COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
KOCHI-22
SCHEME AND SYLLABUS FOR
M.SC DEGREE PROGRAM IN MICROBIOLOGY (MODIFIED 2020)
APPLICABLE W.E.F. 2020 ADMISSIONS

SEMESTER-I

Course subjects		Instruction				Evaluation		
Course no.(total credits)	**Course name**	**Credits**	**Core/ Elective**	**Hours/ week**	**prerequisites**	**Internal**	**End semester**	**Total**
20-340-0101	Bacteriology	4	C	3L+1L+1T	Nil	50	50	100
20-340-0102	Fungi	4	C	3L+1L+1T	Nil	50	50	100
20-340-0103	Microbial genetics	4	C	3L+1L+1T	Nil	50	50	100
20-340-0104	Microbial biochemistry	4	C	3L+1L+1T	Nil	50	50	100
20-340-0105	Biostatistics & Principles of analytical techniques	4	C	3L+1L+1T	Nil	50	50	100
	TOTAL FOR SEM -I		**20C**		**-**	**250**	**250**	**500**

C-core; E-elective; All tutorial classes will be online

SEMESTER-II

Course subjects		Instruction				Evaluation		
Course no./ .(total credits)	**Course name**	**Credits**	**Core/ Elective**	**Hours/ week**	**prerequisites**	**Internal**	**End semester**	**Total**
20-340-0201	Microbial Physiology	4	C	3L+1L+1T	Nil	50	50	100
20-340-0202	Fermentation technology	4	C	3L+1L+1T	Nil	50	50	100
20-340-0203	Biosafety, bioethics and IPR	2	C	2L+1T	Nil	50	50	100
20-340-0204	Bioinformatics	3	C	3L+1L+1T	Nil	50	50	100
20-340-0205	Project Proposal Preparation and Presentation	1	C	1P+ 1T	Nil	100	-	100
20-340-0206	Critical Analysis of Classical Papers	1	C	1P + 0T	Nil	100	-	100
20-340-0207	Enzymology	4	E	3L+1L+1T	Nil	50	50	100
20-340-0208	Food microbiology	3	E	3L+1L+1T	Nil	50	50	100
20-340-0209	Plant –microbe interactions	3	E	3L+1L+1T	Nil	50	50	100
	TOTAL FOR SEM -II		15C 10E			400 150	200 150	600 300

C-core; E-elective; All tutorial classes will be online

SEMESTER-III

Course subjects		Instruction				Evaluation		
Course no./ .(total credits)	**Course name**	**Credits**	**Core/ Elective**	**Hours/ week**	**prerequisites**	**Internal**	**End semester**	**Total**
20-340-0301	Recombinant DNA technology	4	C	3L+1L+1T	Nil	50	50	100
20-340-0302	Immunology and Immunotechnology	4	C	3L+ 1P +1T	Nil	50	50	100
20-340-0303	Molecular Virology	4	C	3L+ 1P +1T	Nil	50	50	100
20-340-0304	Industrial microbiology	3	E	2L+ 1P+0T	Nil	50	50	100
20-340-0305	Functional Genomics	2	E	2L+ 1P+1T	Nil	50	50	100
20-340-0306	Environmental Microbiology	3	E	3L+ 1P+1T	Nil	50	50	100
20-340-0307	Diagnostic and Pharmaceutical microbiology	3	E	2L+ 1P+1T	Nil	50	50	100
20-340-0308	Biodegradation and Solid waste management	3	E	2L+ 1P+1T	Nil	50	50	100
	TOTAL FOR SEM -III		**12C** **15E**			**150** **250**	**150** **250**	**300** **500**

C-core; E-elective; All tutorial classes will be online

SEMESTER-IV

Course subjects		Instruction				Evaluation		
Course nos	**Course name**	**Credits**	**Core/ Elective**	**Hours/ week**	**prerequisites**	**Internal**	**End semester**	**Total**
20-340-0401	**Skill development and Entrepreneurship**	**4**	E	4	Nil	100	-	100
20-340-0402	Dissertation	**12**	**C**	-	-	200	200	400
	Comprehensive viva voce &Seminar	**1**	**C**	-	-	100	100	200
Total for semester IV			**13C** **4E**			**300** **100**	**300**	**600** **100**
Compulsory Elective SWAYAM/ NPTEL		3	E			100	-	100
GRAND TOTAL FOR M.Sc. BIOTECHNOLOGY PROGRAM			**60C** **29E**			1100 500	900 500	2000 1000

C-core; E-elective; All tutorial classes will be online

PROGRAM OUTCOMES FOR M.SC. MICROBIOLOGY

After finishing the program the Microbiology Master's students will able to

P.O.1. Demonstrate an Understanding of fundamental principles of bacteriology, virology, biochemistry, microbial genetics, and other allied subjects.

P.O.2. Gain proficiency in basic and analytical laboratory techniques in microbiology and be able to apply scientific methods to experimentation processes, enabling them to gain skilful job in industries and research labs

P.O.3. Design, conduct experiments and interpret experimental data using various statistical tools

P.O.4. Develop research plans and hypothesis for project and be able to defend their dissertation.

P.O.5. demonstrate analytical thinking and problem solving abilities.

P.O.6. have ability to present their work through written, oral and visual presentations.

P.O.7. Have ability to apply informatics for analysis of biological data for experimental and research purposes.

P.O.8. Acquire communication skill, learn to be team players, hone leadership qualities through various activities during their course work.

P.O.9. Gain Understanding of the skills required for entrepreneurship

COURSE REQUIREMENTS

Minimum credits to pass a semester	-16 credits
Maximum credits that can be taken per semester	-24 credits
Minimum credits to pass the M.Sc. program	-72 credits
At least one interdepartmental elective (level-2) (On or before semester III)	-3 or 4 credits
At least one elective course from SWAYAM/NPTEL (On or before semester IV)	-3 or 4 credits

Each credit earned requires 2.5 hours of study per week. This includes contact hours and self-study.
Each lab credit requires 3 hours of lab.

Internal evaluations for semester I to III

Exam Type	Course with lab (Marks)	Courses without Lab (Marks)
Internal Tests	30 (2 tests of 15 marks each)	45 (3 tests of 15 marks each)
Assignments	5	5
Practical Exam*	15	-
Internal Marks Total	50	50
End Semester Examination	50	50
Total Marks	100	100

45% marks is the Minimum required to pass end semester examination
50% minimum aggregate (internal + end semester) to pass each course

*****For all courses that contain laboratory Practicals, Laboratory evaluations are 100 % internal and will have a weightage of 15% (15 marks/100) of the total marks for the particular course.

All courses will be 100% internal evaluation.

Internal evaluations for semester I to III

Each theory course and its associated laboratory course of will be of 100 marks each.

Laboratory evaluations are 100 % internal.

20-340-0205, 20-340-0206, 20-340-0401 evaluation will be completely internal

20-340-0205 Evaluation - One internal examination covering all modules (20 marks), Project Proposal Report (40 marks) and Proposal Defense (40 marks)

20-340-0206 Evaluation - Class assignments (50 marks) and presentation (25marks) and final review (25 Marks).

20-340-0401 Evaluation - Class assignments/activities (50 marks) and final presentation (50marks)

Pattern of question paper for end semester examination

The questions will be framed to test the students at all the learning levels planned for the particular OBE course.
Maximum marks=50

Part-A: (10) MCQs OR match the following OR very short answer questions - no choice (10 x 0.5 = 5 marks)

Part-B: Answer Any Ten out of Eleven short answer questions of 1.5 marks each (10 x 1.5 = 15 marks)

Part-C: Answer Any Five out of six long answer questions of 4 marks each. (5 x 4 = 20 marks)

Part-D: Answer any one out of three Essay type question of 10 marks (1x10 =10 marks)

SEMESTER-I

20-340-0101 BACTERIOLOGY (4C) (3L + 1P + 1T)

Course description: This course in bacteriology is aimed at imparting basic knowledge about classification, structure, nutrition, growth, reproduction, and distribution of eubacteria cyanobacteria and archaebacteria. This course also imparts knowledge and skills in various practical techniques in cultivation, identification and maintenance of bacteria for their study and application. Further the students also learn and Understand physical and chemical methods of control of microorganisms and would apply these concepts in antimicrobial therapy and control of contaminants and pathogens.

Learning outcomes (LO) of the course: After completing the course the student will be able to

L.O.1. Explain and classify bacteria using molecular taxonomy (Understand level)

L.O.2. Describe and apply knowledge on nutritional requirements and nutritional groupings in isolating, cultivating and preserving different bacteria from environment for various studies and applications (Understand and Apply)

L.O.3. Describe the ultrastructure of bacteria and archaebacteria

L.O.4. Differentiate and evaluate the physical, chemical and biological control of microorganism in various situations in real life besides conducting advanced studies on microorganisms.(apply and Analyze)

L.O.5. Design practical experiments and use the same in study of bacteria and creating new knowledge (create)

MODULE I

Systematic position and Classification of bacteria: Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese; Historical account of bacterial classification, Detailed description of bacterial classification according to the 1st and 2nd edition of Bergey's Manual of Systematic Bacteriology; Introduction to bacterial taxonomy – morphological, biochemical and molecular taxonomy; Significance of G +C content, Plasmid profiles, DNA Barcoding, DNA finger printing methods, Importance of 16S rRNA in microbial identification and taxonomy.

MODULE II

Growth requirements and cultivation: Nutritional requirements and Nutritional groupings of bacteria; Media for cultivation of bacteria, Growth curve & factors effecting growth and growth rates. Different methods of cultivation and preservation of bacteria; Culture collection and maintenance of bacteria as stock culture; Distribution of microorganisms in soil, water, air and in extreme environments. Culture-dependent and culture-independent approaches for Understanding microbial diversity in the environment:

MODULE III

Eubacteria Morphology, Ultrastructure and Reproduction of bacteria, and cyanobacteria; Cell wall structure, difference between Gram positive and Gram-negative bacteria: - *Bacillus, E. coli*; Pili, Flagellum, Endospores, Toxins, Plasmids; Horizontal gene transfer and antibiotic resistance; Adaptation to environmental conditions.

MODULE IV

Archaea: Morphology, ultrastructure and reproduction of archaea; Archaeal Phylogeny, Ecology, Habitats and Physiology; - Archaea and Extremophiles-halophiles, thermophiles, barophiles; Life at hyper salinity; Genome organization in Halophilic archaea- Adaptation strategies of halophiles and hyperthermophiles at extreme conditions; Regulation of gene expression in archaea and bacteria representing extreme habitats; Protein and enzyme stability in hyper-extremophiles.

MODULE V:

Physical and chemical control of microbes. **Principles of antimicrobial therapy**: Various methods of control of microorganisms: physical, chemical and biological. Different methods of Sterilization- moist heat sterilization, Dry heat sterilization, Filter sterilization of thermolabile substances and air, chemical sterilization, Disinfection, and antisepsis, Antimicrobials, classification and modes of action. Antimicrobial resistance and their impact

LAB-1 BACTERIOLOGY

1. Sterilization techniques, Medium preparation and Plating techniques
2. Enumeration of heterotrophic bacteria from air, water, soil and food samples
3. Gram staining to differentiate Gram positive and Gram negative bacteria
4. Spore staining of *Bacillus* sp.
5. Hanging drop motility test
6. Biochemical and physiological tests for Identification of *Bacillus* sp, and *E.coli ,*
7. Growth of bacteria-growth curve by turbidity and colony counting
8. Antibiotic Sensitivity test
9. Enumeration of coliforms by MPN technique
10. Isolation of *Rhizobium* from root nodules of leguminous plant and characterization.

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20-340-0102 FUNGI (4C) (3L + 1P + 1T)

Course description: This course in fungi is aimed at imparting basic knowledge about general characteristics, classification, diversity, structure, nutrition, growth, reproduction, and distribution of fungi. The course also include knowledge on antagonistic infections by yeasts and fungal infections in man besides dealing with mycorrhizal fungi, endophytic fungi, and agriculturally important toxigenic fungi. Further this course also imparts knowledge and skills in bioprospecting the knowledge on secondary metabolites of fungi that have economic importance and biotechnological applications of fungi for their study and application.

Learning outcomes LO) of the course: After completing the course the student will be able to

L.O.1. Explain and classify fungi using molecular taxonomy (Apply)
L.O.2. Describe the nutritional requirements and cultivation of fungi, their rastructure and reproduction of fungi (Understand)
L.O.3. Differentiate the antagonistic infections by yeasts and fungi and disease management in human beings (analyze)
L.O.4. Compare the role of mycorrhizal fungi and its beneficial interactions, fungal endophytes and their adaptation besides important toxigenic fungi of agricultural importance(analyze)
L.O.5. Explain fungal secondary metabolites for deriving valuable bioactive products, industrial enzymes etc. besides biotechnological applications of fungi in solving environmental problems and in food industry (Understand)
L.O 6. Devise experiments for lab scale production of biomolecules (create)

MODULE I

General characteristics of fungi. Classification of fungi, Morphology and ultrastructure of fungi- *Aspergillus* sp, *Penicilium* sp, Fungal growth and reproduction. Sexual and asexual reproduction in fungi; Methods for the study of fungi. Cultivation of fungi. Characteristics of Mushrooms.

Fungal Systematics and diversity: Implications of molecular and biochemical methods including rDNA analysis, RFLP, RAPD and other fingerprinting techniques, fatty acids, polysaccharides and lipids and role of secondary metabolites in systematics. Distribution of fungi in various environments

MODULE II

Yeasts: -Morphology, ultrastructure and reproduction of yeasts- *Saccharomyces cerevisiae*, *Candida albicans;* Industrial applications of *Saccharomyces sp*

Antagonistic interactions in yeasts: Mycocinogeny and diversity of mycogenic yeast strains, characteristics of mycocins, mode of action, genetic basis of mycocinogeny, important mycocins, applications of antagonistic yeasts.

MODULE III

Fungal infections in man. Superficial and deep mycoses. Opportunistic fungal infections & Mycotic poisoning. Common fungal diseases of human and fungal pathogens associated with fungal diseases; Common laboratory contaminants. Molds and their association with other organisms.

MODULE IV

Mycorrhizal fungi: Diversity of endo and ectomycorrhizal fungi. Biology of arbuscular mycorrhizal fungi: signaling, penetration and colonization inside roots, culturing and benefits, recent advances in the field of mycorrhiza.

Fungal endophytes of tropical plants and their applications: Endophytic fungi, colonization and adaptation of endophytes. Endophytes as latent pathogens and biocontrol agents; secondary metabolites from endophytic fungi

Agriculturally important toxigenic fungi: Biodiversity, Chemical and biological characterization of toxic metabolites, toxigenic fungi in sustainable agriculture with special emphasis on biopesticides

MODULE V

Secondary metabolites from fungi: Terpenes, Non-ribosomal peptides, hydrophobins, peptaibols, indole alkaloids, detailed emphasis on polyketides.

Biotechnological applications of fungi:-Yeasts as producers of bioactive molecules such as pigments, lipids, organic acids and EPS, yeasts as probiotics, yeasts in bioremediation, yeasts in alcoholic fermentations.
Fungi as producers of industrial enzymes, secondary metabolites, bioactive substances and use of fungi in bioremediation and waste and waste water management

LAB-2 FUNGI

1. Isolation of fungi from air, water and bread
2. Slide culture technique for fungi
3. Isolation of *Aspergillus* sp, *Penicillium* sp, *Mucor*sp, *Rhizopus* sp and Lactophenol cotton blue mounting (slide culture technique)
4. Observation of asexual spores of fungi
5. Observation of reproductive structures of fungi
6. Culturing and Staining of Yeast *Saccharomyces cerevisciae*
7. Isolation and Identification of *Candida albicans* by phenotyping and genotyping
8. Cultivation of button mushrooms

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20-340-0103 MICROBIAL GENETICS (4C) (3L + 1P + 1T)

Course description: This basic course in bacterial genetics includes gene expression and regulation in prokaryotes as well as Genetic analysis of bacteria using various techniques. It also includes mutation and its various applications and implications. This course also covers the role of extrachromosomal inheritance and includes processes of gene transfer in bacteria such as conjugation, transformation and transduction. The study of Bacteriophages, their genes, lytic and lysogenic cycle as well as regulation is also included. In addition the various techniques to analyse the genomes of microbes is also included.

Learning outcomes (LO)of the course: After completing the course the students will be able to

L.O. 1.Describe the organization of the bacterial chromosome, gene, cistron, operon, regulon and their regulatory mechanisms **(Comprehension**)
L.O.2. Apply various techniques to analyze the genes and genomes in bacteria**. (Apply level)**
L.O.3. Conduct genetic analysis for diagnosis and epidemiology **(Apply level)**
L.O.4. Describe types of mutations, mutagens and mechanism of mutation **(Comprehension**)
L.O.5. Demonstrate gene transfer processes in bacteria **(Apply level**)
L.O.6. Describe the molecular mechanisms of lytic and lysogenic phages **(Comprehension**)
L.O.7. Demonstrate how genes are expressed and regulated **(Apply level**)

MODULE I

Organization of the bacterial chromosome, gene, cistron, operon, regulon, and their regulation mechanisms
Regulation of gene expression:gene copy number, transcriptional control-promotors, terminator, attenuators, anti-terminators; Control of gene expression. Induction and repression- the *lac* operon, regulatory mutants of the *lac* operon Positive gene regulation, negative gene regulation and attenuation, using, *gal*, *trp*, *ara* and *tol* operons, with emphasis on recent advances. Quorum sensing and cross talks.

Mutation: Importance and uses of mutation analysis. Types of mutations, spontaneous and induced mutagenesis, phenotypes, Reversions versus suppression. Complementation; Mechanism of mutation; chemical mutagens, UV irradiation-photo reactivation; SOS repair;
Isolation and identification of mutants, selecting mutants, replica plating, mutant enrichment; reverse genetics

MODULE II

Extra chromosomal inheritance: Plasmids -antibiotic resistance, colicins, bacteriocins, virulence determinants, plasmids in plant associated bacteria, metabolic activities-biodegradation; molecular properties of plasmids, plasmid maintenance and control of replication, plasmid stability, classification of plasmids, methods for studying plasmids.
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Gene transfer and mapping by conjugation: Molecular mechanism of gene transfer by conjugation – genes and proteins involved. Regulation of gene transfer by conjugation. Transfer systems in Gram positive bacteria. Ti plasmid transfer system and its application in creating transgenics.

Gene transfer by transformation and transduction: Natural transformation and competence. Molecular basis of natural transformation – DNA uptake competence systems in gram positive and gram negative bacteria. Regulation of competence in *B.subtilis*. Importance of natural transformation. Artificially induced competence. Generalized versus specialized transduction - T4 and lambda phage. Mapping bacterial genes by transduction.

MODULE III

Movable genes: Transposons- Discovery and Classes of bacterial transposons and Transposable elements, IS elements, composite transposons, replicative& non-replicative transposons, Mu transposition;
Regulation of transposition activity. Molecular mechanisms of transposition – genetic evidence supporting the mechanisms.
Effects of transposition in bacteria. Genetic requirements for transposition. Conjugative transposons; Mu transposon, Mutransposons and gene fusions, Yeast Ty-1 transposon. Site-specific recombination – *loxP*-Cre system, phase variation system in *Salmonella*. Transposition like events in retroviruses/retrotransposons.

MODULE IV

Genetics of bacteriophages: Single stranded DNA bacteriophages-φ β X174, M13; RNA phages MS2; Double stranded DNA phages T4, λ.
Lytic development cycle using phages T4 and T7 as models. Regulation of expression of genes in phage T4 – transcriptional activators, anti-termination, a new sigma factor and replication-coupled transcription. Regulation of gene expression in phage T7 – a phage-encoded RNA polymerase. Replication of T4 versus T7 phages – recent advances. Replication and packaging of filamentous phages M13 and f1 – recent advances.
Lysogenic phages: Lambda phage – gene and promoter organization. Lambda lytic cycle – regulation of gene expression – very early, early and late genes. Establishment and maintenance of lysogeny. Regulation of gene expression in lysogenic phase - role of cI, cII and cIII proteins. Lambda immunity region and immunity to superinfection. Events leading to induction – role of cI and cro repressors in regulating the events. Other lysogenic phages – P2 and P4. Lysogenic phages and bacterial pathogenesis.

MODULE V

Genetic analysis of bacteria:, Gene mapping, conjugational analysis, transformation and transduction,
Molecular techniques in gene mapping-gene libraries, Restriction mapping and PFGE, DNA sequence determination, genome sequencing; PCR analysis of mutants, site directed mutagenesis; Analysis of gene expression-western blots, Northeren blots, RT-PCR, Diagnosis and epidemiology-gene probes for detection of

pathogens, Detection of virulence genes; diagnostic use of PCR, molecular epidemiology, RFLP analysis, genetic fingerprinting, Human diseases and gene therapy; recombination tests and gene replacements.

Genetic analysis of phages – complementation and recombination tests with phages. Genetic experiments with the rII genes of phage T4. Deciphering the genetic code using rII mutants. Constructing phage genetic linkage maps using two-factor and three factor crosses.

Assays to analyze transposition events – suicide vectors and mating out assays. Transposon mutagenesis, cloning genes by transposon mutagenesis, mini-Mu elements and their use in *in vivo* cloning.

LAB-3 MICROBIAL GENETICS

1. Replica plating for transfer of bacterial colonies (L.O. 1, 2 & 4)
2. Isolation of plasmid DNA and determination of molecular weight by electrophoresis (L.O. 2, 3 & 5)
3. Restriction mapping (L.O. 2,3 & 5)
4. Bacterial conjugation (L.O. 2,3 & 5)
5. Competent cell preparation and Transformation (L.O. 2,3 & 5)
6. Induction of beta-galactosidase in *E.coli*and regulation (L.O. 1, 2 & 7)
7. Ames test for detecting mutagens(L.O. 1& 4)
8. Tn5 mutagenesis for induction of kanamycin resistance in *Rhizobium* sp.(L.O. 1 & 4)
9. Isolation of coliphages from sewage(L.O. 5 & 6)
10. Determination of one-step growth curve of bacteriophages(L.O. 5 & 6)
11. PCR for detection of pathogens in clinical sample (L.O. 2 &3)

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20-340-0104 MICROBIAL BIOCHEMISTRY (4C) (3L + 1P + 1T)

Course description: This is a basic course that looks at the metabolic pathways in microbes. The student will gain Understanding about energy metabolism in microbes, cell wall synthesis as well as the various catabolic and anabolic pathways in microorganisms, especially bacteria. In addition the course deals with bacterial photosynthesis, bacterial luminescence and quorum sensing pathways.

Learning outcomes (LO) of the course: After completing the course the students will be able to

L.O.1. Comprehend various thermodynamic principles governing biochemical changes, Review bioenergetics, free energy, redox potential, biological oxidation (Comprehension level)
L.O.2. Describe the role of ATP in biosynthesis and the various modes of ATP generation
L.O.3. Elucidate chemistry of various biomolecules and identify biomolecules (carbohydrate, fatty acid amino acid and nucleic acid) (Apply level)
L.O.4. Illustrate carbohydrate, fatty acid amino acid and nucleic acid metabolic pathways and their regulation (Analyze level)
L.O. 5. Describe bacterial photosynthesis and metabolism
L.O.6. Apply the Understanding of metabolic pathways to biotechnological and biochemical research (Apply level)

MODULE I

Bioenergetics: Overview of thermodynamics, Relationship between G and Keq.; High energy compounds, standard free energy of hydrolysis of ATP, structural basis of the group transfer potential of ATP; Oxidation reduction potential, different types of oxidation reduction reactions.

Carbohydrate Chemistry & metabolism: Overview of Carbohydrate chemistry. Glycolysis, Pentose phosphate pathway, Entner-Doudoroff pathway. Citric acid cycle, Glyoxalate cycle. Biochemistry of fermentations. Macromolecular synthesis-peptidoglycan, starch, glycogen, chitin

MODULE II

Lipid Chemistry & metabolism: Overview of fatty acids and lipid chemistry. Biosynthesis of Fatty acids and phospholipids; Catabolism of fatty acids and Phospholipid; Regulation of fatty acid metabolism; Synthesis of polyisoprenoid compounds and porphyrins. Synthesis of lipopolysaccharides,

MODULE III

Aminoacid Chemistry & metabolism: Overview of amino acids and protein. Biosynthesis of amino acids –an overview; Catabolism of amino acid carbon skeleton; synthesis of other N-compounds via amino acids pathways - function and metabolism; Metabolism of aromatic amino acids & Histidine, Cysteine and Serine;

MODULE IV

Nucleic acid Chemistry & metabolism: Overview of nucleic acids, Purines and Pyrimidines, Biosynthesis & catabolism of purines and pyrimidines; Regulation of purine and pyrimidine metabolism; Biosynthesis of nucleotide coenzymes; Inhibitors of nucleotide biosynthesis as chemotherapeutic agents.

MODULE V

Bacterial electron transport system; Bacterial photosynthesis, Bacterial luminescence- structure of photosynthetic apparatus in prokaryotes, pigments and lipids in photosynthetic apparatus in prokaryotes, Electron transport and N-fixation (in Blue green algae); anoxygenic photosynthesis(Green algae), Quorum sensing and mechanisms.

LAB-4 MICROBIAL BIOCHEMISTRY

Suggested List of Practical lab

1. Identification of carbohydrate (Sugars), amino acids/protein, cholesterol and triglycerides and nucleic acids
2. Estimation of carbohydrate (Sugars), protein, cholesterol and triglycerides and nucleic acids by spectroscopic analysis
3. Estimation of serum SGOT and SGPT levels

4. Fluorescence spectroscopy to study effect of temperature and pH on protein structure.
5. Estimate Tm (Effect of temperature on DNA)
6. Determination of catalase enzyme activity of various bacterial strains
7. Other biochemical like citrate utilization, indole, Conversion of lactose to acid, etc using bacterial strains

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20-340-0105 BIOSTATISTICS & PRINCIPLES OF ANALYTICAL TECHNIQUES (4C) (3L+1P+1T)

Course description: Biostatistics topics include data and data types, tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; and random sample and other study types. Bioinstrumentation introduces fundamental principles of biotechnological instruments/techniques like optical and Electron microscopes, Colorimeter, spectrophotometer, Chromatographic techniques, Centrifuges, Radio isotope technology, Immunoassay system and Electrophoresis used in biotechnology labs.

Learning outcomes (LO) of the course: After completion of the course, the students will be able to:

L.O. 1 Explain the conceptual framework of basic methods of bio- statistical analysis
L.O. 2 Develop a conceptual framework that integrates techniques and methods in biostatistics: thus student will learn that the principles of biostatistics are grounded in scientific learning.
L.O. 3 Apply descriptive statistical techniques, commonly used, to summarize scientific data.
L.O. 4 Select, use and interpret results of principal methods of inferential statistics and design.
L.O. 5 Communicate the results of statistical analysis accurately and effectively: thus the student will able to write technical reports and make technical presentation containing statistical results and work.
L.O.6 Handle instruments independently for analysing samples of Biotechnology experiments.

Module I

Biostatistics I: Statistical data – types of data: primary, secondary, qualitative and quantitative - methods of collection: population, sample, sampling techniques - classification of data: frequency distribution and graphical

presentation of data. Scales of measurements. Measures of central tendency - mean, median and mode. Measures of dispersion - Range, mean deviation, standard deviation, standard error and co-efficient of variation.

Module II

Biostatistics II: Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design..

Module III

Basic Microscopy: Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy

Advanced Microscopy: Confocal microscope: scanning optical microscope, confocal principle. nonlinear microscopy: multiphoton microscopy, tandem scanning (spinning disk) microscopes, advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy, Total Internal Reflection Microscopy; Near-Field Microscopy, Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM), Electron microscopy, AFM

Module IV

Principles and applications of advanced molecular Biology Techniques: Basic principles and applications of pH meter, Colorimeter, Spectrophotometers and Centrifuges

Chromatographic techniques- Paper chromatography, Thin layer chromatography, Column chromatography, Gas Chromatography, HPLC

Types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR

ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray: 16S rRNA typing;

Diagnostic proteomics: SELDI-TOF-MS, 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases. LCMS & NMR technological platforms. Metabolomics, lipidomics, metagenomics

X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, small- angle X-ray scattering

Module V

Immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, microarrays, transgenic mice, gene knock outs.

LAB-5 **BIOSTATISTICS AND BIO INSTRUMENTATION**

1. Classify data collected by themselves using frequency table and represent it graphically.
2. Analyse data for mean, median and mode.
3. Analyse data for mean deviation, standard deviation, standard error and co-efficient of variation
4. Analyse a set of data for correlation and regression.
5. Determine probability for different types of events.
6. Test the significance of data using test t-, chi square test and ANOVA.
7. Analyse various statistical data by using MSExcel and SPSS software"
8. Micrometry and Haemocytometry
9. Calibrate the pH meter and test the pH of different sample solutions.
10. Estimate the concentration of the given sample (Beer-Lambert's law)
11. Prepare a plant extract and perform TLC
12. Gas chromatography and HPLC- demonstration.

13. Phase contrast, Fluorescence, Confocal and Electron microscopy- demonstrations.
14. Identify a specific protein marker expressed in a cell using Immunocytochemistry and microscopy techniques.

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SEMESTER II

20-340-0201 MICROBIAL PHYSIOLOGY (4C) (3L + 1P + 1T)

Course description: This is a basic course in Microbial Physiology. The course content includes the study of bacterial photosynthesis and respiration. Bacterial permeation sporulation and adaptations stress physiology, quorum sensing and communications among microorganisms, adaptations in extreme environments, as well as fungal physiology. This is important in order to Understand and mind the various microbial processes for industrial, diagnostic or medical applications

Learning outcomes (LO) of the course: After completing the course the student will be able to

L.O.1 Differentiate between prokaryotes and eukaryote photosynthesis and respiration (analyse)
L.O.2 Describe the organization of the microbial cell wall and membrane, the various transport systems and the secretory systems and their regulation in microbial control(Understand)
L.O.3 Describe the mechanism of sporulation and other adaptations for survival (Understand)
L.O.4 Describe stress physiology and other adaptations in extremophiles (Understand)
L.O 5 Demonstrate the mechanism of quorum sensing and quenching in microbial growth, pathogenesis and control (Apply)
L.O 6 Explain fungal physiology and adaptations in extreme environments and apply the knowledge in real time situations (Understand)

MODULE 1

Bacterial Photosynthesis and Respiration: Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria, Carbon dioxide fixation pathways.

Bacterial aerobic respiration, components of electron transport chain, free energy changes, and electron transport, oxidative phosphorylation and theories of ATP formation, inhibition of electron transport chain, Electron transport chain some heterotrophic and chemolithotroph bacteria.

Bacterial anaerobic respiration- introduction. Nitrate, carbonate and sulphate as electron acceptors, Electron transport chain in some anaerobic bacteria. Catalase, super oxide dismutase, mechanism of oxygen toxicity.

MODULE II

Bacterial permeation-Structure and organization of membranes (Glyco-conjugates and proteins in membrane systems), membrane transport in bacteria- simple passive, facilitated diffusion, group translocation, different mechanisms of active transport (Proton motive force, PTS, role of permease in transport, different permeases in *E. coli*. Transport of amino acids and inorganic ions and their mechanism, ABC transporters; siderophores and iron transport, Protein export in microbes, protein export pathways and antimicrobial therapy.

MODULE III

Bacterial sporulation and physiological adaptation- Molecular architecture of spores, induction and stages of sporulation, influence of different factors on sporulation, cytological and macromolecular changes during sporulation, Heat resistance and sporulation, Resistances of spores to drugs; Regulation of enzyme activity and gene expression

MODULE IV

Stress Physiology- Effect of oxygen toxicity, pH, osmotic pressure, heat shock, cold shock, and others etc on bacteria and fungi: Adaptations in extremophiles- thermophiles, psychrophiles, halophiles, acidophiles and alkalophiles. Adaptation and their significance in biotechnology applications; Quorum sensing and signal transduction, cell to cell communications in microorganisms, chemotaxis. Quorum sensing and cross talks, Quorum quenching in microbial growth and in pathogenesis; Bacteriorhodopsin and bioluminescence.

MODULE V

Fungal Physiology- nutrient transport in fungi; Fungi nutrition and cellular biosynthesis, physiology of growing hypha, hyphal aggregates; Overview of fungal biosynthetic pathways, quorum sensing in fungi, Adaptation of fungi to extreme environments

LAB-6 MICROBIAL PHYSIOLOGY

1. Isolation of Photosynthetic bacteria
2. Glucose uptake by *E. coli* / *Saccharomyces cerevisiae* [Active and Passive diffusion]
3. Effect of UV, pH, disinfectants, chemicals and heavy metal ions onspore germination of *Bacillus* SP.
4. Determination of Sulfur Oxidation Rate of *Thiobacillusthiooxidans.*
5. Estimation of calcium ions present in sporulating bacteria by EDTA method.
6. Demonstration of utilization of sugars by oxidation and fermentation techniques
7. Observation of biofilm formation and assessment of quorum sensing molecules

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20-340-0202 FERMENTATION TECHNOLOGY (4C) (3L + 1P + 1T)

Course description: This course gives the student an insight into bioprocesses for industrial applications. Differences between bio- and chemical processes, types of bioprocesses, screening for industrially important organisms, strain improvement strategies are all part of this course. In addition the kinetics of fermentation in batch and continuous mode, the mass transport processes, reactor design, types of reactors, process control and downstream processing of biological are included.

Learning outcomes (LO) of the course: After completing the course the student will be able to

L.O.1. Differentiate chemical and biological processes (analyze)
L.O.2. Employ various methods of strain improvement of industrial organisms.(Apply)
L.O.3. Employ batch processes, as well as sterilization processes for application.(Apply)
L.O.4. Differentiate between batch and continuous processes(analyze)
L.O.5. Explain mass and heat transfer processes in fermentation (Understand)
L.O.6. Explain process control and scale-up and also downstream processing (Understand)
L.O.7. Select processes such as solid state, submerged fermentation or immobilization for production (Analyze)
L.O.8. Employ different downstream processing for enzyme purification (Apply)

MODULE I
Introduction to microbes in industrial processes. Isolation and screening of industrially useful microorganisms, Primary and secondary screening, Strain improvement in industrial microbiology; improvement of characters other than product yield. Improvement of strains for increased yield and other desirable characteristics-mutation and selection, Genetic recombination Screening, detection and assay of fermentation products (physical, chemical and biological assay).

MODULE II
Types of fermentations: aerobic and anaerobic; submerged and Solid State; Importance of media in fermentation, media formulation and modification. Design of fermentation media Kinetics of growth in batch, continuous, fed-batch fermentation,
- Storage of cultures for repeated fermentations,

MODULE III
Sterilization: thermal death kinetics, batch & continuous sterilization systems, Sterilization of air, fibrous filters; sterile filtration of biologicals.
Fermentation process: Inoculum development, scaling up and modelling of process form shake flask to industrial fermentation etc.

MODULE III
Mass transfer-Mass transfer coefficient for gases and liquids; Dimensionless groups - Reynolds no.; Mass transfer resistance; Rate of oxygen transfer; Oxygen transfer coefficient; Rheological properties of intermediates; Heat transfer – heat transfer coefficients, heat exchanger design.

MODULE IV

Design of a fermentor, instrumentation and process control; Types of fermenters Parts and their functions. Types of reactors; Auxiliary instrumentation of bioreactors; Microprocessor controlled fermenters.
online measurements; Monitoring variables such as temperature, aeration, agitation, pressure, pH, foaming; Computers in bioprocess control systems; Economic aspects of bioprocess.

MODULE V

Downstream processing. Separation of cells, cell disruption and recovery; Direct extraction of products and metabolites; Large scale separation techniques like chromatographic and affinity techniques; membrane filtration –ultra filtration and reverse osmosis; Spray drying, drum drying & freeze drying.

LAB-7 FERMENTATION TECHNOLOGY

Suggested List of Practicals

1. Primary screening of organism for amylase production
2. Submerged fermentation for the production of α-amylase
3. Solid state fermentation for the production of citric acid A. Niger
4. Immobilization of whole cells for the production of enzyme
5. Partial purification of enzymes and chromatographic separation
6. Production of rifamycin using Nocardia strain.
7. Ethanol production using *Saccharomyces cerevisiae*
8. Microbial production of dextran by *Leuconostoc mesenteroides*

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11. P. Gunasekaran, Laboratory Manual In Microbiology 2007, New Age International publishers
12. Basanta Kumar Rai, Dil Kumar Subba, Basic Practical Manual on Industrial Microbiology 2016, Dharan Multiple Campus, Nepal

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20-340-0203 INTRODUCTION TO BIOETHICS, BIOSAFETY AND IPR (2C) (2L+0P+1T)

Course Description: This course introduces bioethics, biosafety and the IPR issues related to biotechnological research. It reviews ethical, legal and social issues and practices related to various applications of biotechnology including genetic testing and therapy, cloning, use of stem cells, etc. The practical aspects of performing responsible conduct of research will also be discussed. Discussion topics include biosafety issues regarding rDNA research as well as the various guidelines. The course will also discuss release of genetically modified organisms to the environment, its impact and safety issues. In addition the role of IPR and role of patent in biotechnology and procedures for patenting and protection of traditional knowledge will be discussed.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

LO1: Understand the ethical, moral, social and legal issues underlying products and processes developed by biotechnology and microbiology (Understand)

LO2: Analyse and select appropriate biosafety measures for the conduct of experiments using various living organisms (Apply)
LO3: Explain the process of risk assessment analysis of the release of genetically modified organisms (Understand)
LO4: Identify potential ethical issues in the conduct of research experiments and to avoid committing unintentional research misconduct (Analyse)
LO5: Understand the process of applying for a provisional and complete patent through national and PCT mode (Understand)
LO6: Explain the various measures to protect to biodiversity and traditional knowledge from exploitation by unjust commercial interests (Comprehend)

MODULE I

Ethics and Bioethics: Freewill and Determinism, Morals and values, Theories of Ethics

Ethical, moral, social and legal issues in Biotechnological research: Relevance of regulation and control of research in biotechnology, societal obligations of a biotechnologist; Concerns relating to experimentation on animals, genetic engineering of plants and animals for food (GM foods), cloning, stem cell research, human gene therapy and genetic modifications, genetic testing and screening, human clinical trials and drug testing, bi-weapons program/bioterrorism.

MODULE II

Research Ethics: Responsible Conduct of Research; fabrication, falsification, and plagiarism; Authorship; Conflicts of Interest; Peer review and collaboration; Data and data management; Use of animal subjects and animal protocols; Use of human subjects and IEC; Rigor and reproducibility, Research misconduct - case studies of major research misconduct.

MODULE III

Biosafety: Safety issues in different fields of Biotechnology, General Guidelines for recombinant DNA (rDNA) research**,** The Cartagena Protocol on Biosafety; NIH Guidelines; Guidelines for recombinant DNA research in India.

Classification of microorganisms according to pathogenicity; Containment facilities and Biosafety practices.

Risk Analysis and Assessment: Release of GM organisms to the environment- Environmental Impact Assessment and risk analysis. Safety assessment of GMO foods and human clinical trials; GLP and GMP

MODULE IV

Intellectual Property Rights (IPR): Different types of IPR, Patents – Origin and Treaties, Criteria for patentability, Issues of Patentability, PCT, Patent applications-rules and procedures, Impact of patents on the pharma sector, Patenting of life forms.

MODULE V

Protection of Traditional Knowledge: Plant variety protection, Registration of newer varieties, Rights and obligations: Farmers and breeders rights. Protection of biodiversity, Convention on Biodiversity and the Indian Biodiversity Act, Protection of Traditional Knowledge

REFERENCES:

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20-340-0204 BIOINFORMATICS (CORE - 3C) (2L + 1P+1T)

Course description: This is an introductory course in bioinformatics. It includes the study of biological databases, primary and secondary databases and their importance; Sequence alignment and database search; phylogeny and Phylogenetic trees: Nucleotide sequence analysis: Tools and methods; Protein sequence analysis; and getting an idea of the various web resources available for scientific and research use.

Learning outcomes (LO) of the course: After completing the course the student will be able to
L.O.1. Describe data handling (Understand)
L.O.2. Understand basic scripts in PERL, PYTHON (Understand)
L.O.3. Retrieve data (Sequences) from databases (Apply)
L.O.4. Execute the use of various tools for sequence alignment and database search (Apply)
L.O.5. Construct molecular phylogeny and phylogenetic trees (Create)
L.O.6. Employ basic tools used in proteomics (Apply)
L.O.7. Describe the structural analysis tools in genomics and proteomics. (Understand)

MODULE I
Introduction Of Databases:-Concept of data, data models, data representation, mining, various types of databases, biological data and data analysis. Programming in PERL, PYTHON, Outline of Oracle, SQL, VB and Database management System (DBMS).

MODULE II
Biological Databases: Introduction to protein and nucleic acid databases; Sequence databases - Primary and secondary databases, composite databases, annotated databases, genomes and organism specific databases, protein databases, disease databases, small molecule databases, Toxicology Database.
NCBI, Entrez, file formats for sequence databases. Retrieval of biological data.

MODULE III
Sequence alignment and database search: Pair-wise sequence alignment, Multiple sequence alignment, Dot plots; Local and global alignment theory, Dynamic programming methods, FASTA and BLAST algorithms, database search using BLAST and FASTA; VAST, Similarity & distance, Similarity scores, Weight matrices, Heuristic method, Hidden Markov Models and their application in sequence analysis.

MODULE IV
Genomics and Proteomics:
Genomics: Phylogenetic analysis:-Evolution, elements of phylogeny, methods of phylogenetic analysis, Phylogenetic tree of life, comparison of genetic sequence of organisms, phylogenetic analysis tools-Phylip, ClustalW.

Proteomics:-Protein sequence information, composition and properties, physicochemical properties based on sequence, sequence comparison, Pair-wise sequence alignment, gaps, gap-penalties, scoring matrices, PAM250,BLOSUM62, ClustalW, Clustal Omega, BLASTp, Mascot

MODULE V
Structural Bioinformatics: Structural databases:- Protein Data bank (PDB), PIR, Nucleic Acid Data Bank (NDB),Molecular modeling Data Bank (MMDB).

Protein Structure Prediction:- D Primary structure analysis and prediction, Secondary structure analysis and prediction, motifs, profiles, patterns and fingerprints search.

LAB-8 BIOINFORMATICS

Suggested Practical Lab session

1. Biological Databases:

a. Retrieve the sequence of Human insulin gene from GenBank (L.O.3)

b. Retrieve the sequence of Human insulin from UniProt (L.O.3)

2. Find the similarity between sequences using BLAST and FASTA (L.O.4)

3. Align more than two sequences and find out the similarity between those sequences using CLUSTAL O (L.O.4)

4. The phylogenetic relationships of nucleotide using MEGA (L.O.5)

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20-340-0205 PROJECT PROPOSAL PREPARATION AND PRESENTATION (1C) (1L-0P-1T)

Course Description: The purpose of this course is to introduce the students to the scientific method and help students organize ideas, material and objectives for their dissertation. It is also intended to help students to begin the development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

LO1: Understand and practice the scientific method and the source of scientific information (Comprehend)
LO2: Identify potential research area/problem for study by analysing gap in current knowledge by gathering and analysing scientific literature (Apply)
LO3: Critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis (Analyse)
LO4: Frame a hypothesis and device a research plan and methodology for testing the hypothesis/finding solution for the problem (Analyse)
LO5: Perform research design and planning after creating, analysing and critically evaluating different technical solutions (Analyse)
LO6: Write the Project Report containing all the technical details and budgeting requirements (Create)
LO7: Make a presentation and successfully defend it by communicating effectively (Create)

MODULE I (3 hours)
Scientific Methodology: Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology

MODULE II (2 hours)
Source of Scientific Information: Journals (current and back volumes): Indexing journals, abstracting journals, research journals, review journals, e-journals; Impact factor; NCBI-Pub Med., Data Bank and Data Mining; INFLIBNET, INSDOC.

MODULE III (3 hours)
Process of Communication: Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences;

MODULE IV (2 hours)
Scientific communication: Presentation skills – formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

MODULE V (5 hours)
Scientific communication - Writing: Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, REFERENCES; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Project Proposal Preparation
Selection of research lab and research topic: Students should first select a lab (topic) wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest and help them select a topic for their project. The topic of the research should be hypothesis driven.

Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.

Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

Proposal Presentation
Oral Presentation: Students will have to present the their project proposal in front of the class and defend the research methodology, significance of the study, etc. and explain the anticipated results as well as answer the queries by the class members.

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5. Movie: Naturally Obsessed, The Making of a Scientist.
6. John W. Creswell 2013Research design, Qualitative, Quantitative and Mixed methods Approaches, , Sage publications Inc.
7. Debbie Holmes.2010. Research methods for the Biosciences: OUP Oxford
8. Gurumani N., Research methods for the Biosciences, 2011, MJP publishers
9. Arumugam N., Research Methodology for Life sciences, 2015, Saras Publications

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20-340-0206 CRITICAL ANALYSIS OF CLASSICAL PAPERS (1C, 0L-1P-0T, 15 HOURS)

Course Description: The objectives of this course are to familiarize students with classic literature to make them appreciate how ground breaking discoveries were made without, necessarily, use of high-end technologies.

Students may be divided in groups of two and each group may be responsible for one classical paper. Each week there may be a 1.5 hour presentation cum discussion for each of the papers. Each student will come to class after reading the paper and at the end of the semester each student will be asked to write a mini-review (3-4 pages long) on any one classical paper, other than the one he/she presented/discussed.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

LO1: Appreciate the path-breaking work published in classical papers (Understand)
LO2: Apply data analysis tools and logical reasoning in the in-depth study and critical analysis of primary literature data (Apply)
LO3: Generate hypothesis from primary literature and anecdotal data (Analyze)
LO4: Ability to effectively summarize a compendium of research work or information (Create)

Sample Papers for Discussion

DNA, genes, operon

1. Watson JD and Crick FH; (1953) Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid, Nature. 1953 Apr 25;171(4356):737-8

Note: In this one page paper Watson and Crick first described the structure of DNA double helix

2. Meselson M and Stahl FW (1958) Messelson & Stahl experiment demonstrating semi-conservative replication of DNA.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82

Note: The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology"

3. Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn (1990) *In vivo* alteration of telomere sequences and senescence caused by mutated *Tetrahymena* telomerase RNAs; Nature 344, 126-132, 1990

Note: This paper demonstrates that the telomerase contains the template for telomere synthesis

4. Alexander Gann (2010) Jacob and Monod: From Operons to EvoDevo. Current Biology 20, R718–R723, September 14, 2010 ª2010 Elsevier Ltd All rights reserved DOI 10.1016/j.cub.2010.06.027.(Introduction material, not for student presentation

Genetic exchange and Mutations

1. Miller, J.H. (1992) A Short Course in Bacterial Genetics: A Laboratory Manual and Handbook for Escherichia coli and Related Bacteria. Cold Spring Harbor Laboratory Press, Cold Spring Harbor.(Introduction material, not for student presentation

2. S. E. Luria and M. Delbrück 1943, MUTATIONS OF BACTERIA FROM VIRUS SENSITIVITY TO VIRUS RESISTANCE,GENETICS *November 20, 1943 vol. 28 no. 6 491-511*

Note: this paper describes how the authors proved the hypothesis that the resistant bacteria arise by mutations of sensitive cells independently of the action of virus. It also explain how mutation rate can be calculated.

3. Cairns, J., Overbaugh, J. & Miller, S. The origin of mutants. *Nature* **335,** 142–145 (1988). https://doi.org/10.1038/335142a0

Note: As the result of studies of bacterial variation, it is now widely believed that mutations arise continuously and without any consideration for their utility. In this paper, the authors review the source of this idea and then describe some experiments suggesting that cells may have mechanisms for choosing which mutations will occur.

Bacterial transformation

1. Fred Griffith (1928) The significance of pneumococcal types. J. hygiene, 27(2)115-159

Note: This paper describes the transformation of the avirulent form of pneumococci to virulent form

2. Avery OT, Macleod CM, McCarty, 1944 M Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid fraction isolated from *Pneumococcus* type III. J Exp Med. 1944 Feb 1;79(2):137-58.

Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.

3. Hershey AD and Chase M. (1952) Independent functions of viral protein and nucleic acid in growth of bacteriophage; J Gen Physiol. 1952 May;36(1):39-56.

Note: Note: This paper demonstrates that protein is not the hereditary material.

Transposons

1. Controlling Elements and the Gene BARBARA McCLINTOCK: http://www.evolocus.com/Publications/McClintock1956.pdf

Note: In this paper, the author describes transposition

2. N Kleckner, RK Chan, BK Tye, D Botstein(1975) Mutagenesis by insertion of a drug-resistance element carrying an inverted repetition, - Journal of molecular biology. 97, 565-575

3. Judith Bender and Nancy Kleckner, 1986 Genetic evidence that Tn10 transposes by a nonreplicative mechanism, Cell, 45:801-815

Note: The authors present genetic evidence that the tetracycline resistance element Tn10 transposes by a nonreplicative mechanism.

4. James Hicks, Jeffrey N. Strathern & Amar J.S. Klar (1979) Transposable mating type genes in *Saccharomyces cerevisiae,*; Nature 282, 478-483,1979

Note: This paper provided evidence for 'cassette hypothesis' of yeast mating type switches *i.e.* interconversion of mating types in yeast *(S. cerevisiae)* occurs by DNA rearrangement

5. Lisa A. Mahnke Braam‡§, Igor Yu Goryshin and William S. Reznikoff **(1999) A mechanism for** Tn*5* inhibition carboxyl-terminal dimerization*he Journal of Biological Chemistry, 274, 86-92. doi: 10.1074/jbc.274.1.86J

Note: This paper explain the mechanism of inhibition by Tn5, a prokaryotic transposable elements

Gene regulation

1. Michael Emmer, Benoit deCrombrugghe, Ira Pastan, and Robert Perlman (1970).Cyclic AMP Receptor Protein of *E. coli:* Its Role in the Synthesis of Inducible Enzymes, PNAS June 1, 1970 66 (2) 480-487; https://doi.org/10.1073/pnas.66.2.480
   Note: this paper explain the role of cAMP binding protein in synthesis of beta gactosidase in *E. coli*
2. François Jacob and Jacques Monod 1961, Genetic regulatory mechanisms in the synthesis of proteins† J. mol.Biol. 3:318 ;https://doi.org/10.1016/S0022-2836(61)80072-7
3. Stock, J., Stock, A. & Mottonen, J. Signal transduction in bacteria. *Nature* **344,** 395–400 (1990). https://doi.org/10.1038/344395a0
4. David M., et al., 1988. Cascade regulation of *nif* gene expression in *Rhizobium meliloti.* Volume 54, Issue 5, Pages 671-683; https://doi.org/10.1016/S0092-8674(88)80012-6

DNA finger printing

1. J R Lupski, G M Weinstock (1992) Short, interspersed repetitive DNA sequences in prokaryotic genomes.J Bacteriol. 1992 Jul; 174(14): 4525–4529. doi: 10.1128/jb.174.14.4525-4529.1992

Note: this paper explains the application of repetitive DNa sequences in estimating relative degrees of similarity and for clonal similarity

2. J Versalovic, M Schneider, FJ De Bruijn, JR Lupski, 1994 Genomic fingerprinting of bacteria using repetitive sequence-based polymerase chain reaction. Methods in molecular and cellular biology 5 (1), 25-40

Developmental genetics

1. Philip Youngman, Peter Zuber, John B. Perkins, Kathleen Sandman, Michele Igo, Richard Losick, New Ways to Study Developmental Genes in Spore-Forming Bacteria.*Science* 19 Apr 1985:Vol. 228, Issue 4697, pp. 285-291;DOI: 10.1126/science.228.4697.285

Note: .(Review material, not for student presentation)

2. Shimkets, L J. "Social and developmental biology of the myxobacteria." *Microbiological reviews* vol. 54,4 (1990): 473-501. Note:
   Note: (Review material, not for student presentation)
3. Driks A. Overview: Development in bacteria: spore formation in Bacillus subtilis. *Cell Mol Life Sci*. 2002;59(3):389-391. doi:10.1007/s00018-002-8430-x

Note: (Review material, not for student presentation)

20-340-0207 ENZYMOLOGY 4E (3L+ 1P +1T) ELECTIVE

Course description: This course on enzymology covers classification, nomenclature, isolation and purification of enzymes. It also includes the structure and general properties of enzymes, mechanisms of enyme catalysis, Enzyme kinetics, different types of enzyme inhibition, regulation of enzymes and applications of enzymes.

Learning outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Explain principles underlying classification & nomenclature of enzymes (Understand)
L.O.2. Employ suitable methods for isolation and purification of enzymes from different sources (Apply)
L.O.3. Describe the structure and general properties of enzymes and their mechanism of action (Understand)
L.O.4. Apply enzyme kinetics to study enzyme characteristics and analyze kinetic parameters to differentiate different types of enzyme inhibition.
L.O.4. Evaluate the role of regulatory enzymes in the regulation of metabolic pathways (Analyze)
L.O.5. Discuss the applications of enzymes in medicine, industry and genetic engineering and synthetic enzymes.(Understand)

Module –I

Enzyme nomenclature and classification: The Enzyme Commission's system of classification and nomenclature; The six main classes of enzymes and their subclasses.
Extraction and Purification of Enzymes: Extraction of soluble and membrane bound enzymes; Purification of enzymes; Criteria of enzyme purity; Assay of enzymes; Zymography.

Module –II

Structure and General properties of enzymes: Active site; Enzyme substrate complex; Reaction coordination diagram; Lowering of activation energy; Specificity of enzyme-Types of specificity,lock and key hypothesis, induced fit hypothesis and strain or transition state stabilization hypothesis; Mechanism of enzyme catalysis: Acid-base catalysis,covalent catalysis and metal ion catalysis ; Factors affecting enzyme activity; Isozymes; Coenzymes; Metalloenzymes; Membrane bound enzymes; Multienzyme complexes.

Module –III

Kinetics of enzyme catalysed reactions: The relationship between initial velocity and substrate concentration - Michaelis-Menton, Lineweaver–Burk, Eadie-Hofstee and Hanes-Woolf equations and their applications; Pre-

steady state kinetics, Fast kinetics to elucidate the intermediates and rate limiting steps; Kinetics of bisubstrate enzyme catalyzed reactions – Ping-pong and random order mechanisms
Enzyme inhibitors: types of inhibitors; Mechanism of enzyme inhibition –competitive, non–competitive, uncompetitive and mixed inhibition; Allosteric and irreversible inhibition; Hill equation.

Module –IV
Regulatory enzymes and metabolic regulations: Allosteric enzymes- Properties,Sigmoid kinetics; important metabolic pathways regulated by allosteric enzymes; Regulation of enzymes by covalent modification and zymogen activation.
Investigations of active site structure: methods of active site mapping.

Module –V
Applications of Enzymes; Applications in medicine-diagnostic enzymes, therapeutic enzymes,Enzymes as reagents in clinical chemistry, Enzymes and inborn errors, Industrial applications of enzymes; Applications in genetic engineering.
Synthetic Enzyme: Ribozymes, Catalytic antibodies, Enzyme engineering (Protein engineering).
Enzyme Immobilization; Immobilization of enzymes and their applications, Kinetics of immobilized enzymes.

LAB-9-ENZYMOLOGY: Suggested List Practicals:

1. Extraction of an enzyme from animal/plant/microbial source.
2. Ammonium sulfate/Acetone precipitation of the extracted enzyme.
3. Purification of the enzyme by a suitable chromatographic techniques.
4. Determination of molecular weight by SDS PAGE.
5. Progress curve for the enzyme catalyzed reaction.
6. Assay of the enzyme to determine activity and specific activity
7. Effect of [S] on velocity: Michaelis-Menton Plot and Lineweaver-Burk plot- determination of Km and Vmax.
8. Determination of optimum pH of the enzyme.
9. Determination of optimum temperature.
10. Effect of inhibitors on enzyme activity.

REFERENCES:

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5. Chaplin, M.F.,Burke ,C.(1990). *Enzyme technology*.Cambridge University Press.
6. Grundwald, D. Peter. (2018). *Biocatalysis: Biochemical Fundamental and Applications*.2nd reprint Edition. Imperial College Press
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20-340-0208 FOOD MICROBIOLOGY (3E) (3L + 1P + 0T)

Course description: This course deals with the food microbiology including topics on microorganisms associated with different kinds of food materials used for human consumption, microbial quality assessment, industrial food fermentations that covers fermented food production, applications of food grade enzymes in food and beverage production, food poisoning and intoxications food preservation methods and applications, food safety, food quality assurance, and regulations and rules governing food quality control and assessment,

Learning outcomes (LO) of the course: After completing the course the student will be able to

L.O.1. Examine microorganisms associated with various food materials, contamination and spoilage of food (Analyze)

L.O.2. Access of food quality employing different approaches (Evaluate)

L.O.3. Produce various fermented food and beverages at industrial levels employing microorganism and microbial enzymes (Apply)

L.O.4. Analyze the role of poisoning and intoxications caused by microorganisms in quality control and safety of food (Analyze)

L.O.5. Employ various food preservation methods (apply)

L.O.6. Analyze the various food safety regulations and rules for effective quality assessment and food safety (Analyze)

MODULE I

Microorganisms associated with vegetables, fruits, food, seafood and milk; Contamination and Spoilage of vegetables, fruits, food, seafood and milk; Analysis of microbial quality of food and milk; Plate count, Bioburden analysis, Applications of biosensors for food quality control analysis

MODULE II

Industrial Food fermentations: Lactic Starter cultures &their biochemical activities; production and preservation of the following fermented foods: Soy sauce fermentation by Molds; Fermented vegetables – Sauerkraut; Fermented Meat – Sausages; Fermented foods-oriental, Rice, cereal and wheat based fermented foods; probiotics microbes, prebiotics, synbiotics, functional foods

MODULE III

Fermented food products and beverages Production and application of Baker'sYeast; Microbiology of fermented milk products (acidophilus milk, yoghurt); Cheese production, types of cheeses; Role of microorganisms in beverages – tea and coffee fermentations. Vinegar Fermentation Application of microbial enzymes in food industry

Fermented fruit wines- grape wine, sake, banana wine, and cashew wine

MODULE IV

Food poisoning - Food borne diseases, Newer pathogens and emerging foodborne diseases.Foodborne infections and intoxications; bacterial with examples of infective and toxic types -*Clostridium, Salmonella, Shigella, Staphylococcus, Campylobacter, Listeria*, *Vibrio cholerae, Vibrio parahaemolyticus*, Enterohemorrhagic *E. coli;* Mycotoxins in food with reference to *Aspergillus* sp;

Food preservation methods; Principles of food preservation**,** Sterilizations using Radiations - UV, Gamma and microwave; Temperature- refrigeration, deep freezing, freeze drying, drying, dehydrating, pasteurization, canning; Natural preservatives; Chemical and naturally occurring antimicrobials; use of antibiotics and bacteriocins.

MODULE V

Food safety: - Types of hazards affecting food industry, Food safety risks of allergens, Basic principles of food sanitation and hygiene, Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP),

Quality assurance Food regulations, grades and standards: Differences between Quality Assurance and Quality Control, Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP.

Food safety objectives - National food legislation/ authorities and their role - product certifications : ISI mark of BIS, AGMARK, FPO, MFPO, international organization and agreements-food and agricultural organization (FAO), Food Law: FD&C Act, Additive/Color Amendments; NLEA, Food Law and Regulation: Safety, GMP overviews, Food Law and Regulation: 2011 Food Safety and Modernization & 2002; FSSAI; Food Bioterrorism Acts.

LAB-10-FOOD MICROBIOLOGY

Suggested List of Practicals

1. Enumeration of microorganisms associated with food and drinking water samples
2. Isolation of food poisoning bacteria from contaminated foods, & Dairy products
3. Production and estimation of lactic acid by *Lactobacillus*Sp

4. Extraction and estimation of diacetyl.
5. Sauerkraut fermentation
6. Extraction and detection of aflatoxin for infected foods.
7. Production of fermented milk by *Lactobacillus acidophilus*.
8. Rapid analytical techniques in food quality control using microbialBiosensors.

REFERENCES:

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20-340-0209 PLANT -MICROBE INTERACTIONS (3E)-(2L + 1P + 1T)

Course description: This advanced course in Plant- Microbe interactions includes the study of Plants as microbial habitat, cellular plant pathogens and the diseases they cause, Defense of plants and stress responses, Invasion of plant tissue - establishment of symbiotic relations, Signal transduction & biotrophic invasion strategies, Resistance mechanisms against attack by plant pathogens and plant immune system, , Molecular Basis of Plant Disease Resistance, Plant defense responses against viruses, and Engineering pathogen resistance in crop plants

Learning outcomes (LO) of the course: After completing the course the student will be able to

L.O.1 Analyse the importance plant -microbe interactions with reference to plant diseases (Analyze)
L.O.2. Evaluate plant defense mechanisms, Defense of plants and stress responses and a large number of important problems within agriculture, horticulture and forestry (Analyze)
L.O.3.Discuss interactions between plants and non-pathogenic/symbiotic bacteria and fungi in agriculture, horticulture and forestry (Understand)

L.O 4 Examine hypotheses for why plants and microbes react in certain ways in pathogenic and symbiotic interactions (Analyze)

L.O 5 Discuss invasion of microbes into plant tissue and role of mycorrhiza and rhizobia in plant health (Understand)

L.O.6. Apply the knowledge on the molecular plant disease resistance mechanisms in plant disease management (Apply)

L.O.7 Discuss plant viral diseases and engineering of disease resistant plants for plant disease management (Understand)

MODULE I

Plants as microbial habitat; Introduction to plant-microbe interactions: importance, variety, and two examples (*Metarhizium* and *Agrobacterium*); Introduction to cellular plant pathogens and the diseases they cause

MODULE II

Overview of plant defense mechanisms, Defense of plants and stress responses and a large number of important problems within agriculture, horticulture and forestry; Infection mechanisms; attachment; enzymes; the role of toxins and other compounds; endophytes producing plant secondary metabolites of commercial value, anticancer drugs.

MODULE III

Invasion of plant tissue - establishment of symbiotic relations (mycorrhiza, rhizobium); Rhizobia infection in legumes; Signal transduction & biotrophic invasion strategies, Microbial recognition and evasion of host immunity,

MODULE IV

Resistance mechanisms against attack by plant pathogens (including nematodes) and insects; gene-for-gene interactions; The plant immune system - Connecting virulence & resistance; induced resistance; non-host resistance, Molecular Basis of Plant Disease Resistance

MODULE V

Plant defense responses against viruses, Plant virus transmission; Engineering pathogen resistance in crop plants: Current trends and future prospects

LAB-11- PLANT -MICROBE INTERACTIONS

Suggested List of Practicals

1. Isolation of pathogenic bacteria and pathogenic fungi from leaves and stem of an economically important plant showing disease symptoms
2. Identification of pathogenic bacteria
3. Identification of pathogenic fungi
4. Isolation of mycorrhiza from root nodules and analyze the structure under microscope
5. Isolation of Rhizobium from root nodules and identify the same

REFERENCES

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3. Jones &Dangl 2006. The plant immune system. Nature 444:323-9
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7. Pallas & Garcia 2011. How do plant viruses induce disease? Interactions and interference with host components. J Gen Virol 92:2691-2705

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15. Ajit Varma: Mycorrhiza Manual 1998 Springer Lab Manual. Springer, Berlin, Heidelberg
16. W. F. Harrigan, Margaret E. McCance, Laboratory Methods in Microbiology 1996 Academic Press London

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SEMESTER III

20-340-0301 RECOMBINANT DNA TECHNOLOGY (4C) (3L + 1P + 1T)

Course description: This is an advanced course dealing with the tools and techniques involved in manipulating DNA. The various modules elaborate the different enzymes, the types of vectors used, the expression systems, the heterologous host systems used as well as the various cloning strategies and the processes involved therein. In addition techniques such as PCR, blotting, site directed mutagenesis, gene transfer and various screening strategies are also included.

Learning outcomes (LO) of the course: After completing the course the student will be able to
L.O.1. Elaborate the different enzymes, vectors, as well as cloning strategies.(Understand)
L.O.2. Apply the different enzymes used in rDNA technology (Apply)
L.O.3. Use different types of vectors for cloning (Apply)
L.O.4. Produce a genomic DNA library and screening for recombinants (Create)
L.O.5. Construct a probe and do blotting techniques (Create)
L.O.6. Apply site directed mutagenesis technique (Apply)
L.O.7. Employ different types of PCR techniques for gene amplification and clone the amplicon (Apply)
L.O.8. Demonstrate heterologous gene expression (Apply)
L.O.9. Compare various genome editing tools (Analyze)

MODULE I
Enzymes in rDNA technology: Restriction–modification systems, Deoxyribo nucleases: exonucleases and endonucleases, Restriction enzymes-type-I, II, and III. S1 Nucleases, DNA Ligases, Alkaline phosphatase, DNA polymerase.

MODULE II
Cloning strategies: Shot gun cloning, amplicon cloning, cDNA cloning and its advantages and disadvantages.
Construction of genomic DNA and cDNA libraries: Cloning Vectors -plasmids, lambda phage, SV40, Phagemids; Construction of artificial chromosome vectors-BAC & YAC; Expression systems and their applications.

MODULE III
Recombinant DNA-tailing, cohesive ends: Use of linkers, blunt end methods; *In vitro* packaging, Host vector systems; Probe construction; recombinant selection and screening; Southern hybridization, Colony hybridization, Plaque hybridization.

MODULE IV

Applications: PCR: RT-PCR, Inverse PCR, Nested PCR, LAMP; Molecular Markers - RAPD, RFLP, DNA finger printing, microsatellites and mini satellites, SNPs, ESTs, Barcoding;
Site directed mutagenesis;

Gene transfer in animals and plants: direct gene transfer and molecular chimeras Microinjection, electroporation, biolistics, direct gene transfer using PEG, calcium chloride, calcium phosphate; Vector mediated gene transfer-Agrobacterium mediated transfer.

MODULE V

Heterologous protein expression in prokaryote and Eukaryotes- Expression in *E. coli*, yeasts and mammalian cells; Advantages and disadvantages of the various expression systems; cloning of genes into vectors; production and subsequent characterization of the recombinant protein.

Genome editing strategies: CRISPR-cas, TALENS, ZFNs, engineered nucleases, meganucleases; MAGE; Applications

LAB-12 RECOMBINANT DNATECHNOLOGY

Suggested Practical Lab session

1. Isolation of genomic DNA (Bacteria, bacteriophage, plant and rat liver) and Isolation of metagenomic DNA
2. Isolation of plasmid DNA from transformed *E.coli*
3. Restriction digestion and analysis of DNA
4. Isolation of total RNA and cDNA library construction(Demo)
5. Preparation of competent cells and Transformation in *E.coli*
6. Construction of genomic DNA library
7. PCR Techniques – BOX, ERIC, Nested
8. Real time PCR (demonstration)
9. LAMP (demonstration)
10. DNA sequencing (demo by industrial visit)

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20-340-0302 IMMUNOLOGY AND IMMUNOTECHNOLOGY (4C) (3L + 1P + 1T)

Course Description:This course is intended to provide a solid grounding in immunology, starting with the basic concepts and proceeding to a deeper Understanding of the mechanisms of immune functioning. Special emphasis is given to the 'team-work' in immune responses. The course also underscores how the system can go wrong, and how it can be corrected or managed using innovative technology. The recent enhanced appreciation of the preeminence of the innate immune system, the importance of the intestinal immune system, and the immunomodulatory potential of the gut microbiota are also highlighted. The course also points out the tremendous scope for basic and applied immunological research.

Learning outcomes (LO) of the Course: After completing this course, the students should be able to:

L.O.1. Define/recognize the fundamental organization and associations of the immune system. (Comprehension level)

L.O.2. Explain /describe/discuss how the immune system functions in a 'team-work' fashion, and how it is regulated. (Comprehension level)

L.O.3. Explain/describe/discuss how the immune system can go wrong, and what types of immuno-pathologies result. (Comprehension level)

L.O.4. Apply appropriate strategies, techniques, and technologies in the management of Immune system disorders. (Apply level)

L.O.5. Analyze the intricate regulatory mechanisms of the immune system in specific clinical conditions such as hypersensitivities, immunodeficiencies, and autoimmune diseases. (Analyze level)

L.O.6. Assess the feasibility of adopting or adapting technologies from other disciplines in the correction and/or management of deranged immune systems. (Assess level)

MODULE I

Introduction to the Immune System : Historical landmarks, branches, broad divisions of immune system, antigens vs.immunogens, haptens and carriers, epitopes and paratopes. Hematopoiesis, Theories on immune system functioning; Cells and molecules of the immune system, Inflammation: cellular and molecular events, acute and chronic inflammation, contribution to hypersensitivity and autoimmune reactions; Overview of comparative immunology; Overview of psychoneuroendocrinoimmunology (PNEI); Overview of the circadian – immune connection; Overview of ecoimmunology

MODULE II

Humoral and Cell-mediated immune responses: Structure and functions of primary and secondary lymphoid organs; Development, maturation, and functions of T- and B lymphocytes, molecular markers of T- and B-lymphocytes; structure and functions of antibodies, monoclonal vs. polyclonal antibodies, primary and secondary immune responses, clonal selection and clonal expansion, effector cells of the immune system and their specific roles; Generation of receptor diversity (BCR and TCR), subsets of T- and B- cells; Complement: the 3 pathways, regulatory molecules, disorders of the complement system

MODULE III

Strategies of immune functioning: MHC/HLA: its structure, functions, and role in antigen presentation, disorders of antigen processing and presentation, relative risk associated with specific MHC haplotypes; Lymphocyte trafficking and interaction at the germinal centers, role of HEV in lymphocyte trafficking ; Immune responses against bacteria, fungi, parasites, viruses, and prions ; Immune evasion strategies of pathogens.

MODULE IV

Clinical immunology; Immunodeficiencies; Hypersensitivity reactions; Autoimmune diseases; Transplantation immunology; Tumor immunology

MODULE V

Immunoprophylaxis and immunotechnology: Nanotechnology and its applications in immunology; Hybridoma technology and its applications in medicine; Vaccines: their development, and applications in medicine; Immune manipulation of the intestinal immune system, and the gut microbiota; Consolidated

immunotherapeutic strategies with respect to hypersensitivity, autoimmunity, transplantation, immunodeficiencies, and tumor immunology

LAB-13 IMMUNOLOGY AND IMMUNOTECHNOLOGY

Suggested list of Practicals

1. Differential white cell count **(M.1)**
2. Haemagglutination (Direct and Indirect) **(M.1)**
3. Immunodiffusion (Ouchterlony, Mancinii) **(M.2)**
4. Complement fixation test**(M.2)**
5. Coombs' test **(M.2)**
6. Basic immunoelectrophoresis **(M.2)**
7. Rocket immunoelectrophoresis **(M.2)**
8. Western blotting **(M.4)**
9. ELISA **(M.4)**
10. HLA typing (immunological and PCR-based)**(M.4)**

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20-340-0303 MOLECULAR VIROLOGY *(*4C) (3L + 1P + 1T)

Course description: The aim of this course is to provide basic knowledge of viruses, viral diseases, and topics important to the control of viral infections including vaccines and antiviral therapy. The course also covers current trends in emerging viral infections important to public health and biosafety practices in virology laboratories. The students acquire practical skills related to the culture, purification and handling of viruses

Learning outcomes (LO) of the course: Upon completion of the course, the students will be able to

L.O.1. Understand the classification and nomenclature of viruses, virus structure and cell biology of viral infection and replication (Comprehension level)

L.O.2. Describe some of the major viral diseases, their pathogenic mechanisms and clinical symptoms (Comprehension level)

L.O.3. Employ testing viral diseases by various techniques and conduct diagnostic tests for viral diseases (Application level)

L.O.4. Describe different types of antiviral drugs and vaccines and their mechanisms of action (Comprehension level)

L.O.5. Employ biosafety practices for handling infectious viruses (Application level)

L.O.6. Show practical knowledge on virus culture, isolation, quantification and virus infection (Application level)

MODULE I

Introduction to virology: Classification and nomenclature of viruses. Cellular receptors and virus-receptor interactions. Viral entry pathways-fusion, endocytosis, uncoating, cytoplasmic trafficking, nuclear entry. Replication of virus, maturation and release.

MODULE II

Pathogenesis of viral diseases: (1) DNA Viruses: Herpesvirus (Herpes simplex viruses, Epstein Barr Virus), Papillomavirus (Human Papilloma Viruses). (2) + RNA Viruses: Picornavirus (Poliovirus), Togavirus (Chikungunya virus), Flavivirus (Dengue Virus), Coronavirus. (3) – RNA Viruses: Paramyxovirus (Measles, Nipah), Orthomyxovirus (Influenza virus), Filovirus (Ebola virus). (4) RT using Viruses: Retrovirus (HIV), Hepadnavirus (Hepatitis B virus). Emerging and re-emerging viruses that infect humans and animals: Nipah, SARS-CoV2, *etc.* Viral oncogenesis. Immune response to viral infection, viral immune escape mechanism.

MODULE III

Diagnosis of viral diseases: microscopy, serological diagnosis-ELISA. PCR immunocytochemistry, immunohistochemistry, haemagglutination, Western blot. Cultivation and enumeration of animal viruses. Plaque assay, LD 50 and TCID 50.

MODULE IV

Biosafety in virology laboratory:Classification of viruses into hazard groups. Bio-safety level and biosafety cabinets. Disinfection, decontamination, solid and liquid waste disposal in virology laboratory

MODULE V

Antiviral agents and vaccines: Interferons - mode of action and importance in therapy. Antivirals and antiretrovirals-mechanism of action, HAART therapy. Viral vaccine- Different types and their production – Killed and attenuated vaccines, recombinant viral vaccine, subunit vaccines. Virus as vectors for vaccination. Adjuvants. Vaccine delivery.

LAB-14 MOLECULAR VIROLOGY

Suggested List of Practicals

1. Prepare cell culture for virus production
2. Virus isolation, quantification and preparation of virus stocks
3. Virus cell entry assay
4. DNA isolation from virus infected cells and virus detection by real-time PCR
5. RNA isolation from virus infected cells and viral gene expression analysis by real-time PCR
6. Virus diagnosis by immunofluorescence- preparation of cells and staining cells infected with virus

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20-340-0304 INDUSTRIAL MICROBIOLOGY (3E) (2L+ 1P+1T)

Course description: This course gives an overview of the various biotechnology based industries and the biotechnologically produced product. The course also discusses briefly the production process of various products like cheese, enzymes, antibiotics, vaccines, aminoacids, citric acid, biogas, hydrogen production etc.

Learning outcomes (LO) of the course: After completion of the course the students will be able to

L.O.1 Explain large scale production of fermented food products (Understand)
L.O.2 Practice spawn preparation and mushroom cultivation in a small scale (Apply)
L.O.3 Analyse bread making, milk and milk product processing (Analyze)
L.O.4 Explain the application of Microbes in production of antibiotics, vitamins, and vaccines (Understand)
L.O.5 Discuss Microbial production of polysaccharides, alcohol, amino acids, enzymes, etc (Understand)
L.O.6 Produce Biopesticides and biofertilizers (*Pseudomonas*) in small scale (Apply)
L.O.7 Describe Biogas, biodiesel and fuel cells/hydrogen production(Understand)

MODULE I

Fermented products: Industrial production of Cheese, bread, mushroom, wine, vinegar, Probiotics, Prebiotics, Neutraceuticals, Fermented Ayurvedic medicines.

MODULE II

Microbial production of antibiotics: Penicillin, Streptomycin, Cephalosporin. Microbial production of vaccines - bacterial and viral; Toxoid production. Microbial production of vitamins-B_{12} , riboflavin, and gibberellins.

MODULE III

Microbial polysaccharides: Xanthan gum, chitin, chitosan, Microbial production of industrial chemicals - alcohol, lactic acid, citric acid, Microbial production of amino acids- Glutamic acid, L- lysine

Microbial production of enzymes: Proteases, amylases, invertase, pectinases, Enzyme immobilization and their applications in food and other industries

MODULE IV

Processes and Applications: Biopesticides - *Bacillus thuringiensis*, *Trichoderma*, Baculoviruses; Biofertilizers - *Rhizobium, Azolla, Acetobacter, Anabaena, Mycorrhizae,* Phosphate solubilizing bacteria / Microbial ore leaching - copper, gold.

MODULE V

Biofuels : Biogas production, methane, bioethanol, biodiesel / Fuel cells - hydrogen production

LAB-16 INDUSTRIAL MICROBIOLOGY

Suggested Practical Lab session

1. Prepare spawn of *Pleurotus* sp (L.O.2)
2. Cultivate oyster mushroom for household use (L.O.2)
3. Industrial visit to Milma and Modern bread (L.O.3)
4. Production of Pseudomonas biofertilizer in talc powder (L.O.6)

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20-340-0305 FUNCTIONAL GENOMICS 2E (1L+ 1P+1T)

Course description. In this course, we use the genomics approach to Understand the proteome, predict protein structure from DNA sequence data, Understand protein-protein interactions, and the use of different tools for the analysis of genomic data sets. In addition, this course also includes the methods for gene annotation to gene prediction.

Learning outcomes (LO) of the course: After completing the course the student will be able to

L.O.1. Understand Protein sequencing, Nucleic acid sequencing and their analysis. (Understand)
L.O.2. Analyze Gene expression, and establish genomic library. (Analyze)
L.O.3. Design primer for a specific marker gene (Create)
L.O.4. Describe proteins interaction, activity, modification and function. (Understand)
L.O.5. Apply Protein modelling and molecular dynamics methods to study structure from sequence (Apply)
L.O.6. Discuss the Design drugs from data of functional genomics and proteomics (Understand)
L.O.7. Analyse the metagenomics data of soil microbiome for resistome, diversity and function (Analyze level)
L.O.8. Analyze the transcriptomics data of soil for expression of resistance components (Analyze level)

Module I

Visualization and protein structure prediction: Protein structure prediction for known folds and unknown folds (secondary structure prediction, prediction of transmembrane regions, homology modeling); Online modeling servers (e.g.-SWISSMOD), Molecular visualization software-kinemages and chemscape, Chime molecular visualization, Rasmol, pymol, Discovery Studio.

Module II

Structural proteomics: Methods of sequence based protein prediction. Definition of protein families - protein families and classification, SCOP and CATH, patterns, profiles, sequence vs family comparison. Homology modeling, prediction of protein structure from sequences, functional sites, FSSP, 3Dee

Module III

Protein folding: Protein folding problem, protein folding classes, protein identification and characterization:- AACompIdent, TagIdent, PepIdent and MultiIdent, PROSEARCH, PepSea, PepMAPPER, FindPept, Predicting transmembrane helices.

Module IV

Tools and methods in genomics: Stand-alone packages for sequence alignment- Bioedit, MEGA, Submitting DNA sequence in genbank - bankIt, Sequin, tbl2asn, Primer designing, Tools for primer designing.

Gene ontology and annotation; Prediction of genes and protein coding regions, Conserved sequence pattern discovery; Tools for gene prediction; Whole genome analysis; Gene mapping; Genome sequencing strategies, Next Generation Sequencing platforms, analysis, Metagenomics - MGRAST.

Module V

Drug designing: Introduction, Structure-based drug designing approaches:- Target Identification and Validation, receptor mapping, active site analysis and pharmacophore mapping, Grid maps. Introduction to docking methods to generate new structure; Tools and Molecular docking programs: AutoDock, Dock, HEX, Cheminformatics.

LAB-15: *GENOMICS AND PROTEOMICS* **Suggested List of Practicals**

1. Find the secondary and tertiary structure of the given protein sequence. (L.O. 5)
2. Design primer for mitochondrial COX1 gene (L.O.3)
3. Analyze the metagenomics data of soil microbiome for resistome, diversity and function (L.O.7)
4. Analyze the transcriptomics data of soil for expression of resistance components (L.O.8)
5. Design drugs for a given cancer marker as receptor (L.O.6)
6. Docking of the given ligand on receptor and find the interactions (L.O.6)

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20-340-0306 ENVIRONMENTAL MICROBIOLOGY (3E) (2L + 1P + 1T)

Course description: This course gives the student an insight into environmental microbiology including Brief history and development of environmental microbiology; aerobiology, aquatic microbiology, Microbial diversity in soil and in extreme environments; Culture-dependent and culture-independent approaches for Understanding microbial diversity in the environment; Microbial interactions;: microbes in biodegradation of organic compounds, microbes in waste management including Liquid waste andSolid waste, Bioremediation of environmental pollutants and Microbes and mineral recovery.

Learning outcomes (LO) of the course: After completing the course the student will be able to

L.O.1 Discuss the significant contributions of microbiologists, emergence of environmental microbiology, and significant applications of microbes in solving environmental pollution problems (Understand)

L.O.2. Analyze the Role of microorganism in maintenance of fertility of soil and self-purification of rivers and aquatic bodies for application (analyze)

L.O.3. Differentiate microbial diversity in the environment by culture-dependent approaches and their limitations, and by culture-independent molecular approaches (analyze)

L.O 4 Discuss the Diversity of microbes in air, aquatic environments, and drinking water and apply the same for conservation of environment and sustainable utilization of environmental resources(Understand)

L.O.5. Discuss the Diversity of microbes in soil and in extreme environments for conservation of environment and sustainable utilization of environmental microorganisms (Understand)

L.O.7 Examine microbial degradation of organic compounds, and role of microbes in waste and waste water management and apply the same (Analyze).

L.O.8 Discuss Bioremediation of environmental pollutants and role of microbes in mineral recovery and biomining of mineral ores (Understand)

MODULE I

Brief history and development of environmental microbiology: History and development of microbial ecology highlighting significant contributions of microbiologists and emergence of environmental microbiology, and significant applications of microbes in solving environmental pollution problems.Role of microorganism in maintenance of fertility of soil and self-purification of rivers and aquatic bodies; Environmental Concerns in releasing genetically engineered microorganisms in environment; Microorganisms in biological warfare and bioterrorism.

MODULE II

Culture-dependent and culture-independent approaches for Understanding microbial diversity in the environment: Methodologies in studying environmental microorganism including exotic environment like space Understanding microbial diversity in the environment by culture-dependent approaches and their limitations, and by culture-independent molecular approaches (DNA heterogeneity by reannealing denatured environmental DNA, ARDRA, analysis of FAME profiles, measuring metabolic capabilities using BIOLOG microtitre plates, using DNA probes and PCR primers, G+C analysis, slot-blot hybridization of commModuley DNA, and fluorescent *in situ* hybridization of intact cells).

MODULE III

Aerobiology- -Microbial contamination of air – Sources of contamination- Microbial indicators of air pollution. Enumeration of bacteria in air, Air sampling devices. Air sanitation. Effect of Air Pollution on plants and Human.

Aquatic microbiology: Diversity of microbes in aquatic environments, Microbiology of drinking water, – Water pollution and water borne pathogens –Bacteriological examination of water – Indicator organisms. Purification and disinfection of water

MODULE IV

Microbial diversity in soil: Diversity of microbes in terrestrial (agricultural and desert soils) environments, and animal (cattle, termites, pests such as cockroach and nematodes, and human being), plants and their role in ecosystem.

Microbial diversity in extreme environments: Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, barophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles. Role of microbes in marine fouling and corrosion

MODULE V

Biodegradation: microbial degradation of cellulose, lignocellulose, paper, textiles, leather, rubber, emerging contaminants and xenobiotics

Liquid waste management: Treatment of sewage (Primary, Secondary and Tertiary treatments) and Treatment of Industrial effluents (distillery, textile, pulp and paper)..

Solid waste management: composting, anaerobic digestion& bio methanation

Bioremediation of environmental pollutants: Petroleum hydrocarbons and pesticides.

Microbes and mineral recovery: Bioleaching of copper, gold and uranium.

LAB-17 ENVIRONMENTAL MICROBIOLOGY

Suggested List of Practicals

1. Isolation of bacteria and fungi from air, water and soil
2. Estimate microbial diversity in the mangrove sediment environment by culture-dependent approaches and by culture-independent molecular approaches- Detection of bacteria by PCR

3. Enumerate the fecal coliforms in drinking water by MPN
4. Determine the rate of degradation of cellulose under submerged fermentation using cellulase producing fungi
5. Phenol degradation by *Pseudomonas* sp
6. Estimation of BOD, & COD of municipal sewage

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20-340-0307 DIAGNOSTIC & PHARMACEUTICAL MICROBIOLOGY (3E) (2L + 1P + 1T)

Course description: This advanced course in 'diagnostic & pharmaceutical microbiology includes Microbiology laboratory safety including Biological Safety Cabinets; Bio containment, Biosafety Levels; Biosafety guidelines ;Diagnostic cycle; Etiology, pathogenesis and laboratory diagnosis o various infections; Serodiagnosis of infectious diseases; Molecular techniques in diagnostic microbiology. In addition, this course includes Pharmaceutical Microbiology aspects principles and methods of different microbiological assay of pharmaceutical products; Assessment of a new antibiotic and testing of antimicrobial activity of a new substance; Preservation of pharmaceutical products using antimicrobial agents, and evaluation of microbial stability of formulations

Learning outcomes (LO) of the course: After completing the course the student will be able to

L.O.1. Employ biosafety levels and biosafety guidelines at the level of individuals and institutions. (Apply))
L.O.2. Apply the knowledge on diagnostic cycle covering topics on specimen collection, transport and processing (Apply)
L.O.3.Discuss the significance of quality control and quality assessment in diagnostic microbiology (Understand)
L.O.4. Apply knowledge on etiology, pathogenesis for laboratory diagnosis of various samples of infections (Apply)
L.O.5. Employ serodiagnosis and molecular techniques in diagnostic microbiology (Apply)
L.O.6. Discuss the methods for standardization of antibiotics, testing of antimicrobial activity of a new substance.(Understand)
L.O.7. Employ preservation of pharmaceutical products using antimicrobial agents, evaluation of microbial stability of formulations.(Apply)

MODULE I

Microbiology laboratory safety - Biological Safety Cabinets; Biocontainment, Biosafety Levels; Biosafety guidelines- biosafety concerns at the level of individuals, institutions; Laboratory and associated infections. Good microbiological practices. Classification of biological agents based on hazards. Mailing of biohazardous materials.

MODULE II

Diagnostic cycle; General concepts for specimen collection, transport and processing. Infection control, Emerging infections; Quality assurance & quality control in microbiology, Accreditation of laboratories; Normal microbial flora of the human body.

MODULE III

Etiology, pathogenesis and laboratory diagnosis of- Blood Stream infections, Respiratory Tract infections, Central Nervous System infections, Gastrointestinal Tract infections, Urinary Tract infections, Genital Tract infections. Sexually transmitted diseases. Nosocomial infections.

Skin, soft tissue and wound infections. Burn infections. Infections of sinuses, bone and bone marrow. Infections of eye and ear. Pyogenic infections. Infections in immunocompromised and immunodeficient patients. Infections in foetus and neonates.

MODULE IV

Serodiagnosis of infectious diseases; Molecular techniques in diagnostic microbiology. Automation in Microbiology; Laboratory control of antimicrobial therapy; Immuno-prophylaxis, Immuno-modulation in infections. Human microbiome -and its role in disease/life style disorders; in health and wellness.

MODULE V

Pharmaceutical Microbiology: Principles and methods of different microbiological assay; Methods for standardization of antibiotics, vitamins and amino acids; Assessment of a new antibiotic and testing of antimicrobial activity of a new substance; Microbial spoilage of pharmaceutical products, source types of microbial contaminants; assessment of microbial contamination and spoilage. Preservation of pharmaceutical products using antimicrobial agents, evaluation of microbial stability of formulations.

LAB-18 DIAGNOSTIC &PHARMACEUTICAL MICROBIOLOGY

Suggested list of Practicals

1. Collection of infectious samples from patients with throat infection/ skin infection, and urine and isolate bacteria
2. Isolate normal microflora associated with tooth and nose and palm
3. Use of PCR based molecular assay of human pathogens and food poisoning bacteria Vibrio parahaemolyticus, Vibrio cholerae and E.coli
4. Microbiological assay of antibiotics by cup plate method and other methods
5. Sterility testing of pharmaceuticals.

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20-340-0308 BIODEGRADATION AND SOLID WASTE MANAGMENT (3E) (2L + 1P + 1T)

Course description: This advanced course in 'Biodegradation and Solid waste management' includes Environmental effects on microbial degradation of polysaccharides and organic compounds, bioremediation strategies, characteristics of different types of solid wastes and the components of solid waste management, the prevailing MSW laws in India, Collection and treatment of solid waste, composting, landfills, incineration, management of biomedical wastes and Recent development in solid waste reuse including energy augmentation and disposal.

Learning outcomes (LO) of the course: After completing the course the student will be able to

L.O.1. Explain characteristics of different types of solid wastes and the components of solid waste management, and comply with the prevailing MSW laws in India governing it. (Understand)

L.O.2. Understand and analyse the solid waste collection systems, route optimization techniques and processing of solid wastes and apply the knowledge of mathematics, science, and engineering for effective solid waste collection systems, for waste collection route optimization and for processing of solid waste

L.O.3. Explain the design, operation, and maintenance of different methods of treatment design in composting systems, maintain and operate the aerobic and anaerobic composting process for effective organic waste recycling.(Understand)

L.O. 4. Describe the operation, and maintenance of sanitary landfill construction and operations of landfill facilities, energy recovery systems and management of leachate systems and apply the same in effective solid waste management (Understand)

L.O.5. Describe the operation, and maintenance of Incineration (Understand)

L.O.6 Analyze waste and apply the knowledge of laws for handling of biomedical wastes (Analyze)

L.O.7 Discuss recent developments in Power generation using solid wastes, use of alternative sources for single use of plastic and Best Management Practices (BMP)(Understand)

MODULE I

Strategies of microbial degradation and bioremediation; Environmental effects on microbial degradation of polysaccharides and organic compounds, Kinetics of biodegradation; Bioremediation of organic and inorganic pollutants; Remediation Technologies

MODULE II

Introduction to solid wastes: Definition of solid wastes, Sources, classification and characteristics of solid wastes, Agro-industrial wastes, plastic wastes, Industrial solid wastes, Food and seafood industry solid wastes; Municipal Solid Waste (Management and Handling) Rules in India, Swachh Bharath mission, its objectives and activities in making clan India, Alternatives to plastic usage.

MODULE III

Collection and treatment of solid waste: Systems of collection of solid wastes, transfer stations, collection equipment's, route optimization techniques and numerical problems on route optimization. Processing techniques of solid wastes (principle of operation and function only); various methods of refuge processing, recovery, recycle

and reuse. - Mechanical volume reduction, Chemical volume reduction, Mechanical size reduction and component separation

MODULE IV

Composting: Composting, factors affecting composting process, aerobic and anaerobic composting, Indore and Bangalore method of composting, mechanical composting process, vermin-composting

Landfills: Sanitary land filling – trench method and area method Factors considered for a landfill site selection, leachate collection systems, control of gas movement and gas recovery systems.

Incineration: Incineration process, factors affecting incineration process, and air pollution prevention in incinerators, pyrolysis process.

MODULE V

Biomedical Waste, Biomedical Waste Handling Rules and its Impact on Human Health.

Recent development in solid waste reuse and disposal: Power generation, Building with construction materials and Best Management Practices (BMP)

LAB-19 BIODEGRADATION AND SOLID WASTE MANAGMENT

Suggested List of Practical

1. Degradation of cellulosic paper wastes using cellulolytic fungi and cellulase
2. Degradation of starch rich vegetable residues using enzyme cocktail and microbial consortia
3. Prepare a report on Quantity of solid waste generated from village or town
4. Identify the different sources and types of solid waste generated for a village or town
5. Field visit to locations where municipal solid wastes are processed
6. Field visit to locations where biomedical solid wastes are processed
7. Prepare a report on Best Management Practices (BMP) for disposal of solid waste generated in your places.
8. Prepare a report on treatment methods adopted in sanitary landfill area to reduce solidwaste quantity

REFERENCES

1. George Tchobanoglous et.al., “Integrated Solid Waste Management”, Mc-Graw-Hill, Inc.New York, 1993.
2. Howard S. Peavy et al., “Environmental Engineering”, Mc-Graw-Hill Book Company, NewYork, 1985.
3. A.D. Bhide and B.B. Sudareshan, “Solid Waste management in Developing Countries”, NEERI, Nagpur 1983.
4. Environmental Engineering (Vol II)”- S.K Garg Khanna Publishers, New Delhi 2009.
5. Robert A. Corbit, “Standard Handbook of Environmental Engineering”, McGraw Hill Inc., New Delhi,1990.
6. P AarneVesilind, William Worrel and Reinhart, Solid Waste Engineering, Thomson Brooks,Cole.
7. Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Urban Development, Govt. of India, 2000.
8. Management and Handling Rules for Municipal Solid Waste and Biomedical Waste and Plastic Waste, MOEF publications
9. Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Urban Development, Govt. of India, 2000.
10. Management and Handling Rules for Municipal Solid Waste and Biomedical Waste andPlastic Waste, MOEF publications

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SEMESTER IV

20-340-0401 INNOVATION AND ENTREPRENEURSHIP FOR BIOLOGISTS (4E, 2L-2P-0T) 60 HOURS)

Course Description: The objective of this course is to expose the students to the field of innovation and entrepreneurship with a specific focus on life science. Student will also be familiarized with the process of developing a life science enterprise. In this course you will learn the tools and trades of becoming an entrepreneur. Course will teach you the various aspects of entrepreneurship; from the fundamentals of selecting an idea and developing a product or process; Preparing a business plan to Identifying and securing investors; setting up a company to meeting the regulatory requirements. Student teams will perform various activities of entrepreneurship: from identifying a market need after market survey and coming up with a solution to making a business plan and pitching to investors.

This course is conducted jointly by Department of Biotechnology and School of Management Studies at CUSAT and outside resource persons experienced in life science entrepreneurships and soft-skill training who will be invited for discussion/workshops. This course will be conducted in workshop mode. Case studies will be included with active participation. The practical component will include case studies, discussions, brainstorming, presentations, etc.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

LO1: Describe the various programmes and opportunities for entrepreneurship in life science in India (Understand)
LO2: Apply innovation tools such as ideation and design thinking for generating innovative ideas (Apply)
LO3: Analyse real time data to explore and establish relationships in the areas of entrepreneurship decisions (Analyse)
LO4: Identify potential funding sources and how to sell the idea for successful funding (Apply)
LO5: Evaluate various business ideas in the field of life science and select the most appropriate one on the basis of opportunity identification, opportunity evaluation and feasibility studies (Evaluate)
LO6: Generate new bio-entrepreneurship ideas and create business plans and proposals for starting business or business expansion/diversification. (Create)

MODULE I (5 hours)
Innovation and entrepreneurship: Invention-innovation differences; Types of innovation; creativity; innovation ecosystem; challenges of innovation management; steps in innovation management; technology and innovation-new business models. State and scope of life science innovations and entrepreneurship in India and the world; unique opportunities and challenges of Bio-entrepreneurship.

MODULE II (6 hours)
Entrepreneurship: Definition, traits, characteristics, qualities and functions of entrepreneurs; Entrepreneurial Behaviors and entrepreneurial motivation; Entrepreneurship Theories; Entrepreneurship types: Social entrepreneurship and Technology entrepreneurship, Family business; Startup landscape and innovation hubs; Innovation in Indian context.

MODULE III (6 hours)
Entrepreneurship: Role in economic development. Entrepreneurial climate in India; Ease of doing business, Government support for entrepreneurship, Start-up India Programme, Pradhan Mantri Mudra Yojana, Assistances for Biotech enterprises, BIRAC/BIG, Business Incubation and other schemes. MSME Policy: various schemes and support.

MODULE IV (7 hours)
Idea generation: Design thinking, customer journey mapping, Idea evaluation; lean startup; Business plan: elements-technical-marketing-financial, preparation of Business plans.
Sources of Finance: Venture capital, angel investment, crowd funding. Mechanics of setting of new enterprises – forms of business organization.

MODULE V (6 hours)
Protection of Intellectual Property Rights, Patent, Trademark and Copyrights. Managerial problems of new enterprises; production purchasing, financing labor and marketing problems.

PRACTICALS (30 hours)

Case studies, Discussion, Brainstorming, Presentations, etc.

REFERENCES:

1. Innovation and Entrepreneurship, Drucker, Peter, 1985, Heinemann, London.
2. Patterns of Entrepreneurship Management, Kaplan, J.M and Warren A.C., John, 2013, Wiley & Sons Inc.
3. Entrepreneurship Development and Small Business Enterprises, Charantimath Poornima M, 2018, Pearson.
4. The Lean Start Up, Ries, Eric, 2011, Crown Publishing, USA.
5. Entrepreneurial Policies and Strategies- The Innovator's Choice, Manimala, Mathew J, 1999, SAGE Publications.
6. The IDEATE Method, Identifying High-Potential Entrepreneurial Ideas, Cohen, Dan Pool, Greg & Neck, Heidi, 2020, SAGE Publications.
7. Managing Innovation and Entrepreneurship, Kearney, Claudine & Hisrich, Robert D, 2013, SAGE Publications.
8. Biotechnology Entrepreneurship - Starting, Managing, and Leading Biotech Companies, Ed. Craig Shimasaki, 2014, Academic Press.
9. Art of the Start 2.0, Guy Kawasaki, 2015, Portfolio.
10. A Biotech Manager's Handbook - A Practical Guide, Eds. M O'Neill M M Hopkins, 2012, Woodhead Publishing
11. Innovation, Commercialization, and Start-Ups in Life Sciences, James F. Jordan, 2014, CRC Press.

20-340-0402 DISSERTATION (12C), COMPREHENSIVE VIVA VOCE AND SEMINAR (1C)

Description: This course covering 3-5 months will be conducted by the students in the department or in other research institutions in India or aboard. THE AIM of the dissertation is to allow the student to apply all the theoretical, analytical as well as experimental practices learnt over the previous three semesters to work independently / or with supervision on a research project under the guidance of the concerned project supervisor. The dissertation work can include experimental, computational, field based, human study, clinical study, industry related or other research projects. The project work shall be reviewed periodically and at the end of the semester each student need to submit a project report as per the format given below. At the end of the semester, each student shall submit a project report comprising of the following.

a. Introduction
b. Objectives.
c. Literature Review.
d. Application and feasibility of the project.
e. Project implementation action plan.(Materials and methods)
f. Detailed documentation of the work done including figures, tables, diagrams, etc (Results/outputs and discussion)
g. Summary

h. Future scope and conclusions
i. REFERENCES

The thesis should be written in English about the research that the master degree candidate conducted independently. The thesis will be evaluated based on the regulations of the University, program and laboratory that the candidate belongs to and the following criteria.

1. A title clearly identifies the topic of the thesis.
2. An introduction (background, objective), methods, results, discussion, figures, tables and REFERENCES are presented in a standard thesis style.
3. Relevant research is critically investigated and analyzed in the background and objective.
4. Methods are described in detail, so it is clear why they were selected for the research.
5. Data are shown accurately and clearly in the text using figures and tables.
6. Results are interpreted critically and discussed in reaching logical conclusions.
7. The thesis includes original and creative findings.
8. REFERENCES are listed completely and accurately and with careful attention paid to research ethics, including plagiarism and proper citation.

The end semester evaluation of the project will be by a team comprising of 3 internal examiners including senior faculty members. The HOD will act as the Convener of the Committee. The final evaluation of the project shall include the following.

1. Presentation of the work
2. Oral examination
3. Demonstration of the project against objectives
4. Quality and content of the project report

Learning outcomes (LO) of the course: On completion of this course the student will be able to:

L.O.1. Conduct literature survey in the concerned field of research and identify and concentrate on a research / industry related problem in the specified field.

L.O.2. Apply required theory and experiments on the problem

L.O.3. Construct a project proposal through extensive study of the literature and / or discussion with learned resource persons in academy or industry

L.O.4. Create an action plan of the project work to be carried out through deliberations.

L.O.5. Realize various steps involved in completing a project work like literature survey, methodology adopted (field study / survey / experiments / numerical work), analysis of the data to arrive at final results and conclusions.

L.O.6. Analyze the data generated and discuss in context of current status

L.O.7. Prepare, Present and defend self-prepared report, verified by the project guide to a peer audience.

Additional information for the students/instructors/supervisors

The dissertation will be organized to contain the following

1. Cover page with the
    i. Title of the research work in ALL CAPS Arial 12 font
    ii. Name of the student, registration no.
    iii. Name of affiliated department, university
2. The inner page will also include all the above
3. Certificate from the HOD
4. Evaluation sheet with the names of the reviewers/examiners
5. Certificate from the Supervisor
6. Certificate from student
7. Acknowledgements-no more than one page
8. List of contents
9. The dissertation will have an
    a. Introduction
    b. Objectives.
    c. Literature Review.
    d. Application and feasibility of the project.
    e. Project implementation action plan.(Materials and methods)
    f. Detailed documentation of the work done including figures, tables, diagrams, etc (Results/outputs and discussion)
    g. Summary
    h. Future scope and conclusions
    i. REFERENCES
    j. appendix can show supplemental data, etc
    k. certificates from IBSC/IAEC/HEC as per case

The following criteria may be applied when assessing a dissertation. The grade assigned depends on the level to which the standards have been met.

Definition of research scope and goals

- The research scope has been suitably defined, in the form of a clear and erudite noteworthy research question
- The objectives of the thesis clearly are stated
- Evidence of intellectual enquiry towards research query from an initial phase in the dissertation

Grasp of the topic

- The student demonstrates a knowledgeable grasp of the topic and Understanding of the scope of research
- The student demonstrates Understanding of the relevant theoretical literature
- The student demonstrates skills in making use of literature and other relevant sources of information for advancing research goals

Methods, conclusions

- The student demonstrates an ability to devise suitable investigation designs for attainment of project goals
- The student demonstrates capability to apply the chosen methods
- The dissertation contains REFERENCES to the relevant scholarly publications in the field
- The dissertation presents well-founded conclusions drawn from the results
- The dissertation answers the research question(s) presented

Contribution to knowledge and thesis structure

- The dissertation is relevant to the set goal and arrives at an answer to the research question
- The dissertation is a well-organized logical whole
- The dissertation rigorously develops and offers research-based arguments and analysis that substantiates, modifies, challenges or in other ways adds to the current Understanding of the relevant subject/issue

Presentation and language

- The dissertation is proofread, edited, and technically of the high standard expected of scholarly outputs
- The dissertation is written in a coherent, formal style and forms a well-ordered whole
- The dissertation observes the conventions and practices of the chosen referencing style (any style can be used, as long as it is used consistently and correctly)