Appendix - VI (H)

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY KOCHI-22
SCHEME AND SYLLABUS FOR
M.SC DEGREE PROGRAM IN MICROBIOLOGY (APPLICABLE W.E.F. 2024 ADMISSIONS)

SEMESTER-I

COURSE SUBJECTS		INSTRUCTION			EVALUATION			
Course no.	Course name	Credits	Core/ Elective	Hours/ week	Prerequisites	Internal	End semester	Total
24-340-0101	Bacteriology	4	C	3L+ 1T+2P	Nil	50	50	100
24-340-0102	Yeasts and Fungi	4	C	3L+ 1T +2P	Nil	50	50	100
24-340-0103	Microbial Genetics and Molecular Biology	4	C	3L+ 1T +2P	Nil	50	50	100
24-340-0104	Microbial Biochemistry	4	C	3L+ 1T +2P	Nil	50	50	100
24-340-0105	Biostatistics	2	C	2L+ 1T +0P	Nil	50	50	100
24-340-010X	Elective - I	3	E	2L+ 1T +2P	Nil	50	50	100
24-340-010X	Elective - II	3	E	3L +0T +0P	NIL	50	50	100
TOTAL FOR SEM -I		**18 C**				**250**	**250**	**500**
		6 E				**100**	**100**	**200**

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

Elective – I

24-340-0106 Analytical Techniques – I

Elective – II

24-340-0107 Molecular Cell Biology

SEMESTER-II

COURSE SUBJECTS		INSTRUCTION			EVALUATION			
Course no.	Course name	Credits	Core/ Elective	Hours/ week	Prerequisites	Internal	End semester	Total
24-340-0201	Fermentation Technology and Industrial Microbiology	4	C	3L+ 1T +2P	Nil	50	50	100
24-340-0202	Bioinformatics	3	C	2L+ 1T+ 2P	Nil	50	50	100
24-340-0203	Scientific Communication and Critical Analysis of Research Papers	1	C	1L+ 0T +2P	Nil	100		100
24-340-0204	Microbial Physiology	4	C	3L +1T+ 2P	Nil	50	50	100
24-340-0205	Molecular Virology	4	C	3L +1T+ 2P	Nil	50	50	100
24-340-0206	Biosafety, Bioethics and IPR	2	C	2L+ 1T+ 0P	Nil	50	50	100
24-340-020X	Elective - III	3	E	2L+ 0T +2P	Nil	50	50	100
24-340-020X	Elective - IV	3	E	3L+ 0T +0P	Nil	50	50	100
TOTAL FOR SEM - II		**18 C**				**350**	**250**	**600**
		6 E				**100**	**100**	**200**

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

Elective – III

24-340-0207 Analytical Techniques –II

Elective – IV (Choose any ONE)

24-340-0208 Plant-Microbe Interactions

24-340-0209 Biofuels and Bioenergy

SEMESTER-III

COURSE SUBJECTS		INSTRUCTION			EVALUATION			
Course no.	Course name	Credits	Core/ Elective	Hours/ week	Prerequisites	Internal	End semester	Total
24-340-0301	Recombinant DNA Technology	4	C	3L+ 1T +2P	Nil	50	50	100
24-340-0302	Advanced Immunology	4	C	3L+ 1T +2P	Nil	50	50	100
24-340-0303	Project Proposal Preparation and Presentation	1	C	1L+ 1T+ 0P	Nil	100		100
24-340-0304	Food Microbiology	3	C	2L+ 1T +2P	Nil	50	50	100
24-340-0305	Medical Microbiology	3	C	2L +1T+ 2P	Nil	50	50	100
24-340-030X	Elective - V	3	E	3L+ 0T+0P	Nil	50	50	100
24-340-030X	Elective - VI	3	E	3L+ 0T +0P	Nil	50	50	100
24-340-030X	Elective - VII	3	E	3L+ 0T +0P	Nil	50	50	100
TOTAL FOR SEM – III		**15 C**				**300**	**200**	**500**
		9 E				**150**	**150**	**300**

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

Elective - V, VI & VII (Choose any THREE)

24-340-0306 Next Generation Sequencing and Data Analysis
24-340-0307 Environmental Microbiology
24-340-0308 Microbiomes
24-340-0309 Biodegradation and Solid Waste Management
24-340-03010 Gene Silencing and Genome Editing
24-340-03011 Algal Biotechnology

SEMESTER-IV

COURSE SUBJECTS		INSTRUCTION			EVALUATION			
Course no.	Course name	Credits	Core/ Elective	Hours/ week	Prerequisites	Internal	End semester	Total
24-340-0401	Dissertation and Seminar	12	C	0L+ 0T +24P	Nil	200	200	400
24-340-0402	Comprehensive Viva -Voce	2	C	2L+ 0T+ 0P	Nil	100	100	200
24-340-040X	Elective - VIII	2	E	1L+ 0T +2P	Nil	100		100
24-340-XXXX	Elective - IX	2/3/4	E				100	100
TOTAL FOR SEM – IV		**14 C**				**300**	**300**	**600**
		5 E				**100**	**100**	**200**
GRAND TOTAL FOR M.Sc. MICROBIOLOGY PROGRAM		**65 C**				**1200**	**1000**	**2200**
		26 E				**450**	**450**	**900**

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

Elective - VIII

24-340-0403 Entrepreneurship for Biologists

Elective - IX

24-340-XXXX MOOC/SWAYAM

PROGRAMME OUTCOMES FOR MSc. PROGRAMME

After successfully completing the programme, the MSc. students will be able to:

PO 1. Demonstrate a degree of mastery in the various fields of Biotechnology and acquire interdisciplinary /multidisciplinary/transdisciplinary knowledge base and develop a collaborative approach to formulate constructive arguments and rational analysis for achieving common goals and objectives.

PO 2. Communicate effectively by gaining the ability to reflect and express thoughts and ideas effectively in verbal and nonverbal way; Ability to acquire knowledge and skills, including unlearning misconceptions and relearning concepts necessary for participating in learning activities throughout life, through self-paced and self-directed learning.

PO 3. Demonstrate leadership qualities that span the ability to work effectively and lead respectfully with diverse teams; setting direction, formulating a goal, building a team that can help achieve the goal, motivating and inspiring team members to engage with the goal.

PO 4. Demonstrate analytical thinking and problem-solving abilities enabling them to analyze, evaluate and interpret evidence, arguments, and claims; reflect relevant implications to the reality; formulate logical arguments; critically evaluate practices, policies and theories to develop knowledge and understanding.

PO 5. Identify a problem using literature survey, formulate hypothesis, develop a research plan, execute the research plan, write the project report and communicate effectively through written, oral and visual methods and develop the capacity to extrapolate from what one has learned and apply their competencies to solve problems and later contextualize into research and apply one's learning to real life situations.

PO 6. Identify and evaluate new business ideas in the field of life science and take it forward by creating a business plan by identifying funding source and executing the plan; collaborate and network with personnel in educational institutions, research organizations and entrepreneurial ventures in India and abroad and using management skills to guide people to the right destination, in a smooth and efficient way..

PO 7. Nurture the right ethical and social consciousness that contemplates the research implications and understands societal needs and responsibilities; appreciates and develops environmentally sound and sustainable solutions.

PO 8. Develop the correct attitude and mindset that appreciate equity, inclusiveness and sustainability and diversity; acquire ethical and moral reasoning and values of unity, secularism and national integration to enable to act as dignified citizens; able to understand and appreciate diversity, managing diversity and use of an inclusive approach to the extent possible.

PO 9. Ability to aim at personal development by meeting economic, social, and cultural objectives, and adapting to changing trades and demands of work place through knowledge/skill development/ re-skilling.

PROGRAMME SPECIFIC OUTCOMES OF M.Sc. MICROBIOLOGY

PSO1. Develop rigorous academic standard and in-depth understanding of the fundamentals through deep and meticulous theoretical and practical knowledge as well as gain competence and understanding in the various fields of microbiology: bacteriology, mycology, virology, parasitology and other allied subjects.

PSO2. Show proficiency in performing and analysis of the various basic and advanced laboratory techniques employed, including analytical techniques by obtaining the ability to analyze, discuss, interpret, draw conclusions from quantitative/qualitative data and experimental evidences as well as critically evaluate ideas, evidence and experiences from an unprejudiced and reasoned perspective.

PSO3. Understand and apply microbiological techniques and their handling; Acquire good skill of handling and troubleshooting in instrumentation, techniques, analysis of biomolecules and its role and fate for understanding the biological systems/ processes.

PSO4. Execute the gathered technical knowhow to carry out cell-based cloning, PCR cloning, production of metabolites from Plant/animal/microbial cells, culture and plating-based techniques, sterilization methods, bioinformatics, designing of green technologies for environmental management for sustainable development.

PSO5. Understand, apply and follow good laboratory practices; handling pathogens and their subsequent related research following biosafety practices as defined by WHO; keeping personal and ambient safety into concern.

PSO6. Nurture excellent research aptitude enabling to design, execute, analyze and interpret a research problem with statistical tools and bring a meaningful scientific conclusion maintaining scientific ethics.

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	-	80 credits
At least one interdepartmental elective/ (level-2)/ SWAYAM or NPTEL (On or before semester III)	-	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 2 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 Practical's, 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.

24-340-0204, 24-340-0303, 24-340-0401 evaluation will be completely internal

24-340-0204 Evaluation - Class assignments (50 marks) and presentation (25marks) and final review (25 Marks).

24-340-0303 Evaluation - One internal examination covering all modules (20 marks), Project Proposal Report (40 marks) and Proposal defence (40 marks)

24-340-0401 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 for the particular OBE course.

Maximum marks=50

Part-A: 10 compulsory questions from all modules- no choice (10 x 2 = 20 marks)

Part-B: Answer any one from the choices given for each module (5 x 6= 30 marks)

SEMESTER-I

24-340-0101 BACTERIOLOGY (4C, 3L + 1T +2P)

Course description

This course in bacteriology is aimed at imparting basic knowledge about classification, structure, nutrition, growth, reproduction, and distribution of eubacteria. 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.

Course outcomes (CO)

After completing the course, the student will be able to

Course Outcome		Cognitive Level
C.O.1	Explain and classify bacteria using microbial taxonomy	Understand
C.O.2	Describe the ultrastructure of bacteria and archaebacterial	Understand
C.O.3	Describe and apply knowledge on nutritional requirements and nutritional groupings in isolating, cultivating, and preserving different bacteria from environment for various studies and Applications	Apply
C.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
C.O.5	Design practical experiments and use the same in study of bacteria and creating new knowledge	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	-	3	-	-	-
CO2	3	-	3	-	-	-
CO3	2	2	2	2	1	-
CO4	2	2	2	2	1	-
CO5	2	2	2	2	1	1

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(8h)**

Historical developments of Microbiology – Contributors of Microbiology – Anton Van Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Alexander Fleming, Joseph Lister, Hargobind Khorana.

Modern Microbiology - Landmark achievements in 20th century.

Microbial Taxonomy -Definition and systematics, Nomenclatural rules and identification. Haeckel's three kingdom classification, Whittaker's five kingdom approach - Woese domain system. Major characteristics used in taxonomy – morphological, physiological and metabolic, genetic and molecular taxonomy. Bergey's Classification of bacteria. Numerical taxonomy, Identification characters-morphological, staining, physiological, biochemical and molecular (mol % G+C, nucleic acid hybridization, 16SrRNA sequencing) characters.

MODULE II **(12h)**

Overview of Microbial world – Bacteria, Fungi, Algae, Virus, Protozoa (introduction only). **Biology of Microorganisms**: Differences between prokaryotic and eukaryotic cell.

Overview of eubacterial cell organization: cell structure, size, shape, arrangement membrane, cell wall, cytoplasmic inclusions, mesosomes, flagella and motility (flagellar motility, spirochete motility, twitching and gliding motility, ciliary and amoeboid movement. Chemotaxis and Phototaxis), capsule, pili, fimbirase, endospore, ribosomes, capsule, glycocalyx, slime layer and S layer. Biofilms

General structure and characteristics of Archaea.

MODULE III **(12h)**

Microbial nutrition: Microbial nutrient requirements – macro-nutrients, micro-elements growth factors - sources of nutrients – nutritional classification of bacteria – Phototroph Chemotroph, Autotroph (lithotroph), Heterotroph (organotroph), Photoautotroph,Photoheterotroph, Chemoautotroph, Chemoheterotroph - Nutritional patterns of pathogens –Saprophytes - Auxotroph. Factors influencing bacterial growth – pH, temperature, oxygen, pressure, radiation. Biogeochemical cycles, C, N, P, S cycles

Bacterial reproduction – asexual (binary fission, budding, baeocyte and spore formation), sexual (conjugation, transduction, transformation). Growth curve. Batch, fedbatch, continuous culture. Measurement of bacterial growth.

Bacterial genome: Genome organization of *E.coli* and salient features of genomes

Bacterial secretion system: Introduction

Quorum sensing and Quorum quenching: Discovery, role as illustrated by bioluminescence

MODULE IV **(8h)**

Cultivation of bacteria. Culture media-solid, liquid, semisolid media. Simple media, Differential media, Special media enriched media, enrichment media, selective media, indicator media, sugar media, transport media. Aerobic and anaerobic media. **Aerobic Culture Methods** – pour plate, spread plate, streak plate, lawn, stroke, stab cultures, shake culture, liquid cultures. **Anaerobic culture methods** – anaerobic jars, gaspak, anaerobic chamber. **Culture Preservation** – serial sub culturing, mineral oil overlay, cryopreservation, lyophilisation. Culture Collection Centres. **Culture-independent methods:** Molecular typing, metagenomics, Microbiomes

MODULE V **(5h)**

Control of microbes. Sterilization and Disinfection – principle, methods and mechanism of action – Physical Agents, Incineration, dry heat, moist heat, filtration, Radiation – (UV and ionising). Chemical agents –disinfectants – phenol, aldehydes, halogens, hypochlorites. Testing of disinfectants – phenol coefficient test, Rideal Walker test. Principles, functioning and types of Biosafety cabinets

Antimicrobials: classification and modes of action, Antimicrobial resistance and their impact

SUGGESTED LIST OF PRACTICALS

1. Sterilization techniques, media 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. Sterility testing and barrier testing.

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24-340-0102 YEASTS AND FUNGI (4C, 3L + 1T + 2P)

Course description

This course in Mycology is aimed at imparting basic knowledge about general characteristics, classification, diversity, structure, nutrition, growth, reproduction, and distribution of fungi. The course also includes 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.

Course Outcomes (CO)

After completing the course, the student will be able to:

	Course Outcome	Cognitive Level
C.O.1	Explain the fundamental aspects of fungi, their classification, morphology, reproduction, mushroom characteristics, cultivation, and the use of molecular methods for understanding fungal diversity and distribution.	Understand
C.O.2	Explain yeast morphology, reproduction, and antagonistic interactions, focusing on mycocin production and applications.	Understand
C.O.3	Explain common fungal diseases, opportunistic infections, mold associations (including entomopathogenic fungi), and mycotic poisoning.	Understand
C.O.4	Compare the role of endo and ectomycorrhizal interactions, fungal endophytes and their adaptation in plants besides, agriculturally important toxigenic fungi, highlighting their features, biology, and applications in agriculture,	Analyze
C.O.5	Devise experiments for lab scale production of secondary metabolites deriving valuable bioactive products, industrial enzymes etc. besides biotechnological applications of fungi in solving environmental problems.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	-	2	-	-	-
CO2	3	3	-	-	-	-
CO3	3	-	3	3	-	-
CO4	2	-	2	2	-	-
CO5	-	-	1		2	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(9h)**

Characteristics of Fungi: Eukaryotic, heterotrophic organisms, chitinous cell walls, multicellular (hyphae/mycelium) or unicellular (yeasts), Reproduction sexually and asexually via spores. Classification: Major classes: Zygomycetes, Ascomycetes, Basidiomycetes, Deuteromycetes, Based on reproductive structures and life cycles. Morphology and Ultrastructure: Hyphae: Thread-like structures forming mycelium, Spores: Reproductive cells produced for dispersal. Growth and

Reproduction: Asexual: Budding, fragmentation, or asexual spores, Sexual: Fusion of specialized cells to form spores, Characteristics of Mushrooms and Cultivation: Fruiting bodies of Basidiomycetes with caps, stalks, and gills, cultivated commercially using substrates and controlled environments.

Fungal Systematics and Diversity, Molecular Methods: RFLP, RAPD, DNA sequencing for identification, Environmental Distribution: Found in soil, water, air, as symbionts or parasites.

MODULE II (7h)

Morphology and Ultrastructure: *Saccharomyces cerevisiae:* Unicellular, budding reproduction. *Candida albicans:* Oval cells, pseudohyphae or true hyphae. Reproduction: *Saccharomyces cerevisiae* and *Candida albicans*: Antagonistic Interactions: Mycocinogeny and Diversity yeasts produce antifungal compounds; mycocins. Mycogenic yeasts in mycocin production. Characteristics and Applications of Mycocins Used in biocontrol, food preservation, and biotechnology.

MODULE III (9h)

Common Fungal Diseases: Superficial Mycoses: Skin, hair, and nail infections like. Deep Mycoses: Infections affecting internal organs, Opportunistic Infections: In Immunocompromised: *Aspergillosis, candidiasis*, and *Pneumocystis pneumonia*. Severe Complications: Common in HIV/AIDS, cancer, and transplant patients.

Molds and Associations: Entomopathogenic Fungi: *Beauveria bassiana* parasitizes insects, used in biocontrol. Mycotic Poisoning: Toxins in food from molds like Aspergillus and Claviceps can cause poisoning.

MODULE IV (10h)

Mycorrhizal Fungi: Salient Features: Symbiotic with plant roots Endo- vs. Ectomycorrhizal: Biology of Arbuscular Mycorrhizal Fungi (AMF): Signaling, Penetration and Colonization. Fungal Endophytes of Tropical Plants: Entophytic Fungi: Colonization and Adaptation in tropical forest:

Agriculturally Important Toxigenic Fungi: Toxigenic Fungi: harmful toxins affecting Biopesticides: Utilization of fungi as safe biopesticides.

MODULE V (10h)

Secondary metabolites from fungi: Terpenes, Non-ribosomal peptides, Indole alkaloids, polyketides.

Biotechnological applications of fungi: Fungi as producers of industrially important enzymes- Starch hydrolyzing enzymes, xylanases, *action on plastics by secreting degrading enzymes,* Biodegradation, *Fungi as producers of* pigments and antimicrobials, Fungi in bioremediation of toxic metals from waste water, fungal applications in pulp and paper manufacturing, Bioactive compounds from mushrooms

Industrial applications of *Saccharomyces sp.* - yeasts as probiotics, yeast in alcoholic fermentation

SUGGESTED LIST OF PRACTICALS

1. Isolation of fungi from air, water and soil
2. Identification of *fungi using* Lactophenol cotton blue mounting
3. Identification of fungi using Slide culture technique
4. Observation of spores of fungi
5. Observation of reproductive structures of fungi
6. Culturing and Staining of Yeast *Saccharomyces cerevisciae*

7. Cultivation of mushrooms

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24-340-0103 MICROBIAL GENETICS AND MOLECULAR BIOLOGY (4C, 3L + 1T + 2P)

Course description

This basic course in bacterial genetics includes macromolecular synthesis and processing, gene expression and regulation in prokaryotes. It also includes mutation and its various applications and implications. This course reviews genetic exchange and recombination processes in bacteria, 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.

Course Outcomes (CO)

After completing the course the students will be able to

Course Outcome		Cognitive Level
C.O.1	Comprehend macromoelcular synthesis and processing in bacteria	Understand
C.O.2	Describe the organization of the bacterial chromosome, gene, cistron, operon, regulon and their regulatory mechanisms, and Demonstrate how gene are expressed and regulated	Apply
C.O.3	Differentiate the processes of DNA exchange and recombination in bacteria and Demonstrate gene transfer processes in bacteria	Analyze
C.O.4	Comprehend the role of transposition in gene transfer and exchange, mutation and repair in bacteria	Understand
C.O.5	Describe the molecular mechanisms of lytic and lysogenic phages	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	-	-	-
CO2	2	2	2	2	-	-
CO3	2	2	2	2	-	-
CO4	3	-	3	3	-	-
CO5	3	-	3	-	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(10h)**

Macromolecular synthesis and processing-Structure of DNA, Bacterial Nucleoids, REP , DNA Replication, Model of DNA Replication, Initiation of DNA Replication, Termination of DNA Replication and Chromosome Partitioning; RNA Synthesis: Transcription, RNA Turnover, RNA Processing; Protein Synthesis: Translation, Transfer RNA, Charging of tRNA, Ribosome Structure and Synthesis, Initiation of Polypeptide Synthesis, Elongation, Peptide Bond Formation, Translocation, Termination, Posttranslational Processing, ; Protein Folding and Chaperones;Protein Trafficking; Secretion of Proteins Across the Outer Membrane, Protein Degradation, Degradation of Abnormal Proteins, Energy-Dependent Proteases, Antibiotics that affect Nucleic Acid and Protein Synthesis, Agents Affecting DNA Metabolism, Agents Affecting Transcription, Agents Affecting Translation,

MODULE II: **(10h)**

Regulation of prokaryotic gene expression-Regulation of gene expression: gene copy number, transcriptional control-promotors, terminator, attenuators, anti-terminators; Transcriptional Control, DNA-Binding Proteins, The lac Operon: A Paradigm of Gene Expression, Catabolite Control: Sensing Energy status, Class I and Class II CRP-Dependent Genes, The Catabolite

Repressor/ Activator Protein Cra, Catabolite Control: The Gram-Positive Paradigm, The gal Operon: DNA Looping with a Little Help from Hu, The Arabinose Operon: One Regulator, Two Functions; Attenuation Controls - Transcriptional Attenuation Mechanisms, Translational Attenuation Control; Translational Repression;

Global Control Networks, Communication with the Environment: Two-Component Regulatory Systems, Examples of Integrated Biochemical and Genetic Controls, Phosphate Uptake: Communication Between Transport and Two-Component Regulatory Systems, Quorum Sensing: How Bacteria Talk to Each Other

MODULE-III **(9h)**

Bacterial genetics: DNA exchange, recombination-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.

Gene transfer and mapping by conjugation**:** Molecular mechanism of gene transfer by conjugation; 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 IV **(8h)**

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, Mu transposons and gene fusions, Yeast Ty-1 transposon. Site-specific recombination – *loxP*-Cre system, phase variation system in *Salmonella*. Transposition like events in retroviruses/retrotransposons.

Mutagenesis, and repair- Mutation: Importance and uses of mutation analysis. Types of mutations, spontaneous and induced mutagenesis, phenotypes, Reversions versus suppression. Complementation; Mechanism of mutation; chemical mutagens; different DNA Repair Systems;Isolation and identification of mutants, selecting mutants, replica plating, mutant enrichment; reverse genetics

MODULE V **(8h)**

Genetics of bacteriophages: Single stranded DNA bacteriophages-φ β X174, M13; RNA phages MS2; Double stranded DNA phages T4, λ.

Lytic 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.

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SUGGESTED LIST OF PRACTICALS

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

REFERENCES

1. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press; 2007.
2. Fundamental Bacterial Genetics by Nancy Trun and Janine Trempy, 1st edition; Blackwell Science Publishers; 2004.
3. Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002.
4. Microbial Genetics by Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, 2nd edition; Narosa Publishing House; 1987.
5. Molecular genetics of bacteria. Jeremy W. Dale, John Wiley and sons. 3rd Edition. 1998.
6. Molecular Biology of the Gene – Watson et al. ,6th edition, 2007
7. Genes – Benjamin Lewin – XI, 2014 Jones and Bartlett Pub Inc
8. Genetics : Analysis of Genes and Genomics-Hartle,Daniel L , 8th edition, 2011, Jones and Barlett, USA
9. Molecular Cell Biology-Lodish, Baltimore et al., 8th edition, 2016, W.H.Freeman and Co
10. Principles of Genetic - E.J. Gardner and D.P. Snustad, 7th edn,2015, John Wiley and Sons
11. Genetics-Monroe W. Strickberger 3rd revised edition, 2008, Prentice Hall Pvt. Ltd
12. Manual of Commercial Methods in Clinical Microbiology, Truant, Allan L (Ed.) 2nd edition, 2016, ASM Press, Washington
13. Practical Biotechnology, Ramdas P, 1st edn. 2007 Jaypee Publishers
14. Laboratory exercises in Microbiology, Harley and Prescott,5TH edition, The McGraw−Hill Companies, 2002

24-340-0104 MICROBIAL BIOCHEMISTRY (4C, 3L + 1T + 2P)

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 processes and their regulation in microorganisms, especially bacteria. In addition the course deals with bacterial fermentation pathways, photosynthesis, bacterial luminescence, nitrogen fixation.

Course Outcomes (CO)

After completing the course, the students will be able to:

Course Outcome		Cognitive Level
C.O.1	Comprehend various thermodynamic principles governing biochemical changes, Review bioenergetics, free energy, redox potential, biological oxidation	Understand
C.O.2	Elucidate chemistry of various biomolecules and identify biomolecules (carbohydrate, fatty acid amino acid and nucleic acid)	Apply
C.O.3	Illustrate carbohydrate, fatty acid amino acid and nucleic acid metabolic pathways and their regulation	Analyze
C.O.4	Apply the understanding of metabolic pathways to biotechnological and biochemical research	Apply
C.O.5	Describe bacterial photosynthesis and inorganic metabolism and their regulation	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	-	-	-
CO2	2	-	2	2	-	-
CO3	2	-	2	2	-	-
CO4	2	-	2	2	-	2
CO5	3	3	-	3	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(10h)**

Central pathways of carbohydrate metabolism- Alternate Pathways of Carbohydrate Metabolism, Fructose Bisphosphate Aldolase Pathway, Alternate Pathways of Glucose Utilization, Entner-Doudoroff or Ketogluconate Pathway, Phosphoketolase Pathway, Oxidative Pentose Phosphate Cycle, Gluconeogenesis, Regulation, Glycogen Synthesis, Tricarboxylic Acid Cycle, Glyoxylate Cycle

Energy Production, , structural basis of the group transfer potential of ATP; Oxidation reduction potential, different types of oxidation reduction reactions; Substrate-Level Phosphorylation, Oxidative Phosphorylation, Measurement of PMF, Electron Transport Systems, Anaerobic Respiration, Conversion of PMF to Energy, Structure of F1F0, pH Homeostasis,

Fermentation pathways- Lactic Acid–Producing Fermentations, Butyric Acid — and Solvent-Producing Fermentations, Mixed-Acid Type, Propionic Acid and Acetic Acid Fermentation, Fermentation Pathways,

MODULE II **(8h)**

Lipids and sterols-Lipid Composition of Microorganisms, Straight-Chain Fatty Acids, Branched-Chain Fatty Acids, Ring-Containing Fatty Acids, Alk-1-enyl Ethers (Plasmalogens), Alkyl Ethers, Phospholipids (Phosphoglycerides), Glycolipids, Biosynthesis of Fatty Acids, Biosynthesis of Phospholipids, Degradation of Fatty Acids and phospholipids, Biosynthesis of Isoprenoids, Synthesis of lipopolysaccharides

MODULE III (8h)

Nitrogen metabolism-Biological Nitrogen Fixation ,The Nitrogen Fixation Process, Components of the Nitrogenase System , Symbiotic Nitrogen Fixation, Inorganic Nitrogen Metabolism, Assimilation of Inorganic Nitrogen, General Reactions of Amino Acids, (Catabolism of amino acid carbon skeleton) Amino Acid Decarboxylases, Amino Acid Deaminases, Amino Acid Transaminases (Aminotransferases), Amino Acid Racemases

Biosynthesis and metabolism of aminoacids- Amino Acids, Glutamate (α-Ketoglutarate) Family, Aspartate and Pyruvate Families, Serine-Glycine Family, Aromatic Amino Acid Family, Histidine Biosynthesis; The Aromatic Amino Acid Pathway- Phenylalanine, Tyrosine, and Tryptophan,

MODULE IV (6h)

Purines and Pyrimidines -Biosynthesis and catabolism of Purines, Biosynthesis and catabolism of Pyrimidines, Interconversion of Nucleotides, Nucleosides, and Free Bases: Salvage Pathways, Regulation of Purine and Pyrimidine Biosynthesis, Riboflavin Biosynthesis, Thiamine Biosynthesis, Inhibitors of nucleotide biosynthesis as chemotherapeutic agents.

MODULE V (8h)

Photosynthesis and inorganic metabolism-Characteristics and Metabolism of Autotrophs, Photosynthetic Bacteria and Cyanobacteria, Autotrophic CO2 Fixation and Mechanisms of Photosynthesis, anoxygenic photosynthesis(Green algae), Electron transport chain in some anaerobic bacteria. Catalase, super oxide dismutase, mechanism of oxygen toxicity. Hydrogen Bacteria, Nitrifying Bacteria, Sulfur Bacteria, Iron Bacteria, Methylotrophs, Methanogens structure of photosynthetic apparatus in prokaryotes, pigments and lipids in photosynthetic apparatus in prokaryotes, Bacterial luminescence and Electron transport

Text Book- Microbial Physiology 4th Edition Albert G. Moat John W. Foster Michael P. Spector A John Wiley & Sons, Inc., Publication

SUGGESTED LIST OF PRACTICALS

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. Fluorescence spectroscopy to study effect of temperature and pH on protein structure.
4. UV- spectrum of DNA and Protein
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
8. Lactic acid fermentation

REFERENCES

1. Voet, D. &Voet J. G. *Biochemistry* (2012). 4th edition, John Wiley and Sons
2. Lehninger, A. L., Nelson, David L., Cox, Michael M. (2013).Principles of Biochemistry.6th revised edition. Freeman and Co.

3. Devlin, Thomas. M. (2010).Text book of Biochemistry with Clinical Correlations- 7th edition. John Wiley & Sons.
4. Robert, K., Granner, D. K., & Mayes, P. A. M. (2003). Harper's illustrated biochemistry.
5. White, Abraham. (2004).Principles of Biochemistry.6th edition. Tata Mcgraw-Hill.
6. The Physiology and Biochemistry of Prokaryotes-David White, 4th revised edition,2011, Oxford University Press
7. General Microbiology- Roger Y. Stanier et al., 5th Edition, 1987, Prentice Hall Macmillan Education Ltd.
8. The Physiology and Biochemistry of Prokaryotes-David White, 4th revised edition,2011, Oxford University Press
9. Cooper T.G. (2015). Tools of Biochemistry.2nd edition, Wiley-Interscience
10. Sadasivam S. and Manickam A.(2009). Biochemical Methods, 2ndedn.New Age International Ltd Publishers.
11. Mu, P., & Plummer, D. T. (1988). Introduction to practical biochemistry. Tata McGraw-Hill Education.
12. Jayaraman J.(1992).Laboratory manual in Biochemistry.John Wiley.

24-340-0105 BIOSTATISTICS (2C, 2L+1T+0P)

Course Description

This course includes understanding and interpreting data in biology and health science, summarizing data using descriptive statistics like measure of central tendency and dispersion, grasping fundamental statistical concepts like probability and sampling distributions and performing basic statistical analyses such as hypothesis testing and estimation. This course emphasizes the methods for performing inference on population means and proportions via sample data and random sample and other study types.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1	Understand and interpret commonly reported statistical measures in Biological science	Understand
C.O.2	Demonstrate a good understanding of descriptive statistics and graphical tools	Understand
C.O.3	Summarize data using descriptive statistics like measures of central tendency and dispersion	Analyze
C.O.4	Grasp fundamental statistical concepts like probability and sampling distributions	Analyze
C.O.5	Perform basic statistical analyses such as hypothesis testing and estimation	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	-	2	-	-	-	3
CO2	-		-	-	-	1
CO3	-	1	-	-	-	3
CO4	-	1	-	-	-	3
CO5	-	1	-	-	-	3

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(5h)**

Origin and Developments of Statistics: Types of Statistics, Characteristics of Statistics, Importance and usefulness of Statistics

Statistical Investigation: Collection of Data, Primary Data, Secondary Data, Methods of Data Collection

MODULE II **(5h)**

Frequency Distribution: Preparation of Frequency Distribution, Cumulative Frequency Distribution

Diagrammatic Presentation of Data: Bar diagrams, Deviation bars, Pictograms, Pie diagrams, Squares, Histogram

Exploratory analysis of Data using MATLAB

MODULE III **(5h)**

Measure of central Tendency: Mean, Median and Mode

Measure of Dispersion: Range, Mean Deviation, Standard Deviation, Standard error and Coefficient of Variation

Introduction to MSEXCEL&SYSTAT

Correlation: Types of Correlation, Properties, Covariance; Regression: Lines of Regression
Linear Algebra and Regression Techniques

MODULE IV **(8h)**

Theory of Probability: Random Experiment, Events, Axioms of Probability, Conditional Probability; Error propagation; Populations and samples, expectation
Distribution: Binomial Distribution, Poisson distribution, Normal Distribution
Probability & Sampling Distribution with MS Excel
Experimental designs-simple and factorial

MODULE V **(7h)**

Test of Significance: Procedure for Testing of Hypothesis, Test of Significance for Difference of Proportions- Large Sample
Small Sample Tests: Students *'t'* distribution, t-test for difference of Means, Chi-square Distribution
Analysis of Variance: One-way Classification, Two-way Classification , Power analysis
Analyzing Data with XLSTAT

REFERENCES

1. Panse V .G. & Sukhatme, P.V (1967).Statistical Methods for Agricultural Workers, ICAR.
2. Campbell R.A (1989). Statistics for Biologists 3rd edition, Cambridge University Press.
2. Snedecor G.W. & Cochran, W.G.(1989). Statistical Methods 8thedn. Oxford University
3. Fisher R.A.(2017). Statistical Methods for Research Workers. Oliver & Boyd
4. Balaji K., Raghavaiah A.V.S. & Jayaveera K.N.(2012). Biostatistics. International Publishing house.
5. Irfan A. Khan & Atiya Khanum (1994). Fundamentals of Biostatistics. Ukaaz Publications.
6. Ekwal Imam (2015). Applied Statistical Techniques. New India Publishing Agency
7. L.R. Potti (2007) A Full Course In Statistics. Yamuna Publications

24-340-0106 ANALYTICAL TECHNIQUES - I (3E, 2L+1T+2P)

Course Description

Analytical techniques-I introduces fundamental analytical techniques employed in the field of biotechnology like microscopy, spectroscopy, centrifugation techniques, chromatographic methods and radioisotope techniques. Students will learn the principles, methodologies and applications of these techniques, with a focus on acquiring practical skills for data acquisition, analysis, and interpretation. They will gain a comprehensive understanding of the theoretical foundations and practical applications of basic analytical techniques.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1.	Understand the principles and applications of various microscopy techniques.	Understand
C.O.2.	Explain the principles of spectroscopic techniques to identify and characterize chemical compounds in various samples.	Understand
C.O.3.	Demonstrate proficiency in using centrifugation techniques to separate biomolecules based on their size, shape, and density.	Apply
C.O.4.	Apply chromatographic methods for qualitative and quantitative analysis of complex mixture of samples.	Apply
C.O.5.	Understand the use of radioisotopes in clinical diagnosis and biotechnological applications.	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	-	-	-	-
CO2	3	3	-	-	-	-
CO3	2	-	2	-	-	-
CO4	2	-	2	-	-	-
CO5	3	3	-	-	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(7h)**

Basic Microscopy: Light microscopy; lenses and microscopes, refractive index, magnification, resolution: Rayleigh's Approach, Dark-field; Phase Contrast, Differential Interference Contrast; Fluorescence microscopy; Confocal microscopy; Electron microscopy: TEM and SEM.

MODULE II **(6h)**

Spectroscopy: Principles of spectroscopy, Electromagnetic radiation, Colorimetry and UV-Visible spectrophotometry, Fluorescence Spectrophotometry, Atomic Absorption Spectrophotometry, FTIR, Raman Spectroscopy, Mass Spectrometry, Nuclear Magnetic Resonance (NMR) spectroscopy, CD spectroscopy, X-ray spectroscopy.

MODULE III **(5h)**

Centrifugation: Basic principles of sedimentation, Types of centrifuges: Micro centrifuge, High speed & Ultracentrifuges; Types of rotors, Preparative and analytical ultracentrifugation methods; preparative centrifugation; differential and density gradient centrifugation; analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

MODULE IV **(6h)**

Chromatography: Principles of chromatography: Adsorption and Partition chromatography, Planar chromatography: Paper and Thin-layer chromatography, Column chromatography: Gel filtration chromatography, Ion-exchange chromatography, Affinity chromatography, Gas chromatography, HPLC and FPLC.

MODULE V **(6h)**

Radioisotope techniques: Measurement of radioactivity; Geiger-Muller counter, scintillation counter, autoradiography, radiotracer techniques, radioisotopes in diagnostics and biotechnology, radioimmunoassay, positron emission tomography, radioactive DNA and protein labeling and probing.

SUGGESTED LIST OF PRACTICALS

1. Preparation of microscope slides with various biological specimens.
2. Visualizing fluorescently labelled cells using fluorescent microscopy.
3. Estimate the concentration of the given sample using spectroscopy.
4. Centrifugation for fractionation of homogenate.
5. Prepare a plant extract and perform TLC.
6. Separation of mixture of compounds using column chromatography.
7. Demonstration of Gas chromatography and HPLC.
8. Demonstration of Confocal and Electron microscopy.

REFERENCES

1. Ackerman E A, Ellis L E E, Williams L E (1979). Biophysical Science. Prentice-Hall Inc.
2. Willard, H.H., Merritt L.L. Dean J.A. and Settle F.A (1986). Instrumental Methods of Analysis", 7th Ed., Wadsworth Publishing Co.
3. Chang R (1971). Basic principles of spectroscopy. McGraw
4. Pesce A J, Rosen C G, Pasty T L. Fluorescence Spectroscopy: An introduction for Biology and Medicine. Marcel Dakar.
5. Stanford J R (1975). Foundation of Biophysics. Academic Press.
6. Henry B Bull (1971). An Introduction to physical biochemistry. F A Devis Co.
7. Perkampus H (1992). UV-VIS Spectroscopy and its applications. Springer-Verlag.
8. Michael M Cox and David N Nelson: Principles of Biochemistry
9. Donald L Pavia(2015) Introduction to Spectroscopy. Congregate Learning India Pvt.Ltd.
10. Rodney Cotteril 2002 Biophysics, An Introduction; Wiley publication.
11. Patrick F. Dillon 2012 Biophysics: A Physiological Approach; Cambridge University Press.
12. Heide Schatten 2012. Scanning Electron microscopy for the Life Sciences: Cambridge University press
13. Marimuthu R. 2011n Microscopy and Microtechnique. MJP Publishers
14. Prakash S.Bisen and Anjana Sharma. Introduction to instrumentation in life sciences. Publishers-Taylor and Francis Ltd. CRC press
15. Sivasankar B. Bioseparations; Principles and Techniques. Publisher: PHI Learning Pvt. Ltd
16. Selected Papers

24-340-0107 MOLECULAR CELL BIOLOGY (3E, 3L+0T+0P)

Course description

This course will focus on understanding the structure and function of the cell, which is fundamental to all of the biological sciences. The advanced course in cell biology will focus on both Prokaryotic and Eukaryotic cell biology. The course will help to develop insight into the complexities of cell structure and function and the molecular events that mediate cellular processes, with specific focus on membrane structure and composition, transport and trafficking; the cytoskeleton and cell movement; and the integration of cells into tissues. In addition, the course will also cover important cellular processes such as cell cycle regulation, signal transduction, metabolic processes, apoptosis and will attempt to relate defects in these various cellular processes to human diseases.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1	Develop a deeper understanding of cell structure and how it relates to cell functions.	Understand
C.O.2	Analyse the structure and function of biological membranes, and its cell-cell and cell- matrix interactions.	Analyse
C.O.3	Analyse the mechanisms that control cell signalling and how it regulates cellular functions.	Analyse
C.O.4	Analyse how cells grow, divide and die, and how these important processes are regulated.	Analyse
C.O.5	Apply the knowledge gained after studying the process of cellular organization into multicellular tissues and identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	3	-	-	-	-
CO2	2	-	-	-	-	-
CO3	2	-	-	-	-	-
CO4	2	2	-	-	-	-
CO5	2	2	-	-	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(12 h)**

The dynamic cell: overall stability from dynamic parts: Organisation and functions of cellular constituents, subcompartmentalization of the cellular archetecture, spatial organization and dynamic regulation of cell membranes, structure and functional organisation of the cellular organelles, interactions between different organelles, Fertilization, Early development and gastrulation, Organogenesis, Regeneration

MODULE II **(8 h)**

Cells In Their Social Context: Microenvironment of the Cell, Cell communication, Cell polarity, Cytoskeleton-Microfilaments, Microtubules, intermediate Filaments, Actin Dynamics**,** Membrane Channels, receptor mechanisms of action, Cell-Cell Interaction, Cell-Matrix Interactions, Cell Migration and its Control Mechanisms, Axis and cell fate specification

MODULE III **(8 h)**

Cell Signaling and Signal Transduction: Ligands and surface receptors, GTP binding proteins, cAMP and Calcium signaling, Receptors and associated kinases, RTK signaling and other mechanisms, Major cell–cell signaling pathways, Relationships between Signaling Pathways

MODULE IV **(8 h)**

Cellular Growth Control and Regulation: Regulation of the cell division cycle, Regulation of DNA replication, Regulation of mitosis and meiosis, Cell cycle checkpoints, *Factors Influencing Cell Growth and Survival,* Cellular senescence, Molecular mechanisms of cell death; Autophagy-dependent cell death, Lysosome-dependent cell death, Apoptosis, Necroptosis, Ferroptosis, Pyroptosis, Cellular Senescence

MODULE V **(9 h)**

Integrating Cells into Tissues: Epithelia and general connective and supporting tissues; Reticular, Bone, Cartilage and Adipose tissues, blood, lymphoid tissues and haemopoiesis, Specialized skeletal connective tissues, i.e. cartilage, bone, Muscle and Nervous, Specialized defensive cells, Stem Cells and Tissue Regeneration.

SUGGESTED LIST OF PRACTICALS

1. Cell culture facilities in practice
2. Cell culture in vitro
3. Trypsination and methods for detachment of cells
4. Cell counting and reseeding
5. Cell imaging analysis of marker proteins for visualising; various organelles, proliferation, apoptosis, cell matrix, differentiation and proteins involved in signal transduction
6. Cell cycle stages by FACS analysis
7. Histology
8. Tissue fixation
9. Tissue sectioning using cryostat
10. Visualization of the processed tissue samples
11. Immunocytochemistry

REFERENCES

1. Molecular Biology of the Cell **(**7th Edition**);** by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter; Garland Science; 2022
2. Molecular Cell Biology_(9th Edition) by Chris A. Kaiser, Kelsey C. Martin, Harvey Lodish, Arnold Berk, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Matthew P. Scott , Published by W. H. Freeman; 2021
3. Essential Cell Biology (6th Edition) by Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander D.Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter; Garland Science; 2023
4. Cell Biology (8th Edition); by Gerald Karp, Janet Iwasa, WallaceMarshall; Wiley; 2019

5. The Cell: A Molecular Approach (9th Edition) by Geoffrey M. Cooper, Robert E. Hausman; Sinauer Associates; 2023
6. Becker's World of the Cell, (9th Edition) by Jeff Hardin Gregory Paul Bertoni; Pearson; 2015
7. Freshney, R. I. Culture of specific cell types. John Wiley & Sons, Inc.; 2005
8. Culture of Animal Cells. R. Ian Freshney, John Wiley & Sons, Inc.; 2005
9. Cell Biology: A Laboratory Handbook, Volumes 1, 2, 3; Edited by Julio E. Celis, Academic Press, 1994
10. Developmental Biology, Michael J. F. Barresi & Scott F. Gilbert; Sinauer Associates Inc; 12th edition, 2019

SEMESTER II

24-340-0201 FERMENTATION TECHNOLOGY AND INDUSTRIAL MICROBIOLOGY (4C, 3L+1T+2P)

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.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1	Employ various methods of strain improvement of industrial organisms	Understand
C.O.2	Employ batch processes, as well as sterilization processes for application	Understand
C.O.3	Evaluate factors that contribute in enhancement of cell and product formation during fermentation process	Understand
C.O.4	Analyze kinetics of cell and product formation in batch, continuous and fed-batch cultures	Analyze
C.O.5	Differentiate the rheological changes during fermentation process	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	1	2	-	1	-
CO2	2	-	2	3	-	-
CO3	2	-	-	-	-	-
CO4	1	-	-	3	-	-
CO5	1	-	-	2	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(5h)**

Range of fermentation technology and its chronological development. Basic principle component of fermentation technology. Types of microbial culture.

Isolation and screening of industrially useful microorganisms, Primary and secondary screening.

Strain improvement in industrial microbiology: mutation and genetic manipulations. Culture Preservation techniques.

Screening, detection and assay of fermentation products (physical, chemical and biological assay).

MODULE II **(7h)**

Growth kinetics, primary and secondary metabolites. Feedback inhibition and repression.

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 **(5h)**

Design of bioprocess vessels: Significance of impeller, Baffles, Sparger,

Types of culture/ production vessels: Air-lift, Cyclone column, Packed Tower and their application in production process, Principles of upstream processing.

Sterilization: thermal death kinetics, batch & continuous sterilization systems, Sterilization of air, fibrous filters; sterile filtration of biological.

MODULE IV **(8h)**

Introduction to Oxygen requirement in Bioprocess. Energetics of microbial growth in fermenter: Reaction rates, Heat and Mass Transfer, Transport phenomenon in reactors, macroscopic balance of energy and energy flow.

Design of a fermenter, instrumentation and process control; Types of fermenter Parts and their functions.

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 **(5h)**

Introduction to Upstream and downstream processing of industrial fermentations: Cell disruptions, Flocculation, Filtrations, Ultra Filtration, Ultra centrifugation, Gel filtration, Chromatographic methods, two phase aqueous separations, Cell and Enzyme immobilizations.

Fermentation of Antibiotics (Penicillin, Streptomycin), Organic acids (Citric acid, Lactic acid), Enzymes (Penicillin G, Streptokinase), Ethanol and Recombinant Proteins (Insulin).

SUGGESTED LIST OF PRACTICAL

1. Primary screening of organism for amylase production
2. Submerged fermentation for the production of □-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*
9. Growth and death kinetics.

REFERENCES

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24-340-0202 BIOINFORMATICS (3C, 2L+1T+2P)

Course Description

This course provides a comprehensive introduction to the exciting field of bioinformatics, equipping you with the foundational knowledge and skills to navigate the vast world of biological information. The course covers the various aspects of biological data, data management, Introduction to various biological databases, understanding the concepts of sequence alignments and phylogenetic analysis, and exploring the various frontiers in genomics and structural bioinformatics. This course also explores the intersection of Artificial Intelligence and Bioinformatics, equipping students with the knowledge and skills to apply AI techniques to biological data analysis.

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Course Outcomes (CO)

After completing the course the student will be able to

Course Outcome		Cognitive Level
C.O.1	Understand how to categorize and utilize various biological databases	Understand
C.O.2	Understand the basic concept of data mining, file formats and interpretation	Understand
C.O.3	Execute the use of various tools for sequence alignment and database search	Apply
C.O.4	Construct molecular phylogeny and phylogenetic trees and prediction of proteins structures	Analyze
C.O.5	Understanding the basic concepts of Next generations sequencing techniques and Artificial Intelligence	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	1	-	-	3	-	-
CO2	-	2	-	2	-	-
CO3	1	1	-	3	-	-
CO4	-	3	2	3	-	-
CO5	-	-	1	3	2	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(8 hrs)**

Introduction to Bioinformatics: Definition and scope in Bioinformatics, Importance of biological data in Bioinformatics research, Concept and type of biological databases (Primary, Secondary and Tertiary databases), Concept of data, data models, data representation and mining, Biological data and data analysis. Introduction to Programming in PERL, Python, Oracle, Structured Query Language, Visual Basics and Database Management System (DBMS).

MODULE II **(10 hrs)**

Biological Databases, data storage and retrieval: Major public biological databases and their resources, Introduction to protein and nucleic acid databases, Genome databases, Organism specific databases, Disease databases, Small molecule databases, Toxicology Database. NCBI, Entrez, file formats for sequence databases. Retrieval of biological data.

File formats for biological data, Searching biological databases, Interpreting search results and extracting relevant data from databases

MODULE III **(10 hrs)**

Introduction to Sequence alignments: Definitions and importance of sequence alignments, Concepts of homology and its role in alignments. Types of sequence alignments: Pair-wise sequence alignment, Multiple sequence alignment, Local and global sequence alignments. Alignment algorithms: Scoring matrices, Gaps and Gap penalties, Dynamic programming methods and heuristics method, FASTA and BLAST algorithms, Applications of sequence alignments: Identification of conserved functional domains and motifs, Predicting protein structures using homology modelling

MODULE IV **(9 hrs)**

Phylogenetic analysis and structural bioinformatics: Evolution, elements of phylogeny, methods of phylogenetic analysis, Phylogenetic tree of life, comparison of genetic sequence of organisms, phylogenetic analysis tools-Phylip, ClustalW. Structural databases- Protein Data bank, Protein Information Resource, Nucleic Acid Data Bank, Molecular Modelling Data Bank (MMDB). Computation methods in structural biology, Basics of protein structure prediction. Drug Designing: Introduction to drug designing, Structure-based drug designing approaches, Introduction to docking methods.

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MODULE V **(9 hrs)**

Introduction to Next-generation sequencing and artificial intelligence: Definition and scope of NGS. Introduction to NGS concepts and different sequencing platforms. Introduction to Genome sequencing, transcriptome sequencing and Metagenomics. Introduction to the core concepts of Artificial intelligence, machine learning and deep learning in bioinformatics. Explore various AI algorithms and their applications in biological data analysis- AI for biological sequence analysis and AI for protein structure and function predictions

SUGGESTED LIST OF PRACTICALS

1. Introduction to basic command-line tools for bioinformatics data processing
2. Retrieve the nucleotide/protein sequence of gene/protein of interest from databases
3. Find the similarity between sequences using BLAST- using online, offline and standalone versions
4. Multiple sequence alignment using bioedit, clustal omega
5. Construct a phylogenetic tree using dataset of DNA or protein sequences
6. Analyze a real-world NGS dataset to explore gene expression patterns.
7. Analyze a real-word metagenome data
8. Analyze a protein structure using a visualization tool and identify key features
9. Homology based protein structure prediction using SWISS-MODEL

REFERENCES

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12. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press.

24-340-0203 SCIENTIFIC COMMUNICATION AND CRITICAL ANALYSIS OF RESEARCH PAPERS (1C, 1L+0T+2P)

Course Description

This course aims to equip students with essential skills in effectively communicating scientific concepts and critically analysing research literature. Through interactive lectures and paper presentations, the students will learn how to articulate complex ideas with clarity and precision, while also improve their ability to evaluate the validity, reliability, and significance of research findings. Each week, two-hours will be dedicated for this course, during which each student is given the opportunity to present a research paper of their interest and follow it up with a group discussion with their classmates and teachers. By the end of the course, students will have developed the proficiency to craft well-structured scientific reports, deliver compelling presentations, and engage in insightful discussions on contemporary scientific issues, thus empowering them to excel in both academic and professional settings.

Course Outcomes (CO)

After completing the course, the student will be able to:

Course Outcome		Cognitive Level
C.O.1.	Appreciate the path-breaking work published in research papers	Understand
C.O.2.	Apply data analysis tools and logical reasoning in the in-depth study and critical analysis of primary literature data	Apply
C.O.3.	Generate hypothesis from primary literature and anecdotal data	Analyze
C.O.4.	Ability to effectively summarize a compendium of research work or information	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	-	-	-	-	-	1
CO2	-	-	-	-	-	1
CO3	-	-	-	-	-	1
CO4	-	-	-	-	-	1

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(1h)**

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 II **(2h)**

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.

MODULE III **(12h)**

Student presentations

Guidelines for selecting research papers for presentation:

1. Impact factor: Research papers selected for presentation should have an Impact Factor exceeding 5, ensuring the inclusion of high-quality, influential studies that have made significant contributions to their respective fields.
2. Citation metrics: Preference should be given to papers with a substantial number of citations, indicating widespread recognition and influence within the scientific community. Papers demonstrating robust citation metrics serve as reliable indicators of their importance and relevance in the field.
3. Relevance and timeliness: Papers should be selected based on their relevance to current research trends and emerging topics within the discipline. Emphasis should be placed on choosing papers that address timely issues and contribute to advancing knowledge in key areas of interest.
4. Rigorous peer review: Papers undergoing rigorous peer review processes, preferably from reputable publishers/journals (Springer, John Wiley & Sons, Taylor & Francis, Elsevier etc), with stringent editorial standards, should be prioritized. This ensures the integrity and reliability of the research findings presented, enhancing the credibility of the selected papers.
5. Contribution to advancing knowledge: Selected papers should represent significant advancements or breakthroughs in their respective fields, offering novel insights, innovative methodologies, or transformative outcomes that contribute to the advancement of scientific knowledge and understanding.

General guidelines for paper presentation:

1. A total duration of 40 minutes, with an additional 20 minutes designated for interactive discussion, is allocated for each student presentation.
2. Adherence to the assigned time limit is strongly encouraged to ensure effective time management during the presentation session.
3. The presenting student is required to submit a concise summary (1-2 pages) of the research paper of their choice one-day prior to their presentation.
4. Other students in the batch are required to submit their summaries within two days following the presentation.
5. Students are urged to utilize the subsequent assessment criteria as a reference while preparing for their presentations, as they will be evaluated based on the following marking pattern.

Criteria	**Maximum Marks**
The Standard and Quality of the paper selected	20
Presentation, Delivery, and Time management	30
Subject Knowledge/ Answering Questions	20
Summary writing	10
Overall quality	20
Total	**100**

24-340-0204 MICROBIAL PHYSIOLOGY (4C, 3L + 1T + 2P)

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

Course outcomes (CO)

After completing the course the student will be able to

Course Outcome		Cognitive Level
C.O.1	Analyze the differences in prokaryotes and eukaryotic cellular organization, photosynthesis and respiration	Analyze
C.O.2	Comprehend the organization of the microbial cell wall and membrane, differentiate the various transport systems, and their regulation	Analyze
C.O.3	Understand the mechanism of bacterial cell division, differentiation, sporulation and other adaptations for survival	Understand
C.O.4	Comprehend stress physiology, and other adaptations in extremophiles	Understand
C.O.5	Comprehend the mechanism of quorum sensing and quenching in microbial growth and pathogenesis and control and apply the knowledge in real time situations	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	2	-	-	-
CO2	2	2	2	-	-	-
CO3	3	3	3	-	-	-
CO4	3	3	3	3	-	-
CO5	2	-	2	2	-	2

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(8h)**

Introduction to microbial physiology-The Escherichia coli Paradigm, Cell Structure, The Cell Surface, Synthesis of DNA, RNA, and Protein, Metabolic and Genetic Regulation, Microbial Genetics, Chemical Composition, Oxidation–Reduction Versus Fermentation, Nitrogen Assimilation, Endospores, Growth, Continuous Culture, Factors Affecting Growth, Nutrition, Oxygen, Carbon Dioxide, Extremophiles, Microbial Stress Responses

Cell structure and function-The Eukaryotic Nucleus, Bacterial Nucleoids, Nucleosomes, Mitochondria,

Microbial Cell Surfaces, Eukaryotic Cell Surfaces, Prokaryotic Cell Surfaces, Surface Layers of Bacteria, Peptidoglycans of Bacterial Cell Walls, Peptidoglycan (Murein) Synthesis, Teichoic Acids and Lipoteichoic Acids, Outer Membranes of Gram-Negative Bacteria, Enterobacterial Common Antigen, Cytoplasmic Membranes, Permeability and Transport, Periplasm, Other Membranous Organelles, Capsules, Microbial Biofilms,

Organs of Locomotion, Cilia and Flagella of Eukaryotes, Bacterial (Prokaryotic) Flagella, Chemotaxis, Swarming Motility, Motility in Spirochetes, Gliding Motility, Pili or Fimbriae,

MODULE II **(8h)**

Membrane structure and function-metabolite transfer-Structure and organization of membranes (Glyco-conjugates and proteins in membrane systems), Structure of model membrane, Danielli-Davson Trilaminar sandwich model, Fluid mosaic model of the Singer and Nicolson, Unit membrane of Robertson; lipid bilayer and membrane, protein diffusion, osmosis, fluidity and permeability of membrane.

Metabolite Transport and protein export- Facilitated Diffusion, Mechanosensitive Channels, ATP-Binding Cassette Transporter Family, Chemiosmotic-Driven Transport, Establishing Ion Gradients, Specific Transport Systems, ATP-Linked Ion Motive Pumps, The Histidine Permease, siderophores and iron transport, Phosphotransferase System; protein transport and protein translocation pathways

MODULE III **(8h)**

Bacterial cell division-Cell Division in Gram-Negative Rods, Cell Division in Gram-Positive Cocci, Cell Division in Gram-Positive Bacilli, General Reviews, Cell Division in Gram-Negative Rods, Cell Division in Gram-Positive Cocci, Cell Division in Gram-Positive Bacilli

Bacterial differentiation & sporulation-Bacillus Endospore Formation, Life Cycle of Bacillus, Stages of Sporulation, Physiological and Genetic Aspects of Sporulation, Sporulation Genes, Initiation, Transition from Stage II to Stage III, Forespore Development, Final Stages of Sporulation,. Regulation of enzyme activity and gene expression

Myxobacterial Developmental Cycle- *Myxococcus xanthus*; Caulobacter Differentiation - Life Cycle of *Caulobacter crescentus* - Structure, Genetics, and Regulation; Regulation and Checkpoints of the Cell Cycle of *C. crescentus*, Endospore Formation, Germination and Outgrowth of Endospores,

Fungal physiology of growing hypha, hyphal aggregates; nutrient transport in fungi;

MODULE IV **(8h)**

Microbial stress responses-Osmotic Stress and Osmoregulation, Osmotic Control of Gene Expression, Aerobic to Anaerobic Transitions, Formate Nitrate Regulation, Nitrate Response, ArcAB System; Oxidative Stress, Regulation of the Oxidative Stress Response, pH Stress and Acid Tolerance; Thermal Stress and the Heat Shock Response; Nutrient Stress and the Starvation — Stress Response, Starvation — Stress Response; Adaptations in extremophiles- thermophiles, psychrophiles, halophiles, acidophiles and alkalophiles. Adaptation of fungi to extreme environments, Adaptation and their significance in biotechnology applications;

MODULE V **(8h)**

Host parasite interactions-Overview of Host–Parasite Relationships; Structures and Functions Involved in Host–Parasite Interactions; Adherence/Colonization, Virulence Factor Secretion Systems, Exotoxins, Quorum Sensing - 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. quorum sensing in fungi, Paradigms of Bacterial Pathogenesis- Enteropathogenic *Escherichia coli, Salmonella* Enterica Serovars, *Listeria Monocytogenes*, *Chlamydia* spp,- Adherence/Colonization Virulence Factor Secretion Systems

Text Book- Microbial Physiology 4th Edition Albert G. Moat John W. Foster Michael P. Spector A John Wiley & Sons, Inc., Publication

SUGGESTED LIST OF PRACTICALS

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 on spore germination of *Bacillus* spp.
4. Determination of Sulfur Oxidation Rate of *Thiobacillus thiooxidans.*
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 evaluation of biofim formers
8. Assessment of quorum sensing

REFERENCES

1. Microbial Physiology and Metabolism 1995,Caldwell D.R. Brown Publishers.
2. Microbial Physiology,1999, Moat A.G. and Foster J. W. Wiley.
3. Prokaryotic Development by Brun. Y.V. and Shimkets L.J. 2000. ASM Press.
4. Microbial physiology volume 4 of Basic microbiology Outline Studies in Biology, 1976, Ian W. Dawes, Ian W. Sutherland, Wiley
5. The Bacterial Spore: From Molecules to Systems 2016, Adam Driks, Patrick Eichenberger, Wiley
6. Quorum Sensing: Molecular Mechanism and Biotechnological Application 2019**,** edited by Giuseppina Tommonaro, Academic press
7. Quorum Network (Sensing/Quenching) in Multidrug-Resistant Pathogens 2019**,** edited by Rodolfo Garcia-Conteras, Thomas K. Wood, Maria Tomás, Frontiers in cellular and infection in Microbiology
8. Chemical Communication Among Bacteria 2008, Stephen Carlyle Winans, Bonnie L. Bassler, ASM Press,
9. Microbial Physiology: A Laboratory Manual 2008, National Dairy Research Institute, Karnal, Publisher NDRI,
10. Applied Microbial Physiology**:**A Practical Approach, *Volume 183 of Applied Microbial Physiology*, 1997, P. Malcolm Rhodes, Peter F. Stanbury IRL Press at Oxford University Press

24-340-0205 MOLECULAR VIROLOGY *(*4C, 3L+1T+2P)

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. Replication mechanisms, molecular pathogenesis, host-pathogen interactions, immune evasion strategies, development of antivirals and vaccines, and the relationship between viral evolution and emerging viruses will be taught using representative viruses from different viral families. Rather than covering most of the important microorganisms, select representative model organisms will be taught in detail with the goal that students will be able to apply knowledge and concepts in self-study moving forward in their education and careers.

The course also covers currenttrends in emerging viral infections important to public health and biosafety practices in virology laboratories.

Course outcomes (CO)

After completing the course, the students will be able to

Course Outcome		Cognitive Level
C.O.1	Understand the classification and nomenclature of viruses, nature of viruses and their structure	Understand
C.O.2	Describe molecular details of replication of viruses with different nucleic acid genomes	Analyse
C.O.3	Describe some of the major viral diseases, their pathogenic mechanisms, transmission and clinical symptoms. Describe how specific viruses evade and/or subvert host innate and adaptive immune functions	Analyse
C.O.4	Employ testing viral diseases by various techniques and conduct diagnostic tests for viral diseases and explain how specific antiviral therapies interfere with viral biology to treat infection	Apply
C.O.5	Employ biosafety practices for handling infectious viruses	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	-	-	-	-
CO2	2	2	-	-	-	-
CO3	2	2	-	-	-	-
CO4	2	2	2	2	1	-
CO5	2	2	2	2	1	1

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(5h)**

Introduction to virology: History and principles of virology, Virus structure and morphology, Classification, and nomenclature of viruses, ICTV and Baltimore. Routes of entry and transmission, acute and persistent infections, tissue tropism

MODULE II **(15h)**

The viral replication cycle: Replication strategies for DNA and RNA genome viruses, Host-

pathogen interactions, viral receptors, attachment and entry of enveloped and non-enveloped viruses, Viral entry pathways-fusion, endocytosis, uncoating, cytoplasmic trafficking, nuclear entry, replication, maturation, and release

MODULE III **(15h)**

Molecular Pathogenesis and Transmission of viral diseases:

(1) dsDNA Viruses: Herpesvirus (Adeno virus, Herpes simplex virus, Pox Virus),
(2) ssDNA Viruses : Parvovirus
(3) dsRNA viruses – reoviruses
(4) + ssRNA Viruses: Picornavirus (Poliovirus), Coronavirus.
(5) -ssRNA Viruses: Orthomyxovirus (Influenza virus), paramyxoviruses, rhabdoviruses
(6) ssRNA viruses with Reverse Transcriptase – retroviruses.
(7) dsDNA viruses with Reverse Transcriptase – hepadnaviruses

Emerging and re-emerging viruses that infect humans and animals: Filovirus (Ebola virus), Nipah, SARS-CoV2, Togavirus (Chikungunya virus), Flavivirus (Dengue Virus), *etc.*

Viral oncogenesis. Immune response to viral infection, viral immune escape mechanism.

MODULE IV **(8h)**

Detection and prevention: Eradication of viral diseases. 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. **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. Anti- sense RNA, siRNA, ribozymes

MODULE V **(2h)**

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

SUGGESTED LIST OF PRACTICALS

1. DNA isolation from virus infected cells and virus detection by real-time PCR
2. RNA isolation from virus infected cells and viral gene expression analysis by real-time PCR
3. Virus diagnosis by immunofluorescence- preparation of cells and staining cells infected with virus

REFERENCES

1. Knipe David N, Hawley Peter M, Fields Virology Vol.I, 6th ed. 2013, Lippincott Williams and Wilkins, A,Wolters, Kluwer Business, USA
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7. R. Ian Freshney. Culture of Animal Cells: A Manual of Basic Technique. Wiley.
8. Brian WJ Mahy and Hillar O Kangro. Virology Methods Manual Elsevier
9. John R. Stephenson, Alan Warnes. Diagnostic Virology Protocols: Methods in Molecular Medicine. HumanaPress. Springer Link
10. https://www.who.int/news-room/fact-sheets/detail/nipah-virus
11. https://novel-coronavirus.onlinelibrary.wiley.com/
12. https://www.nih.gov/coronavirus
13. https://www.ncbi.nlm.nih.gov/books/NBK554776/
14. Editors: Nicholas Johnson,The Role of Animals in Emerging Viral Diseases Academic Press, 2014, Pages 365
15. Brenda S. P. Ang, Tchoyoson C. C. Lim, Linfa Wang. Nipah Virus Infection Journal of Clinical Microbiology,Volume 56 Issue 6 e01875-17, June 2018, Chapter 11 - Nipah Virus: A Virus with Multiple Pathways of Emergence. Pages 293-315 A Review Article:
16. Editors: **Saxena**, Shailendra K. (Ed.)2019 Coronavirus Disease 2019 (COVID-19) ,Epidemiology, Pathogenesis, Diagnosis, and Therapeutics
17. Marco Cascella; Michael Rajnik; Arturo Cuomo; Scott C. Dulebohn; Raffaela Di Napoli.2019Features, Evaluation and Treatment Coronavirus (COVID-19) - https://www.ncbi.nlm.nih.gov/books/NBK554776/

24-340-0206 BIOSAFETY, BIOETHICS AND IPR (2C, 2L-1T-0P)

Course Description

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

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1	Understand the ethical, moral, social, and legal issues underlying products and processes developed by biotechnology and microbiology	Understand
C.O.2	Analyse and select appropriate biosafety measures for the conduct of experiments using various living organisms and to assess risk	Apply
C.O.3	Identify potential ethical issues in the conduct of research experiments and to avoid committing unintentional research misconduct	Analyse
C.O.4	Understand the process of applying for a provisional and complete patent through national and PCT mode	Understand
C.O.5	Explain the various measures to protect biodiversity and traditional knowledge from exploitation by unjust commercial interests	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	-	-	3	-
CO2	2	2	-	-	2	-
CO3	2	2	-	-	2	-
CO4	3	3	-	-	3	-
CO5	3	3	-	-	3	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I (14h)

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 **(10h)**

Critical Thinking: Elements of Reasoning, Logic and Rationality; Bias and Prejudice, Common Fallacies; Media Literacy; Gender Equality

Professional and 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 **(6h)**

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 **(7h)**

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

MODULE V **(8h)**

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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4. Intellectual property rights in agricultural Biotechnology, F. H. Erbisch and K. M. Maredia, 2nd edition, 2003, Cambridge University Press.
5. The Cambridge Textbook of Bioethics, Ed. Peter A. Singer, 2008, Cambridge University Press.
6. Biotechnology, Biosafety and Biodiverstiy, Sivamiah Shantharam, Jane F. Montegomery, 1999, Oxford & IBH Publ. New Delhi.

7. Genetically modified Food Sources, Safety Assessment and Control, Tutelyal, VA, 1st edition, 2013, Academic Press.
8. Bioethics: An Introduction to the History Methods and Practice, Jecker Nany S, Johsen Albert, Perlman, Robert A, 2nd ed., 2010, John & Bartlett, New Delhi.
9. Environmental Safety of Biotech and Conventional IPM Technology, Sharma, HC Dhillon, MK, Sahrawat, KN, 2012, Stadium Press LLC. USA.
10. Bioethics and Biosafety, Sathish MK, 2008, IK International.
11. Intellectual Property Rights, Neeraj Pandey and Khushdeep Dharni, 2014, PHI Learning, Pvt. Ltd.
12. Walter Sinnott Armstrong and Robert Fogelin, Understanding Arguments: An Introduction to Informal Logic. 8th Ed. 2009, Wadsworth Cengage Learning.

24-340-0207 ANALYTICAL TECHNIQUES - II (3E, 2L+1T+2P)

Course Description

Analytical techniques - II provides advanced knowledge on analytical techniques commonly used to study cells, tissues, proteins, and nucleic acids like advanced microscopy, immunological techniques, genomic analysis, proteomic analysis and electrophoresis. Emphasis will be placed on understanding the underlying principles, instrumentation, data analysis and interpretation of results for each technique. This course will develop proficiency in selecting and applying appropriate analytical techniques to address specific research questions and solve practical problems in biological science.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1.	Employ advanced microscopy techniques to gain insights into cellular dynamics, subcellular organization, and biomolecular interactions in living and fixed specimens.	Apply
C.O.2.	Perform immunological assays to detect, quantify and characterize immune cells, antibodies and antigens in studying immune response.	Apply
C.O.3.	Apply genomic analysis techniques to investigate the structure, function, and regulation of genes.	Apply
C.O.4.	Understand the principles and applications of proteomic analysis techniques to identify, quantify, and characterize proteins in biological samples.	Understand
C.O.5.	Understand the principles and applications of electrophoretic techniques for separating, analyzing, and quantifying nucleic acids and proteins	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	-	-	-	-
CO2	2	-	2	-	-	-
CO3	2	-	-	2	-	-
CO4	3	-	3	-	-	-
CO5	3	-	-	3	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I (7h)

Advanced Microscopy: 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), Atomic Force Microscopy (AFM).

MODULE II **(6h)**

Immunological techniques: ELISA, ELISPOT assay, hemagglutination, immunoprecipitation, immunofluorescence microscopy, flow cytometry and immune-electron microscopy; surface plasmon resonance, biosensor assays for assessing ligand-receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction.

MODULE III **(6h)**

Genomic analysis: Types of PCR: multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, ARMS; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; microarray: 16S rRNA typing; EST; SAGE; Blotting techniques - Southern, Northern; Gene transfer and transfection methods.

MODULE IV **(6h)**

Proteomic analysis: Western blot; Mass spectrometry: API, electrospray, MALDI-TOF, SELDI-TOF-MS, FT-ICR-MS and Orbitrap; iTRAQ; iCAT; X-ray crystallography, crystal preparation methods and data analysis.

MODULE V **(5h)**

Electrophoresis: General principles, electrophoresis of nucleic acids: Agarose, pulse-field and sequencing gels, Capillary electrophoresis, Single-molecule electrophoresis. Electrophoresis of proteins: SDS-PAGE, native gels, gradient gels, isoelectric focusing, two dimensional gels, gel-free protein electrophoresis.

SUGGESTED LIST OF PRACTICALS

1. FRET-based experiment to study protein-protein interactions.
2. Demonstration of ELISA and Immunoelectrophoresis.
3. Demonstration of flow cytometry.
4. PCR experiment to amplify specific DNA sequence.
5. Western blot to detect the expression of a target protein in a biological sample.
6. Agarose gel electrophoresis to separate DNA fragments based on their size.
7. SDS-PAGE to separate proteins.
8. Identify a specific protein marker expressed in a cell using Immunocytochemistry and microscopy techniques.

REFERENCES

1. David T. Plummer, An introduction to Practical Biochemistry, Tata McGraw Hill Edition, 1988
2. Keith Wilson and John Walker, Practical Biochemistry - Principles and techniques,
3. Cambridge University Press, U.K; 5th Edition, 2003.
4. Rapley and Walker, Molecular Biomethods Handbook, Humana Press, Totowa, NewYork, 2003.
5. Wilson K and Walker J "Principles and Techniques of Biochemistry and Molecular Biology" 6th Ed. Cambridge University Press, 2005.
6. D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.

7. R. Scopes, Protein purification-Principles & Practices, 3rd Edition, Springer
8. Verlag,1994.
9. Freifelder D.; Physical Biochemistry, Application to Biochemistry and Molecular
10. Biology, 2nd edition, W.H. Freeman & Company, San Fransisco, 1982.
11. Willard, H.H., Merritt L.L. Dean J.A. and Settle F.A (1986). Instrumental Methods of Analysis", 7th Ed., Wadsworth Publishing Co.
12. Selected Papers

24-340-0208 PLANT-MICROBE INTERACTIONS (3E, 3L+0T+0P)

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, Defence of plants and stress responses, Invasion of plant tissue-establishment of symbiotic relations; pathogen invasion strategies, Resistance mechanisms against attack by plant pathogens and plant immune system, Methods employed for disease diagnosis, Molecular Basis of Plant Disease Resistance, Plant defence responses against viruses, and Engineering pathogen resistance in crop plants

Course outcomes (CO):

After completing the course the student will be able to

Course Outcome		Cognitive Level
C.O.1	Analyse the importance of plant-microbe interactions concerning plant diseases	Analyse
C.O.2	Understand and analyse the different plant defence mechanisms and discuss interactions between plants and non-pathogenic/symbiotic bacteria and fungi in agriculture, horticulture and forestry	Analyse
C.O.3	Apply the conventional and advanced methodology to study the plant-pathogen interaction	Apply
C.O.4	Apply the knowledge on the molecular plant disease resistance mechanisms	Apply
C.O.5	Discuss plant viral diseases and apply that knowledge to generate engineered disease-resistant plants	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	-	-	-	-	-
CO2	3	1	-	-	-	-
CO3	2	2	1	-	-	-
CO4	1		1			1
CO5	2	1	1	-	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(6h)**

Plants as microbial habitat; Introduction to plant-microbe interactions: importance, variety, and two examples (*Fusarium oxysporum* and *Xanthomonas campestris*), symbiotic relations (mycorrhiza, rhizobium), plant diseases cycle, control of plant diseases

MODULE II **(6h)**

Overview of plant defence mechanisms, Defence 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; secondary metabolites of commercial value

MODULE III **(6h)**

Methodology to study plant-microbe interaction- culture techniques, transcriptome profiling, metabolic profiling, proteomics, microscopy, and spectroscopic techniques

MODULE IV **(6h)**

Resistance mechanisms against insect attack; gene-for-gene interactions; The plant immune system- Connecting virulence & resistance; induced resistance; non-host resistance

MODULE V **(6h)**

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

REFERENCES

1. Agrios, George N. *Plant pathology*. Elsevier, (2005).
2. Bhadauria, Vijai. "OMICS in plant disease resistance. "*Current Issues in Molecular Biology* 19.1 (2016): 1-2.
3. Bouarab, Kamal, Normand Brisson, and Fouad Daayf, eds. *Molecular plant-microbe interactions*. CABI, (2009).
4. Butter, Nachhattar Singh. *Insect Vectors and Plant Pathogens*. CRC Press, (2018).
5. Chrispeels, Maarten J., and David E. Sadava. *Plants, genes, and crop biotechnology*. Jones & Bartlett Learning, (2003).
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7. Khaled, Alfadhl Yahya, et al. "Early detection of diseases in plant tissue using spectroscopy–applications and limitations." *Applied Spectroscopy Reviews* 53.1 (2018): 36-64.
8. Schirawski, Jan, and Michael H. Perlin. "Plant–microbe interaction 2017—the good, the bad and the diverse." *International Journal of Molecular Sciences* 19.5 (2018): 1374.
9. Sharma, Pradeep, Dinesh Yadav, and R. K. Gaur, eds. *Bioinformatics in Agriculture: Next Generation Sequencing Era*. Elsevier, (2022).
10. Tronsmo, Anne Marte, et al. *Plant pathology and plant diseases*. CABI, (2020).

24-340-0209 BIOFUELS AND BIOENERGY (3E, 3L+0T+0P)

Course Description

This course focus on bioenergy and the utilization of biomass and biomass waste for energy recovery. The conversion of waste to biofuels, bioenergy and bio-products has been included in the course. The course encompasses thermochemical energy processes (combustion, gasification, pyrolysis), mechanical and chemical processes (oil extraction and trans-esterification), finally biochemical processes (fermentation, anaerobic digestion and bio-electrochemical system). The emphasis is given to Bioelectrochemical system. The Bioelectrochemical system used for the conversion of waste to energy such as microbial fuel cell and microbial electrochemical cell has been detailed in this course.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
CO 1	Comprehend various technologies used for the synthesis of Biofuel and generation of energy	Understand
CO 2	Illustrate the detailed mechanism and technologies used for the conversion of waste to Bioenergy	Understand
CO 3	Learn the development of microbial fuel cell system for bio-electricity production	Understand
CO 4	Learn the development of microbial electrochemical system for bio-hydrogen production	Analyze
CO 5	Practical application of the Bioelectrochemical system	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	1	1	-	-	-	-
CO2	1	-	-		-	-
CO3	-	-	-	3	-	-
CO4	-	-	-	3	-	-
CO5	-	-	-	3	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

Module I **(5h)**

Fundamental concepts in understanding Biofuel/Bioenergy production, Renewable feedstock and their production, Biomass pre-processing: drying, size reduction, and densification, Various Biofuels/Bioenergy from biomass

Module II **(7h)**

Biomass conversion to heat and power: thermal gasification of biomass, anaerobic digestion, Biomass conversion to Biofuel: thermo chemical conversion, syngas fermentation, Biochemical conversion to ethanol: biomass pre-treatment, Different enzymes, enzyme hydrolysis, and their applications in ethanol production
Biodiesel production from oil seeds, waste oils and algae

Module III **(5h)**

Conversion of waste to Biofuels, bio-products and Bioenergy, Types of waste and their distributions, Strategies for waste management, Waste preparation and Pre-treatment for conversion, Technologies for conversion of waste to energy and products.

Module IV **(8h)**

Bioenergy derived from Electro-chemically active biofilms**:** Bioelectricity production, Synthesis of metal Nano-particles, Bio-hydrogen production, Environmental remediation, Microbial fuel cell: Types of Reactors, Methodology**,** Polarization curve, Coulombic efficiency, cyclic voltammetry, Tafel Analysis and Microbial electrolysis cell.

Module V **(5h)**

Environmental impacts of Biofuel production, Energy balance and life-cycle analysis of Biofuel production, Value-added processing of Biofuel residues and co-products;

REFERENCES

1. Lee, S., & Shah, Y. T. (2012). *Biofuels and bioenergy: processes and technologies*. CRC Press.
2. Hakeem, K. R., Jawaid, M., & Rashid, U. (Eds.). (2014). *Biomass and bioenergy: Applications*. Springer.
3. Luque, R., & Clark, J. (Eds.). (2010). *Handbook of biofuels production: Processes and technologies*. Elsevier.
4. Nelson, V. C., &Starcher, K. L. (2015). *Introduction to renewable energy*. CRC press.
5. Cheng, J. (Ed.). (2017). *Biomass to renewable energy processes*. CRC press.
6. Logan, B.E., 2008. Microbial Fuel Cells. Wiley & Sons, Inc., Hoboken, NJ.
7. Rabaey, K., Angenent, L., Schroder, U., & Keller, J. (Eds.). (2009). *Bioelectrochemical systems*. IWA publishing.

SEMESTER III

24- 340-0301 RECOMBINANT DNA TECHNOLOGY (4C, 3L+1T +2P)

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. The students will also gain an understanding of gene editing strategies

Course objectives (CO)

After completing the course, the student will be able to:

Course Outcome		Cognitive Level
C.O.1	Apply different enzymes and vectors in rDNA technology	Apply
C.O.2	Produce genomic and cDNA libraries and screen for recombinants	Apply
C.O.3	Apply different molecular techniques to study gene expression; and in diagnosis and epidemiology; and also gene editing tools and techniques	Apply
C.O.4	Analyze recombinants using different gene transfer techniques	Analyze
C.O.5	Study and analyze heterologous protein expression in prokaryote and Eukaryotes	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	2	2	-	-
CO2	2	-	2	2	-	-
CO3	2	-	2	2	-	-
CO4	1	1	1	1	-	1
CO5	2	2	-	2	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(8h)**

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.

Cloning Vectors -plasmids, lambda phage, SV40, Phagemids; shuttle vectors, Construction of artificial chromosome vectors-BAC & YAC

MODULE II **(8h)**

Cloning strategies, selection and screening: Shot gun cloning, amplicon cloning, cDNA cloning and its advantages and disadvantages. Construction of genomic DNA and cDNA libraries; 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 III **(8h)**

Techniques: Types of PCR- - Restriction mapping and PFGE, DNA sequence determination, genome sequencing; Molecular Markers-RAPD, RFLP, DNA finger printing, microsatellites and mini satellites, SNPs, ESTs, Barcoding; Site directed mutagenesis; PCR analysis of mutants, site directed mutagenesisTransposon mutagenesis, cloning genes by transposon mutagenesis, mini-Mu elements and their use in *in vivo* cloning. Analysis of gene expression-western blots, Northeren blots, RT-PCR, Human diseases and gene therapy;
Genome editing strategies: CRISPR-cas, TALENS, ZFNs, engineered nucleases, meganucleases; MAGE; Applications

MODULE IV **(8h)**

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 **(8h)**

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.

SUGGESTED PRACTICAL LAB SESSION

1. Isolation of genomic DNA (Bacteria, bacteriophage, plant and rat liver) and genomic DNA library construction
2. Preparation of competent cells and Transformation in *E.coli*
3. Isolation of plasmid DNA from transformed *E. coli*
4. Restriction digestion and analysis of DNA
5. Isolation of total RNA and cDNA library construction (Demo)
6. PCR Techniques -nested, multiplex, Real time PCR (demonstration)
7. DNA sequencing (demo by industrial visit)

REFERENCES:

1. Winnaker, E.L. (2018). From Genes to Clones. India. VCH Panima Educational Book Agency.
2. Karcher, S.J. (1995). Molecular Biology-A Project Approach (1st ed.). Academic Press.
3. Primrose, S.B. (2006). Principles of Gene manipulation and Genomics (7th ed.). Blackwell Scientific Publications.
4. Lodish, H., Berk, A, et al. (2021). Molecular Cell Biology (9th ed.). W.H. Freeman.
5. Watson, J.D. (2014). Molecular Biology of the Gene (7th ed.). Pearson.
6. Lewin, B., Goldstein, E.S., et al. (2018). Genes–XII. Jones and Bartlett Learning
7. Sambrook, J., Fritsch, E. F., &Maniatis, T. (1989). Molecular cloning: a laboratory manual (No. Ed. 2). Cold spring harbor laboratory press.
8. Ausubel, F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A., &Struhl, K. (1987). Current protocols in molecular biology New York. NY: Wiley.
9. Freshney, R. I. Culture of animal cells, a manual of basic technique.

24-340-0302 ADVANCED IMMUNOLOGY (4C, 3L + 1T + 2P)

Course Description

This course aims to establish a comprehensive foundation in immunology, beginning with fundamental principles and progressing to a nuanced comprehension of immune mechanisms. Significant focus is placed on the collaborative nature of immune responses. Additionally, the course addresses instances of immune dysfunction and explores innovative technologies for correction or management. Key topics include the emerging significance of the innate immune system, the pivotal role of the intestinal immune system, and the immunomodulatory capabilities of gut microbiota. Furthermore, the course underscores the vast opportunities for both fundamental and applied research in immunology.

Course Outcomes

After completing this course, the students should be able to:

Course Outcome		Cognitive Level
C.O.1	Understand the fundamental organization and associations of the immune system, including its key components and their interactions.	Understand
C.O.2	Gain a comprehensive understanding of humoral and cell-mediated immune responses, lymphoid organ structure and function, lymphocyte development and maturation, antibody structure and function, receptor diversity generation, and the complement system, including associated disorders.	Understand
C.O.3	Understand the intricate mechanisms of immune function, including antigen presentation, lymphocyte trafficking, and immune responses to various pathogens, while also exploring disorders affecting these processes and the strategies pathogens employ to evade immune surveillance.	Understand
C.O.4	Analyze the intricate regulatory mechanisms of the immune system in specific clinical conditions, and assess the feasibility of incorporating technologies from other disciplines to correct or manage dysregulated immune responses.	Analyze
C.O.5	Apply appropriate strategies, techniques, and technologies for managing immune system disorders, considering both conventional and innovative approaches.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	-	-	-	-
CO2	3	3	-	-	-	-
CO3	3	3	-	-	-	-
CO4	2	-	2	-	-	-
CO5	2	-	2	2	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(5h)**

Introduction to Immunology: Historical overview and basic concepts - Key events in immunology history - Branches of the immune system and antigen distinctions, Haematopoiesis and immune cells, Understanding inflammation and its types, Psycho-neuro-

endocrino-immunology (PNEI) - Interdisciplinary study of psychology, neurology, endocrinology, and immunology, Circadian rhythm and immunity, Ecoimmunology - Impact of ecological factors on immune responses

MODULE II **(12h)**

Understanding immune system and its components: Humoral and Cell-mediated Immune Responses, Lymphoid organs structure and functions - Overview of primary and secondary lymphoid organs, Lymphocyte development and functions - T and B lymphocyte development and maturation - Antibody structure and functions - Immune response types and cellular mechanisms, Receptor diversity generation - BCR and TCR diversity generation mechanisms - Identification of T and B cell subsets, Complement System - Three pathways and regulatory molecules overview - Disorders associated with the complement system

MODULE III **(10h)**

Immuno-mechanisms: Major Histocompatibility Complex (MHC/HLA) - Structure, functions, and antigen presentation role - Disorders affecting antigen processing and presentation, Lymphocyte trafficking and germinal centre interaction - Mechanisms of lymphocyte trafficking and interaction at germinal centres - Role of High Endothelial Venules (HEV) in lymphocyte trafficking.

Immune responses to pathogens: Immune responses during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, Immune evasion strategies of pathogens

MODULE IV (**10h)**

Clinical Immunology: Immunodeficiencies (Congenital and Acquired), Hypersensitivity reactions, Autoimmune diseases, Transplantation immunology, Tumor immunology, Gut microbiota

MODULE V (**8h)**

Immunotechnology: Hybridoma technology and antibody generation, Immune manipulation of the intestine, Vaccines, Immunotherapy

SUGGESTED LIST OF PRACTICALS

1. Differential white cell count
2. Haemagglutination
3. Immunodiffusion (Ouchterlony, Mancinii)
4. Basic immunoelectrophoresis
7. Rocket immunoelectrophoresis
8. ELISA
9. IgG purification

REFERENCES (FOR THEORY)

1. Roitt's Essential Immunology 13 th ed. (2017) Delves, P.J., Martin S.J., Burton, D.R., and Roitt, I.M., Wiley Blackwell
2. Janeway's Immunobiology 9 th ed. 2017 Murphyn K., and Weaver, C., Garland Science
3. Kuby Immunology 8 th ed. (2019) Punt, J., Stranford, S., Jones, P., and Owen, J.A., Macmillan Education
4. Immunology 8 th ed. (2013) Male, D., Brostoff, J., Roth, D.B., Roitt, I.M. Elsevier
5. Primer to the Immune Response 2 nd ed. (2014) Mak, T.W., Saunders, M.E., and Jett, B.D., Elsevier Inc.
6. Cellular and Molecular Immunology 1 st South Asia ed. (2017) Abbas, A.K., Lichtman, A.H., and Pillai, S., Elsevier

7. Immunology and Immunotechnology (2006) Chakravarty, A.K. Oxford University Press
8. Immunology for Pharmacy (2012) Flaherty, D.K., Elsevier
9. Immunology Essential and Fundamental 3 rd ed. (2011) Pathak, S., Palan, U. , Capital Publishing Company
10. Essentials of Clinical Immunology 6 th ed. (2014) Chapel, H., Haeney, M., Misbah, S., and Snowden, N. Wiley Blackwell

REFERENCES (FOR PRACTICALS)

1. Practical Immunology, 4th Ed (2008), Frank C. Hay, Olwyn M. R. Westwood, Wiley-Blackwell.
2. Laboratory Protocols in Applied Life Sciences (2014) Bisen P.S., CRC Press.
3. A Handbook of Practical and Clinical Immunology Vol. 1., 2 nd ed. (2017) Talwar G.P., and Gupta S.K., CBS Publishers
4. A Handbook of Practical and Clinical Immunology Vol. 2., 2 nd ed. (2017) Talwar G.P., and Gupta S.K., CBS Publishers

24-340-0303 PROJECT PROPOSAL PREPARATION AND PRESENTATION (1C, 1L+1T+0P)

Course Description

The purpose of this course is to equip students with the knowledge and skills necessary to develop and present innovative project proposals. It covers all critical aspects of proposal writing, from identifying needs and formulating objectives to crafting persuasive arguments and creating impactful presentations. It is also intended to help students begin the development of communication skills and to prepare the students to present their topic of research and explain its importance to their classmates and teachers.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1	Define and explain the purpose and key components of a scientific research proposal and develop a well-structured research question and formulate clear objectives for their scientific project	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	-	-	-	-	-	1

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I (15 hrs)

Introduction to Scientific research proposals: Define and explain the purpose of a scientific research proposal, Defining research questions and objectives, Importance of ethical considerations in research, Exploring research methodologies, Developing a realistic research timeline and budget, structuring the research proposal, use of information technology tools to enhance the quality of the proposal, Various funding opportunities, The art of scientific presentation: Techniques for effective delivery of the proposal, mastering audience engagement skills, practice presentation and peer feedback, incorporating feedbacks and refining the proposal.

Project Proposal Preparation

Selection of research topic: Students should first select a research topic of their interest. The mentor or senior researchers should be able to help the students read papers in the areas of interest and help them to prepare the proposal. 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 which

should also contain the timeline and budget of the proposed project

Proposal Presentation

Oral Presentation: Students will have to present 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.

General guidelines for project presentation:

1. A total duration of 40 minutes, with an additional 20 minutes designated for interactive discussion, is allocated for each student presentation.
2. Adherence to the assigned time limit is strongly encouraged to ensure effective time management during the presentation session.
3. The presenting student is required to submit a concise summary (1-2 pages) of the research project one-day prior to their presentation.
4. Students are urged to utilize the subsequent assessment criteria as a reference while preparing for their presentations, as they will be evaluated based on the following marking pattern.

Criteria	Maximum Marks
The Standard and Quality of the proposal	20
Presentation, Delivery, and Time management	30
Subject Knowledge/ Answering Questions	20
Summary writing	10
Overall quality	20
Total	**100**

REFERENCES

1. On Being a Scientist: A Guide to Responsible Conduct in Research. (2009). United States: National Academies Press.
2. Bhatnagar, N. (2011). Effective Communication and Soft Skills. India: Pearson Education India.
3. Oruc, A. (2012). Handbook of Scientific Proposal Writing. United Kingdom: Taylor & Francis.
4. Holmes, D., Moody, P., Dine, D., Trueman, L. (2017). Research Methods for the Biosciences. United Kingdom: Oxford University Press.
5. Friedland, A. J., Folt, C. L., Mercer, J. L. (2018). Writing Successful Science Proposals. United Kingdom: Yale University Press.
6. Scientific Methods Used in Research and Writing. (2020). United Kingdom: CRC Press.

24-340-0304 FOOD MICROBIOLOGY (3C, 2L+1T+2P)

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.

Course outcomes (CO)

After completing the course, the student will be able to

Course Outcome		Cognitive Level
C.O.1	Examine microorganisms associated with various food materials, contamination and spoilage of food and assess of food quality employing different approaches	Analyze
C.O.2	Produce various fermented food and beverages at industrial levels employing microorganism and microbial enzymes	Apply
C.O.3	Analyze the role of poisoning and intoxications caused by microorganisms in quality control and safety of food	Analyze
C.O.4	Employ various food preservation methods	Apply
C.O.5	Analyze the various food safety regulations and rules for effective quality assessment and food safety	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	2	2	-	-
CO2	2	2	2	-	-	-
CO3	2	2	2	2	-	-
CO4	2	2	2	2	-	-
CO5	2	2	2	2	2	2

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(3h)**

Introduction to Food Microbiology: Microbiology of food, Factors affecting microbial growth and survival in food, Intrinsic, extrinsic and implicit factors. Hurdle effect. Sources of contamination and spoilage of vegetables, fruits, meat, seafood, milk and canned foods. Biochemical changes - fermentation, putrefaction and lipolysis. Microbiological examination of food. Applications of biosensors for food quality control analysis

MODULE II **(10h)**

Fermented food products and beverages: Nutritional value of fermented foods. Lactic acid bacteria and their properties, lactic starter cultures &their biochemical activities. Types of fermentation, batch, continuous and fed batch. Production and preservation of the following fermented foods: Soy sauce fermentation by Molds; Fermented vegetables – Sauerkraut; Fermented Meat – Sausages; yeast for bread production, fermented milk products ((acidophilus milk, yoghurt); Cheese production, types of cheeses; Role of microorganisms in beverages – tea, vinegar, wines, beer, vinegar fermentation , Application of microbial enzymes in food industry. Other fermented foods probiotics microbes, prebiotics, synbiotics, functional foods;

Microorganisms as food: single cell proteins, Mushrooms. Use of genetically modified microorganisms in food processing. Low alcohol beer, lager beer.

MODULE III **(10h)**

Food poisoning - Food borne diseases, Foodborne infections and intoxications**; Bacterial pathogens, clinical features, isolation, identification, association with food, and prevention measures** 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;

MODULE IV **(4h)**

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

MODULE V **(3h)**

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. Food safety objectives (FSO), Government regulatory practices and policies. FDA, EPA, HACCP.

Food safety objectives - National food legislation/ authorities and their role - FSSAI;Product certifications : ISI mark of BIS, AGMARK, FPO, MFPO, international organization and agreements-food and agricultural organization (FAO), Codex Alimentarius Commission (CAC) **Food Law:** Food Safety and standard act, 2006 , PFA Act, , Food safety and standard Regulations 2011 Food Safety Modernization act, 2002 (FSMA); FD&C Act, Additive/Color Amendments; NLEA, Food Bioterrorism Acts. Food Imports regulation, Regulation of Biotechnology and Genetic Modifications

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. Isolation and detection of major food poisoning bacteria, E.coli, Salmonella, V. cholerae, Listeria etc.
4. Production and estimation of lactic acid by *Lactobacillus* Sp
5. Sauerkraut fermentation
6. Production of fermented milk by *Lactobacillus acidophilus*.

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13. PepplerH. J & D. Perlman,1979, Microbial Technology 2nd Edition Fermentation Technology, AcademicPress
14. Robinson RK 1990, *Dairy microbiology,* Elsevier Science Pub. Co., London; New York, 2nd Ed
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16. Wood BJB 1998, *Microbiology of fermented foods,* Blackie Academic & Professional, London, 2nd edition.
17. Peppler H. J & D. Perlman ,1979, Microbial Technology 2nd Edition Fermentation Technology, AcademicPress
18. Shen, Cangliang, Zhang, Yifan 2017, Food Microbiology Laboratory for the Food Science Student-APractical Approach, Springer International Publishing
19. FSSAI Manual of methods of analysis of foods microbiological testing- Lab Manual 14, 2012, , FSSAI,New Delhi

24-340-0305 MEDICAL MICROBIOLOGY (3C, 2L+1T+2P)

Course description

This course will integrate basic microbiology and infectious diseases. The objective of this course is to provide the students with the background and up-to-date identifications of microbes that cause specific diseases in humans. The intention is also to provide students with the tools needed to understand medical microbiology, to stress key principles of microbial pathogenesis, the applications of clinical microbiology diagnostic techniques and the selection and use of key antimicrobial agents. The students will be introduced to important human pathogens and describe the relevant etiology, pathogenesis, diagnosis and epidemiology of different types of infections like respiratory, urinary, nosocomial infections etc.

Course outcomes (CO)

After completing the course the student will be able to

Course Outcome		Cognitive Level
C.O.1	Understand the basic concepts of pathogenesis and virulence role that certain microorganisms play in particular human diseases.	Understand
C.O.2	Understand the molecular basis of microbial pathogenicity and the mechanism of antimicrobial resistance.	Understand
C.O.3	Apply knowledge on etiology, pathogenesis for laboratory diagnosis of different types of infections like respiratory, urinary, nosocomial infections etc.	Apply
C.O.4	Employ molecular biology techniques in microbial epidemiology.	Apply
C.O.5	Discuss the methods for standardization of antimicrobial activity of a new substance and preservation of pharmaceutical products using antimicrobial agents	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	-	3	-	3	-
CO2	3	-	-	3	-	-
CO3	2	-	-	2	2	-
CO4	2	-	-	2	-	-
CO5	2	3	-	-	3	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I (10 h)

Classical view of microbial pathogenicity: Define pathogenicity and virulence; Quantitative measures of pathogenicity: minimal lethal dose (MLD), LD50, ID50, TCID50. Virulence determinants: colonization, microbial toxins, extra cellular enzymes, and invasiveness. Normal microbial flora of the human body. Facultative / obligate intracellular pathogens. Direct and indirect tissue damage by micro-organisms, indirect damage via inflammation, immune responses. The spread of microbes through the body: direct and indirect spread, microbial factor promoting spread, spread via lymphatic, blood and via other pathways.

MODULE II **(10 h)**

Molecular microbial pathogenicity: Molecular Koch's postulates, multiplicity of virulence determinants, coordinated regulation of virulence genes, and environmental regulation of virulence determinants by two component signal transudation systems, antigenic variation; clonal and panmictic nature of microbial pathogens, type three secretion system (TTSS, T3SS), Role of biofilms and quorum sensing in microbial pathogenecity. Mechanisms of emergence of new pathogens: horizontal gene transfer (HGT) and pathogenicity islands (PAI).

Antimicrobial resistance (AMR): Recent concepts – Multidrug efflux pumps, extended spectrum beta-lactamases (ESBL), X-MDR M. tuberculosis, Methacillin-resistant *S. aureus* (MRSA), Role of integrons.

MODULE III **(10 h)**

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

Emerging and re-emerging pathogens: Illustrate emerging and re-emerging pathogens *V. cholerae* 0139, X-MDR *M. tuberculosis*, *Helicobacter pylori*, Enterohaemorrhagic *E. coli* (EHEC), *Cryptosoridium parvum,* Bird/swine flu, AIDS and Dengue Hemorrhagic Fever, opportunistic fungal pathogens.

Diagnostic cycle: Sample collection and handling of clinical samples. Quality assurance & quality control in microbiology, Accreditation of laboratories.

MODULE IV **(10 h)**

Molecular microbial epidemiology: Objectives of microbial epidemiology. Biochemical and Immunological tools - biotyping, serotyping, phage typing, multilocus enzyme electrophoresis (MLEE); Molecular typing: RAPD, rep (REP, ERIC, BOX)-PCR, IS based typing, PFGE, AFLP, MLST, VNTR and whole genome sequence; Use of geographical information system (GIS) for microbial epidemiology.

Rapid diagnostic principles: Nucleic acid probes in diagnostic microbiology, nucleic acid amplification methods, Real-time PCR, Lateral flow assays, diagnostic sequencing and mutation detection, automated instruments for detection / diagnosis of infectious agents (BACTAC and Vitek-2, GeneExpert).

MODULE V **(5 h)**

Pharmaceutical Microbiology: principles and methods of different microbiological assay of pharmaceutical products; 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.

SUGGESTED LIST OF PRACTICALS

1. Isolate normal microflora associated with tooth and nose and palm
2. Use of PCR based molecular assay of human pathogens.
3. Microbiological assay of antibiotics by cup plate method and other methods.
4. Sterility testing of pharmaceuticals.

REFERENCES

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2. Levinson's Review of Medical Microbiology and Immunology, 11th Edition.
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10. Wilson's principles of bacteriology, virology and immunology.Edward Arnold,8thed
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15. Mackie, T.J., McCartney, J.E., and Collee, J.G. (1989). Mackie & McCartney practical medical microbiology. Churchill Livingstone, 13th ed
16. Black, J.G. (1999). Microbiology : principles and explorations. Prentice Hall
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18. Kindt, T.J., Goldsby, R.A., Osborne, B.A., and Kuby, J. (2006). Kubyimmunology.W.H. Freeman, New York. 6th ed.
19. Forbes, B.A., Sahm, D.F., Weissfeld, A.S., and Bailey, W.R.D.m. (2007). Bailey &
20. Scott's diagnostic microbiologyt. Elsevier, Mosby, London. 12th ed.

24-340-0306 NEXT GENERATION SEQUENCING AND DATA ANALYSIS (3E, 2L+1T+2P)

Course Description

This course provides a strong understanding of the different Next-generation sequencing platforms, which have become the premier tool in genetic and genomic analysis. The course will also provide a better overview of the different public datasets and different file formats in the NGS platforms. The course provides hands-on experience on the R and Linux platforms, which are the inevitable tools for NGS data processing. The course will also introduce the basics of structural biology and molecular docking. The course layout has adapted to the needs of beginners in the field of life science and allows students with no or little background in bioinformatics to get a first hands-on experience in this fast-evolving topic

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1	Explain the fundamentals of next-generation sequencing technologies	Understand
C.O.2	Explain the NGS workflow, data files and formats	Understand
C.O.3	Analyze and visualize data using R	Analyze
C.O.4	Effectively analyze and interpret RNA sequencing and genome data	Analyze
C.O.5	Effectively predict and analyze the structure of proteins	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	1	-	-	2	-	-
CO2	-	2	-	3	-	-
CO3	1	1	-	3	-	-
CO4	-	3	2	3	-	-
CO5	-	-	1	3	-	2

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I (6 hrs)

Introduction to Next Generation Sequencing (NGS): Principles of NGS technology, Major Applications of NGS, Different NGS Platforms: Illumina, Ion Torrent Semiconductor Sequencing, Pacific Biosciences SMRT, Oxford Nanopore Technologies. Data mining: Database for biological datasets, accessing information from public databases, Sequence storage and retrieval and various file formats

MODULE II (5 hrs)

Operating Systems and Concepts: Basic introduction to different Operating systems. Linux: Introduction to Linux, basic commands used for Navigation and Directory controls. File Maintenance Commands, Display Commands and print commands, working with the files, file attributes, pipes, wildcards, working with processes working

with basic editors. Basic regular expressions, string search applications using regular expressions. Spreadsheet applications: An introduction to the different spreadsheet applications

MODULE III **(6 hrs)**

Introduction to R: Defining the R project, Obtaining R, Generating R codes, Scripts, Text editors for R, Graphical User Interfaces (GUIs) for R, R Studio, R Packages. R Objects and data structures: Variable classes, Vectors and matrices, data frames and lists, Data sets included in R packages, Summarizing and exploring data, Reading data from external files- tables, fasta files, Storing data to external files, creating basic plots like histograms, scatterplots and bar charts, Creating and storing R workspaces.

MODULE IV **(7 hrs)**

RNA Seq and Genome sequencing: Principles of RNA Sequencing and experimental design, De novo and Resequencing approaches. File format and Quality control: Quality control of datasets obtained from public datasets, Filtering, adapter removal, Mapping, RNA-Seq Data Normalization, Identification of Differentially Expressed Genes, Functional Analysis of identified genes. Genome sequencing: Principles of Genome sequencing and experimental design, Sequencing Strategies for De novo Assembly: Assembly of Contigs, Assessment of Genome Characteristics, Contig Assembly Algorithms; Scaffolding, Assembly Quality Evaluation and Gap Closure. Comparative genomics: Tools and applications

MODULE V **(6 hrs)**

Structural databases: Introduction to structural databases, Protein Data Bank, Molecular Modelling Data Bank, Protein structure prediction- homology modelling, fold recognition, template free modelling. Protein folding problems, Introduction to drug designing and docking methods to generate new structures, Tools for molecular docking.

SUGGESTED LIST OF PRACTICALS

1. Introduction to the Linux command line interface
2. Introduction to R: Setting up of R and R studio environment, importing and exporting data, creating and managing data structures and visualizing data
3. Downloading and exploring RNA-Seq datasets from public repositories
4. Quality control of RNA-Seq data, Alignment of raw reads to reference, perform differential expression analysis using DESeq2 or EdgeR, identification of enriched GO terms and pathways using online tools or R packages
5. Denovo genome assembly using SPAdes. Running SPAdes assembly with different parameters and exploring options.
6. Evaluating the quality of assembled contigs using QUAST or other online tools
7. Navigating RCSB PDB website for efficient searching and retrieval, visualizing the structures, identifying and characterizing ligand binding sites, comparing protein structures for similarities and differences

REFERENCES

1. Datta, S., & Nettleton, D. (2014). *Statistical analysis of Next-generation sequencing data*. New York: Springer.
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3. Gentleman, R., Carey, V., Huber, W., Irizarry, R., & Dudoit, S. (Eds.). (2006). *Bioinformatics and computational biology solutions using R and Bioconductor*. Springer Science & Business Media.
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5. Jones, N. C., Pevzner, P. A., & Pevzner, P. (2004). *An introduction to bioinformatics algorithms*. MIT press.
6. Mandoiu, I., & Zelikovsky, A. (2016). *Computational methods for next generation sequencing data analysis*. John Wiley & Sons.
7. Metzker, M. L. (2010). Sequencing technologies—the next generation. *Nature reviews genetics*, *11*(1), 31-46.
8. Pevsner, J. (2015). *Bioinformatics and functional genomics*. John Wiley & Sons.
9. Sarwar, S. M., & Koretsky, R. M. (2016). *UNIX: the textbook*. CRC Press.
10. Sung, W. K. (2017). *Algorithms for next-generation sequencing*. CRC Press.

24-340-0307 ENVIRONMENTAL MICROBIOLOGY (3E, 3L+0T+0P)

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 and solid waste, bioremediation of environmental pollutants.

Course outcomes (CO)

After completing the course, the student will be able to

Course Outcome		Cognitive Level
C.O.1	Discuss the significant contributions of microbiologists, emergence of environmental microbiology, biogeochemical roles, and significant applications of microbes in solving environmental pollution problems	Understand
C.O.2	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	Apply
C.O.3	Discuss the diversity of microbes in soil and in extreme environments for conservation of environment and apply the same for sustainable utilization of environmental microorganisms	Apply
C.O.4	Discuss about indicator organisms, municipal solid and liquid waste management and apply using waste management techniques	Apply
C.O.5	Discuss Bioremediation of environmental and metal pollutants and use microbe for bioremediation or organic and metal pollution	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	-	-	-	-
CO2	2	2	2	-	-	-
CO3	2	2	2	-	-	-
CO4	2	2	2	-	-	-
CO5	2	2	2	-	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(3h)**

Brief history and development of environmental microbiology: History and development of microbial ecologyhighlighting significant contributions of microbiologists and emergence of environmental microbiology, and significant applications of microbes in solving environmental pollution. Microbial biogeochemistry, C, N, S, P, Fe cycles. 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. **Culture-dependent**

and culture-independent approaches for Understanding microbial diversity in the environment:

MODULE II **(3h)**

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. Role of microbes in marine fouling and corrosion. Marine microbes and climate change

MODULE III **(9h)**

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.

MODULE IV **(9h)**

Indicator Microorganisms, Total Coliforms, Fecal Coliforms and Escherichia coli.. Fecal Enterococci. Clostridium perfringes. Bacteroides and Bifidobacterium. Heterotrophic Plate Count, Bacteriophages. Municipal Wastewater Treatment, Drinking Water Treatment The Nature of Wastewater, Conventional Wastewater Treatment. Oxidation Pools. Septic Tanks. Wetlands Systems Sludge Processing. Treatmentof Industrial effluents (distillery, textile, pulp and paper).. **Solid waste management:** composting, anaerobic digestion& bio methanation

MODULE V **(6h)**

Microorganisms and Organic Pollutants, The Overall Process of Biodegradation, Contaminant Structure, Toxicity, and Biodegradability. microbial degradation of cellulose, lignocellulose, paper, textiles, leather, rubber, emerging contaminants and xenobiotics. Environmental Factors Affecting Biodegradation, Biodegradation of Organic Pollutants. Bioremediation. Bioremediation of environmental pollutants: Petroleum hydrocarbons **Genetically modified microorganisms and Biotechnology.**

Microorganisms and Metal Pollutants. Metals in the Environment. Metal Solubility, Bioavailability, and Speciation.Metal Effects on the Microbial Cell. Mechanisms of Microbial Metal Resistance and Detoxification, Microbial Metal Transformations, Microbial Approaches in the Remediation of Metal-Contaminated Environments.

REFERENCES

1. Atlas R.M., Bartha R., Benjamin Cummings 1993.Microbial Ecology Publishing Co, Redwood City, CA.,
2. A.H. Varnam& M.G. Evans, 2000 Environmental Microbiology Manson Publishing Ltd.,.
3. Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, 2007.Manual ofEnvironmental Microbiology ASM Press,

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24-340-0308 MICROBIOMES (3E, 3L+0T+0P)

Course description

This course provides an overview on the role of microbiome in human health and disease. It focuses on conceptual framework and technologies for understanding how microbiome, particularly gut microbiome impact human health and well-being. This course will cover the various microbiomes such the gut, soil, plant, oral, skin etc. The course will also discuss the dysbiosis and rebalancing of the microbiome. The course will also cover various omics techniques used to study the microbiome and microbiome strategies for treatment of diseases.

Course outcomes (CO)

After completing the course, the students will be able to:

Course Outcome		Cognitive Level
C.O.1	Illustrate ecological principles of the human microbiome, and the importance of conservation of the global microbiomes of peoples from different human populations to development and health	Understand
C.O.2	Discuss the growing importance of considering the human gut microbiome in the treatment and prevention of diseases and illness and to assess the potential of the microbiota (probiotics) and diet (prebiotics) to achieve and maintain health	Apply
C.O.3	Discuss the significance of microbiome of environment, soil, water, plant, skin, oral cavity etc and to apply the same for maintaining human health and ecological balance	Apply
C.O.4	Discuss and understand the current technologies in next generation sequencing and metagenomics in interpreting the role of the human microbiome	Apply
C.O.5	Discuss the application of microbiome for therapeutic purposes	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	-	-	-	-
CO2	2	2	-	-	-	-
CO3	2	2	-	2	-	-
CO4	2	2	-	-	-	-
CO5	2	2	-	-	2	2

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I (5h)

Introduction to the human microbiome. Human microbiome at various taxonomic levels, from the domains of bacteria, fungi and viruses down to species and strain-level differences. Other microorganisms of the human microbiome, The mycome and virome in health and disease. Pathobionts and pathogens, Opportunistic infections, Spore-forming opportunists. Dynamics of microbiome from birth to adulthood. The importance of organismal microbiomes for immunity and metabolism. Genetic differences and microbiomes.

MODULE II **(10h)**

The gut microbiome, Diet and the human microbiome, Microbial imbalances and pertubations: Dysbiosis and the gut microbiome, Antibiotics and the human microbiome, Drug metabolism by the microbiome, Behavior and the microbiome (the gut brain axis), Rebalancing of the microbiome: Probiotics, prebiotics and the human microbiome, Current probiotics – from fecal transplants to yoghurts

MODULE III **(10h)**

The skin microbiome. Environmental Microbiome. (Soil, water). Plant microbiome, Animal microbiome. Oral Microbiome, The Microbiome of the Genourinary System Oncobiome. Specialised pathogens and their tricks, Food poisoning, enteropathogenic *E. coli* and *Salmonella* (type III secretion systems II), Yersinia and the black death (type III secretion systems I) STDs and *Neisseria gonorrhoeae* (genomic flexibility)

MODULE IV **(10h)**

Introduction to metagenomics and next generation sequencing. DNA-based analysis of microbial communities, 16S rRNA gene amplicon sequencing and shotgun metagenomics sequencing methods. Functional analysis of the microbiome from DNA sequence functional analysis, metatranscriptome, metabolome, proteome, and glycome.

MODULE V **(10h)**

Exchange between the human microbiome and the built environment. Comparative microbiomes from other animals. Next generation therapies for microbial dysfunction and pathology Phage therapy. Microbiome engineering and its promises. Use of animals in microbiome research.

REFERENCES

1. The Gut Microbiome in Health and Disease (2018). Dirk Haller. The Gut Microbiome in Health and Disease. ISBN 978-3-31-990544-0, 978-3-31-990545-7
2. Fundamentals of Microbiome Science: How Microbes Shape Animal Biology. (2018). Angela e Douglas. ISBN. 978140088982
3. The Microbiomes of Humans, Animals, Plants, and the Environment. 2021. Andrés Moya. ISBN: 2662-6128, PRINT ISSN: 2662-611X
4. The Marine Microbiome. 2022. Lucas J. Sta, Mariana Silvia Cretoiu
5. Gut Microbiome-Related Diseases and Therapies. 2021..Maria Gazouli. George Theodoropoulos

24-340-0309 BIODEGRADATION AND SOLID WASTE MANAGEMENT (3E, 3L+0T+0P)

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.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1	Identify various types of solid wastes and their sources	Understand
C.O.2	Examine the physical and chemical composition of wastes	Analyze
C.O.3	Analyze the activities associated with the management of solid waste	Analyze
C.O.4	Evaluate the techniques and methods used in recovery of materials and energy from solid wastes	Evaluate
C.O.5	Categorize and manage the hazardous waste	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	-	-	-	3	-	-
CO2	-	-	-	3	-	-
CO3	-	-	-	2	-	-
CO4	-	-	-	3	-	-
CO5	-	-	-	2	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(5h)**

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 **(8h)**

Solid Waste: Definitions, Characteristics, and Perspectives: Types of solid wastes, sources of solid wastes, properties of solid wastes,

solid waste management: an overview Engineering Systems for Solid Waste Management: Solid waste generation; on-site handling, storage and processing; collection of solid wastes; transfer and transport; processing techniques; ultimate disposal; Integrated SW Management concepts

MODULE III **(7h)**

Systems for Resource and Energy Recovery: Processing techniques; RRR approach, materials-recovery systems; recovery of biological conversion products; recovery of thermal

conversion products; recovery of energy from conversion products; materials and energy recovery systems

MODULE IV **(5h)**

Disposal of SW: Dumping of solid waste; sanitary land fills – site selection, design and operation of sanitary landfills – Leachate collection & treatment. Identify methods of solid waste disposal during a site visit and follow safety precautions

MODULE V **(5h)**

Hazardous Waste Management: Introduction; Concern about Hazardous Waste Management; Characteristics of Hazardous Waste; Transportation and Disposal of Hazardous Waste; Industrial/biomedical waste, E- waste management

REFERENCES

1. Integrated Solid Waste Management, Engineering Principles and Management Issues, Tchobanoglous G, Theisen H and Vigil SA, McGraw Hill Education, 2014, Indian Edition
2. Waste Management Practices: Municipal, Hazardous and Industrial, John Pichtel, CRC Press, 2014, 2nd Edition
3. Solid Waste Engineering, Vesilind PA, Worrell W and Reinhart D, Brooks/Cole Thomson Learning Inc., 2010, 2nd Edition
4. Environmental Engineering, Peavy, H.S, Rowe, D.R., and G. Tchobanoglous, McGraw Hill Education, 2017, 1st Indian Edition
5. Handbook of Solid Waste Management, Tchobanoglous G and Kreith F, McGraw-Hill Education, 2002, 2nd Edition
6. Geotechnical Aspects of Landfill Design and Construction, Qian X, Koerner R M and Gray D H, Prentice Hall, 2002, 1st Edition
7. Hazardous Waste Management, LaGrega M.D., Buckingham P.L. and Evans J.C., Waveland Pr Inc., 2010, Reissue Edition
8. Hazardous Wastes - Sources, Pathways, Receptors, Richard J. Watts, John Wiley and Sons, 1998, 1st Edition.

24-340-0310 GENE SILENCING AND GENOME EDITING (3E, 3L+0T+0P)

Course Description

The RNA Interference and Genome Editing course explores the principles, techniques, and applications of RNA interference (RNAi) and genome editing technologies. This course provides students with a comprehensive understanding of the molecular mechanisms underlying RNAi and genome editing, as well as practical skills in designing and implementing experiments utilizing these techniques. Ethical considerations and current advancements in the field are also discussed.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1	Understand the molecular mechanisms of RNA interference.	Understand
C.O.2	Explore the principles and applications of genome editing technologies.	Understand
C.O.3	Develop skills in designing and executing RNAi and genome editing experiments using computational approaches	Apply
C.O.4	Analyze the ethical implications of RNAi and genome editing.	Analyze
C.O.5	Analyse case studies to comprehend real-world applications and challenges of RNAi and genome editing.	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	-	-	1	-	-
CO2	3	2	-	-	-	-
CO3	2	1	-	1	-	-
CO4	1	-	-	-	-	-
CO5	2	-	-	1	1	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I (6h)

Introduction to RNA Interference (RNAi)- Definition and historical context ; Mechanisms of RNAi: Small interfering RNA (siRNA) and microRNA (miRNA); Applications in gene regulation, functional genomics, and therapeutics. **RNAi Techniques**- Design and synthesis of siRNA and miRNA; Delivery methods for RNAi molecules; Assays for evaluating RNAi efficiency and specificity

MODULE II (6h)

Genome Editing Technologies- Overview of genome editing tools: CRISPR-Cas9, TALENs, ZFNs, etc.; Molecular mechanisms of genome editing; Applications in gene knockout, knock-in, and modulation

MODULE III (6h)

CRISPR-Cas9 Technology- CRISPR components: Guide RNA (gRNA), Cas9 protein; Designing gRNA for target specificity; Applications in genome editing and gene regulation.

Practical Applications of RNAi and Genome Editing- Gene silencing in model organisms and cell lines; Genome editing for disease modelling and therapeutic development; RNAi and genome editing in agriculture and biotechnology

MODULE IV **(6h)**

Ethical Considerations in RNAi and Genome Editing- Ethical guidelines and regulatory frameworks; Germline editing vs. somatic cell editing; Case studies: Ethical dilemmas in RNAi and genome editing research and applications

MODULE V **(6h)**

Current Trends and Future Directions-Advances in RNAi and genome editing technologies; Emerging applications in medicine, agriculture, and biotechnology; Challenges and opportunities in the field. **Case Studies and Discussion**- Analysing landmark studies in RNAi and genome editing B. Debating ethical issues and societal implications

REFERENCES

1. "RNA Interference: Methods for Plants and Animals" (2008) edited by T. Doran and C. Helliwell, eISBN : 978-1-78064-365-6
2. Genome Editing-Current Technology Advances and Applications for Crop Improvement (2022) edited by: Shabir Hussain Wani and Goetz Hensel. Springer
3. "CRISPR-Cas: A Laboratory Manual"(2009) edited by Jennifer A. Doudna and Prashant Mali. CSH Press
4. "RNA Interference: Challenges and Therapeutic Opportunities" (2015) edited by Mouldy Sioud, Springer
5. "Ethics of Genome Editing" (2021) European Group on Ethics in Science and New Technologies

24-340-0311 ALGAL BIOTECHNOLOGY (3E, 3L+1T+0P)

Course Description

Algal biotechnology course explores the diverse applications of algae in biotechnology, bioenergy, environmental remediation and various industrial applications. Students will learn the nutritional and commercial importance of algae, uses of different algal species, algal cultivation methods, biochemical composition of algae, and the potential biotechnological applications of algae. They will gain a comprehensive understanding of the potential and challenges associated with harnessing algal resources for sustainable development.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		Cognitive Level
C.O.1.	Understand the significance of algae in biotechnology and environmental applications.	Understand
C.O.2.	Understand the ecological roles and economic importance of different algal species.	Understand
C.O.3.	Explain the different cultivation systems used for algae.	Understand
C.O.4.	Analyze the biochemical composition of algae, including lipid, protein, carbohydrate, and pigment content.	Analyze
C.O.5.	Analyze the potential of algae to serve as a sustainable energy source, provide nutritional resources, and contribute to applications in phycoremediation, agriculture and pharmaceuticals.	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	-	-	3	-	-
CO2	3	-	-	3	-	-
CO3	3	-	-	3	-	-
CO4	2	2	2	-	-	-
CO5	2	-	-	2	-	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(8h)**

Introduction to algal biotechnology: Resource potential of algae; commercial utility of algae. Algae as a source of food and feed; Algae as a source of pigments, fine chemicals, fuel and bio-fertilizers. Distribution of economically important algae in India.

MODULE II **(10h)**

Algal diversity and use: Uses of algae *Spirulina, Dunaliella, Haematococcus, Chlorella, Scenedesmus, Porphyridium. Gracilaria, Gelidium, Sargassum, Turbinaria, Laminaria, Macrocystis, Porphyra* and *Ulva*.

MODULE III **(9h)**

Algal Cultivation Techniques: Algal production systems; Strain selection; Algal growth curve; Culture media; indoor cultivation methods and scaling up. Measurement of algal growth. Large-scale cultivation of algae. Evaporation and uniform dispersal of nutrients; Harvesting algae. Drying.

MODULE IV (8h)

Biochemical Composition of Algae: Protein, amino acids, lipids, waxes, glycerol, vitamins, pigments, chlorophyll, carotenoids and phycobiliproteins content in algae. Algal immobilization and its applications; Blue-green algal bio-fertilizer: Method of preparation, application and its advantages over inorganic fertilizers. Liquid seaweed fertilizer: Method of preparation and application.

MODULE V (10h)

Biotechnological applications of algae: Algae producing biodiesel; Advantages over other sources of biodiesel; Cultivation and extraction methods. Utilization of algae for dietary supplementation (for fish, livestock, and humans), agricultural purposes, and pharmaceutical applications. Phycoremediation, Sewage disposal and waste treatment of industrial effluent. Role of algae in nanobiotechnology.

REFERENCES

1. Barsanti, Laura & Paolo Gualtieri (2005). Algae-Anatomy, Biochemistry and Biotechnology. Taylor & Francis, London, New York.
2. BECKER, E.W. 1994 Microalgae-Biotechnology and microbiology. Cambridge University Press.
3. Chandramohan, D. (2007). Prospects of Biodiesel from marine microorganisms. Proceedings of the National Workshop on BIODIESEL, Organised by School of Energy, Environment & Natural Resources, Madurai Kamaraj University, Madurai and Ahimsa Agri division, Chennai, 17th and 18th October, 2007.
4. Trivedi, P.C. (2001). Algal Biotechnology. Pointer publishers, Jaipur, India.
5. Pulz; O. & Gross; W (2004). Valuable products from biotechnology of microalgae. Appl Microbiol Biotechnol 65: 635-648.
6. Chácon-Lee, T.L. & González-Mariño, G.E. (2010). Microalgae for “healthy” foods – possibilities and challenges. Comprehensive reviews in food science and food safety, 9.
7. Varfolomeev, S. D. & Wasserman, L. A. (2011). Microalgae as a source of biofuel, food, fodder, and medicines. Applied Biochemistry and Microbiology, 49, 789-807.
8. Gouveia, L.(2011). Microalgae as a feedstock for biofuels. Springer Briefs in Microbiology, London.Rapouso, M.F.J., Morais, R.M.S.C., Morais, A.M.M.B. (2013). Bioactivity and applications of sulphated polysaccharides from marine microalgae. Marine Drugs, 11, 233-252.
9. Sambamurty, A.V.S.S. (2015). A Textbook of Algae. S Chand. New Delhi
10. Dinabandhu Sahoo and B.D. Kaushik. (2012). Algal Biotechnology and Environment. I.K. International, New Delhi.
11. Mihir Kumar Das. (2010). Algal Biotechnology. Daya Publishing House, New Delhi.
12. Ian Morris. (1977). An introduction to the algae. Hutchinson & Co (Publishers) Ltd. London

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SEMESTER IV

24-340-0401 DISSERTATION AND SEMINAR (12C),
24-340-0402 COMPREHENSIVE VIVA VOCE (2C)

Course 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

Course outcomes (CO)

On completion of this course the student will be able to:

Course Outcome	
C.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.
C.O.2.	Apply required theory and experiments on the problem
C.O.3.	Construct a project proposal through extensive study of the literature and / or discussion with learned resource persons in academy or industry
C.O.4.	Create an action plan of the project work to be carried out through deliberations.
C.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.
C.O.6.	Analyze the data generated and discuss in context of current status
C.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)

24-340-0403 ENTREPRENEURSHIP FOR BIOLOGISTS (2E, 1L+0T+2P)

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.

Course Outcomes (CO)

After completing the course, the student will be able to:

Course Outcome		Cognitive Level
C.O.1	Describe the various programmes and opportunities for entrepreneurship in life science in India	Understand
C.O.2	Apply innovation tools such as ideation and design thinking for generating innovative ideas	Apply
C.O.3	Analyse real time data to explore and establish relationships in the areas of entrepreneurship decisions.	Analyse
C.O.4	Identify potential funding sources and how to sell the idea for successful funding	Apply
C.O.5	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

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	-	-	-	-	-
CO2	2	2	-	-	2	-
CO3	2	2	-	-	2	-
CO4	2	2		-	2	-
CO5	1	1	-	-	2	-

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation.

MODULE I **(6h)**

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 **(6h)**

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 **(6h)**

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 **(6h)**

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 **(6h)**

Protection of Intellectual Property Rights, Patent, Trademark and Copyrights. Managerial problems of new enterprises; production purchasing, financing labor and marketing problems.

SUGGESTED LIST OF PRACTICALS

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.
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