and skills will enhance the teaching – learning process. Students perform a research project in all the semester that will enable them to address research problems relevant to society as well as the field of microbiology. As per the New Education Policy, research work has been incorporated in all the 4 semesters of the course. A major research project to be conducted in the form of research/ industrial training/ survey/ internship will provide hands and skill based training to the students in specialized areas of Microbiology. A minor elective in the first year of the course work will expose students to subjects in different faculty.

2. Learning Outcomes based approach to Curriculum Planning:

The learning outcomes based curriculum framework for MSc Microbiology defines understanding and knowledge of the subject as well as the technical and practical aspects such as students graduating in microbiology demonstrate the requisite skills required to function as a competent microbiologist after acquiring the degree. The students are also trained in such a way that they develop critical thinking and problem solving as related to the microbiology which can be applicable in any field of research, industry as well as academia. The curriculum developed, teaching–learning outcomes and the assessment strategies are such that the students are able to apply their knowledge and training of microbiology to solve the problems of microbiology as these exist or appear from time to time in the society.

3. Postgraduate Attributes in Microbiology:

- Develop highly skilled and knowledgeable members of the society that can use their enhancements for solving real life problems
- Develop outlook and attitude, develop the current skills and abilities, learn new capability to contribute as global citizens.
- Develop a research oriented, problem and critical thinking outlook towards to different problems and have ability to think through in out of box innovative manner using skills and training imparted to them.
- Enhance student's academic career of the students, increase their employability, train them as entrepreneurs
- Enhance abilities to develop a positive approach, requisite soft skills, socialistic approach, team contributors, leadership qualities for successful career and personal life choices.
- Provide highly skilled and knowledgeable human resources for all domains of scientific quests such as agricultural sector, food industry, dairy industry, medical and paramedical field, pharmaceutical, space research and research institutes.

4. Vision Statement of MSc program

The M.Sc. Microbiology Course is offered with the aim to produce microbiologists of excellent caliber, with good research, teaching and technical skills and at the same time being sensitive to the needs of the society and environment

5. Mission Statement

The mission of the Department of Microbiology is to provide:

1. A learning environment that encourages post graduate student about microbiology and the its applications in different fields of science
2. Fundamental research training for students who will become future leaders in science, medicine, and industry;

3. Create awareness about the significance and scope of Microbiology amongst students and local and global citizens through research, awareness programs, conferences, seminar organizations
4. Conduct research that advances the frontiers of knowledge in the field of microbiology

6. Objectives of the Programme

The aim and objectives of the M.Sc. Microbiology program essentially focus to develop skills of student for a successful career.

A. The course structure emphasizes to put enough efforts in theory as well as laboratory work so as to gain thorough knowledge of the subject.
B. The course includes project work that would develop and nourish the scientific approach and research attitude of the students.
C. Genetic engineering, Biotechnology, Bioinformatics, Immunotherapy, nanobiotechnology, Omics technologies are the new horizons of the interdisciplinary subject Microbiology which might provide solutions to various problems of the society. The course work is essentially framed to acquaint the students with all the recent advances in this field.
D. It is compulsory & essential for the students to read research papers, publications and deliver seminars that would better help them to know the recent advances in the subject and also develop the communication skills.
E. The program is designed in such a way that it is essential for the students to read original publications, put enough efforts in laboratory work for practicals and project, be acquainted with all the recent advances in the field like Bioinformatics, drug designing and develop all the skills for a successful career.
F. Programme includes value added courses as well as skill enhancement courses

7. Programme Outcomes:

The aim and objectives of the M.Sc. Microbiology program essentially focus todevelop skills of student for a successful career.

MSc MICROBIOLOGY PROGRAMME OUTCOME	
PO1	**Domain knowledge**: demonstrate knowledge of basic concepts, principles and applications of specific science discipline
PO2	**Resource utilization:** cultivate skills to acquire and use appropriate learning resources including library, e-learning resources, ICT tools to enhance knowledge based and stay abreast of recent developments
PO3	**Analytical and Technical Skills**: Ability to handle/use appropriate tools/techniques/equipment with an understanding the standard operating procedures, safety aspects/limitations
PO4	**Critical thinking and problem solving**: Identify and critically analyse problems in discipline with appropriate tools/techniques/approaches to arrive at viable conclusions/solutions
PO5	**Effective Communications**: Communicate effectively in spoken and written forms.

	Demonstrate ability to make presentations, write reports, dissertation etc
PO6	**Environment and Society**: Analyse impact of scientific and technological advances on environment and society and need for sustainable development
PO7	**Ethics**: Commitment to professional ethics and responsibility
PO8	**Innovation and Entrepreneurial skills:** Develop zeal and ability to work towards innovative solutions by identifying research problem, design experiments and analyse results and interpret to explore innovative solutions. Develop entrepreneurial mind set towards science and technology

8. Programme Specific Outcomes:

At the end of this course the students will be able to:

MSc MICROBIOLOGY PROGRAMME SPECIFIC OUTCOMES	
PSO1	Able to apply the knowledge and skill based microbiological training for addressing research problems related to any discipline
PSO2	Demonstrate knowledge and understanding of microbiological problems and solve scientific and technological issues.
PSO3	Perform duties as research fellows/scientist/ microbiologist in biological sciences.
PSO4	Learn desired microbiological skills and techniques through understanding principles, performing practicals and research project training
PSO5	Eligible for jobs as microbiologist in food and beverages industry, pathology laboratories, microbial testing of any product to certify quality control and assurance
PSO6	Contribute to the development of innovative and creative scientific knowledge, technology development and creators of entrepreneurs and self sustainable individuals

9. Course duration and Eligibility Criteria:

The M.Sc. degree course will be of two years duration.

Admission to M.Sc. (Microbiology) course shall be open to a student who holds a Bachelor's degree (B.Sc./ B.Tech./ B.Pharma/ B.V.Sc./M.B.B.S.) with any of the subjects amongst Zoology, Botany, Chemistry, Microbiology, Biochemistry, Environmental Science, Biotechnology, Mathematics, Physics, Medical Laboratory Technology, Medical Microbiology, Bioinformatics, Food Technology, Nutrition Science, Computer Science, Hospital Administration and allied subjects at Bachelor level with minimum marks prescribed by the University (relaxation of 5% for SC/ST students).

10. Total intake capacity: 30 (can be changed as per University norms).

11. Medium of Instruction: English

REVISED SYLLABUS NEP 2020: MSc MICROBIOLOGY, CSJM UNIVERSITY, KANPUR
PROPOSED EFFECTIVE DATE: JULY 2023 ACADEMIC SESSION

I[ST] YEAR / I[ST] SEM						
COURSE CODE	TYPE	COURSE TITLE	MINIMUM CREDITS	CIA	ESE	MAX. MARKS
L040701TN	CORE	General Microbiology	4	25	75	100
L040702TN	CORE	Biochemistry	4	25	75	100
L040703TN	CORE	Analytical Techniques and Biostatistics	4	25	75	100
L040704TN	CORE	Cellular Microbiology	4	25	75	100
L040705PN	PRACTICAL	PRACTICALS	4	25	75	100
	PROJECT	Review writing/ Synopsis presentation/ Internship/ Project				-
	MINOR ELECTIVE *	From any Other Faculty/MOOC	4	25	75	100
			24			**600**
I[ST] YEAR / II[ND] SEM						
L040801TN	CORE	Bacterial Metabolism and Physiology	4	25	75	100
L040802TN	CORE	Fundamentals of Molecular Biology	4	25	75	100
L040803TN	CORE	Recombinant DNA Technology	4	25	75	100
L040804TN	OPEN ELECTIVE	Virology	4	25	75	100
L040805TN		Mycology and Phycology				
L040806PN	PRACTICAL	PRACTICALS	4	25	75	100
L040807RN	PROJECT	Review writing/ Synopsis presentation/ Internship/ Project #	8	25	75	100
TOTAL			28			**600**
II[ND] YEAR / III[RD] SEM						
L040901TN	CORE	Microbial Genetics	4	25	75	100
L040902TN	CORE	Cellular and Molecular Immunology	4	25	75	100
L040903TN	CORE	Agriculture and Environmental Microbiology	4	25	75	100
L040904TN	ANY TWO ELECTIVES TO BE CHOSEN	Marine Microbiology	4	25	75	100
L040905TN		Microbial Genomics, Proteomics and Bioinformatics	4	25	75	100
L040906TN		Bioethics, Biosafety and Intellectual Property Rights (IPR)				
L040907TN		Molecular Host Microbe Interactions				
L040908TN		Food Microbiology				
L040909TN		Medical Microbiology				
L040910PN	PRACTICAL	PRACTICAL	4	25	75	100
	PROJECT	RESEARCH PROJECT/ DISSERTATION				-

TOTAL			24			600
II[ND] YEAR / IV[TH] SEM						
L041001TN	CORE	Industrial Microbiology	4	25	75	100
L041002TN	ANY ONE ELECTIVE TO BE CHOSEN	Pharmaceutical Microbiology	4	25	75	100
L041003TN		Nanobiotechnology				
L041004TN		Advanced Immunology & Immunotechniques				
L041005TN		Entrepreneurial Microbiology				
L041006TN		Extreme Microbiology				
L041007TN		MOOC				
L041008RN	PROJECT	Summer internship/ Training/ Review writing/ Case study #	4	25	75	100
L041009RN	PROJECT	RESEARCH PROJECT/ DISSERTATION##	12	50	150	200
TOTAL			24			500
GRAND TOTAL			100			2300

CIA: Continuous Internal Assessment ESE: End Semester Examination

NOTE:

1. *A MINOR ELECTIVE FROM OTHER FACULTY SHALL BE CHOSEN IN 1ST YEAR (EITHER Ist / IInd SEMESTER) AS PER AVAILABILITY.
2. In First year of PG program, there will be a Review writing/ Synopsis presentation/ Internship/ Project as per guidelines issued earlier, and will be of 4 credit (4 hr/week), in each semester. The student shall submit a report/dissertation for evaluation at the end of the year, which will be therefore of 8 credit s and 100 marks
3. #Summer internship will be undertaken during summer vacation that falls between II and III semester of the programme, the report along with certificate shall be submitted and evaluated in IV semester, and its credit will also be counted in IV semester.
4. Summer Internship can be done in form of Internship/Survey/Field work/Research project/ Industrial training/ Review, and a report/dissertation shall be submitted that shall be evaluated via seminar/presentation and viva voice.
5. Any course from MOOCS of the relevant discipline may be selected after approval from coordinator & Head / Director as 10th semester elective paper.
6. ##In second years of M.Sc. Microbiology program, there will be a Research Project or equivalently a research-oriented Dissertation as per guidelines issued earlier and will be of 6 credit (6 hr/week), in each semester. Student will submit Project Report/ Dissertation at the end of 4th semester that will be evaluated for 12 credit hours for a total of 200 marks. The evaluation shall be done by seminar/presentation and viva voice.
7. The student straight away will be awarded 25 marks if he/she publishes a research paper on the topic of Research Project or Dissertation.

Semester I

L040701T GENERAL MICROBIOLOGY

Course Objectives: The objective of the course is to understand basic working principles in microbiology and have knowledge for differentiating different microbial forms.

Course Outcomes:

CO1. Demonstrate theory and practical skills in microscopy and their handling techniques and staining procedures

CO2. Identify use of different culture media and their applications and microbial techniques for microbial growth estimation, cultivation and culture preservation for routine microbiological skill handling

CO3. Develop methods associated with the various physical and chemical growth requirements of bacteria and get equipped with various methods of disinfection and sterilization.

CO4. Understand different systems for microbial classification and nomenclature for study of biodiversity.

CO5. Apply the knowledge to understand the differentiating microbial characteristics for their identification and further characterization

Course Content:

Unit 1: History, development and scope of microbiology. Major contributions of scientist to microbiology (Antony van Leeuwenhoek, Lazzaro Spallanzani, John Tyndall, Louis Pasteur, Joseph Lister, Iwanowski, Robert Koch). #Contribution of Indian researchers, Indian Knowledge System, Pure culture Isolation Techniques; Microscopy and preparation of microbial samples: wet mount, smear; Staining: types; simple and differential staining

Unit 2. Nutritional requirement and Growth of microorganism: culture media- types, factors affecting growth, Measurement of growth, growth phases, growth kinetics, diauxic growth, synchronous and asynchronous culture; batch, fed batch and continuous culture; Growth of aerobic and anaerobic bacteria. Culture preservation and Culture Collection.

Unit 3: Physical and Chemical control of microorganisms: Disinfectants and Sterilization principles. Antimicrobial chemotherapy

Unit 4. Microbial Taxonomy, Systematics, Phylogeny and Nomenclature. Hierarchial organization of organisms- Haeckel, Whittaker and Woese classification. Numerical and Chemotaxanomy of microorganism. Salient features of archaebacteria and eubacteria. Classification of bacteria according to Bergey's Manual of Determinative Bacteriology.

Unit 5. Differentiating features, habitats, reproduction and classification of Mollicutes, Slime Molds, Algae, Fungi, Viruses

Suggested Reading:

1. Microbiology. Prescott LM, Hurley JP, Klein DA. Microbiology- Edition. McGraw Hill Publication, New York
2. Microbiology. M J Pelczar, Chan, Krieg. 5th Edition. Mc Graw Hill
3. Microbiology. RP Singh. Kalyani Publisher
4. Textbook of Microbiology. Dubey & Maheshwari. S Chand Publications.

L040702TN BIOCHEMISTRY

Course Objectives:

1. The primary objective of the course is to build a strong foundation in the area of structure and function of biomolecules and their metabolism.
2. The major objective of this paper is to develop a clear understanding of various aspects of biomolecules, their structure and function. Enzymes their kinetic behavior along with diverse metabolic pathways to enable students to better understand courses taught later such as Molecular biology and recombinant DNA technology.

Course Outcomes:

Upon successful completion of the course, the student:

1: To know the basic concept of life on the molecular level.
2: Chemical nature of biomolecules, its arrangement and interaction with other biomolecules.
3: To understand the properties of biomolecules and their importance in biological systems.
4: Understanding of concepts of acids, bases, indicators, pKa values, etc. Acquiring skill to determine pKa value of amino acids.
5: Will have learnt basic concepts of enzyme biochemistry, its kinetics and regulation and details of protein, lipid and nucleotide metabolism in E. coli and eukaryotes and its regulation.

Course Content:

Unit 1: Contribution of Indian Researchers in biochemistry, Composition, structure and function of biomolecules –carbohydrates-mono, di and polysaccharides, lipids - storage and structural lipids, proteins - amino acids, peptides, primary, secondary, tertiary and quaternary structure of protein, nucleic acids –Nucleotides and nucleic acid structure. Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).

Unit 2: Principles of biophysical chemistry water, ionization of water, weak acids, and weak bases, pH, buffer, Henderson Hasselbalch equation, biological buffer.

Unit 3: Principles of catalysis, enzymes, its classification and enzyme kinetics, MichaelisMenten equation. regulatory enzymes, Allosteric enzymes, enzyme inhibition, mechanism of enzyme catalysis, isozymes, coenzyme.

Unit 4: Thermodynamics endergonic and exergonic processes, enthalpy, entropy, free energy change, law of thermodynamics, Bioenergetics, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers.

Unit 5: Metabolism of carbohydrates (Glycolysis, Kreb cycle, Gluconeogenesis), lipids (beta oxidation, ketone bodies, biosynthesis of fatty acid), amino acids (amino acid oxidation and urea cycle) nucleotides (degradation and biosynthesis of nucleotides).

Suggested Reading:

1. Lehninger Principles of Biochemistry, Nelson and Cox, Macmillan Higher education
2. Biochemistry. R. H. Garret and C. H. Grishm Nelson Education ltd.
3. Biochemistry Voet and Voet

L040703T: ANALYTICAL TECHNIQUES AND BIOSTATISTICS

Course Objectives:

To introduce the student to the variety of biophysical and biochemical techniques currently available to probe the structure and function of the biological macromolecules, make them aware of the physical principles behind each technique and the instrumentation involved, make them familiar with various methods of analyzing the output data.

Course Outcomes:

Upon successful completion of the course, the student will:

1. Learn about the principle, working and applications of commonly used instruments in microbiology.
2. Get knowledge of applications of different separation and analytical techniques such as electrophoresis, centrifugation, chromatography, etc.
3. Students will be able to handle, calibrate and use the instruments.
4. To formulate basic understanding of biostatistics.
5. To create and grasp the information on kinds of biological data, collection of data and statistical analysis.

Course Content:

Unit 1: Contribution of Indian scientists in various techniques.
Electrophoretic Techniques-Theory and application of polyacrylamide and agarose gel electrophoresis, native and SDS PAGE, IEF

Unit 2: Chromatography techniques – TLC, paper, column chromatography, gel filtration, ion exchange, HPLC, GLC, partition, affinity, adsorption chromatography

Unit 3: Centrifugation techniques – basic principle, type of centrifuge, micro-centrifuge, high speed, ultracentrifuge, preparative centrifugation, (differential and density gradient), analytical centrifugation

Unit 4: Spectroscopy techniques – basic principle, instrumentation and biological application of UV-visible spectroscopy, spectrofluorometry, CD, ORD, atomic spectroscopy (absorption and emission), NMR, ESR

Unit 5: Radioactivity – radioactive and stable isotopes, radioactive decay, unit of radioactivity, measurement of radioactivity- Geiger Mueller, solid and liquid scintillation counting, SPA, autoradiography; application of radioisotopes in biochemistry, clinical application

Unit 6: Introduction to statistics: mean, median, mode, standard deviation, standard error, probability distribution, chi-square test, t- test, f- test, analysis of Variance.

Suggested Reading:

1. Wilson K and Walker J. Principles and Techniques of biochemistry and molecular biology. Cambridge.
2. J. D. Seader and E. J. Henley, Separation Process Principles, 1st Edition (1998), John Wiley & Sons. Inc., New York.
3. Fundamentals of Biostatistics. Khan and Khanum, Shiba Khan. Ukaaz publications
4. Fundamentals of Biostatistics. Veer Bala Rastogi.3 Ed.

L040704TNCELLULAR MICROBIOLOGY

Course Objectives:
The primary objective of the course is to build a strong foundation in the area of prokaryotic and eukaryotic cell structure, division and basic signal transduction pathways.

Course Outcomes:
Upon successful completion of the course, the student:
1. To know basic structural and functional aspects of living cells
2. To differentiate between prokaryotic and eukaryotic cells
3. To understand the organization of prokaryotic and eukaryotic nuclear organization
4. To understand the different cell division, cell cycle progression proteins
5. To infer which protein and pathways can in affected in abnormal/cancer or normal cells
6. To understand the different signal transduction pathways and their functions in cell regulation.

Course Content:

Unit 1: Indian Knowledge System: Cellular microbiology
Cell Theory, Differentiate between prokaryotic and eukaryotic cells. Prokaryotes: Cell morphology, Structure, function and synthesis of cell wall, cell membrane, capsules, Endospores, flagella, pili, cilia. Storage granule metabolism- volutin, polyhydroxybutyrates and glycogen. Gas vesicles, carboxysomes, magnetosomes and phycobilisomes.

Unit 2: Eukaryotes: Structural organization and function of intracellular organelles: Cell wall, molecular organization of cell membrane, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.

Unit 3: Organization of prokaryotic and eukaryotic genes and chromosomes (Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin.

Unit 4: Cell division and cell cycle, cell cycle regulation and control of cell cycle, Cancer and Microbiology

Unit 5. Principles of cell signaling, different types of receptors: G protein, ion channel linked, Enzyme linked receptors, receptors containing intrinsic enzymatic activity, tyrosine kinase receptor, intracellular receptors of extracellular signals, Protein phosphorylation, kinases, phosphatase: serine threonine kinase, tyrosine kinase, histidine kinase activity in bacterial chemotaxis, serine, threonine and tyrosine phosphatase, cyclic nucleotides, Programmed Cell Death

Suggested Reading:

1. Lodish et al., Molecular cell Biology, 4th Edition, W.H. Freeman & Company, 2000.
2. Smith & Wood, Cell Biology, 2nd Edition, Chapman & Hall, London, 1996.
3. Watson et al., Molecular Biology of the gene, 5th Edition, Pearson Prentice Hall. USA, 2003.
4. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley-Blackwell, 2002.
5. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
6. Alberts et al. Molecular biology of cell- Bruce Alberts, Cell Biology – Karp, Cell signaling by John T Hancock (Oxford), Darnell, Prescott, Stanier.

L040705PWPRACTICAL

Course Objectives:
The major objective of the course is to impart hands-on training in basic microbiological, chemical techniques and instrumentation.

Course Outcomes: Upon successful completion students should be able to:

1. Is able to use different sterilization procedures and learn handling of micropipette.
2. Is able to work in Biosafety Cabinet for culturing cells.
3. Is versed with identification and classification of given bacterial isolate by performing variety of cultural, biochemical tests.
4. Can use microscopy for cell imaging.
5. Use various techniques like pH metry, chromatography, centrifugation, spectrophotometry

Content:

1. Basic rules of a Microbiology Laboratory
2. Basic requirements of a microbiology
3. Study the different parts of a bright filed microscope
4. To observe using wet mount preparation for observation of pond algae
5. To perform lactophenol cotton blue staining for observation of fungi
6. Preparation of bacterial smear, fixation of suspension and simple staining for study of bacterial morphology.
7. To perform negative staining using Nigrosine
8. To perform Gram Staining for differentiation of bacteria
9. To perform capsule staining using given microbial sample
10. To perform endopore staining using Schaeffer- Fulton staining method
11. To perform staining of poly hydroxyl alkanoate granules using Sudan Black
12. To study the principle and working of pH meter and preparation of phosphate buffer
13. To study principle, working and types of centrifuges and perform separation of bacterial pellet from supernatant.
14. To study the principle and working of spectrophotometer by turbidometric measurement of bacterial growth
15. To study principle and working of Thin layer chromatography by chlorophyll separation
16. Preparation of nutrient broth and its sterilization
17. Preparation of nutrient agar and pouring of plates
18. To perform serial dilution and isolation of micro-organisms using spread plate technique
19. To perform isolation of pure culture using the streak plate technique
20. To perform pour plate technique
21. Preparation of slants for the preservation of micro-organisms
22. Carbohydrate estimation
23. Protein Coagulation
24. Determination of mean, median and mode of given bacterial population

Suggested Readings:

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications

Semester II

L040801TN BACTERIAL METABOLISM AND PHYSIOLOGY

Course Objective:
This paper aims to give a thorough introduction to bacterial metabolism and microbial physiology. This paper deals with in depth knowledge of the energetic and regulation of different metabolic processes in microorganisms, and enable students to better understand courses taught later such as microbial pathogenicity and biotechnology-based courses.

Course Outcomes:
Upon successful completion of the course, the student:

1. Apply knowledge of theory to practice.
2. Describe the diversity of mechanisms by which microorganisms adapt to their environment.
3. Determine metabolic rates in closed and continuous culture, and balances of carbon and reducing power of different metabolic processes.
4. Solve problems in relation to the metabolism and physiology of microorganisms.
5. Understand the regulation of metabolic pathways and possible process activation of microbial product synthesis.

Course Content:

Unit 1: Transport of nutrients – passive diffusion, facilitated diffusion, active transport (ABC transport, proton and sodium gradient driven active transport), group translocation (phosphotransferase system), iron transport (siderophores); transport proteins; thermodynamics of transport system; bacteriorhodopsin.

Unit 2: Photosynthetic pigments; oxygenic and anoxygenic photosynthesis; autotrophy (calvin cycle, reductive TCA cycle, acetyl CoA pathway); chemolithtrophy (H, N, S, Fe oxidations), methanogens, methanotrophs.

Unit 3: Central catabolic pathways – glycolysis, pentose phosphate pathway, EntnerDoudoroff pathway, Krebs cycle, electron transport system and ATP generation, glyoxylate cycle, fermentation of carbohydrate (homo and heterolactic fermentation), Pasteur effect.

Unit 4: Biochemistry of nitrogen fixation – nitrogenase complex, regulation of nitrogenase by oxygen and combined nitrogen sources; genetics of nitrogen fixation-nif genes and their regulation; nitrification; denitrification; pathways of nitrate and ammonia assimilation; sulphur assimilation; phosphate assimilation (Pho system).

Unit 5: Stress physiology – adaptations to oxygen toxicity, pH, osmotic pressure, temperature; Donnan equilibrium; quorum sensing related signaling pathways, bioluminescence, multicellular organization in microbes (coordination in microbes).

Suggested Reading:

1. Moat A.G. Foster J.W. Spector M.P. 2002. Microbial Physiology (4th ed). Wiley.
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 edn, Oxford University Press 4. Gottschalk, G. 1985 Bacterial Metabolism, second edn, Springer

L040802T: FUNDAMENTALS OF MOLECULAR BIOLOGY

Course Objectives:
The purpose of this course is to introduce the student to the advanced concepts in molecularbiology. Student will gain an understanding of molecular mechanisms of DNA replication, DNArepair, transcription, translation, and gene regulation in prokaryotic and eukaryotic organisms. The students will study the techniques and experiments used to understand these mechanisms.

Course Outcomes:
Upon successful completion of the course, the student:

1. Is able to describe structure of DNA and RNA, organization of eukaryotic genome
2. Is able to compare and contrast the mechanisms of bacterial and eukaryotic DNA replication, DNA repair and and recombination
3. Is able to explain transcription, post-transcriptional processes and various levels of gene regulation in both prokaryotic and eukaryotic organisms
4. Is able to describe translation mechanism in prokaryotes and eukaryotes, regulation of translation, and post-translational processing.
5. Is able to describe various type of inhibitors in gene expression system.

Course Contents:
Unit 1: Genetic information and nucleic acids, DNA as the genetic blue print, experimental evidence, Physical and chemical structure of DNA structure, circular and super helical DNA, denaturation of DNA, renaturation, Hybridization, replication is semiconservative (experimental evidence).

Unit 2: DNA replication, repair and recombination -Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination.

Unit 3: RNA synthesis and processing - transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport, transcriptional inhibitors.

Unit 4: Protein synthesis and processing - Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyltRNAsynthetase, and translational proof-reading, translational inhibitors, Post- translational modification of proteins, Protein trafficking

Unit 5: Control of gene expression at transcription and translation level - regulating the expression of prokaryotic (*lac, trp, ara*operon) and eukaryotic genes response element, role of chromatin in gene expression and gene silencing.

Suggested Reading:

1. George M Malacinski. Freifelder's Essentials of molecular biology. Jones & Bartlett Learning
2. Krebs JE, Goldstein ES, Kilpatrick ST. Lewin's Essential Genes. Jones & Bartlett Learning

L040803TN RECOMBINANT DNA TECHNOLOGY

Course Objectives:
The objective of this course is to make the student familiar with the currently used techniques to manipulate/analyze DNA, RNA and proteins. The student will be made familiar with the methods used to clone genes, make and screen libraries, and the various applications of the polymerase chain reaction. The student will be taught about the methods currently used to carry out genome-wide analyses genome sequencing and global analyses of transcription and protein expression. The student will be made familiar with how recombinant DNA technology has been exploited in the study of biology as well as in the production of pharmaceutical products, transgenic plants & animals.

Course Outcomes:
Upon successful completion of the course, the student:

1. will know about basic principle of RDT, different restriction & modifying enzymes, library construction and screening.
2. Will be familiar with the use of various cloning vectors, expression vectors and purification of recombinant proteins.
3. Will be able to describe the various methods of gene transfer in both plant and animal.
4. Will be able to understand the methods by which labeling of nucleic acid is done and hybridization techniques like southern, northern and western blotting.
5. Will be aware of DNA is sequenced and will gain insights into how entire genomes of organisms are sequence, the many uses of the reporter genes & molecular markers, various applications of PCR, creation of plant and animal transgenics.

Course content:

Unit 1: Basic Tool of RDT: Host controlled restriction and modification, Restriction enzymes & its nomenclature, DNA modifying enzymes, Cohesive & Blunt end ligation, Linkers, Adaptors, Homopolymer tailing, c DNA library & Genomic DNA library construction

Unit 2: Introduction to cloning: Cloning Vectors-plasmid (pBR322, pUC) Cosmid, Phasmid, Bacteriophage λ, Single stranded DNA Vectors (M 13, f1, fd), Cloning vectors for Yeast, Artificial Chromosomal Vectors (BACs, YACs), Prokaryotic & Eukaryotic Expression Vectors with GST, His, MBP tags, Affinity Purification of Recombinant Protein, Yeast two-hybrid system, Phage display technique

Unit 3: Gene Transfer Methodologies: Gene Transfer in Plants- Direct/ Vectorless, Vector mediated gene transfer (Agrobacterium mediated Binary, Conjugate Vector, Viral Vector), Gene Transfer in animals – Direct/ Vectorless, Vector mediated, Embryonic stem cell gene transfer, Genetic manipulation of animals (Production of transgenic/ Knock-out mice), Nuclear transfer technology and animal cloning

Unit 4: Labelling & Detection of nucleic acid: End labeling, Random Priming, Nick Translation using radioactive, Nonradioactive probes, FISH, Hybridization techniques-Southern Blotting, Northern Blotting, Western Blotting, Dot Blot

Unit 5: DNA sequencing, Next-generation sequencing technologies, PCR & its types (including real time, reverse transcriptase), RACE technique, Site-directed mutagenesis, Molecular markers (RAPD, RFLP, AFLP), DNA fingerprinting, Applications of RDT in various fields

Suggested Reading:

1. TA Brown. Gene cloning and DNA analysis. Blackwell Publ.
2. Old and Primrose. Principles of gene manipulation. An introduction to genetic engineering. Blackwell Scientific Publ.

L040804TN-VIROLOGY

Course Objective: The purpose of the course is to enable students to understand viral structure, replication strategies and their importance in microbiology.

Course Outcomes:

Upon successful completion of this course the student will be able to
CO 1: Apply knowledge of virus structure and classification to understand nature of viruses
CO 2: Explain the methods used in cultivation and assay of viruses
CO 3: Discern the general replication strategies of viruses including bacteriophages
CO 4: Describe the structure, replication cycle and pathogenesis of select plant and animal viruses CO 5: Apply knowledge to describe different antiviral mechanisms and recent application in virology

Course Content:

Unit 1: History of Virology; Contribution of Indian Virologists. Classification and Morphology of Viruses: Cataloging the virus through virus classification schemes of ICTV / ICNV. Baltimore's Classification; Ultra-structure of viruses: envelop, capsid and nucleic acid; Virus related agents: viroids, virusoids and prions.

Unit 2: Cultivation and assay of viruses: Cultivation of viruses using embryonated eggs, experimental animals, and cell cultures (Cell-lines, cell strains and transgenic systems). Purification of viruses: Assay of viruses – Physical and Chemical methods (Electron Microscopy and Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end-point dilution assay). Serological Assays.

Unit 3: Viral Multiplication: Mechanism of virus adsorption and entry into the host cell. Replication strategies of DNA and RNA viruses. Post transcriptional processing, translation of viral proteins, assembly, exit and maturation of progeny virions. Latent infections, persistent infections. Host Immune Evasion. Lifecycle of bacteriophages-lytic and lysogenic pathways: T series, λ, Mu, M13, ϕX174; Cyanophages and Mycophages.

Unit 4: Pathogenesis of Viruses: Structure, genomic organization, replication cycle; pathogenesis, diagnosis and control. Poxvirus, Adenovirus, Herpes virus, Hepatitis virus, Rota Virus, HIV, Toga Viruses. Pathogenesis of plant Viruses: TMV, PVX, PVY and insect viruses NPV. Role of insect vectors in transmission of plant viruses. Host cell transformation by viruses and oncogenesis of DNA and RNA viruses.

Unit 5: Control of viral infections through vaccines, interferons, chemotherapeutic agents Antisense RNA, siRNA, ribozymes. Control of plant viral diseases. Recent applications of viruses: Nanotechnology, Phage therapy; Phage Display; Gene therapy etc.

Suggested Reading:

1. Medical Virology 10 Th Edition by Morag C and Tim bury M C. Churchil Livingstone, London.
2. Introduction to Modern Virology 4th Edition by Dimmock N J, Primrose S. B. Blackwell Scientific Publications. Oxford.
3. Virology 3 rd Edition by Conrat H.F., Kimball P.C. and Levy J.A. Prentice Hall, Englewood Cliff, New Jersey.
4. Text Book on Principles of Bacteriology, Virology and Immunology Topley and Wilsons.
5. Molecular Biology, Pathogenesis and Control by S.J. Flint and others. ASM Press, Washington, D.C.
9. Clinical virology Manual by Steven, S., Adinka, R.L., Young, S.A

L040805T MYCOLOGY AND PHYCOLOGY

Course Objectives

The primary objective of the course is to present the diversity of algal, fungal and fungal-like organisms in a systematic order. Special attention will be paid to these taxonomic groups which differed in response to vectors of natural selection related to the occupation of specific ecological niches.

Course Outcomes:

Upon successful completion students should be able to:

1. Assess and understand mycology and phycology.
2. Discuss the importance of fungi in various ecological roles
3. Demonstrate an understanding of how fungi or algae impact human affairs.
4. Identify the distribution of fungi and algae in nature.
5. Understand important field and laboratory methods used in mycology and algology.

Course Content:

Unit 1:Classification of fungi

Classification of fungi General features, structure and cell differentiation (Hyphae and non-motile unicells, motile cells, spores, dormancy, growth of population and colonies). Life cycle of Aspergillus, Penicillium, Yeasts. Salient characteristics, nutrition, reproduction and significance of Myxomycotina; Mastigomycotina; Zygomycotina; Ascomycotina; Basidiomycotina; Deuteromycotina.

Unit 2:Fungal Associations

Heterothallism, sex hormones in fungi. Physiological specialization phylogeny of fungi, Lichens – ascolichens, basidiolichens, deuterolichens. Mycorrhiza – ectomycorrhiza, endomycorrhiza, vesicular arbuscularmycorrhiza. Effect of environment on fungal growth, prevention of fungal growth. Saprophytes, substrate groups and nutritional strategies substrate successions, fungal relationships with plants and animals.

Unit 3:Fungal infections

Fungi as insect symbiont, fungal diseases – mycoses systemic and subcutaneous, candidiasis, Pneumocystis, blastomyxoses, dermotophytosis. Opportunistic fungal infections.

Unit 4:Algal classification and characteristics

Principles, criteria (pigments, flagellation, food reserve and eye spots) and systems of classification of algae. Cyanophyta: cell structure, heterocyst and akinete development, chromatic adaptation, thallus organization and reproduction. A brief account of thallus organization and reproduction in Chlorophyta, Phaeophyta and Rhodophyta; alternation of generation in Phaeophyta and post - fertilization development and site of meiosis in Rhodophyta.

Unit 5:Algal phylum and characteristics

A brief account of Xanthophyta, Chrysophyta, Bacillariophyta, Pyrrophyta, Euglenophyta, Eustigmatophyta, Prasinophyta and Prochlorophyta.
Distribution of algae, algal nutrition, algal thallus, algal reproduction, green algae, diatoms, euglenoids, brown Rhodophyta, Pyrrophyta.

Unit 6: Algal ecology and algal biotechnology

Algae in diverse habitats, algal blooms and Phycoviruses. Algae as food, biofertilizers and source of phycocolloids. . Commercial potential of Spirulina, Dunaliella and Porphyra; hydrogen production by algae.

Suggested Readings:

1. Mehrotra RS and KR Aneja: An introduction to Mycology. New Age International publishers.
2. Introduction to Mycology: CJ Alexopoulos and CW Mims, Wiley Eastern Ltd, New Delhi.
3. Fundamentals of Mycology: JH Burnett, Publisher: Edward.
4. The Fungi: M. Charlile and SC Watkinson, Publisher: Academic Press.
5. Fundamentals of the fungi: E Moore – Landeekeer, Publisher: Prentice Hall.

L040806PNPRACTICAL

Course Objectives

The major objective of the course is to impart hands-on training in metabolism and physiological characterization of microorganisms, and develop skills of testing of fungi, algae, and viruses in various sources. The candidate will study the basic principle behind recombinant DNA technique, and acquire adequate skill required to separate and observe chromosomal DNA in rDNA Technology.

Course Outcomes: Upon successful completion students should be able to:

1. Can make qualitative and quantitative detection of different types of molecules.
2. Understand the effect of various physiological conditions on growth
3. Isolate and handle viruses, fungi and algae
4. Develop method for isolating genomic DNA and plasmid DNA.
5. Appraise restriction analysis of DNA.
6. Analyze the outcome of transformation.

Course Content:

1. To determine the effect of pH, temperature and salinity on growth of given microbial sample
2. To determine the effect of temperature on growth of given microbial sample
3. To determine the effect of salinity on growth of given microbial sample
4. To determine catalase activity of given microbial culture
5. To perform oxidase activity of given microbial culture
6. To perform oxidative fermentative test for given microbial culture
7. To determine amylase forming ability of given isolates
8. T determine gelatinase forming ability of given isolates
9. To perform sugar fermentative tests for given microbial cultures
10. Isolation of fungi by baiting method.
11. Culturing and morphological study of some common molds: *Rhizopus*, *Mucor*, Penicillium, *Alternaria*, *Trichodema*
12. To observe budding of *Saccharomyces cerevisiae*
13. Isolation of algae from soil and water
14. Study of morphology of given algal sample
15. Isolation of bacteriophages from sewage/ Ganga water using plaque assay
16. Study of DAS –ELISA assay for given viruses.
17. Observation of viral pathogenicity using phase contrast microscope.
18. Isolation of bacterial DNA and its separation using agarose gel electrophoresis
19. Preparation of competent cells for transformation.
20. Demonstration of Bacterial Transformation and calculation of transformation efficiency.
21. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis.
22. To demonstrate *in vitro* transcription assay and *in vitro* translation assay

Suggested Readings:

1. Weaver, D. and Tart, R. C., "A Laboratory Manual for General Microbiology" (1998). *Biology*. 46. https://cufind.campbell.edu/biology/46
2. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
3. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications

4. Molecular Cloning: A Laboratory Manual, Volume 1, Joseph Sambrook, David William Russell Cold Spring Harbor Laboratory Press.
5. Molecular Cloning, Volume 2, Joseph Sambrook, Cold Spring Harbor Laboratory Press

L040807RN REVIEW WRITING PRESENTATION/ INTERNSHIP/ PROJECT

Course Objectives:
A term (or research) paper is primarily a record of intelligent reading in several sources on a particular subject. The students will get informed about the topic at the beginning of the session in consultation with the assigned faculty. The progress of the review writing will be developed under regular monitoring of the faculty. At the end of the semester the detailed report and/or presentation on the topic will be submitted to the faculty assigned.

Course Outcomes:
Upon successful completion students should be able to:
1. Collect information of given problem statement and compile it in sequential order.
2. Review notes to find main sub-divisions (problems, possible solutions) of the subject.

Note:
The IPR rights of all such work lie with the University only.

Semester III

L040901T: MICROBIAL GENETICS

Course Objectives:
The objective of this course is to understand how microorganisms can be used as tools to understand various biological phenomena. The student will become familiar with methods of transfer of genetic material in bacteria, and will understand the biology of lytic and lysogenic phages. The student will be acquainted with the importance of bacterial transposition and its applications.

Course Outcomes:
Upon successful completion of the course, the student:
1.Can discuss the importance of mutation analysis, can analyze mutations by complementation and recombination tests, and can design a strategy to create gene replacement in bacteria
2: Is able to explain how plasmid copy number is regulated, can differentiate between Hfr strains and strains carrying F plasmid, and can construct a genetic map of bacterial genome using conjugation-based method
3: Is able to compare and contrast generalized versus specialized transduction, knows how to construct genetic linkage maps using two-factor and three factor cross, is able to discuss the basis of natural competence in bacteria.
4: Is able to list the events in the lytic and lysogenic phases of lambda phage life cycle and the regulatory factors and events involved.
5: Can list the outcomes of transposition events, can design strategies to mutagenize bacteria using transposons, can explain the construction of conditional knockouts

Course Content:
Unit 1: Experimentalevidence for the hereditary molecule in all organisms is DNA. Mutation in bacteria, Auxotrophic & conditional lethal mutants, Types of mutation, Physical and chemical mutagens, biochemical basis of mutation, Reversion verses suppression mutation, Different types of DNA repair mechanism. -direct reversal, mismatch repair, excision repair, recombination repair and SOS repair. Genetic analysis of microbes- bacteria and yeast, complementation

Unit 2: Plasmids: Different types of plasmids, F Factor description and their uses in genetic analyses, col and R plasmids. Function encoded by plasmids, Replication of plasmids, incompatibility, host range, copy number, curing of plasmid, Transfer of plasmid Artificial plasmid, Plasmid as vector for gene cloning

Unit 3: Gene transfer mechanisms –Transformation, conjugation and Transduction-Generalized and Specialized, mechanism and application, Molecular basis of recombination, Insertion Sequences & Transposons, types of transposons, site specific recombination

Unit 4: Bacteriophage: Lytic phages T4 &T7, Lysogenic phages lambda and P1 Life cycle, replication, transcription and regulation of gene expression, prions and their genetic composition, disease caused by prions.

Unit 5: Acquired and adaptive immunity in bacteria, antiphage defense system, programmed genetic variation, CRISPR-Cas machinery, spacers, Quorum sensing induced bacteriophage defense mechanism, Programmed genetic variation, Epigenetics

Suggested Reading:

1. Snyder L and Champness W. Molecular genetics of bacteria. ASM Press.
2. David Freifelder. Microbial genetics. Jones & Bartlett Publ.
3. Cronan J. and Freifelder D., Microbial Genetics; Second Edition
4. Khalifa AE; Fundamentals of Microbial Genetics; Lamber Academic Pub.

5. Sundara R.S. Microbial Genetics; Amol Publications Pvt Ltd
6. Modern Microbial Genetics, Second Edition; Editor(s):Uldis N. Streips, Ronald E. Yasbin; Wiley Liss, Inc.

L040902TNCELLULAR AND MOLECULAR IMMUNOLOGY

Course Objective: The purpose of the course is to provide a comprehensive understanding of the biochemical, cellular and molecular components of the immune response

Course Outcomes:
Upon completion of the paper, student would have the following learning outcomes:
CO1: Distinguish between the specificity and memory of acquired versus innate immune response
CO2: Differentiate between different types of specific immune response
CO3: Discuss the generation of immune diversity and different molecular aspects of immune response generation
CO4: Apply knowledge of cellular and humoral immune response to different antigens
CO5: Identify the role of immune response in vaccine development and immunotherapy

Course Content:

Unit 1: Introduction to the immune system, History of Immunology with contribution of Indian Scientists, Physical and chemical barriers, Cells and molecules involved in innate and adaptive immunity, Cytokines and Chemokines, Complement system, Toll-like receptors, Inflammation, Primary and Secondary lymphoid organs.

Unit 2: Major Histocompatibility Complex- genes, structure and functions, antigen presenting cells, antigen processing and presentation, antigens, antigenicity and immunogenicity, Superantigens, Linear and conformational epitopes, paratope,

Unit 3: Primary and Secondary Immune response. Clonal Selection Theory, Humoral Immunity: structure and function of antibody molecules. Generation of antibody diversity, Activation and differentiation of B cells, B cell signaling, Types of B cells, Memory B cells. Antibody engineering-chimeric and hybrid monoclonal antibodies; Catalytic antibodies

Unit 4: T cell Immune response: activation and differentiation of T cells, T cell receptors, genetic diversity of T cell response, T cell signaling, types of T cells, Peripheral and Central tolerance, Autoimmunity, Hypersensitivity.

Unit 5: Immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections. Vaccinology: Active and passive immunization; Hapten & Adjuvants, Types: live, attenuated, killed, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines.

Suggested Reading:
1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman
2. Abul Abbas, AdrewLitchman, Shiv Pillai. Cellular and Molecular Immunology.9th Edition. Elsevier.
3. Janeway et al., Immunobiology, 4th Edition, Current Biology publications.
4. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt
5. Roitt's Essential Immunology.13th Edition, Wiley Black Publications.

L040903TN AGRICULTURE AND ENVIRONMENT MICROBIOLOGY

Course Objectives: The major objective of this paper is to impart basic understanding of environmental and agricultural microbiology including; microbial diversity in the environment in relation to environment and agricultural welfare, ecosystem wellness, microbial interactions with pollutants in the soil and environment and the fate of microbial pathogens in the environment and agricultural fields.

Course Outcomes:

Upon successful completion of the course, the student:

1. Will have an overview of the till date developments in the field of environmental microbiology with special emphasis on the role of microbes in agriculture and mitigating environment pollution.
2. Will be able to describe the role of soil microbes in nutrient transformation, plant-microbe interactions and biotechnology.
3. Understands the role of microorganisms in eco-friendly agriculture and sustainable environmental practices.
4. Will understand the information about inter-relationship of soil and microorganisms, different group of beneficial microorganisms in agriculture, microbes as a biofertilizer, plant pathogen and biocontrol agent.

Course Content:

Unit 1: Environment microbiology: Role of microbes in environment, microbes in air - aerosol and droplet nuclei, assessment of air quality (impactor and impingement methods). Microbes in water – fresh water, deep sea, estuaries, mangroves, hydrothermal vents, eutrophication.

Unit 2: Community ecology: Microbial interactions (symbiosis, mutualism, commensalisms, competition, amensalism, synergism, parasitism and predation), rhizosphere, role of Microorganisms in organic matter decomposition (cellulose, Hemicellulose, Lignins).

Unit 3: Waste treatment: Solid waste treatment – landfill, composting; liquid waste treatment - (aerobic, anaerobic, primary, secondary & tertiary) treatment, advanced treatments (nitrate and phosphate removal). Bioremediation, cometabolism, biodegradation of xenobiotics (pesticides, oil spill hydrocarbons), bioaccumulation of heavy metals and detoxification.

Unit 4: Agriculture microbiology: Plant-microbe (plant growth promoting microorganisms) interaction mechanisms; biological nitrogen fixation (asymbiotic and symbiotic), strategies of transfer of nif genes in plants; biofertilizers types, application methods an agronomic importance.

Unit 5: Major plant disease symptoms caused by fungi, bacteria and viruses. Life cycle, symptoms and control measures of the following diseases: Fungal – *Pucciniagraminis*, *Fusarium oxysporum*. Bacterial – *Xanthomonasoryzae*, *Pseudomonas syringae*. Viral and mycoplasmal – TMV, CaMV, Phytoplasma; biopesticides (fungal, bacterial and viral biocontrol agents).

Suggested Readings:

1. Manual of environmental microbiology,Christon J. Hurst, Ronald L. Crawford Second edition, ASM Press.
2. Agricultural Microbiology: Subbarao
3. Microbial Ecology –Atlas and Bartha.

L040904TN MARINE MICROBIOLOGY

Course Objectives

The aim of this course is to provide students with basic knowledge on the biology and ecology of marine microorganisms, and their ecological role. The study methods and details of the main marine products are also covered.

Course Outcomes:

Upon successful completion students should be able to:

1. Know the basic biology of marine microorganisms and their activities.
2. Understand the ecological role of marine microorganisms and marine microbial communities.
3. Know the main marine products of commercial interest.

Course Content:

Unit 1: Microbes and Marine Environment

Introduction marine microbiology, The world's oceans and seas, Chemical and physical factors in the marine environment- Properties of seawater, Solar radiation and temperature. Marine microbial habitats - The water column and marine snow, Sediments, at surfaces—biofilms and microbial mats, Sea ice, Hydrothermal vents and cold seeps, Living organisms as microbial habitats.

Microbial loop- phytoplankton and cyanobacteria, photoheterotrophic bacteria, heterotrophic bacteria, marine archaea, heterotrophic protists, marine fungi, marine viruses

Unit 2: Dynamics of Marine Microbes

Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming; Nitrogen cycle: Nitrogen fixers; Iron limitation; ocean fertilization; phosphorus cycle; Decomposition of organic matter; Bioleaching and biodeteroriation of natural and synthetic materials.

Unit 3: Marine viruses

Marine phages and giant marine viruses, significance of viruses in marine ecosystem Movement of viruses between biomes; Marine viruses as major players in the global ecosystem and global climate change, Effect of viruses on ecology of the marine ecosystem, Marine virus interactions with prokaryotes, planktons, non-host Organisms

Unit 4: Marine Pollution

Sources marine pollution, kinds of pollution and pollutants, enteric viral pollution, effects of marine pollution on marine fauna and flora, effects of marine pollution on microorganisms, eutrophication of estuarine and coastal ecosystems, monitoring of marine pollution, environment protection regulations, impact assessment and standards, marine microbes and climate change.

Unit 5: Marine Microbial Disease

Mechanisms of pathogenicity of marine food borne pathogens – Aeromonas, Vibrio, Salmonella, Pseudomonas, Cornybacter.

Unit 6: Marine products

Microbes of biotechnological importance; Primary and secondary metabolites - enzymes, antibiotics, organic acid, toxins, biosurfactants and pigments.

Algal products – single cell protein, hydrocolloids, agarose, carrageen alginates and other by products

Commercial development of marine natural products- chitosan, chitin.

Suggested Readings:

1. Colin Munn, Marine Microbiology: Ecology & Applications 2nd Edition. Garland Science, Taylor & Francis, 2009. ISBN: 978-0815365174.
2. David L. Kirchman, Microbial Ecology of the Oceans, 2nd Edition, John WIley& Sons, 2008.
3. M.T. Madigan and J.M. Martinko, Biology of Microorganisms, 11th Edition, Pearson Prentice Hall, USA, 2006

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.

L040905T: MICROBIAL GENOMICS, PROTEOMICS AND BIOINFORMATICS

Course Objective:
With the completion of the course, the students will acquire detailed knowledge of different advances in the field of genomics, proteomics and transcriptomics using bioinformatics and computation biology tools.

Course Outcomes:
Upon successful completion of the course, the student:
CO 1: Describe history and advanced in technologies for obtaining genomics and proteomics data
CO 2: Explain data obtained from using genomics and proteomics in silico and wet lab tools
CO 3: Apply knowledge of different Omics technologies to microbial systems
CO 4: Discuss recent advances, techniques and applications in the field of genomics, transcriptomics and proteomics
CO 5: Application based understanding of different bioinformatics databases and softwares

Course Content:

Unit 1: Introduction to Genomics, Transcriptomics and Proteomics; Current Status of microbial genomics- History and Scope. Developments in India with respect to genomics and proteomics. Whole genome cloning- Shotgun & Hierarchial cloning. BAC, YAC, Metagenomics; Next Generation Sequencing methodology, 3rd generation sequencing

Unit 2. Introduction to Bioinformatics and OMICS; History and Scope of Bioinformatics; Biological databases; primary nucleotide sequence databases, Annotated sequence databases, protein sequence and structure databases; Organism specific databases

Unit 3. Types of Genomics: Structural Genomics, Functional Genomics, Metagenomics, Single Cell Genomics; GenBank, Ref Seq–NCBI, EMBL & DDBJ–retrieving sequences. Genome sequence comparison, SNP analysis, Genome annotation and Gene prediction. Transcriptomics: RNA structure prediction, High throughput Screening methodologies, Microarrays

Unit 3: Proteomics: Basics of mass spectrometry. Maldi TOF and ESI, and their application in proteomics. Peptide sequencing by tandem mass spectrometry, Affinity purification of protein, Protein Microarrays, Protein Structural databases; Protein structure prediction: homology and ab initio methods.

Unit 4: Comparative genomics: Tools used for phylogenetic analysis – Ribosomal Database Project, Clustal, MEGA, Interactomics tools

Unit 5: Recent advances in genomics and proteomics. Application of microbial genomics and proteomics. GWAS, IPR in genomics and proteomics.
Sequence analysis software: BLAST, CLUSTAL W

Suggested Reading
1. Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins. 2nd Edition by Baxevanis.
2. Functional Genomics. A Practical Approach Edited by Stephen P Hunt and Rick Liveey (OUP) 2000.
3. Introduction to Bioinformatics. A Lesk.
4. Bioinformatics: Sequence and Genome Analyis. David Mount. CSHL Press

L040906TH BIOETHICS, BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (IPR)

Course Objectives:
The major objective of this course is to create awareness on the biosafety, bioethics and patenting of biotechnological processes and products so that students can understand legal, ethical and social impacts of microbiological research and can apply the knowledge to our daily life to solve various environmental problems.

Course Outcomes:
Upon successful completion students should be able to:
CO1: Understand the concepts, criteria, and importance of biosafety and IPR.
CO2: Analyze the basic principles and legal framework of intellectual property rights and its application to biotechnology.
CO3: Understand regulatory guidelines and steps involved in protection of intellectual property rights.
CO4: Identify good laboratory procedures and practices, describe the standard operating procedures for microbiological research.

Course Content:
Unit 1: Bioethics
The principles of bioethics Legality, morality and ethics, autonomy, human rights, beneficence, privacy, justice, equity etc. Bioethics and microbiological applications. General issues related to environmental release of genetically modified microorganisms. Ethical issues related to the use of animal as models for microbial diseases.

Unit 2: Biosafety Guidelines
Introduction; biosafety issues in biotechnology; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms. Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.

Unit 3: Guideline for use of radioisotopes
AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions.

Unit 4: Introduction to Intellectual Property
Patents, Types, Trademarks, Copyright & Related Rights, Industrial Design and Rights, Traditional Knowledge, Geographical Indications- importance of IPR – patentable and non patentables – patenting life – legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO).

Unit 5: Grant of Patent and Patenting Authorities
Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner.

Unit 6: Agreements andTreaties
GATT, TRIPS Agreements; Role of Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV &Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.

Suggested Readings:

1. Bare Act, 2007.Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., New Delhi.
2. Kankanala C (2007). Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution

Pvt. Ltd. New Delhi.
3. Mittal, D.P. (1999). Indian Patents Law, Taxmann, Allied Services (p) Ltd.
4. Singh K K (2015). Biotechnology and Intelectual Property Rights: Legal and Social Impliocations, Springer India.
5. Goel D &Prashar S (2013).IPR, Biosafety and Bioethics. Pearson.
6. Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management. Jasen Publications, Tiruchirappalli, India.

L040907TN:MOLECULAR HOST-MICROBE INTERACTIONS

Course Objectives:
To provide an understanding of the biology, physiology, genetics, and biochemistry of interactions between hosts and their pathogens; To provide a good working knowledge of current research tools to address questions in host (human or plant)-pathogen interactions and application of the knowledge in obtaining diseases resistant plants.

Course Outcomes:
Upon successful completion students should be able to:
CO1: Acquire the knowledge about the molecular mechanisms of the interaction between the host (plant or human) and pathogenic microbes.
CO2:Critically analyse the literature on a specific scientific area of infectious disease.
CO3: Describe pathogen type and mechanisms of microbial pathogenesis
CO4: Analyse the molecular mechanisms involved in various disease
CO5: Application of knowledge for pathogen control strategies

Course Content:

Unit 1: Molecular Mechanisms of Pathogenicity I: Human Pathogen
Entry of microorganisms in to the host, portals of entry, adherence, penetration of host defense; contribution of capsules, cell wall components and enzymes in pathogenicity; antigenic variation, penetration into the host cell cytoskeleton; mechanisms of host cells damage caused by bacterial pathogens.

Unit 2: Molecular Mechanisms of Pathogenicity II: Human Pathogen
Pathogenic properties of viruses, viral mechanisms for evading host defenses, viral cytopathic effects, pathogenic properties of fungi, protozoa, helminthes,and algae; portals of exit for human pathogens.

Unit 3: Genetics of Plant Disease and Plant Defense
Genes and disease, variability in organisms, adapted pathogen vs non-adapted pathogen, types of plant resistance, quantitative or horizontal resistance, *R*-gene resistance or vertical resistance, apparent resistance, non-host resistance, avirulence (*avr*) genes, gene for gene hypothesis, hypersensitive responses (HR); Plant defense: pre-existing structural and chemical defenses, induced structural and biochemical defenses, immunization of plants against pathogens, systemic induced resistance (SAR), induced systemic resistance (ISR), concept of defense priming in plants.

Unit 4: Molecular Mechanism of Plant Pathogenesis
Concepts of pathogenicity and virulence, Fungal pathogenicity functions (formation of infection structures, degradation of plant cuticle and cell wall, overcoming the plant secondary metabolites, production of fungal toxins and signaling components), bacterial pathogenicity functions (adhesions, surface polysaccharides, secretion systems, effectors, cell wall degrading enzymes bacterial phytotoxins, regulatory networks and sensing system) and viral pathogenicity factors.

Unit 5: Plant Immunity
Recognition of pathogen and plant immune responses: The zigzag model of plant immunity, PAMP-

triggered immunity, effector-triggered susceptibility and effector-triggered immunity, plant defensesignaling components and downstream events, plant hormones in plant defense responses.

Unit 6: Plant Protection

Application of genetic engineering in plant disease control, transgenic and gene manipulation approach for crop protection, use of chemical elicitors in inducing plant defense responses.

Suggested Readings:

1. Willey, J.M., Sherwood, L., Woolverton, C.J., 2010. Prescott's Microbiology. 8th edition, McGraw-Hill.
2. Agrios, G. N., 1988. Plant Pathology, Academic Press.
3. John A Lucas, 1998. Plant Pathology and Plant Pathogens, Wiley-Blackwell, CRC Press.
4. Dickinson, C. M., 2003. Molecular Plant Pathology, Bios Scientific Publisher
5. Robert, N., Trigiano, Windham, M. T. and Windham, A.S., 2003. Plant Pathology: Concepts and Laboratory Exercises, CRC Press.
6. Bridge, P.D and Clarkson, J.M., 1998. Molecular Variability of Fungal Pathogens, CAB, International
7. Singh, R. S., 2008. Plant Diseases, Oxford and IBH Publishing Co. Pvt Ltd
8. Singh, R. S., 2008. Principles of Plant Pathology, Oxford and IBH Publishing Co. Pvt Ltd.
9. Dhingra, O.D. and James, B. Sinclair, 1995. Basic Plant Pathology Methods, CRC Press
10. Bishen, PS. 2014. Microbes in Practice. I.K. International Publishing House Pvt. Ltd.
11. Aneja, KR, Jain, P and Aneja, KR. 2008. A Text book of Basic and Applied Microbiology. New Age International Publishers, New Delhi.

L040908TH-MEDICAL MICROBIOLOGY

Course Objectives:

The course will enable students to differentiate between different morphological, biochemical, serological and pathogenicity features of microbial pathogens. Student will also learn about the significance of normal microbiota and the diagnosis and treatments of various infection types.

Course Outcomes:

Upon successful completion of the course, the student:

1. Will have gained insight on medically important microbial pathogens
2. Will attains knowledge of various micropathogenecity strategies and antimicrobial resistance mechanisms
3. Learn about the different bacterial diseases and their causative agents and their pathogenesis mechanisms
4. To gain knowledge about fungal and viral diseases and their pathogenesis mechanism
5. Understand the role of zoonotic infections and emerging infectious diseases.

Course Content:

Unit 1: Early discovery of pathogenic microorganism, Normal microflora of human body, True and Opportunistic pathogens; virulence factor and pathogenicity factor of bacteria and virus, Infection, Adhesion, colonization, Invasion, toxigenicity, infectivity, transmissibility, communicability. Antibiotics and antibiotic resistance mechanisms.

Unit 2: Bacterial disease: Morphology, cultural characteristics, pathogenesis, lab diagnosis & treatment of Causative agent of air borne disease (Diptheria, pertussis, tuberculosis), Food and water borne disease (typhoid, shigellosis, cholera), soil borne disease (anthrax, tetanus and gas gangrene), contact disease(leprosy)

Unit 3: Fungal disease: Etiology, geographical distribution, pathogenesis, symptomatology, lab diagnosis and treatment of *Candida, Histoplasma, Aspergillus and Cryptococcus, Dermatophytes*

Unit 4: Viral disease: Pneumotropical (Influenza), Dermotropical (Herpes, chicken pox, small pox, measles and rubella), Viscerotropic (Hepatitis, Acquired immunodeficiency syndrome), Neurotropic (Rabies and Polio).

Unit 5: Zoonotic infection: Bacterial (Brucellosis, Plague) Viral (Hemorrhagic and encephalitic fever), Parasitic (Malaria, Leishmaniasis)

Suggested Reading:

1. Chaechter M. Medoff G. and Eisenstein BC. (1993) Mechanism of Microbial Diseases 2nd edition. Williams and Wilkins, Baltimore.
2. David Greenwood, Richard CD, Slack, John Forrest Peutherer. (1992) Medical Microbiology. 14th edition. ELBS with Churchill Livingstone.
3. Joan Stokes E, Ridgway GL and Wren MWD. (1993). Clinical Microbiology, 7th edition. Edward Arnold. A division of Hodder and Stoughton.
4. Ronald M. Atlas. (1989) Microbiology. Fundamentals and Applications. II edition, Maxwell Macmillan international editions.
5. Topley& Wilsons's. (1990) Principles of Bacteriology, Virology and Immunity, VIII edition, Vol. III Bacterial Diseases, Edward Arnold, London.
6. Ananthanaran and Paniker's "Text of Microbioloy". Universities Press

L040909TH FOOD MICROBIOLOGY

Course Objectives:

The course will enable students to understand the phenotypic and biochemical identification of food associated molds, yeasts, yeast-like fungi and bacteria. The course will teach the strategies to develop fermented and non-fermented milk products. The role of microbes in food spoilage, preservation and various food borne diseases will be discussed.

Course Outcomes:

Upon successful completion of the course, the student:

1. Knows traditional food preservation techniques including drying, salting, pickling, refrigeration, freezing, oxidation, vacuum packaging, canning/bottling, smoking, sugaring, chemical preservation and irradiation.
2. Gains knowledge about factors influencing microbial growth in food: extrinsic and intrinsic factors
3. Gathers information regarding microbes causing food intoxications and food-borne infections.
4. Gains knowledge about conventional methods for food quality analysis and is able to use the most recent techniques of quantification and detection of food borne microbes and pathogens.
5. Gains knowledge about microbiology of milk and production and evaluation of the quality of starter cultures and fermented milk products such as yogurt cheese etc.
6. Will know about production and evaluation of the quality of starter cultures and fermented milk products.
7. Understands the relevance of microbial standards for food safety, quality assurance programs that revolutionize food safety and understands the use and production of probiotics and prebiotics.

Course Content:

Unit 1: Microorganisms important in food microbiology: molds, yeasts, bacteria – General characteristics classification and importance. Principles of food preservation- Asepsis, Preservation by use of high temperature, drying, chemical preservatives and additives, preservation by radiation.

Unit 2: Factors influencing microbial growth in food: extrinsic and intrinsic factors, Microbial spoilage of food. Spoilage of fish, meat, poultry, eggs, fruits and vegetables and canned foods.

Unit 3: Classification of food borne diseases. Bacteral and Viral Food borne diseases- *Brucella, Clostridium, Escherichia, Salmonella, Shigella, Listeria, Vibrio* and *Yersinia*. General methods for diagnosis of infections, intoxications and preventive measures.

Unit 4: Microbiology of milk: Sources of microorganisms in milk and types of microorganisms in milk. Microbial contamination of milk (SPC, direct microscopic count, reductase and phosphatase test) Dehydration and Pasteurization of milk.

Unit 5: Food fermentations: Starter cultures, their biochemical activities and production of following fermented foods: Oriental foods- Mycoprotein, Tempeh, Soyasauce, Idli, Natto and Poi. Dairy fermented foods- Cheese, Yogurt and Butter, Fermented vegetables- Sauerkraut.

Unit 6: Application of microbial enzymes in food industry. Production and application of baker's yeast. Genetically modified foods. Biosensors in food. Food laws and quality control-HACCP, PFA, FPO, BIS, AGMARK, ISI, FDA. Beneficial uses of microorganisms. Concept of prebiotics and probiotics.

Suggested Reading:

1. Food microbiology by M.R. Adams and M.O. Moss, royal Society of Chemistry
2. Modern food microbiology, James. M Jay 4th edition CBS publishers and distributers New Delhi
3. Fundamental Food Microbiology 3rd edition Bibek Ray. CRC press 2006

L040910PNPRACTICALS

Course Objectives:

To impart training on various methods/techniques/instruments used in the study and application of genetics, molecular immunology, agriculture, environment, extremophiles and host-microbe interactions.

Course Outcomes:

Upon successful completion students should be able to:

1. Demonstrate an understanding of the concepts of microbial genetics.
2. Use the properties of microorganisms, principally bacteria, as bioindicators of contamination and to remedy problems of contamination and other environmental impacts.
3. Deal with plant-associated microbes and to combat diseases that attack important food crops.
4. Evaluate extremophiles for beneficial characteristics.
5. Uses basic methods and research tools applied in host-microbe interactions.
6. Design and present results of aimmunotechniquess-based experiment.

Content:

1. Isolation and enumeration of aero microflora using settle gravity method
2. Isolation of urease producing isolates.
3. Detection of biofilm forming ability of isolates using Congo Red Binding agar
4. Isolation of Enterobactericeae from sewage water using EMB/ MacConkeys Agar
5. Presumptive MPN test
6. Determination of Dissolved oxygen and Biological Oxygen Demand of given water sample
7. IMVic and TSI test for differentiation of Enterobactericeae
8. Determination of R: S value of rhizospheric soil
9. Isolation of Rhizobiafrom root nodules
10. Isolation and enumeration of isolated from phyllosphere
11. Isolation of phosphate solubilizing bacteria using Pikovaskiya Agar
12. Plant growth promoting products: HCN, Indole acetic acid
13. Isolation of UV resistant mutants

14. Isolation of antibiotic resistant mutants and their isolation using replica plating method
15. Demonstration of antigen antibody precipitation using Widal test
16. Blood group estimation
17. Clinical diagnosis of viral diseases by PCR, ELISA
18. Isolation of pathogen from diseased plant parts and In planta growth kinetics of pathogens
19. Demonstration of Hypersensitive responses in plants
20. Isolation and characterization of microbes from mangroves
21. Isolation and characterization of microbes from coastal waters
22. Studies on halophiles isolated from seawater. [Pigmentation and Salt tolerance]
23. Studies on alkalophiles isolated from sea water. [Study at least one enzyme]
24. Perform DOT ELISA
25. To perform Total Leukocyte Count of the given blood sample.
26. To perform Differential Leukocyte Count of the given blood sample.
27. MBRT of milk samples and their standard plate count.
28. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
29. Isolation and detection of food borne bacteria (*Staphylococcus* or *Salmonella*) from different food samples.
30. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
31. Isolation of spoilage microorganisms from bread.
32. Study of bacterial flora of skin by swab method.
33. Perform antibacterial sensitivity by Kirby-Bauer method.

*Perform any of the suggested practicals. Practicals maybe changes as per course instructor.

Suggested Readings:

1. Campbell, JL "A Manual of Scientific and Practical" Publ. BiblioBazaar.
2. Dr. R. C. Dubey and Dr. D. K. Maheshwari 'Practical Microbiology' S. Chand Publications
3. Molecular Cloning: A Laboratory Manual, Volume 1, Joseph Sambrook, David William Russell Cold Spring Harbor Laboratory Press.
4. Molecular Cloning, Volume 2, Joseph Sambrook, Cold Spring Harbor Laboratory Press
5. Molecular Microbiology: Diagnostic Principles and Practice (ASM Books Book 51) 3rd Edition, Kindle Edition by David H. Persing, Fred C. Tenover, Randall T. Hayden, Margareta Ieven, Melissa
6. Miller, Frederick S. Nolte, Yi-Wei Tang, Alex van Belkum

Semester IV

L041001TH INDUSTRIAL MICROBIOLOGY

Course Objectives:
The course will enable students to edge of the role of microbes in industrial production of different biochemicals/ bio-molecules. The strategies for development of microbial strains, upstream and downstream processes optimization will be covered for industrially relevant microbial products and therapeutic proteins.

Course Outcomes:
Upon successful completion of the course, the student:

1. Learn about the concepts of processes, instruments, management, quality etc. being used in industries to produce the products using microorganisms.
2. Acquire knowledge of the environmental and nutritional factors affecting the production of various metabolites.
3. Will attains knowledge of various fermentation optimization strategies.
4. Acquires knowledge about the production process of various industrially relevant microbial products.
5. Able to solve the difficulties related to the microbial production of certain metabolites.

Course Content:

Unit 1: Screening for production strains, strain improvement, Maintenance of industrially important microorganisms, scale up and scale down of the fermentation process (shake flask – lab fermenter – pilot plant - production level), Parameters to be scaled-up (fermenter design, media, sterilization of media, etc).

Unit 2: Construction and types of fermentors, media, sterilization, inoculum preparation (bacterial, fungal, immobilization), aeration, agitation, foam control. Downstream processing of biologicals, economics of fermentation process, Hygiene and safety.

Unit 3: Fermented beverages – beer and wine; Development of industrially important microbial enzymes (amylolytic enzymes, proteases); production of organic acids by microbes (citric acid, acetic acid); industrial production of amino acids (L-lysine, L-glutamate), microbial production of vitamins (B2, B12).

Unit 4: Production process of antibiotics (penicillin, streptomycin); industrial production of interferon, microbial production of insulin, vaccine production and formulation, Biotransformation of steroids.

Unit 5: Microbial production of polymers (xanthan, dextran), production of bioplastic compound - polyhydroxyalkanoates; Generation of microbial biomass as single cell protein, mushroom; production of bacterial, algal and fungal biofertilizers and their application methods.

Suggested Readings:

1. Casida, L.E., 1984, Industrial Microbiology. Wiley Eastern, New Delhi
2. Prescott and Dunn's.: Industrial Microbiology, AVI Publishing Co. USA.
3. Waites M.J. et al.: Industrial Microbiology, Blackwell Science Ltd.
4. Glazer A.N and Nikaido H.: Microbial Biotechnology, W.N. Freeman and Co.

L041002T PHARMACEUTICAL MICROBIOLOGY

Course Objectives:
The goal of the course is for students to acquire the necessary practical skills for application of microbes in production of pharmaceutically active compounds.With the completion of the course, the students will acquire detailed knowledge of antimicrobial agents, methods for assaying antimicrobial products, Quality control for drug production, regulatory bodies and opportunities for employability.

Course Outcomes:
Upon successful completion students should be able to:

1. Identify different antimicrobial agents and it's mode of action.
2. Process involved in Drug discovery and development.
3. Regulatory guidelines in pharmaceuticals product.
4. Understanding of types & synthesis of antimicrobial agents
5. To understand production process of antibiotic development
6. To learn aboutregulatory bodies associated with developing pharmaceutical product

Course Content:

Unit 1: Introduction to chemotherapeutic agents
History and development of chemotherapeutic agent, Properties of antimicrobial agents, Types of chemotherapeutic agents – Synthetic, Semisynthetic, Natural. Antibiotics: Types of antibiotics with their mode of action; antibacterial, antifungal, antiviral, antiprotozoal

Unit 2: Antibiotic resistance and development of new therapeutics Development of antibiotic resistance, Mechanism of antibiotic resistance, Antimicrobial Peptides: History, properties, sources, mode of action, application. Phage therapy: introduction to phages, lytic cycle, types of phages involved in phage therapy Plant based therapeutic agents.

Unit 3: Sterilization and Microbial spoilage of pharma products
Microbial contamination spoilage and hazard: Sources of contamination, factors affecting survival and growth, breakdown of active ingredient and general formulations. Principles of sterilizations with respect to pharmaceutical industries. Methods of sterilizations: Steam, dry heat, Radiation, Gaseous and Filtration

Unit 4: Preservation of Pharma Products: Principles of preservation
Objectives of preservation, the ideal preservative, rational development of a product preservative system etc. Antimicrobial preservatives and their properties: antimicrobial activity, factors affecting antimicrobial activity, preservative monographs. Preservative stability and efficacy. Methods of Preservative evaluation and testing.

Unit 5: Drug Discovery and Development
Microbial, Recombinant, Biochemical and Molecular level screening systems and their construction/ design strategies. Conventional Process; Bio-prospecting. Search of database/data mining for Drug designing; Preclinical and Clinical trials; Estimation of toxicity: LD50 and ED50; Rational Drug Design – Principle (Structure activity relationship -SAR) and Tools (applications of High through Put Screening, Combinatorial synthesis, Pharmaco-genomics)

Unit 6: Regulatory practices, biosensors and applications in Pharmaceuticals Financing R&D capital and market outlook. IP, BP, USP. Government regulatory practices and policies, FDA perspective. Reimbursement of drugs and biologicals, legislative perspective. Rational drug design. Immobilization procedures for pharmaceutical applications (liposomes). Macromolecular, cellular and synthetic drug carriers.

Suggested Readings:

1. Pharmaceutical Microbiology – Edt. byW.B.Hugo&A.D.Russell Sixth edition. Blackwell scientific Publications
2. Prescott's Microbiology 8th Edition by Willey, Joanne, Sherwood, Linda, Woolverton, Chris
3. Pharmaceutical Microbiology by AshutoshKar
4. Hugo, WB and Russell, AD. Pharmaceutical Microbiology, (2003). Blackwell Science, Oxford, UK.
5. Krogsgaard L, Lilijefors T. and Madsen, U. Textbook of Drug Design and Discovery, (2004). Taylor and Francis, London.
6. Geoffrey Hanlon and Norman Hodges. Essential Microbiology for pharmacy and pharmaceutical science. (2013).Wiley Blackwell.
7. S. P. Vyas & V. K. Dixit. Pharmaceutical Biotechnology. (2003) CBS Publishers & Distributors, New Delhi.
8. Bhatia R and Ichhpujani RL. Quality Assurance in Microbiology. (1995). CBS Publishers, New Delhi.
9. Gregory Gregoriadis. Drug Carriers in biology & Medicine. (2001). Academic Press New York.

L041003T NANOBIOTECHNOLOGY

Course Objectives:

The objective of the course is to provide foundational knowledge of the Nanoscience and related fields and to make the students acquire an understanding the Nanobiotechnology and Applications.

Course Outcomes:

Upon successful completion students should be able to:

1. Learn about the background on Nanoscience.
2. To provide an introduction to the field of nanoscience and nanotechnology and its scope in biotechnology
3. Understand the different structure and properties of different types of nanostructures
4. Understand bio based nanostructures and their working and applications
5. To have application based understanding of nanobiotechnology in the different fields
6. Understanding of safety and toxicity issues related with nanobiotechnology

Course Content:

Unit 1: Introduction to nanotechnology

What is nanotechnology? - What is Nanobiotechnology? - What is nanomaterial? Evolution of Nanoscience – Need of Nanotechnology – Hurdles for Nanotechnology development – Factors affecting the manufacturing process of nano materials – Role of physicists, chemists, medical doctors, engineers, biologists and computer scientists in nanotechnology. Ethics and society

Unit 2: Classification of nanostructures

Nanospheres, Nanotubes, Nanorods, Nanowires, Nanosheets, Quantum dots - Effects of the nanometre length scale - Changes to the system structure - How nanoscale dimensions affect properties - Nanocomposites - Graphene - Carbon Nanotubes - Fullerenes - Natural Nanomaterials - Bio-inspired nanomaterials.

Unit 3: Synthesis Methods of Nanomaterials

Physical synthesis- Ball Milling - Electrodeposition - Spray Pyrolysis - Thermal evaporation Chemical synthesis - Sol-Gel Process - Metal Nanocrystals by Reduction - Solvothermal Synthesis - Biological Synthesis - Protein-Based Nanostructure Formation - DNA-Templated Nanostructure Formation - Protein Assembly

Unit 4: Protein based nanostructures
Protein based nanostructures, Biomolecular Nanomotors (*E. coli*), myosin based mammalian nanostructure, nanobiosensors, self assembly structures,Nano Printing of DNA, RNA, and Proteins, Biochips Applications in Nano Scale Detection, Lab-on-a-chip Devices (LOC)

Unit 5: Nanotechnology for drug development and medical applications
Nanotechnology for drug solubilization and drug delivery. Diagnosis using nanomaterials. Nanotherapy for cancer treatment – Interior artery expansions – Replacing joints with better stuff. - Radioactive tuberene cages in Nuclear medicine.

Unit 6: Cleaner environment with Nanotechnology
Cleaning the air with Nanotechnology – Nanotechnology for water treatment. Microbial nanoparticles. Nanocarbon ball as deodorizer in ferment process. Biomotors for engineered devices. Possible harm from Nanomaterials (Fate of nanomaterials in environment; cytotoxicity and Ecotoxicity models and assays; Life Cycle Assessment, Containment).

Suggested Readings:

1. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons, Ltd., UK, 2005.
2. Nano:The Essentials: Understanding Nanoscience and Nanotecnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
3. Nanostructures &Nanomaterials: Synthesis, Properties & Applications, GuozhongGao, Imperial College Press, 2004.
4. Encyclopedia of Materials Characterization, C. Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Butterworth-Heinemann Publishers, 1992.
5. Nanotechnology: Basic Science and Emerging Technologies - Mick Wilson, KamaliKannangara, Geoff Smith, Michelle Simmons, BurkhardRaguse, Overseas Press, 2005.
6. Nanoparticles as Drug carriers, Vladimir P Torchilin, Imperial College Press, USA, 2006.

L041004TN ADVANCED IMMUNOLOGY AND IMMUNOTECHNIQUES

Course Objectives:
This course will teach the biology of the Immune system and apply this knowledge to an understanding of human disease and basic immunological research and various immunotechniques.

Course Outcomes:
Upon successful completion students should be able to:
CO1: Demonstrate detailed knowledge of how the immune system normally responds to infection.
CO2 :Apply knowledge and incorporate principles to show how aberrations in immuno-regulation underlie autoimmunity, immunodeficiency, allergy and cancer.
CO3: Acquire, analyse and interpret experimental data on research in immunology.
CO4: Apply immunotechniques for assaying cellular and humoral immune responses
CO5: Explain working of the immune system to protect from foreign material

Course Content:

Unit 1: Immunology – Overview
Distinguishing features of innate and specific immune response, Passive and Active immunity, Three lines of immune defense, Primary and secondary lymphoid organs, Haematopoiesis- innate and acquired immune cells, Inflammation, Cytokines, Defensins

Unit 2: Humoral Immunity
Classes and subclasses, structure-function relationship, isotypes, idiotypes and allotypes. B cell receptor and B cell signalling, B cell differentiation. T cell dependant and independent B cell activation, Jerne's Idiotypic network

Unit 3: Immunogenetics and Cellular Immunology
Blood groups and transplantation antigens, HLA and disease association, antigen processing and MHC, Theories of antibody synthesis and generation of antibody diversity-molecular basis of repertoire generation, Generation of T cell diversity, Burnets cloning selection theory, TCR, T cell signalling, Types of T and B cells, Regulatory T cells, Immune tolerance- Central and Peripheral mechanisms, Autoimmunity mechanisms

Unit 4: Immunity to infections
Immunity to infection by viruses, bacteria, fungi and parasites and immunity to tumors, autoimmune diseases, Vaccine, adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, edible and plant vaccines, tumor vaccines, principles of vaccination, passive & active immunization, immunization programs & role of WHO in immunization programs. Targeted immunotherapy, Vaccine & peptide therapy in Transplantation

Unit 5: Immunotechniques
Antigen-antibody reactions – complement fixation, agglutination, precipitation, immuno-diffusion, immunoelectrophoresis, Immuno-fluorescence, enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (RIA). Production and applications of monoclonal and polyclonal antibodies for diagnosis and therapy
Flow cytometry analysis, ELISPOT, Intracellular cytokine staining, Cytotoxicity assays, apoptosis assays, generation of transgenic and knock out mice.

Suggested Readings:

1. Therapeutic Immunology, authors. K Frank Austen, Steven J Burakoff, Fred Rosen, Terry B Strom, Publisher : Blackwell Science
2. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
3. Murphy K, Travers P, Walport M. (2008). Janeway'sImmunobiology. 7th edition Garland Science Publishers, New York.
4. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
5. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

L041005T ENTREPRENEURIAL MICROBIOLOGY

Course Objectives
The course is reasoning and application based, making the students eligible for higher studies, jobs in various sectors and entrepreneurship abilities. The course exposes students to various aspects of business development.

Course Outcomes:
Upon successful completion students should be able to:
1. Research and develop entrepreneurship with strong ethics.
2. Understand communication and management skills to usher next generation of Indian industrialists and researchers.
3. Know the importance and scope of the IPR in Microbiology
4. Get acquainted with regulatory practices undertaken at commercial level.

Course Content:
Unit 1: Entrepreneur development
Concept and need of entrepreneurship development, activity, Institutes involved, Differences between

entrepreneurship, Entrepreneur & Enterprise, Government contributions to entrepreneur.
Business Idea to Start-up opportunities, sources, challenges and factors influencing opportunity identification- risk assessment and development, idea canvas.

Unit 2: Microbial cells as fermentation products
Baker's yeast, food and feed yeasts, bacterial insecticides, legume inoculants, Mushrooms, Algae, Enzymes as fermentation products-bacterial and fungal amylases, proteolytic enzymes.
prebiotics, probiotics – their use as flavor enhancers and disease/ infection combats.

Unit 3: Recycling of wastes
Production of biofuels-ethanol, methane, hydrogen, other hydrocarbons, compost, vermicompost, production of single cell protein, mushroom cultivation (*Agaricus campestris*, *Agaricus bisporous* and *Volvoriella volvacea* eg.), microbial bioplastics.
Bioleaching of copper, gold and uranium.

Unit 4: Agriculture technologies
Microbial Bioinoculants – production (Bacterial, fungal and Mycorhhiza), Silent features of secondary agriculture, use of agricultural and agro-industrial waste for biodegradable packaging, higher value secondary products (dietary fiber, phenolic acids), food colours/dyes. Genctic engineering in biological control and plant growth promotory product production, transgenic plants for biotic and abiotic stress resistence, quality enhancement.

Unit 5: Brewing
Media components, preparation of medium, microorganisms involved, maturation, carbonation, packaging, keeping quality, contamination, by products. Production of industrial alcohol.

Unit 6: Patients and secret process
History of patenting, composition, subject matter and characteristics of a patent, inventor, infringement, cost of patent. Patents in India and other countries. Fermentation economics.
Advances and trends, ethical issues, quality control, legislation, FDA & FPO, (India), safety and security at workplace.

Suggested Readings:

1. Prescott LM, Harley JP and Klein DA (2003) Microbiology (10th edition) McGraw Hill, New York.
2. PelczarJr, M.J. Chan, E.C.S and Krei N.R (1993) Microbiology McGraw Hill, New York.
3. Subba Rao NS (1997). Biofertilizer in Agriculture and Forestry, 3rd edition, Oxford & IBU Publications.
4. LE Cassida JR (2005). Industrial Microbiology. New Age International (P) Ltd., New Delhi.
5. Arora. Entrepreneurial Development in India.
6. Aneja, K.R. Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Production Technology, 6th Edition, New age International Publication.
7. Goyal P (2017) Before You Start Up: How to Prepare to Make Your Startup Dream a Reality. Fingerprint! Publishing

L041006TN EXTREME MICROBIOLOGY

Course Objectives

1. The goal of the course is to describe different extreme environments and molecular approaches to explore microbial communities in extreme environments.
2. Comprehend adaptations strategies of various extremophilic microorganisms.
3. Knowledge about extremozymes, exomicrobiology and their application.

Course Outcomes:

Upon successful completion students should be able to:

1. Know the types of microbial diversity flourish in extreme environments.
2. Understand how organisms cope under extreme living conditions with biochemical and molecular

adaption of extremphilic microorganisms.
3. Understand modern techniques used for exploration of unculturable extremophiles.
4. Understand potential application of extremozymes in various industries and in functional genomics.

Course Content:

Unit 1: Introduction to extremophiles
Concept of extremophiles v/s conventional microbial forms &archaea, habitats in universe, econiches, communities and community associations, biofilms, microbial community analysis of extreme environments using various molecular approaches (DGGE, cloning and next generation sequencing, functional genomics and transcriptomics).

Unit 2: Adaptation strategies
Occurrence, Physiological features, adaptation strategies of various extremophilic microbes: a) anearobes, barophiles/ peizophiles, cryophiles& thermophiles; b) oligotrophs, osmophiles, halophiles &xerophiles; c) radiophiles, metallophiles& xenobiotic utilizers; d) alkaliphiles/ basophiles, acidophiles. Potential applications of extremophilic microbes.

Unit 3: Microbes in toxic environments
Ore deposits/ mining areas (Fe, Mn, Cu), Acid mine drainage, waste containing cyanides, xenobiotics, pesticides, heavy metals and radio isotopic materials, extremozymes and their applications, field and case studies.

Unit 4: Mechanisms of sensing stresses
Protein-protein interactions: Two-component systems, sRNAs: Regulating translation mRNA of RpoS (the general stress response activator), Small molecules: The stringent response

Unit 5: Mechanisms of mitigating stresses
Pumping out toxins: Antibiotics
Scavenging toxins: Reactive oxidative species
Promoting tolerance: Extreme heat and cold
Repair calls: Single-stranded DNA damage
Gene expression in hyperthermophilic bacteria and archaea.

Unit 6: Exomicrobiology
Life detection methods - Evidence of metabolism - Evidence of photosynthesis (autotrophic and heterotrophic) - ATP production - Phosphate uptake and Sulphur uptake. Hyper-extremophiles and their novel metabolic machinery and biomolecules- future unique applications.
Antartica as a model for Mars. Search for life on Mars, Viking mission, Viking landers, and Biology box experiment. Gas exchange, Label release and pyrolytic release experiments. Monitoring of astronauts microbial flora: Alterations in the load of medically important microorganisms, changes in mycological autoflora, and changes in bacterial autoflora.

Suggested Readings:

1. Brock, T. D. (1978). Thermophilic Microorganisms and Life at High Temperatures, Springer, New York.
2. Fred A Rainey and Aharon Oren (2006). Extremophiles, Academic Press.
3. Horikoshi, K. and W. D. Grant (1998). Extremophiles-Microbial Life in Extreme Environments,Wiley, New York.
4. Gerday, C. And Glansdorff, N. (2007). Physiology and biochemistry of extremophiles. Washington, DC: ASM Press.

L041007TN-MOOC

Course Objectives
The objective of the MOOC course option is that student can opt any discipline specific course offered by Swayam/ NPTEL etc.

Course Outcomes: Upon successful completion students should be able to:

1. Can get the skills of discipline specific selected course.

L041008RN-SUMMER INTERNSHIP/ TRAINING/ REVIEW WRITING/ CASE STUDY

Course Objectives:
This objective of this summer internship/ training/ review writing, survey work is to impart competent skills to thrive in industries/ research institutions.

Note:
1. Students will be asked for their choice for summer internship/ training/ review writing/ survey work at the end of II semester.
2. Students are required to submit a report for assessment and need to demonstrate the project output.

Course Outcomes: Upon successful completion students should be able to:
1. List the objectives and state the hypothesis of the project.

For societal outreach.

L041009RN-RESEARCH PROJECT/ DISSERTATION

Course Objectives:
This course objective is to impart competent skills to thrive in research institutions and industries.

Course Outcomes:
Upon successful completion students should be able to:

1. List the objectives and state the hypothesis of the research project.
2. Outline the methodology that will be followed to achieve the listed objectives.
3. Employ the finalised methodology to solve the problem which has been undertaken.
4. Analyse the data which has been generated by carrying out several experiments.
5. Evaluate the data – accuracy and precision, sources of errors, specificity, sensitivity and detection limits, regression analysis, reporting results.
6. Organize the inferences to prove the hypothesis.

Note:
1. Project work will involve experimental work.
2. Students are required to do an individual research project.
3. Students are required to submit a report for assessment and need to demonstrate the working of research findings.
4. Students will be asked their choice for Project work at the end of II semester and all formalities of topic and mentor selection will be completed by this time.
5. The IPR rights of all such work lie with the University only.