COCHIN UNIVERSITY OF SCIENCE ANDTECHNOLOGY KOCHI-22
SCHEME AND SYLLABUS FOR
M.Sc.PROGRAMINBIOTECHNOLOGY
(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
24-303-0101	Biochemistryand Enzymology	4	C	3L+1T+2P	Nil	50	50	100
24-303-0102	Genetics	3	C	2L+1T+0P	Nil	50	50	100
24-303-0103	Molecularbiology	4	C	3L+1T+2P	Nil	50	50	100
24-303-0104	Microbiology	4	C	3L+1T+2P	Nil	50	50	100
24-303-0105	Molecular Cell biology	4	C	3L+1T +2P	Nil	50	50	100
24-303-0106	Biostatistics	2	C	2L+1T+0P	Nil	50	50	100
24-303-010X	Elective -I	3	E	2L+1T+ 2P	NIL	50	50	100
TOTAL FORSEM-1		**21C 3E**				**300 50**	**300 50**	**600 100**

C-core; E-elective; All tutorial classes will be online
Elective - I
24-303-0107: - Analytical Techniques – I

SEMESTER-II

COURSE SUBJECTS		INSTRUCTION			EVALUATION			
Course no.	Course name	Credits	Core / Elective	Hours/week	Prerequisites	Internal	End semester	Total
24-303-0201	Bioprocess Technology and Industrial biotechnology	4	C	3L+1T+2P	Nil	50	50	100
24-303-0202	Biosafety, Bioethicsand IPR	2	C	1L+2T+0P	Nil	50	50	100
24-303-0203	Bioinformatics	3	C	3L+1T+2P	Nil	50	50	100
24-303-0204	Scientific Communication and Criticalanalysisof research papers	1	C	1L+0T+0P	Nil	100		100
24-303-020X	Elective -II	3	E	2L+1T+ 0P	Nil	50	50	100
24-303-020X	Elective -III	3	E	2L+0T+2P	Nil	50	50	100
24-303-020X	Elective - IV	3	E	2L+1T+0P	Nil	50	50	100
24-303-020X	Elective - V	3	E	2L+0T +2P	Nil	50	50	100
TOTALFORSEM –II		**10C**				**250**	**150**	**400**
		12E				**200**	**200**	**400**

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

Elective – II
24-303-0205 – Metabolism and Metabolic disorders

Elective – III
24-303-0206 – Analytical techniques II

Elective – IV, V (Choose any TWO)
24-303-0207 – Cancer biology
24-303-0208 – Molecular Neurobiology
24-303-0209 - Nanobiotechnology

SEMESTER – III

COURSE SUBJECTS		INSTRUCTION			EVALUATION			
Course no.	Course name	Credits	Core / Elective	Hours/week	Prerequisites	Internal	End semester	Total
24-303-0301	Recombinant DNA Technology	4	C	3L+1T+2P	Nil	50	50	100
24-303-0302	Advanced Immunology	4	C	3L+1T+2P	Nil	50	50	100
24-303-0304	ProjectProposalpreparation and presentation	1	C	1L+1T+0P	Nil	100		100
24-303-0305	Plant Biotechnology	3	C	2L+1T+ 2P	Nil	50	50	100
24-303-0306	Application of Biotechnology in Medicine	3	C	2L+1T+ 1P	Nil	50	50	100
24-303-030X	Elective - VI	3	E	2L+0T+1P	Nil	50	50	100
24-303-030X	Elective - VII	3	E	2L+1T+0P	Nil	50	50	100
24-303-030X	Elective - VIII	3	E	2L+1T+1P	Nil	50	50	100
TOTALFORSEM –III		**15C**				**300**	**200**	**500**
		9E				**150**	**150**	**300**

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

Elective – VI, VII, VIII (Choose any THREE)

24-303-0307 – Next Generation Sequencing and Data Analysis
24-303-0308 – Stem cell and Regenerative Medicine
24-303-0309 – Environmental Biotechnology
24-303-0310 - Biopharmaceuticals
24-303-0311–Gene Silencing and Genome Editing

SEMESTER IV

COURSE SUBJECTS		INSTRUCTION			EVALUATION			
Course no.	Course name	Credits	Core/ Elective	Hours/ week	Prerequisites	Internal	End semester	Total
24-303-0401	Dissertation and Seminar	12	C	0L+0T+24P	Nil	200	200	400
24-303-0402	ComprehensiveViva -Voce	2	C	2L+0T+1P	Nil	100	100	200
24-303-040X	Elective - IX	2	E	2L+0T +0P	Nil	100		100
24-303-XXXX	Elective - X	2/3/4	E		Nil		100	100
TOTALFORSEM-IV		**14C**				**300**	**300**	**600**
		5E				**100**	**100**	**200**
GRAND TOTAL FOR M. Sc BIOTECHNOLOGYPROGRAM		**61C**				**1150**	**950**	**2100**
		29E				**500**	**500**	**1000**

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

Elective – IX
24-303-0403- Entrepreneurship for Biologists

Elective- X
24-303-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.

PO7. 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 MSC BIOTECHNOLOGY

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 physiological, cellular, and biochemical functions and organization of biological systems at molecular and functional level.

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. 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, bioinformatics, designing of green technologies for environmental management for sustainable development, animal and plant cell culture and other biotechnological methods.

PSO5. 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/MOOC (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.
20-303-0204, 20-303-0304, and 20-303-0401 evaluation will be completely internal
20-303-0205 Evaluation - One internal examination covering all modules (20 marks), Project Proposal Report
(40 marks) and Proposal Défense (40 marks)
20-303-0206 Evaluation - Class assignments (50 marks) and presentation (25marks) and final review (25 Marks). 20-303-0401 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)

DETAILED SYLLABUS

SEMESTER-I

24-303-0101 BIOCHEMISTRY AND ENZYMOLOGY (4C, 3L+ 1T +2P)

Course Description

This course aims to enrich the understanding of the fundamental principles and properties, classification, structure and function significance of biomolecules with special focus given to enzyme catalysis, kinetics and applications. The course provides application-oriented insights on biochemical techniques involved in characterization, activity studies, structure prediction, validation of physical, chemical and biological properties of biomolecules. The course covers the methodology and instrumentation aspect of a clinical biochemistry lab. Also introduces the concepts of glycobiology, proteomics and the emerging fields glycomics and lipidomics**.**

Course Outcomes (CO)
After completing the course, the student will be able

Course Outcome	Description	Cognitive Level
C.O.1	Understanding the fundamentals of biochemistry	Understand
C.O.2	Examine the chemistry of various biomolecules and apply the techniques to identify/purify/predict the structure/synthesise carbohydrates, lipids and their derivatives	Apply
C.O.3	Examine the chemical properties and interpret the quantity of various biomolecules and apply the techniques to identify/purify/predict the structure/synthesise proteins and nucleic acids	Analyse
C.O.4	Investigate the general properties of enzymes using various methods, apply enzyme kinetics to study the nature of enzyme and inhibitors in terms of Km and Vmax Compare the affinity of Enzymes to substrates in terms of Km	Apply
C.O.5	Apply the techniques and handle the equipment used in clinical diagnosis of diseases, based on theoretical knowledge, set up the working model of a clinical biochemistry lab by flow chart	Apply

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

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

MODULE I **(7h)**

Chemical foundations of life: Overview of weak interactions in aqueous systems, Organic reaction mechanisms (Group-transfer reactions, oxidation and reductions, coupled reactions, Elimination, Isomerization and rearrangements), Thermodynamics of phosphate compounds (Phosphoryl-transfer reactions, High energy compounds and Biological energy transducers (ATP, NADH, NADPH, FADH, CoASH), ATP cycle, structural basis of free energy change during hydrolysis of ATP, High Energy phosphate compounds, Nernst equation and Redox-potentials.Thermodynamics principlesin biology and energetics.

MODULE II **(6h)**

Glycobiology and Lipid Biology: Basic structure and reactions and classifications of carbohydrates and lipids, Carbohydrates and lipids as energy source, matter and information molecules. Glycoconjugates and their significance, Glycolipids, Carbohydrate based biomaterials and their applications. Techniques of extraction, separation and structure prediction, applications in biomedical sciences, glycomics and lipidomics.

MODULE III **(7h)**

Proteins and Nucleic acids: Chemical, Biological and Physical properties of Protein and nucleotides and types and classification, Structural organization of proteins, Ramachandran Plot, Globular and fibrous proteins,techniques involved in separation, purification, and sequencing and synthesis of peptides/proteins and techniques involved in structure prediction,Proteomics, Protein ligand interactions and applications in drug development,Structure activity relationships, and nucleotides as energy and information molecules.

MODULE IV **(10h)**

Enzymes: Examples of Enzymatic reactions, chymotrypsin, hexokinase, enolase etc.Reaction rates and Equilibria, Reaction coordinate diagram, Enzyme substrate complex, mechanisms of catalysis. Enzyme kinetics, Michaelis Menton Equation, Line weaver burk plots and other representations, enzyme inhibition and allosteric enzymes and bisubstrate reactions.Applications of enzymes, enzyme significance of isozymes in disease diagnosis, enzymes as therapeutic targetsand the scope of enzyme engineering.

MODULEV **(6h)**

Clinical Biochemistry, Definition and scope of clinical biochemistry in diagnosis, analyses, collection and preservation of biological fluids (blood, urine & CSF), normal values, reagents for analysis, Requirements of setting up of clinical laboratory, collection preparation, preservation, and handling of clinical samples, quality control, Safety measures in clinical laboratory and practices, common techniques and equipment used in clinical diagnosis of communicable and non-communicable diseases.

SUGGESTED LIST OF PRACTICALS

1. Qualitative and Quantitative tests for carbohydrates/proteins/lipids and nucleic acids
2. Cholesterol profiling, Liver and kidney function test
3. Enzyme extraction /purification and Assay to determine activity and specific activity
4. Factors affecting enzyme activity/Fluorescence spectroscopy to study the effect of temperature and p H on protein structure
5. Effect on velocity: MM plot and Lineweaver -Burk Plot determination of Km and Vmax
6. Effect of inhibitors on enzyme activities

REFERENCES

1. Leininger, A. L., Nelson, David L., Cox, Michael M. (2013). Principles of Biochemistry.6th revised edition
2. Biocatalysis: Biochemical Fundamentals and Applications .2nd reprint Edition. Imperial College Press.
3. Combs Jr, G. F., & McClung, J. P. (2016). The vitamins: fundamental aspects in nutrition and health. Academic press.
4. Lurton, R. (2010). Clinical Biochemistry.2nd Edition. Viva books.
5. White, Abraham. (2004). Principles of Biochemistry.6th edition. Tata McGraw-Hill.
6. Cooper T.G. (2015). Tools of Biochemistry.2nd edition, Wiley-Interscience 11. Sadasivam S. and Manickam A. (2009).
7. Biochemical Methods, 2ndedn.New Age International Ltd Publishers.
8. Mu, P., & Plummer, D. T. (1988). Introduction to practical biochemistry. Tata McGraw-Hill Education. 13. Jayaraman J. (1992). Laboratory manual in Biochemistry. John Wiley
9. Enzymes: biochemistry, biotechnology, clinical chemistry. Elsevier. 5. Chaplin, M.F.,Buke ,C.(1990). Enzyme technology.Cambridge University Press. 6. Grundwald, D. Peter. (2016).
10. Biocatalysis: Biochemical Fundamental and Applications.2nd reprint Edition. Imperial College Press 7. Grunwald, P. (2009).
11. Biocatalysis: biochemical fundamentals and applications. Imperial College Press.

24-303-0102 GENETICS (3C, 2L-1T- 0P)

Course Description:
This course aims to take students through the various fields of genetics and classical genetics, covering prokaryotic/phage genetics to yeast and higher eukaryotic domains. On covering all classical concepts of Mendelian genetics across these life forms, students will be exposed to ideas of population genetics, quantitative genetics encompassing complex traits, clinical genetics, and genetics of evolution

CourseOutcomes (CO)
Aftercompletingthecourse,thestudentwillbeableto:

Course Outcome	Description	Cognitive Level
C.O.1	Describe the fundamentals of classical genetics and apply solve problems	Apply
C.O.2	Explain the methods of molecular mapping and analyze crossing data	Analyse
C.O.3	Use pedigree analysis to explain human genetics and the underlying complexities	Analyse
C.O.4	Explain the inheritance of complex traits	Understand
C.O.5	Explain the genetics of evolution	Understand

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

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

MODULEI (12h)
Classical Genetics: Mendelism and extensions of Mendelism, Epistasis, Pleiotropy, Polygenic inheritance, Sex-linked inheritance, extra-nuclear inheritance, chromosome theory of inheritance; Linkage and crossing over; Genetic mapping in – bacteria, bacteriophage, Neurospora, yeast and drosophila; fine structure analysis

MODULEII (9h)
Modern Genetics: Molecular Markers; chromosome mapping and molecular mapping; Development of gene concept
Genomics: Genomes and Genomics, Human genome project; functional genomics and reverse genetics; Comparative genomics

MODULEIII (8h)
Human Disease Genetics: Pedigree analysis of Monogenic traits - Autosomal inheritance-dominant, recessive Sex-linked inheritance, Sex-limited and sex-influenced traits, Mitochondrial inheritance, OMIM number

Complications to the basic pedigree patterns- non-penetrance, variable, expressivity, pleiotropy, late-onset, dominance problems, anticipation, genetic heterogeneity, genomic imprinting and uniparental disomy, spontaneous mutations, mosaicism and chimerism, male lethality, X-inactivation; LOD score for linkage testing, genetic disorders

MODULEIV (8h)

Inheritance of complex traits: Complex traits, measuring and analyzing quantitative variation, narrow sense and broad sense heritability, QTLs and mapping QTLs, Human quantitative traits, Haplotype mapping, and GWAS

Epigenetics: Epigenome and the modifications; Maintenance of epigenome; Epigenetics and development; X-inactivation and genomic imprinting

MODULEV (8h)

Population Genetics and Genetics of Evolution: Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fisher's theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness; Darwin's theory of evolution; Genetic variation in natural populations; Molecular evolution; Speciation; Human evolution

REFERENCES

1. Introduction to Genetic Analysis, Griffith, AJF, Wessler SR, Carol SB and Dobley J., 11th edition, 2015, W.H. Freeman and Co.
2. Genetics: From Genes to Genomes, Hartwell LH, Goldberg ML, Fischer JA and Hood L., 6th edition, 2018, McGraw Hill.
3. Principles of Genetics, E.J. Gardner and D.P. Snustad, 7thedn, 2015, John Wiley and Sons
4. Genetics, Monroe W. Strickberger 3rd revised edition, 2008, Prentice Hall Pvt. Ltd
5. Essential Genetics- A Genomic Perspective- Daniel L.H, 4th edition, 2005, Jones and Bartlett, USA
6. Principles of Genetics, Robert H. Tamarin, 7th edition, 2007, Tata MaGraw-Hill
7. Genetics: a Conceptual Approach, Pierce, B. A., 6th edition, 2016 W.H. Freeman.
8. Evolutionary Genetics, Smith, J. M. 1999, 2nd edition, Oxford University Press.
9. Genetics: Analysis of Genes and Genomics, Hartle, L, 8th edition, 2011, Jones and Barlett, USA
10. Emery's Elements of Medical Genetics, Turnpenny P, and Ellard S, 15th edition, 2017, Elsevier
11. Molecular and Genetic Analysis of Human Traits, Maroni, 2001, Wiley-Blackwell

12. Approaches to Gene Mapping in Complex Human Diseases, Haines and Pericak, 2006, Wiley
13. Selected research papers to be given

24-303-0103 MOLECULAR BIOLOGY (4C, 3L-1T-2P)

Course Description

This course is intended to be an advanced course in molecular biology that builds on the introductory undergraduate Molecular Biology course. The course is designed to focus more on the fundamental principles of molecular biology than go through the vast information in the field. At the end of the course, students can explain the principles underlying life at a cellular level. They will also be able to design appropriate experiments to test hypotheses regarding the inner workings of a cell. This course will also introduce students to the latest discoveries in the field through analysis of original journal articles and presentations by the students.

CourseOutcomes (CO)

Aftercompletingthecourse,thestudentwillbeableto:

Course Outcome	Description	Cognitive Level
C.O.1	Explain the role of chemical interactions in the structure and function of biomolecule	Understand
C.O.2	Describe the fundamental principles of replication and maintenance and gene expression and regulation of gene expression in cells	Understand
C.O.3	Describe the transcription and translation process and apply it to solve problems	Apply
C.O .4	Explain the various levels of regulation of gene expression in and use it to solve problems	Analyze
C.O.5	Describe the gene expression in regulating development	Understand

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

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

MODULEI (6h)

Structure of Macromolecules: Bonds and Interactions in Biology; Classical Experiments in Molecular Biology; Structure of DNA and RNA; Structure of Proteins; Major Techniques in Molecular Biology

MODULEII (12h)

Maintenance of Genome: Genome structure, Chromatin, and the Nucleosome; Replication of DNA, Extrachromosomal Replicons – Plasmid, Mitochondrial and Chloroplast DNA; Mutability and Repair of DNA, Homologous Recombination; Site-specific recombination, Transposition of DNA

MODULE III (11h)

Transcription and Translation of Genetic Information: Mechanism of Transcription; RNA Splicing; RNA Editing; Translation; The Genetic Code; The origin and early evolution of life

MODULE IV (7h)

Control of gene expression: Transcriptional regulation in prokaryotes; *Lac* and *Trp*Operon; Gene Regulation in Lambda Phage Life Cycle; Transcriptional Regulation in Eukaryotes; -Activators, Repressors; Epigenetic regulation; post-translational modifications

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MODULE V (9h)

Regulatory RNAs; Gene Regulation in Development and Evolution- Drosophila embryogenesis, Homeotic Genes; Systems Biology; Model Organisms in Molecular Biology

SUGGESTEDLISTOFPRACTICALS

1. Isolation of genomic DNA from various samples
2. Plasmid Isolation – DNA Topology
3. RNA Isolation – Agarose gel electrophoresis
4. Application of lac operon – Inducible expression of proteins – IPTG – SDS-PAGE

REFERENCES:

1. Molecular Biology of the Gene,7th edition, Watson et al. 2013, CSHL Press (Primary Reference Book)
2. Genes XII, Lewin et. al., 2017, Jones and Bartlett Pub Inc.
3. Molecular Biology of the cell, Alberts, Bruce, 6th edition, 2014, Gorland Pub. Inc.
4. Biochemistry of Nucleic acids -Roger L. P. Adams et al.,11th edition, 2007, Chapman & Hall
5. Molecular Cell Biology- Lodish, Baltimore et al., 8th edition, 2016, W.H.Freeman and Co.
6. Cell and Molecular Biology- E. D. P. De Robertis and E. M. F. De Robertis, Jr., 8thsub.edn., 2011, Kluwer
7. Molecular Biology and Biotechnology: A Comprehensive Desk Reference, Meyers, Robert A, 2011 ed. Wiley, New Delhi.
8. Molecular Biology –David Clark and Nanette K Pazdernik, 2nd edition,2013, Academic press
9. Selected research papers to be given

24-303-0104 MICROBIOLOGY (4C, 3L+1T+2P)

Course Description:

The course will provide both the basics and advanced understanding and applications of Microbiology.The course focuses on molecular mechanisms of classification of microbes and molecular Phylogeny. The course also includes the various transport mechanisms adopted by microbes and their molecular basis. The molecular basis of the nutrient cycles especially N-cycle will also be discussed. In addition, the course will also include the molecular mechanisms underlying bacterial pathogenesis and antimicrobial resistance mechanisms. The course also covers the various measures to control microorganisms.

Course Outcomes (CO)

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

Course Outcome	Description	Cognitive Level
C.O.1	Discuss the scope of microbiology and classification of microbes based on classical and molecular basis and construct phylogenetic trees	Understand
C.O.2	Discuss and use various microbial culturing techniques for microbe isolation	Apply/Analyse
C.O.3	Describe the mechanisms of various transport systems and nutrient cycling in microbes	Understand
C.O.4	Describe the microbial gene transfer mechanisms and analyse strategies to estimate pathogenesis and develop strategies to understand antimicrobial resistance mechanisms	Analyse
C.O.5	Describe the strategies for control of microorganisms	Apply

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

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

MODULE I (12h)

Introduction to microbiology History and scope of microbiology; Koch's postulates.

Microbial classification- Microbes and their types, Viruses, Bacteria, fungi and protozoans – Morphology (cell wall organization) and classification. Abnormal forms of bacteria, archaebacteria, mycoplasma and PPLO

Molecular basis for Classification: Archaebacteria, Eubacteria, cyanobacteria, Yeasts, fungi, microalgae, protozoans and viruses. Phylogenetics and evolution.

MODULE II **(8h)**

Microbial culturing- Cultivation of bacteria/fungi/viruses – nutritional requirements, physical requirements, different types of media & their preparations. Axenic culture, Isolation of pure cultures (Bacteria/fungi/viruses), maintenance and preservation of the pure cultures. Microbial growth kinetics, enumeration of cells by direct and indirect methods. An introduction to metagenomics.

MODULE III **(6h)**

Transport mechanisms in microbes and their regulation: Simple diffusion, facilitated diffusion, active transport and group translocation. **Biogeochemical cycles**: Carbon, Nitrogen, Phosphorus, Sulphur, nitrogen cycles; Nitrogen fixation-leghaemoglobin.

MODULE IV **(12h)**

Pathogenic aspects of microbes. Horizontal gene transfer: transformation, transduction, conjugation, plasmids, transposons. Pathogenicity islands, toxin genes, virulence genes, Biofilms in disease; AMR genes in pathogenesis, Characteristics of pathogenic fungi

Viral Genetics Reproductive cycles of bacteriophage, M13 and lambda.

Important Bacterial, fungal and viral diseases of animals and plants.

MODULE V: **(7h)**

Control of micro-organisms Concept of sterilization and disinfection. Physical and chemical methods of microbial control. Chemotherapeutics, susceptibility test (broth procedures and diffusion methods), mode of action of antibiotics, narrow and broad spectrum (Penicillin, ampicillin, sulphonamide, vancomycin, tetracycline, chloramphenicol), antifungals (clotrimazole, fluconazole), antiretroviral (tenofovir, AZT).

SUGGESTED LIST OF PRACTICALS

1. Sterilization of media, glassware and plasticwares.
2. Isolation of bacteria from soil and its characterization using Gram's staining and Biochemical assays
3. Most probable number (MPN) method for counting coliform
4. Application of specific molecular markers like 16S rDNA/ 18S rDNA /COXa sequence amplification and analysis for molecular classification of microorganisms
5. Construction of phylogenetic tree to understand relatedness
6. Bacterial growth curve and its analysis
7. Antibiotic sensitivity assay
8. Isolation of fungifromair,water andsoil and identificationof*fungi using* Lactophenolcottonbluemounting
9. Identification of fungi using Slideculturetechnique
10. Observation of sporesof fungi

REFERENCES

1. Prescott's Microbiology, 10th Edition Authors: Joanne Willey, Linda Sherwood and Christopher J. Woolverton, 2016
2. Microbiology: An Introduction, 13th Edition Authors: Gerard J. Tortora, Berdell R. Funke and Christine L. Case, 2018
3. Microbiology Fundamentals: A Clinical Approach (3rd Edition) Marjorie Kelly Cowan, Heidi Smith, Jennifer Lusk, 2019
4. Ananthanarayan and Paniker's Textbook of Microbiology, (12th Edition) 20

24-303-0105 MOLECULAR CELL BIOLOGY (4C, 3L+1T+2P)

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	Description	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	Analyse 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
CO1	3	2	-	-	-
CO2	2	-	-	-	-
CO3	2	-	-	-	-
CO4	2	2	-	-	-
CO5	2	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 Signalling and Signal Transduction: Ligands and surface receptors, GTP binding proteins, cAMP and Calcium signalling, Receptors and associated kinases, RTK signalling and other mechanisms, Major cell–cell signalling pathways, Relationships between Signalling 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.

SUGGESTEDLISTOFPRACTICALS

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 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

24-303-0106 BIOSTATISTICS (2C, 2L+1T+ 0 P)

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	Description	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
CO1	-	1	-	-	2
CO2	-	2	-	-	3
CO3	-	1	-	-	3
CO4	-	2	-	-	3
CO5	-	2	-	-	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 StatisticsStatistical Investigation: Collection of Data, Primary Data, Secondary Data, Methods of Data Collection, Design of Experiments – CRD, RBD

MODULE II **(5h)**

Frequency Distribution: Preparation of Frequency Distribution, Cumulative Frequency DistributionDiagrammatic Presentation of Data: Bar diagrams, Deviation bars, Pictograms, Pie diagrams, Squares, Histogram
Exploratory analysis of Data using MS EXCEL

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

MODULEIV **(8h)**

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

MODULEV **(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.
3. Snedecor G.W. & Cochran, W.G. (1989). Statistical Methods 8thedn. Oxford University
4. Fisher R.A. (2017). Statistical Methods for Research Workers. Oliver & Boyd
5. Balaji K., Raghavaiah A.V.S. &Jayaweera. (2012). Biostatistics. International Publishing house.
6. Irfan A. Khan & Atiya Khanum (1994). Fundamentals of Biostatistics. Ukaaz Publications.
7. Ekwal Imam (2015). Applied Statistical Techniques. New India Publishing Agency
8. L.R. Potti (2007) A Full Course in Statistics. Yamuna Publications

24-340-0106ANALYTICAL 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) of the course

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

Course Outcome	Description	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
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.

MODULEII (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 analyticalultracentrifugation 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.
9. Gel filteration - Column chromatography

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.
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6. Henry B Bull (1971). An Introduction to physical biochemistry. F A Devis Co.
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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.

SEMESTER II

24-340-0201 BIOPROCESS TECHNOLOGY AND INDUSTRIALBIOTECHNOLOGY (4 C, 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	Description	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
CO1	2	-	-	1	-
CO2	2	-	-	2	-
CO3	2	-	-	3	-
CO4	1	-	-	3	-
CO5	1	-	-	2	-

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 PRACTICALS

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 *Leuconostocmesenteroides*

REFERENCES

1. Sambamurthy, K. 2007, *Pharmaceutical engineering*. New Age International.
2. Stanbury, P. F., Whitaker, A., & Hall, S. J. 2013, *Principles of fermentation technology*. Elsevier.
3. Peppler, H. Perlman, D.2014, Microbial *technology Vol. I &Vol.II*, 2nd edition, Elsevier
4. Ed. Moo & young 2011, *Comprehensive Biotechnology*. I, &II, 2nd edition Pergamon Pres.
5. Coulson, J. M.*et al*., 2006, Chemical Engineering. I & II, 6th edition, Elsevier.
6. Cruger & Cruger 2005, *Text Book of Industrial Microbiology*.2nd sub edition, Panima pub.
7. Cassida L.E.J.R. 2015, *Industrial Microbiology*. New Age International.
8. Pauline M. Doran 2013, *Biochemical Engineering principles*, Second edition, Elsevier
9. Binswanger, H. (2013). *Practical Enzymology*. 2ndedn. Wiley-VCH.
10. S. Kulandaivelu, Sr., S. Janarthanan.K. Practical Manual on Fermentation Technology, 2012, International Publishing House Pvt. Limited,

24-303-0202 BIOSAFETY, BIOETHICS AND IPR (2C, 1L+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	Description	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
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

MODULEI (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.

MODULEII (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.

MODULEIII (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

MODULEIV (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.

MODULEV (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

1. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology, Padma Nambisan, 2017, Academic Press.
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4. Intellectual property rights in agricultural Biotechnology, F. H. Erbisch and K. M. Maredia, 2nd edition, 2003, Cambridge University Press.
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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.
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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

24-303-0203 BIOINFORMATICS (3C,2L+1T+1P)

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

Course Outcomes (CO)

After completing the course, the student will be able to

Course Outcome	Description	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 protein structures	Analyse
C.O.5	Understanding the basic concepts of Next Generation sequencing techniques and Artificial intelligence	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5
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

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

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

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

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.

MODULE V

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

1. Bergeron, B. P. (2003). Bioinformatics computing. Prentice Hall Professional
2. Cannataro, M., Guzzi, P. H., Agapito, G., Zucco, C., Milano, M. (2022). Arti ficial Intelligence in Bioinformatics: From Omics Analysis to Deep Learning and Network Mining. Netherlands: Elsevier Science.
3. Gibas, C., &Jambeck, P. (2001). Developing bioinformatics computer skills." O'Reilly Media, Inc.".
4. High-Throughput Next Generation Sequencing: Methods and Applications. (2011). Germany: Humana Press.
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6. https://swissmodel.expasy.org/
7. https://www.ebi.ac.uk/Tools/msa/clustalo/
8. Lesk, A. (2013). Introduction to bioinformatics. Oxford University Press.
9. Moorhouse, M., & Barry, P. (2005). Bioinformatics biocomputing and Perl: an introduction to bioinformatics computing skills and practice. John Wiley & Sons
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11. Sudhir Kumar, Koichiro Tamura, and Masatoshi Nei. 1993. MEGA: Molecular Evolutionary Genetics Analysis, version 1.01. The Pennsylvania State University, University Park, PA 16802.
12. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press.

24-303-0204SCIENTIFIC 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	Description	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
CO1	-	1	-	-	1
CO2	-	1	-	-	1
CO3	-	1	-	-	1
CO4	-	1	-	-	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**

24-303-0205 METABOLISM AND METABOLIC DISORDERS (3E, 2L+1T+0P)

Course Description

This advanced course in biochemistry includes the study of metabolic pathways, energetics, regulation of carbohydrates, amino acids, fatty acids, nucleic acids as well as Electron transport chain and Photosynthesis. In addition, the course offers deep understanding in analysing energetics of metabolic pathways, Interpretation of metabolic syndromes and disorders at clinical point of view, basic concepts to develop diagnostic protocols and therapeutic strategies against metabolic errors. Also provides insights in to predicting metabolic pathways and hub proteins with respect to a disease pathogenesis, identification and validation of metabolites as biomarkers.

Course Outcome

After completing the course, the students will be able to

Course Outcome	Description	Cognitive Level
C.O.1	Compare and contrast biosynthetic and catabolic pathways of carbohydrates based on enzymes involves, intermediates and their regulation (Analyse) Interpret the energetics of carbohydrate metabolic pathways. (Apply Level) Interpret the metabolic disorders of carbohydrates and examine how they can be diagnosed clinically	Analyse
C.O.2	Understanding basic metabolic pathways of Lipids and their conjugates, (Understanding). Examine the energetics of lipid metabolic pathways. Develop the protocols to interpret the metabolic disorders of lipids and examine how they can be diagnosed clinically	Understand
C.O.3	Understanding basic metabolic pathways of Purine and Pyrimidines (Understanding). Examine the energetics of purine and pyrimidine metabolic pathways. Develop the protocols to interpret the metabolic disorders of purine and pyrimidine and examine how they can be diagnosed clinically.	Understand
C.O.4	Understanding basic metabolic pathways of amino acids and proteins. Examine the energetics of protein metabolic pathways. Develop the protocols to Interpret the metabolic disorders of amino acids and proteins and examine how they can be diagnosed clinically.	Understand
C.O.5	Interpret metabolic pathways based on proteomics data, Design metabolomic models/protocols to explore novel biomarkers, therapeutic targets and development of therapeutics and diagnostics strategies	Analyse

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

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

MODULE I **(7h)**

Overview of carbohydrate metabolism, basic concepts, Glycolysis, Krebs cycle, Electron Transportchain,Photosynthesis, aerobic and anaerobic respiration, ATP synthesis,Energetics, Pentose phosphate pathway, Gluconeogenesis, Glycogenesis, Glycogenolysis, Regulation of carbohydrate metabolism. Inborn errors of carbohydrate metabolism and diagnosis, Galactosemia and Glycogen storage diseases, Metabolic syndrome and life style diseases,Diabetes and Lactose intolerance.

MODULE II **(7h)**

Lipid metabolism: Biosynthesis and degradation and regulation fatty acids metabolic pathways, Ketone bodies: formation and utilization. Biosynthesis and degradation and regulation of cholesterol, Eicosanoids biosynthesis, Disorders of Lipids:Clinical features and laboratory findings in disorders of triglyceride, lipoprotein and cholesterol metabolism, lipoprotein and apolipoprotein metabolism; HDL, LDL, VLDL, apoA, apoB, apoC, apoE and their receptors. Fat absorption, transport, storage and metabolism, Investigation and principles of treatment of hyperlipidemia, Inbred errors of lipid metabolism, lipid storage diseases and diagnosis.

MODULE III **(6h)**

Nucleic Acid metabolism: Biosynthesis and degradation of purines and pyrimidines, regulation of purines and pyrimidines biosynthesis. Biosynthesis of ribonucleotides and deoxyribonucleotides.Uric acid overproduction and underexcretion; pathology and differential diagnosis of gout, treatment of gout, Enzyme disorders of nucleotide metabolism (Lesh-Nyhan syndrome and Orotic acid urea, diagnosis and treatment.

MODULE IV **(7h)**

Amino acid metabolism and disorders: Protein degradation and turn over, Amino acid synthesis, Catabolism of amino acid nitrogen - transamination, deamination, ammonia formation; urea cycle, regulation and disorders of amino acid metabolism. Clinical features and laboratory findings in disorders of amino acid protein metabolism, protein misfolding and associated clinical pathogenesis, prion proteins and relevance in neurodegenerative diseases.

MODULE V **(9h)**

Metabolomics and application: Pathway analysis and enrichment by insilico prediction and experimental validation,Networks and interactions between metabolites, pharmaceuticals,SNPs and Proteins, techniques of Metabolic profiling and fingerprinting and their applications, diagnosis of metabolic genetic diseases and syndrome, metabolite target analysis,metabolic applications within animals, plants and microbes, transcriptomics and proteomics in system biology and synthetic biology.

SUGGESTED LIST OF PRACTICALS

1. Estimation of carbohydrate (Sugars), protein, cholesterol and triglycerides and nucleic acids by spectroscopic analysis

2. 2.Basic metabolic panel: Clinical biochemical tests for glucose, calcium, electrolytes and Liver function and Kidney function test
3. Chromatographic Techniques to study metabolic intermediates
4. Fluorescence spectroscopy to study ligand protein interaction
5. Proteomics Data analysis, *In- silico* prediction of metabolic pathways, hub proteins, 6. In silico system biology model development, development of metabolic prediction models.

REFERENCES

1. Voet, D. &Voet J. G. Biochemistry (2012). 4th edition, John Wiley and Sons
2. Stryer, Lubertet al., (2015). Biochemistry.8thedition.W.H. Freeman and Co.
3. Lehninger, A. L., Nelson, David L., Cox, Michael M. (2013).
4. Principles of Biochemistry.6th revised edition. Freeman and Co. 4. Devlin, Thomas. M. (2010).
5. Text book of Biochemistry with Clinical Correlations- 7 th edition. John Wiley & Sons.
6. Robert, K., Granner, D. K., & Mayes, P. A. M. (2003).
7. Harper's illustrated biochemistry. 6. Grunwald, P. (2016).
8. Metabolomics: Methods and Protocols, Wolfram and Royston,
9. Metabolomics: A powerful tool in systems Biology, Shoaie and Jens Nielsen, 10.

Introduction to Metabolomics: Nikolaos Raikos

24-303-0206 ANALYTICAL TECHNIQUES-II (3E, 2L+0T+1P)

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	Description	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
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.
9. RT PCR

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.

24-303-0207 CANCER BIOLOGY (3E, 2L +1T +0P)

Course Description

This course aims to provide an inclusive outline of the biology and pathology of cancer by exploring the role of mutations, dysregulated signalling pathways in cell survival, apoptosis, cell cycle regulation, angiogenesis, metastasis and cancer stemness. The courseenriches the basic principles of diagnostics and therapeutic strategies for cancers. In addition, itfosters a deeper insight on techniques to unravel the mechanisms of cancer evolution.

Course Outcomes (CO)

After completing the course, student will be able to

Course Outcome	Description	Cognitive Level
C.O.1	Understanding the fundamentals of carcinogenesis	Understand
C.O.2	Understand the basic principles of genetics and epigenetic changes associated with carcinogenesis Demonstrate the methods to identify genetic and epigenetic changes	Understand
C.O.3	Examine intricate signalling events associated with cancer to interpret receptors, oncogenes and enzymes for developing therapeutics.	Analyse
C.O.4	Investigate the role of various mutations/ oncogenes/ proteins in determining the angiogenic/metastatic and stemness potential of cancer	Apply
C.O.5	Apply the techniques to evaluate and identify novel biomarkers and therapeutic targets	Apply

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

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

MODULE I (5h)

Introduction to cancer, types, etiology and incidence; Causes of Cancer, Types of carcinogens: Chemical, Physical and Biological, cancer as a genetic disease, tumour viruses, Oncogenes and tumour suppressor genes, Oncogenesis, immune evasion mechanisms,Clonal evolution, Stages of carcinogenesis and signalling.

MODULE II (7h)

Genetics and Epigenetics aspects of Carcinogenesis - Defects in DNA repair and their link to cancer; Driver and passenger mutations, mutational analysis, genomic instability, heterogeneity, Epigenetic changes in cancer, methylation, Histone Acetylation, Non coding RNAs, miRNAs in cancer, Cancer metabolism and Warburg effect, Techniques employed to identify non coding RNA, microRNA and epigenetic changes.

MODULE III **(7h)**

Sustaining proliferative signalling: role of growth factors and receptors, complexsignalling enabling enhanced survival, cell cycle deregulation, Major pathways in cancer: Ras,EGFR,Wnt, MAPK, AKT, mTOR,Jak-Stat, etc, anti-apoptotic pathways,Bcl2 family proteins, role of P53events enabling replicative immortalization, role of telomere, Techniques employed in unravelling survival/ apoptosis/cell cycle machinery.

MODULE IV **(6h)**

Angiogenesis, Metastasis and Cancer Stem cells: factors aiding the mechanism of angiogenesis, hypoxia (vegf), metastasis (metalloproteinases, EMT), and cancer stem cell maintenances, side cell population, (stem cell markers and efflux pumps), mechanism of tumour aggression and relapse, Techniques employed to elucidate the mechanism of angiogenesis, metastasis and identification of stem cells.

MODULE V **(7h)**

Diagnosis and Therapeutics of Cancer: Diagnostic techniques and methods, biopsy, histopathology, cytology, FISH, FACS, PET, MRI, CT, mammogram and others; Endoscopy methods, Cancer predisposition, SNPs, RFLP, NGS, Single cell RNA sequencing,exomesequencing, identification and validation of novel markers and therapeutic targets, cancer treatments, surgery, radiation, chemotherapy, immunotherapy, targeted therapy, and precision medicine.

REFERENCES

1. Robert A Weinberg, The Biology of Cancer, 2nd Edition, Garland Publishing (Primary reference)
2. Lauren Pecorino Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, 4th Edition, 2016, Oxford University Press
3. Peter J Selby Margaret A Knowles, An Introduction to Cellular and Molecular Biology of Cancer by 4th Edition, 2005, Oxford University Press.
4. John E. Niederhuber, James O. Armitage, James H Doroshow, Michael B. Kastan, Joel E. Tepper, 6th Ed, Abeloff's Clinical Oncology, 2019, Elsevier.
5. Cancer Medicine, Waun Ki Hong, Robert Bast Jr, William Hait, Donald Kufe, Raphael Pollock, Ralph Weichselbaum, James Holland, Emil Frei, 2010, McGraw-Hill Education.
6. Eds: Sang Hyun Cho and Sunil Krishnan Cancer nanotechnology: principles and applications in radiation oncology, 2013, CRC Press 7. Eds. Shannon Decker, Edward Sausville and Beverly A. Teicher, Tumor Models in Cancer Research 2nd edition, 2011, Humana Press

24-303-0208 MOLECULAR NEUROBIOLOGY (3E,2L+0T+1P)

Course Description

The course structure is aimed at providing in-depth knowledge of the molecular and cellular neurobiology by giving emphasis on human neurobiology. Course introduction focuses on neuroanatomy, neurodevelopment, cell types of the nervous system and mechanisms of neural communication. During the later stages of this course students get a chance to learn regarding more integrated functions of the nervous system like sensory processing and the programming of motor functions. In addition, students will also get a basic understanding about how new memories are formed, stored, and retrieved in the brain. The course also focuses on the neuroscience of brain diseases and also describes the current methods in neuroscience rese arch.

CourseOutcomes (CO)

After completing thecourse,thestudentwillbeableto:

Course Outcome	Description	Cognitive Level
C.O.1	Demonstrate a solid understanding of basic neuroanatomy and nervous system function on a molecular, cellular and systems level.	Understand
C.O.2	Analyse how neurons are connected and it communicates in neuronal circuits that control our behaviour.	Analyse
C.O.3	Analyse the functions of the nervous system such as the regulation of sensation, integration and response; with special emphasis on cognitive functions like learning and memory.	Analyse
C.O.4	Understand and analyse the neurological disorders such as Alzheimer's disease, Parkinson's Disease, Amyotrophic lateral sclerosis (ALS), Huntington's disease, Schizophrenia, psychiatric disorders, Traumatic Brain Injury and Stroke.	Analyse
C.O.5	Analyse the neurobiological techniques, such as brain histology, optogenetics, electrophysiology, CLARITY, behavioural analyses and transgenics, also identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution.	Apply

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

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

MODULEI (8 h)

Organization of the nervous system: Organization of nervous system; CNS, PNS, Neuroanatomy, Meninges, Cerebrospinal fluid, Blood Brain Barrier, Neuron structure and classification, Glial cells: Structure and function of glial cells, Glial – Neuronal interplay, Neurotrophic factors, Neurogenesis; Birth and migration of neurons, Neural stem cells, Brain changes across the lifespan.

MODULE II (8 h)

Propagation of nerve impulses and molecular mechanisms of neurotransmission: Biological and electrical properties of neurons, Ionic Basis of the Resting Membrane Potential, Ionic Basis of the Action Potential, Molecular Mechanisms of Action Potential Generation, Propagation of Action Potentials, Synaptic Transmission, Neurotransmitters; chemistry, synthesis, storage, release and uptake, Ionotropic Neurotransmitters Receptors, Metabotropic Neurotransmitters Receptors and Postsynaptic Mechanisms, Synaptic Integration, Long-Term Potentiation and Depression, Spike-Timing Dependent synaptic Plasticity, Hebb's Postulate

MODULE III (5 h)

Neural Control Systems: Sensory Systems; The Visual System, Audition, Vestibular Sensation and Chemical Senses, Movement and Motor Control, Neural control of; Immune, Cardiovascular, Endocrine and Enteric nervous systems

MODULE IV (6 h)

Complex Brain Functions and Brain Disorders: Circadian Rhythms, Sleep; Brain Waves and Sleep Stages, Neurobiology of Emotion, Reward and Addiction, Learning and Memory; Cognitive development, Visual Recognition, Language, Shortterm, longterm and Working Memory.

Neurodegenerative disorders; Alzheimer’s, Parkinson’s, Huntington’s and Prion Diseases Amyotrophic Lateral Sclerosis, Epilepsy, Psychotic disorders, Schizophrenia, Bipolar disorder

MODULE V (3 h)

Neurobiology Techniques: Neuronal cell culture, Animal behaviour analysis in Neuroscience, Electrophysiology**,** Whole Brain Imaging;fluorescence, functional magnetic resonance imaging (fMRI), positron emission tomography (PET), Electrochemical techniques; exocytosis measurements, fast-scan cyclic voltammetry, Calcium imaging, Optogenetics, CLARITY

SUGGESTEDLISTOFPRACTICALS

1. Culturing and passaging of neuronal cell line
2. Culturing and passaging of primary cells isolated from mice/rat brain
3. Isolation and culturing of neural stem cells from mice/rat brain
4. FACS sorting of stem cells
5. Mice/Rat brain perfusion
6. Brain fixation

7. Tissue processing
8. Tissue Sectioning using cryostat
9. Atlas-based identification of brain regions
10. Immunohistochemistry of the brain sections

REFERENCES

1. Principles of Neural Science (6th Edition) by Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell, McGraw Hill Education; 2021
2. Neuroscience (7th Edition) by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Richard D. Mooney, Michael L. Platt, Leonard E. White; 2023
3. Neuroscience: Exploring the brain (Enhanced Edition 4th Edition) by Mark F Bear, Barry W. Connors, Michael A. Paradiso; 2020
4. Basic Neurochemistry Principles of Molecular, Cellular, and Medical Neurobiology. (9th Edition) by Scott Brady, George Siegel; 2024
5. From Neuron to Brain (6th Edition) by John G. Nicholls, A. Robert Martin, David A. Brown, Mathew E. Diamond, David A. Weisblat, Paul A. Fuchs; 2020
6. Neurobiology (3rd Edition) by Gordon M. Shepherd, 1994
7. Basic Clinical Neuroscience (3rd Edition) by Paul A. young, Paul H. young and Daniel L. Tolbert; 2015
8. Molecular Neuroscience: A Laboratory Manual by Rusty Lansford; Cold Spring Harbor Laboratory Press; 2014
9. Purifying and Culturing Neural Cells: A Laboratory Manual by Ben A. Barres, and Beth Stevens, 2014
10. Molecular Neurobiology, A Practical Approach-1. Chad and H. Wheal; 1991

20-303-0209 NANOBIOTECHNOLOGY (3E, 2L+0T+0P)

Course Description:
The course will provide basic knowledge about the field of nanotechnology and its applications. The syllabus includes discussion about the different types of nanoparticles and techniques used to characterize them. The course will cover in detail about the different areas where nanotechnology is being applied in the medical field. Discussion will also include the translation of nano-based products and its challenges including nanotoxicology.

Course Outcomes (CO)
After completing this course, the students should be able to:

Course Outcome	Description	Cognitive Level
C.O.1.	Understand the fundamental concepts and advantages of nanotechnology for medical and biotechnological applications, including the various types of nanoparticles utilized in these fields.	Understand
C.O.2.	Master the techniques used for characterizing nanoparticles, with a focus on electron microscopy, spectroscopic methods, and other advanced characterization tools.	Remember
C.O.3.	Analyze the diverse areas within biotechnology and medicine where nanotechnology can be effectively applied, considering the synthesis methods and entry mechanisms of nanoparticles into target sites.	Understand
C.O.4.	Apply knowledge of nanoparticle design and surface modification techniques to develop nanoparticles tailored for specific biomedical applications, such as targeted drug delivery and biosensing	Apply
C.O.5.	Evaluate the current landscape of nanotechnology products in clinical and market settings, assessing their advantages, limitations, and potential risks, while also addressing challenges in translating medical nanotechnology to clinical practice.	Analyse

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

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

MODULE I **(5h)**
Introduction to Nanotechnology: Introduction to nano-size, Surface to volume ratio of nanoparticles, Basic quantum mechanics, Introduction to nanobiotechnology and nanomedicine.

MODULE II **(8h)**

Nanomaterial characterisation tools: Electron microscopy – SEM, TEM/ Scanning probe microscopy - AFM, STM, Spectroscopic methods – Absorption and Emission Spectroscopy, FTIR spectroscopy, X-ray photoelectron spectroscopy, NMR spectroscopy, Raman spectroscopy, X ray crystallography, Electron diffraction pattern, Dynamic light scattering, Zeta potential analysis.

MODULE III **(12h)**

Types of nanoparticles used for medical applications: Carbon based nanoparticles – Fullerenes & Carbon nanotubes, Quantum dots, Metallic and metal oxide nanoparticles, Polymeric and Protein nanostructures, DNA nanostructures, Dendrimers, Lipid based nanoparticles- Liposomes & solid lipid nanoparticles.

MODULE IV **(15h)**

Synthesis methods: Top-down and bottom-up methods, Multifunctional nanoparticles, Camouflage nanoparticles, Bioconjugation and surface modifications (techniques and applications).

Nano-bio interactions: Particle-blood and particle-tissue interactions, Entry mechanisms of nanoparticles to solid tumoursites, Targeted delivery.

Nanoplatforms in medicine: Nano-biosensors, Nano-vaccines, Nanoparticles in regenerative medicine.

MODULE V **(5h)**

Concerns and challenges: Nanotoxicology – Potential risks due to nanoparticles to human health, Techniques toasses toxicity, Translation of medical nanotechnology to clinical practice –Nanotechnology translated to clinicalpractice, Challenges in translation.

REFERENCES

1. Nanotechnology: Understanding Small Systems, Third Edition. Ben Rogers, Jesse Adams, SumitaPennathur. 2017 by CRC Press
2. 2.Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Guozhang Cao Imperial CollegePress, 2004
3. Introduction to Nanoscience and Nanotechnology. Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J.Moore. 2008 by CRC Press
4. Medical Nanotechnology and Nanomedicine Harry F. Tibbals. 2010 by CRC Press
5. Nanoparticles in Translational Science and Medicine, Volume 104, 1st Edition, 2011, Academic Press
6. Nanobiotechnology &Nano biosciences, Claudio Nicolini, 2009, Pan Stanford Publishing, Ltd.

SEMESTER III

24-303-0301 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	Description	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	Analyse the recombinants using different gene transfer techniques	Analyse
C.O.5	Study and analyse heterologous protein expression in prokaryote and Eukaryotes	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	1	1	**-**
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, Deoxyribose 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 mutagenesis, Transposon 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 editingstrategies: CRISPR-cas, TALENS, ZFNs, 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 LIST OF PRACTICALS

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.

24-303-0302 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	Description	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.	Evaluate 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
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, Tumour 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
5. Rocket immunoelectrophoresis
6. ELISA
7. IgG purification

REFERENCES

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

24-303-0304 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.

CourseOutcomes (CO)

Aftercompletingthecourse,thestudentwillbeableto:

Course Outcome	Description	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
CO1	-	-	-	-	1

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

MODULE I (15h)

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 for entrepreneurship and evaluated by industry

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 and evaluators.

General guidelines for project presentation:

1. A total duration of 0 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 inResearch. (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.

20-303-0305 PLANT BIOTECHNOLOGY (2C, 2L+1T+ 2P)

Course Description

This course integrates plant physiology with plant tissue culture techniques, covering gene identification, transgenic plant creation, and advanced methods like Map-based cloning. It includes practical training in tissue culture and genetic transformation, alongside discussions on secondary metabolite production, genetic diversity preservation, and plant-based carbon sequestration for climate change mitigation.

Course outcomes (CO)

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

Course Outcome	Description	Cognitive Level
C.O.1	Discuss the fundamental principles and techniques in the fields of plant physiology and practical skills and theoretical knowledge to create and manipulate plant tissues for various applications.	Understand
C.O.2	Device strategies t o provides a solid introduction to plant genome analysis and gene identification techniques, essential for understanding plant genetics and improving crop traits	Analyse
C.O.3	Appreciate the latest techniques that provides a comprehensive overview of gene transfer methods used to produce transgenic plants with desired traits.	Understand
C.O.4	Apply the strategies of genetic engineering that offers powerful tools for enhancing agricultural productivity, improving crop quality, and addressing global food security challenges	Apply
C.O.5	Apply methods for enhancing secondary metabolite production, preserving genetic diversity, and utilizing plant-based carbon sequestration for climate change mitigation.	Apply

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

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

MODULEI (10h)

Overview of uniqueness of plants: General Introduction on physiological processes of higher plants, water relations of plants-, Includes transpiration (water loss), guttation (water exudation), and plasmolysis (cellular water loss). Photosynthesis: Process converting light energy into chemical energy (glucose) in chloroplasts. Involves light reactions (ATP/NADPH production) and Calvin cycle (CO2 fixation). Different pathways (C3, C4, CAM) optimize photosynthesis under varying conditions.

Plant Tissue Culture: Basic concepts: Totipotency: Cells' ability to regenerate into whole plants.Organogenesis: Formation of organs from cultured tissues.Somatic Embryogenesis: Embryo formation from somatic cells. Techniques: Techniques:
Callus, cell suspension, anther, ovule, root, shoot tip, and meristem cultures.
Protoplast culture for genetic manipulation. Micropropagation for rapid, mass plant production, Medicinal and ornamental plant conservation and

propagation.Somaclonal variations and their implications. Artificial seed development for plant propagation and storage.

MODULEII (8h)

Plant Genome analysis; Gene Isolation –Gene Tagging: Identifying genes by linking them to visible markers. Insertional Mutagenesis: Introducing foreign DNA to disrupt gene function and create mutants. Molecular Markers:DNA sequences aiding genetic mapping and trait analysis (e.g.RFLP, RAPD, AFLP SSRs, ESTsSNPs), Mapping Populations, Marker-Assisted Selection (MAS) / Genomic Selection: Identification of Candidate Genes:Genetic Information (Positional Cloning) Biochemical and Expression Analysis:Transformation, Mutant Populations and Knockout Systems:Heterologous Expression Systems: Protein Analysis

MODULEIII (8h)

The Gene transfer Techniques for the production of Transgenic:

Indirect Gene transfer Methods: Structural Features of Ti Plasmid, Mechanism of Gene Transfer to Plants, Molecular Events in Agrobacterium-Mediated Gene Transfer.

Direct gene transfer methods: Particle Bombardment (Biolistics), Silicon Carbide Fiber-Mediated Transformation, Electroporation, Microinjection, PEG-Mediated Transformation.

Reporter Genes: Genes encoding proteins with easily detectable phenotypes (e.g., β-glucuronidase, green fluorescent protein) Scorable and Selectable Markers: (e.g., antibiotic resistance agents (e.g., herbicides, antibiotics) for the identification and propagation of transgenic cells or plants.

MODULEIV (10h)

Applications of genetic engineering in plants:

Golden Rice**:** Engineered to produce beta-carotene, addressing vitamin A deficiency. Bt Crops**:** (Cotton, Brinjal, Mustard) Provide pest resistance via Bt toxin expression**.** Crop Resistance Traits**:** Herbicide Resistance**:** Enables weed control with specific herbicides. Pathogen Resistance**:** Protection against viruses, bacteria, and fungi. Oil Modification**:** Alters oil composition for improved nutrition or industrial use.Current Status of Transgenic Plants**:** Commercial adoption in India and globally, notably Bt cotton. Abiotic Stress Resistance**:** Developing crops resilient to drought, salinity, etc. RNAi Applications: Antisense RNA**:** Targets specific mRNA for gene regulation. Genome Editing Tools**:** ZFNs, TALENs, CRISPR-Cas9 for precise modifications, Control ofPollination**:**Ensure genetic purity via male sterility or GURT, Production of Biopharmaceuticals: Use plants for antibody, vaccine production, with strict regulation.

MODULEV (9h)

Plant metabolic engineering; Secondary metabolite production: plant products of industrial importance, cell suspension culture, growth kinetics and cell viability, nutrient media optimization; Scale-up studies: elicitors and precursors; Modes of culture: batch, fed-batch and continuous cultures, cell immobilization,biotransformation; Principles, design and operation of bioreactors:

instrumentation,agitation, aeration system, temperature, foam control; Downstream processing: extraction,cell disruption, chromatography and purification of metabolites.

Germplasm conservation: Importance of genetic diversity in agriculture and biodiversity conservation, Overview of germplasm conservation techniques. Role of germplasm conservation in climate change resilience.

Carbon sequestration inplants: Strategies for enhancing carbon fixation, Biomass production and carbon storage in plant tissues, Soil carbon sequestration through plant-microbe interactions, Reforestation, afforestation, and carbon farming practices.

SUGGESTED LIST OF PRACTICALS

1. Makingthe stocksofcellculture mediacomponents and growth hormones
2. Performaseptic culture-callus inductionof carrot
3. Studythe effect ofdifferent explants onthecallus induction
4. Induction of rootingand shooting fromcallusculture
5. Perform genetic variation analysis using molecular markers
6. Performgenetransfertoleaf disks /Callus usingAgroinfection
7. AssayforGUSactivityinthe transformed plant tissue

REFERENCES

1. Plant Biotechnology: Current and Future Applications of Genetically Modified Crops" by Nigel Halford and Angela Karp (2019).
2. "Plant Biotechnology and Agriculture: Prospects for the 21st Century" edited by Arie Altman (2021).
3. "Plant Biotechnology: Principles and Applications" by Satbir Singh Gosal and G. S. Chauhan (2020).
4. "Plant Biotechnology: The Genetic Manipulation of Plants" by Adrian Slater, Nigel W. Scott, and Mark R. Fowler (2010).
5. "Plant Biotechnology: Recent Advancements and Developments" edited by Sunil Kumar and Surajit Das (2021).
6. Chilton, M. D., & Tu, J. (2020). Plant Metabolic Engineering. Springer.
7. Tanksley, S. D., & McCouch, S. R. (Eds.). (2021). Plant Genetic Resources and Climate Change. John Wiley & Sons.
8. "Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants" by H. S. Chawla (2011).
9. "Plant Biotechnology and Genetics: Principles, Techniques, and Applications" by C. Neal Stewart Jr. (2008).
10. "Introduction to Plant Biotechnology" by H. S. Chawla (2013).
11. "Plant Biotechnology: The Genetic Manipulation of Plants" by Adrian Slater, Nigel W. Scott, and Mark R. Fowler (2008).
12. "Plant Biotechnology: Techniques and Applications" by C. Neal Stewart Jr. (2010).

24-303-0306 APPLICATIONS OF BIOTECHNOLOGY IN MEDICINE (3E,2L+1T+ 1P)

Course Description:
This is a core course for MSc Biotechnology students, and it deals with the applications of biotechnology in medicine. The former part of this course will introduce the basic concepts/principles involved in animal cell and tissue culture, the requirements of media, and growth characteristics in culture. The latter half of the course elaborates on the human genome project, the molecular basis of human diseases, and the molecular diagnosis of genetic diseases. The course also gives an insight into diagnostic techniques and pharmacogenomics, as well as personalized medicine.

Course Outcomes (CO)
Aftercompletingthecourse, thestudentwillbeableto:

C.O.1	Explain the basic principles of cell culture and design cell culture experiments.	Apply
C.O.2	Describe various applications of cell culture experiments	Understand
C.O.3	Explain the techniques involved in the Genetic Engineering of animals and design small animal experiments	Apply
C.O.4	Device methods for identification of disease-causing genes and explain various molecular therapy methods	Apply
C.O.5	Explain the use of DNA probes for diagnosis in epidemiology and forensic science	Understand

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

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

MODULE I (9h)

Animal cell culture- Principles involved and Characteristics of cells in Culture: History; cell culture laboratory design and practices; Sterilization techniques; Cell Culture media and components; Conditioned media; Identification and Characterization and control of contaminations; Cell counting and viability assay- MTT, LDH, and Alamar assay. Cryopreservation of animal cells, Explant isolation and culture, Growth phases of cell in culture, contact inhibition, anchorage dependency, cell senescence; Visualization of cells.

MODULE II (10h)

Animal tissue culture - Technique and Applications: Primary and secondary cell culture; Differentiation of cells, iPS; Techniques in cloning cells. 3D cell culture, Organ culture; , in vitro disease models - Spheroids, and organoids; organ on a chip; Use of matrix and other materials.
Assisted Reproductive Technology (ART) and In vitro fertilization.
Artificial skin, blood, and tissues; Monoclonal Antibody production; Production of bioactive compounds and growth hormones; Propagation of viruses; Tissue culture vaccines, mRNA Vaccines; baculovirus cell culture

MODULE III (8h)

Animal Experimental Models and their Genetic Engineering: Small Animals used in research- Rat, mice, rabbits, zebra fish; Methods of genetic engineering; Knock-out, Kock-in, Knock-down, inducible, temporal and spatial animal models; and disease models, Application of Transgenic animals for biopharming, and xeno-transplantation. Developing hypoallergenic pets, glo fish, Super pig, and transgenic salmon as food and RIDL mosquitoes for vector control.

MODULE IV (10h)

Molecular medicine and medical biotechnology: Molecular basis of human diseases (hereditary, infectious, chronic, and autoimmune diseases, one example each); Gene hunting-identification of disease-causing genes for monogenic diseases and complex diseases; Gene therapy tools and methods; Current scenario and future prospects of medical biotechnology; Precision medicine- principles and examples; Therapeutic manufacturing and cell-free synthesis; Molecular therapeutics-nanomedicine, biotherapy, ASO and RNAi, cellular therapy, antibody therapy, cytokine therapy.

MODULE V (8h)

Molecular Diagnostics: Molecular diagnosis of genetic diseases - genetic screening for single gene diseases, Complex pre-disposition symptoms using molecular technologies- genetic markers, PCR-based diagnostics, Array-based diagnostics, and Nucleotide polymorphisms;
Genetic testing in Forensic Science: MLP and SLP Technology; Mitochondrial DNA, Y Chromosome analysis, DNA probes for diagnosis in epidemiology and forensic science

SUGGESTED LIST OF PRACTICALS

1. Demonstrate the skill to maintain cell lines in culture.
2. Perform MTT assay
3. Visualization of Cells
4. Handling and maintenance of small animals

REFERENCES

1. Ho, C. S. (Ed.). (2013). Animal cell bioreactors (Vol. 17). Butterworth-Heinemann.
2. Freshney, R.I. (2016). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (7thed.). Wiley Blackwell.

3. Editorial Staff of Annals of the New York Academy of Sciences. (2012). Animal Models (Annals of the New York Academy of Sciences. (1sted.). Wiley-Blackwell
4. Pongracz J. & Keen M. (2009). Medical Biotechnology,1st edition, Elsevier
5. Rehm H. J and Reed G. (2010). Biotechnology: Biological Fundamentals,2nd edition, Wiley.
6. Jogdand S.N. (2008). Medical Biotechnology, Himalaya Publishing House, Mumbai.
7. Nallari P. &Rao V.V. (2010). Medical Biotechnology. 2nd edition, Oxford University Press, India

24-303-0307 NEXTGENERATION SEQUENCING ANDDATA ANALYSIS

(3E, 2L+1T+1P)

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)

Aftercompletingthe course, thestudentwillbeableto:

Course Outcome	Description	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
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.
2. Gentleman, R. (2008). *R programming for bioinformatics*. CRC Press.
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.
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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.

24-303-0308 STEM CELL BIOLOGY AND REGENERATIVE MEDICINE (3E, 2L+0T+1P)

Course description:
Stem cell research and regenerative medicine is one of the fastest growing areas of biomedical research worldwide. Stem cells are specializedcells, which are undifferentiated and capable of self-renewal and have the potential to develop into differentiated cell types. Stem cells act as organisms reserve cells that replacespecialized cells that are damages or lost during the development. During this course we explore several aspects of stem cell biology like the microenvironments or the niches that are required to maintain stem cells, asymmetric cell division, the genes required for stem cell fate, and the use of stem cells for medical/therapeutic applications. In addition, students will also get an insight into stem cell transplantation and tissue engineering in regenerative medicine and the ethical issues involved in this field of research.

Course Outcomes (CO)
After completing the course, the student will be able to:

Course Outcome	Description	Cognitive Level
C.O.1	Describe different types of stem cells and their specific characteristics and how they differ from fully differentiated cells.	Understand
C.O.2	Analyse the role of various intrinsic and extrinsic factors important for stem cell renewal and differentiation.	Analyse
C.O.3	Analyse the validity of applications of stem cells for regenerative medicine and the possible problems that need to be overcome.	Analyse
C.O.4	Apply techniques based on the use of Embryonic/Foetal, Induced pluripotent and adult stem cells for regenerative medicine applications to human diseases.	Apply
C.O.5	Analyse the ethical issues associated with Embryonic/Foetal, induced pluripotent, adult stem cells and stem cell therapy with a global bioethics perspective and identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution.	Analyse

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

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

MODULEI **(8h)**

Origin of stem cells: Origin of stem cells in organogenesis, Properties of Stem cells, Cell fate determination, Cell potency, Embryonic stem cells, Adult/Tissue-specific stem cells, Induced pluripotent stem cells (iPSCs), Cord blood stem cells and amniotic fluid stem cells, Developmental plasticity, Dedifferentiation, Trans differentiation, Somatic Cells by Nuclear Transfer

MODULEII **(5h)**

Tissue-specific/Adult stem cells: Hematopoietic Stem Cells, Mesenchymal Stem Cells, Neural Stem Cells, Epithelial Stem Cells, Skin Stem Cells, , Other tissue specific stem cells, Cancer stem cells, Adult stem cells in tissue homoeostasis.

MODULEIII **(5h)**

Regulation of Stem Cell Fate and Function: Stem cell niche, Morphogens and growth factors, Control of gene expression, Epigenetic regulation, Positional identity and polarity in regeneration, Cellular differentiation and environmental insults/Stress, Morphallaxis, Epimorphosis

MODULE IV **(6h)**

Tissue Engineering and Regenerative Medicine: Three-dimensional cell culture, Organ culture, Organotypic culture, Animal models of stem cell research, Preclinical study design, engineered scaffolds and matrices, Bioprinting of organs and tissues, Artificial skin substitute, Assessing potential stem cell risks and complications, Stem cell therapeutic efficacy and stability, Tumorigenicity

MODULE V **(6h)**

Stem cells from the laboratory to the clinic: Modes of cell and tissue delivery, Biobanking of stem cells, *In vivo* regeneration of tissues by cell transplantation, Immunoisolation techniques, Regulatory perspectives, good laboratory/manufacturing practice (GLP/GMP), Ethical considerations in regenerative medicine, Autologous stem cell therapy, Xenograft and Allograft.

SUGGESTEDLISTOFPRACTICALS

1. Culturing and passaging of stem cells from rat blood
2. Culturing and passaging of stem cells from rat bone marrow
3. FACS sorting of stem cells
4. Culturing of stem cells on 3D scaffolds
5. Stem cell analysis using microscopy techniques
6. Neural stem cell isolation from mice brain
7. Passaging and maintaining neural stem cell cultures
8. Analysis of neutrospheres
9. Characterisation of stem cells using various markers

REFERENCES

1. Principles of regenerative medicine (3rd Edition) by Robert Lanza, Tony Mikos, Robert Nerem; Elsevier Academic press; 2019
2. Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult &Foetal Stem Cells (v. 1). Academic Press; 2013
3. Stem Cells: scientific facts and fiction by Christine Mummery; Ian Sir Wilmut; AnjaVan,De,Stolpe; Bernard Roelen; Elsevier Academic press; 2011
4. Essential of Stem Cell Biology. (3rdEdition) By Robert Lanza and Anthony Atala, Elsevier Academic press; 2013
5. Imaging and Tracking Stem Cells: Methods and Protocols (1stEdition) byKursadTurksen, Springer Science; 2013
6. Stem Cells & Regenerative Medicine (1st Edition), KrishnaraoAppasani and Raghu K. Appasani; Springer Science, 2011
7. Human Stem Cell Technology and Biology: A Research Guide and Laboratory Manual (1st Edition) by Gary S. Stein, Maria Borowski, Mai X. Luong, Meng-Jiao Shi, Kelly P. Smith, Priscilla Vazquez, Wiley-Blackwell; 2011
8. Stem Cells in Regenerative Medicine: Science, Regulation and Business Strategies; (1st Edition) Alain A. Vertes, NasibQureshi, Arnold I. Caplan, Lee E. Babis; Wiley-Blackwell; 2015
9. Purifying and Culturing Neural Cells: A Laboratory Manual by Ben A. Barres, and Beth Stevens, 2014
10. Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult &Foetal Stem Cells (v. 1). Academic Press; 2013

24-303-0309 ENVIRONMENTAL BIOTECHNOLOGY (3E,2L+1T+0P)

Course Description:
Environmental Biotechnology explores the application of biological principles and processes to address environmental challenges. This interdisciplinary field integrates concepts from microbiology, biochemistry, engineering, and environmental science to develop sustainable solutions for pollution control, waste management, and resource recovery. Students will gain an understanding of the role of microorganisms, plants, and biotechnological techniques in mitigating environmental pollution, enhancing ecosystem resilience, and promoting environmental sustainability.

Course outcomes (CO)
Aftercompleting the course. thestudent will beableto:

Course Outcome	Description	Cognitive Level
C.O.1	Discuss the fundamental principles in the fields of Environmental biotechnology that uses biology to tackle environmental issues sustainably,	Understand
C.O.2	Discuss the vital role of microorganisms in environmental processes and develop skills to apply microbial-based solutions to address environmental challenges effectively.	Understand
C.O.3	Apply the skills in selecting, designing, and implementing bioremediation strategies for various environmental contaminants, contributing to the development of sustainable solutions for pollution remediation and environmental protection	Apply
C.O.4	Apply waste management principles and sustainability and device strategies forbioconversion of waste to value-added products, and circular economy	Apply
C.O.5	Explain the importance of environmental monitoring, techniques for assessing air, water, and soil quality,	Understand

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

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

MODULE I (6h)
Introduction to Environmental Biotechnology
Overview of environmental biotechnology, Importance and scope of environmental biotechnology in addressing environmental issues, Historical development and milestones in environmental biotechnology, Principles of sustainable development and their relevance to environmental biotechnology

MODULE II **(6h)**

Environmental Microbiology:

Microbial ecology and diversity in natural environments, Microbial metabolism and interactions relevant to environmental processes, Biodegradation and bioremediation processes, Role of microorganisms in wastewater treatment, soil remediation, and pollution control

MODULE III **(6h)**

Bioremediation Techniques

Introduction to bioremediation techniques and strategies, Physicochemical methods vs. bioremediation approaches, Microbial degradation of organic pollutants, Phytoremediation and its applications in environmental cleanup, Case studies and real-world applications of bioremediation technologies

MODULE IV **(6h)**

Waste Management and Resource Recovery:

Principles of waste management and environmental sustainability, Anaerobic digestion for organic waste treatment and energy recovery, Composting techniques and applications in organic waste management, Bioconversion of waste to value-added products (e.g., biofuels, bioplastics), Circular economy concepts and their integration into waste management strategies

MODULE V **(6h)**

Environmental Monitoring and Assessment:

Importance of environmental monitoring and assessment, Techniques for monitoring air, water, and soil quality, Biomonitoring approaches using indicator species and bioindicators, Risk assessment methodologies for environmental contaminants
Remote sensing and GIS applications in environmental monitoring and management

REFERENCES

1. Environmental Biotechnology: Principles and Applications" by Bruce Rittmann and Perry McCarty (2019)
2. "Biotechnology for Environmental Management and Resource Recovery" by G. Sridevi and T. Satyanarayana (2017)
3. "Environmental Biotechnology: A Biosystems Approach" by Daniel Vallero and Chris Callahan (2010)
4. "Principles of Environmental Biotechnology" by T. K. Bhattacharya and S. A. Dhillon (2015)
5. "Bioremediation: Principles and Applications" by Ronald L. Crawford and Don L. Crawford (2017)
6. "Handbook of Environmental Engineering: Environmental Biotechnology and Biodegradation" edited by Myer Kutz (2019)
7. "Environmental Biotechnology: Basic Concepts and Applications" by Indu Shekhar Thakur (2016)
8. "Biotechnology for Environmental Protection in the Pulp and Paper Industry" edited by Pratima Bajpai (2018)

24-303-0310BIOPHARMACEUTICALS(3E,2L+1T+1P)

Course Description

This course introduces the basic principles of drug action and the principles of pharmacokinetics and pharmacodynamics.Techniquesfordrugdevelopment:Drugdesign,targeting& delivery; Drug discovery and development: Lead development, Preclinical and clinical studies, Pharmaceuticals derived from plants, microorganisms, fungi and marine organisms and other biologicals; Production of recombinant products and Good manufacturing practices (GMP) are the other topics covered.

Course Outcomes (CO)

Aftercompletingthecourse, the student will be able to:

Course Outcome	Description	Cognitive Level
C.O.1	Discussthebasicprinciplesofdrugactionandtheprinciplesofpharmacodynamicsand pharmacokinetics.	Understand
C.O.2	Explain the application of various techniques for drug development: Drug design, targeting & delivery	Understand
C.O.3	Devisestrategiesfordrugdiscoveryanddevelopmentandtoevaluatedrugsderivedfromdifferent sources.	Apply
C.O.4	Describetheproductionofrecombinantbiopharmaceuticalproductssuch ashormones, thrombolytic agents, antiviral agents and recombinant vaccines.	Understand
C.O.5	ExplainGoodmanufacturingpractices (GMP)anddesign standardoperatingprocedures (SOPs)forthe production of biopharmaceuticals.	Understand

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

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

MODULEI (11h)

Basicprinciplesofdrugaction: Drug administration: drug dose, basisofdose-responsecurves and its significance, therapeutic index, therapeutic window, dosage forms, routes of administration;Pharmacokinetics: absorption, distribution, metabolism and elimination of drugs; Pharmacodynamics: types and mechanism of drug action, receptor-mediated drug action, stimulation of second messenger system, drug-receptointeractions, agonists, partial agonists, reversible andirreversible antagonist; Pharmacogenetics.

MODULEII (8h)

Techniquesfordrugdevelopment:Drugdesign: ligand and receptor based,Techniquesformeasuringreceptor-drugbinding andtissue innewdrugdevelopment,Techniquesusedinassayofdrugs,quantification of drugs

in the body, Targeted drug delivery,Application of nano materials in targeted drug delivery, molecular medicine.

MODULEIII (10h)

Pharmacognosy: Importance of natural drug substance, Drugs derived from natural sources such as plants, bacteria, fungi, marine organisms: antibiotics, antivirals and anticancer compounds.

PhasesofDrugDevelopment:drugdiscovery,preclinicalstudies;Clinicalstudies;review byregulatoryauthority, drug approval process and post market drug safety monitoring.

MODULEIV (8h)

Production of recombinant products: Insulin, human growth hormone, erythropoietin, interferon, recombinant vaccines, Food vaccines, Pharming, Monoclonal antibody based therapeutic agents.

MODULEV (8h)

Quality and regulatory guidelines for biopharmaceutical production: Good manufacturing practices (GMP) for the production of recombinant biopharmaceutical products and the establishmentofstandardoperatingprocedures(SOPs)foraproductionprocess,certificationofpharmaceutical products

REFERENCES

1. Calbreath,D.F.,&Ciulla,A.P.(1992).Clinicalchemistry:afundamentaltextbook. WBSaunders Company.
2. Walsh,G.(2003).Biopharmaceuticals:biochemistryandbiotechnology.JohnWiley&Sons.
3. Walsh,G.(2007).PharmaceuticalBiotechnoloy:Conceptsandapplications.John Wiley&Sons.
4. Thompson,A.(1991).BioactivecompoundsfromMarineorganisms.AspectPublicationsLtd.
5. Satoskar, R. S., Rege, N., & Bhandarkar, S. D. (2015). Pharmacology andPharmacotherapeutics-E- Book. Elsevier Health Sciences.
6. Katzung, B.G., Masters, S.B.,&Trevor,A.J.(2004).Basic&clinicalpharmacology.
7. Purohit,S.S.,Kakrani,H.N.,&Saluja,A.K.(2003).Pharmaceuticalbiotechnology. Agrobios(India).

24-340-0311 GENE SILENCING AND GENOME EDITING (3E; 2L+1T+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)
Aftercompletingthecourse,thestudentwillbeableto:

Course Outcome	Description	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	Create
C.O.4	Evaluate the ethical implications of RNAi and genome editing.	Evaluate
C.O.5	Analyse case studies to comprehend real-world applications and challenges of RNAi and genome editing.	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5
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

24-303-0312 INTER-DEPARTMENTAL ELECTIVE: BASIC NEUROSCIENCE(3E,2L+0T+0P)

Course Description

One of the most challenging and interesting problems in the field of biology is to understand the Human brain. According to the society for neuroscience; brain is the most complex living structure in the entire universe. This basic course in Neuroscience will introduce students to the fundamentals of brain function and review the current scientific understanding of brain's inner workings. The course starts by introducing basic neuroanatomical, neurodevelopment, cell types of the nervous system and mechanisms of neural communication. In addition, students will also get a basic understanding about how new memories are formed, stored, and retrieved in the brain. This course aims to attract students from a wide range of backgrounds by providing some insights into the issues and advantages pertaining to interdisciplinary research in the realm of neuroscience.

Course Outcomes (CO)

Aftercompletingthecourse,thestudentwillbeableto:

Course Outcome	Description	Cognitive Level
C.O.1	Develop an understanding of the interdisciplinary nature of neuroscience, focusing on the basic organization of nervous system.	Understand
C.O.2	Analyse major areas of neuroscience with basic understanding of the fundamental concepts of neurobiology.	Analyse
C.O.3	Analyse the basic classes of cells found in the central nervous system and understand the basic human brain organization.	Analyse
C.O.4	Analyse some of the functions of the nervous system such as the regulation of sensation, integration and response; with special emphasis on cognitive functions like learning and memory.	Analyse
C.O.5	Analyse neurological disorders such as Alzheimer's disease, Parkinson 's disease, Amyotrophic lateral sclerosis (ALS), Huntington's disease, Schizophrenia, psychiatric disorders, Traumatic Brain Injury and Stroke and Analyse a given theoretical problem/case study, identify gaps in knowledge and apply knowledge independently to be able to present a scientifically sound solution.	Analyse

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

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

MODULEI (10 h)

Organization of the nervous system: The parts of the nervous system: The human brain and spinal cord, Basic neuroanatomy: Neural differentiation and regionalization of the brain, Cells of the nervous system, Organization of sensory and motor systems.

MODULEII (8 h)

Propagation of nerve impulses and molecular mechanisms of neurotransmission: Chemical and electrical transmission, Neurotransmitters and neuropeptides- chemical nature and mode of action, Neuronal excitability, Signal generation and propagation, Synapses and nerve circuits, post synaptic mechanisms of signal integration.

MODULEIII (8 h)

Sensory and Motor Neuroscience (Basic introduction: functionalities of human Brain): Visual information processing, Somatosensory system, Motor system, Chemoreception, Auditory system, Pain, Addiction, Sleep, Depression

MODULEIV (10 h)

Neuronal Plasticity, Learning, and Memory: Neurogenesis, Stem cells in the Brain, Neural basis of perceiving, learning and remembering, Neural cell migration, Axonal pathfinding, Brain changes across the lifespan

MODULEV (9 h)

Neuro-degenerative disorders and regenerative approaches: Causes for neurodegeneration, Alzheimer's disease, Parkinson's disease, Amyotrophic lateral sclerosis (ALS), Huntington's disease, Schizophrenia, Psychiatric disorders, Traumatic Brain Injury and Stroke, Treatment strategies for neurodegenerative diseases; Neuroimaging, Biomarkers for early identification, Stem cell transplantation.

REFERENCES

1. Principles of Neural Science (6th Edition) by Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell, McGraw Hill Education; 2021
2. Neuroscience (7th Edition) by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Richard D. Mooney, Michael L. Platt, Leonard E. White; 2023
3. Neuroscience: Exploring the brain (Enhanced Edition 4th Edition) by Mark F Bear, Barry W. Connors, Michael A. Paradiso; 2020
4. Basic Neurochemistry Principles of Molecular, Cellular, and Medical Neurobiology. (9th Edition) by Scott Brady, George Siegel; 2024
5. From Neuron to Brain (6th Edition) by John G. Nicholls, A. Robert Martin, David A. Brown, Mathew E. Diamond, David A. Weisblat, Paul A. Fuchs; 2020
6. Neurobiology (3rd Edition) by Gordon M. Shepherd, 1994
7. Basic Clinical Neuroscience (3rd Edition) by Paul A. young, Paul H. young and Daniel L. Tolbert; 2015

SEMESTER IV

24-303-0401 DISSERTATION AND SEMINAR (12C)

24-303-0402 COMPREHENSIVE VIVA-VOCE (2C)

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 and analytical 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.

Courseoutcomes(CO)

Oncompletionofthiscoursethestudentwillbeableto:

CourseOutcome	
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.	Applyrequiredtheoryandexperimentsonthe problem
C.O.3.	Construct a project proposal through extensive studyof the literature and / or discussion with learned resource persons in academy or industry
C.O.4.	Createanactionplanoftheprojectworktobecarriedoutthrough 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.	Analyzethedatageneratedanddiscussincontextofcurrent status
C.O.7.	Prepare,Presentanddefendself-preparedreport,verifiedbytheprojectguide to a peer audience.

- 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 needs 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

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

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
g. (Results/outputs and discussion)
h. Summary
i. Future scope and conclusions
j. References
k. appendix can show supplemental data, etc
l. 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)

24-303-0403 ENTREPRENEURSHIP FOR BIOLOGISTS (2E, 2L-0T-0P)

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)

Aftercompletingthecourse,thestudentwillbeableto:

Course Outcome	Description	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
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 LISTOFPRACTICALS

Case studies, Discussion, Brainstorming, Presentations, etc.
Project proposal preparation for Entrepreneurship

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. 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.
12. Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences, Adams, D. J., & Sparrow, J. C., 2008, Bloxham: Scion.