DBT, GoI Sponsored Program

MSc BIOTECHNOLOGY

Curriculum & Syllabi

Department of Biotechnology
(DST-FIST Sponsored Department)
School of Integrative Biology
Central University of Tamil Nadu
Thiruvarurr – 610 003
India.
www.cutn.ac.in

तमिलनाडुकेन्द्रीयविश्वविद्यालय
(संसदद्वारापारितअधिनियम 2009केअंतर्गतस्थापित)
CENTRAL UNIVERSITY OF TAMIL NADU
(Established by an Act of Parliament, 2009)
नीलक्कुडीपरिसर/Neelakudi Campus, कंगलान्चेरी/Kangalancherry,
तिरुवारूर/Thiruvarur- 610 005, Tamilnadu
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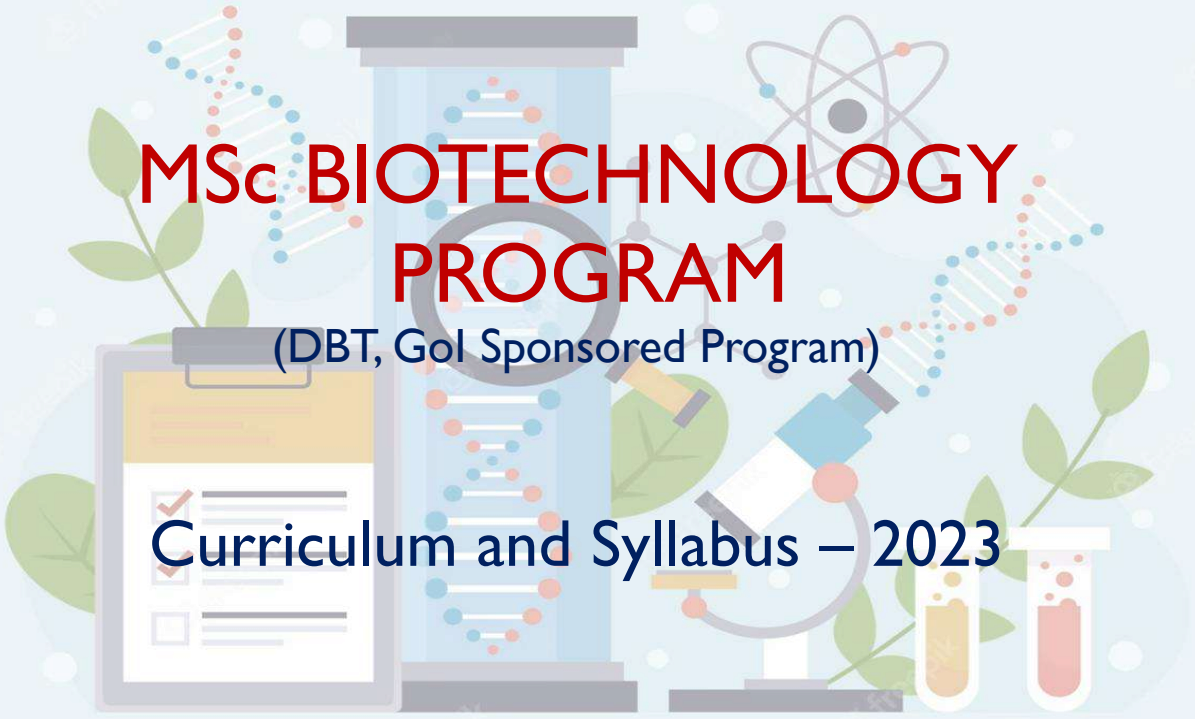

MSc BIOTECHNOLOGY PROGRAM

(DBT, GoI Sponsored Program)

Curriculum and Syllabus – 2023

Department of Biotechnology
(DST-FIST Sponsored Department)
School of Integrative Biology
Central University of Tamil Nadu
Thiruvarur 610005

Department of Biotechnology

School of Integrative Biology

Central University of Tamil Nadu

Established in 2012, as the Department of Life Sciences is now rechristened as the Department of Biotechnology (DBT) is a DST-FIST sponsored department. The department offers three programs, a 5-year-integrated MSc, a 2-year MSc and PhD for aspirants of Biotechnology. The 2-year MSc Biotechnology program is supported by Department of Biotechnology, Government of India. DBT is strengthened by a team of faculty members who commit themselves to the highest standards both in academics and research. It is one of the most vibrant and visible departments in terms of competition for admission among its aspirants. The department boasts of its internationally-trained faculty members with vast teaching experience, high-impact publications, extra-mural research grants and in terms of cutting-edge infra-structure facilities standing as a testimony to its success.

Vision of the Department

Enlighten the potential of biotechnology to achieve newer heights in multi-disciplinary education, research and entrepreneurship, and instil human values and welfare via promoting innovation in biotechnology for nation-building.

Mission of the Department

M1	• To provide an academic ambience that emphasizes creativity and critical thinking among students
M2	• To promote multi-disciplinary education, research and creative analysis among the students across diversified areas in biotechnology
M3	• To display leadership qualities in pedagogy and learning for better understanding of mechanistic concepts in biotechnology

2-Yr MSc Biotechnology Program

A. Program Specific Objectives (PSO)

After two years of successful completion of the program, the students will be able to

PSO1	Achieve high level competence for higher education, research and be adequately qualified for employment in the domain of biotechnology and allied fields.
PSO2	Apply suitable methods in biotechnology, combine experimental and computational approaches to design and conduct experiments with proficiency.
PSO3	Demonstrate appropriate research skills in experimental design with appropriate controls, critical thinking and analysis of results for scientific dissemination.
PSO4	Inseminate ethical values and standards for providing sustained constructive services to the global community
PSO5	Recognize the importance of bioethics, IPR, entrepreneurship, communication and management skills so to be ready to pursue a career as biotechnologists

B. PSO to Mission Statement Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5
M1	x	x	x	x	-
M2	x	x	x	-	x
M3	x	x	x	x	x

C. Graduate Attributes of M.Sc. (Biotechnology) Program

1. **Disciplinary Knowledge:** Appreciate the versatility of biotechnology and select appropriate tools and techniques for fostering innovation, entrepreneurship, industrial advancement, and progress.
2. **Communication Skills:** Acquire adequate oral and written communication skills to convey the mechanistic concepts to the global scientific community with rationality.
3. **Critical Thinking:** Develop the potential to conceive research hypotheses, design and conduct experiments, mining, analysis and interpretation of data, and report the findings.
4. **Problem-Solving:** Apply appropriate statistical skills and computational methods to explore, analyse and authenticate biological data in experiments and research.
5. **Cooperation:** Ability to work autonomously, yet able to cooperate and function effectively as a member or leader of an R & D team.

6. **Biotechniques & ICT Skills:** Acquire training in techniques/skills and understand the scope and applications of biotechnology in well-equipped laboratories using appropriate ICT tools (technique) to be able to solve complex biological problems.
7. **Ethics:** Demonstrate high standards of adherence to universal code of ethics and responsibilities.
8. **Self-Directed Learning:** Access and update current information and literature in science.
9. **Reasoning:** Develop the ability to critically and systematically analyze scientific data to be able to draw unbiased conclusions for fulfilling the objectives.
10. **Creativity:** Experience the opportunity to curate/manage or participate in a variety of extracurricular activities that will cater to the overall personality development and creativity.
11. **Societal and Environmental Concern:** Develop a sense of social, ethical, environmental and professional responsibility.
12. **Harnessing Longevity of Learning:** Understand the importance of continuous learning and practice it through life.

D. Program Outcomes (PO)

On the successful completion of the program, the student will be able to

PO1	Advance adequate knowledge across diverse domains in biotechnology and acquire necessary skillsets to extrapolate modern tools and techniques in the field.
PO2	Apply skills and knowledge acquired in skill imparting and entrepreneurial courses in biotechnology.
PO3	Endorse an interdisciplinary approach for providing better solutions and innovative ideas towards sustainable development and engage in continuous learning.
PO4	Serve as a source of skilled manpower for imparting skills to aspirants of bioentrepreneurship.
PO5	Develop a sense of social, ethical, environmental and professional responsibility to serve humankind.

E. PO to PSO Mapping

	PO1	PO2	PO3	PO4	PO5
PSO1	x	X	x	x	-
PSO2	x	X	x	-	-
PSO3	x	X	x	x	x
PSO4	-	X	-	x	x
PSO5	-	-	x	x	x

MSc BIOTECHNOLOGY

S.No.	Code	Course Title	Hrs	Credits
		SEMESTER I		
1	BTY2101	Biochemistry	3	3
2	BTY2102	Cell and Molecular Biology	3	3
3	BTY2103	Plant and Animal Biotechnology	3	3
4	BTY2104	Microbiology	2	2
5	BTY2105	Genetics	2	2
6	BTY2106	Basics of Mathematics and Statistics	2	2
7	BTY2107	Basics of Chemistry and Physics	2	2
8	BTY2108	Laboratory I: Biochemistry and Analytical Techniques	8	4
9	BTY2109	Laboratory II: Microbiology	4	2
10	BTY2110	Laboratory III: Plant and Animal Biotechnology	4	2
		Total	**33**	**25**
		SEMESTER II		
1	BTY2201	Genetic Engineering	3	3
2	BTY2202	Immunology	3	3
3	BTY2203	Bioinformatics	3	3
4	BTY2204	Genomics and Proteomics	2	2
5	BTY2205	Molecular Diagnostics	2	2
6	BTY2206	Research Methodology and Scientific Communication Skills	2	2
7	BTY22EX	Elective I	2	2
8	BTY22S1	Seminar	1	1
9	BTY2207	Laboratory IV: Molecular Biology and Genetic Engineering	8	4
10	BTY2208	Laboratory V: Immunology	6	3
		Total	**32**	**25**
		SEMESTER III		
1	BTY2301	Bioprocess Engineering and Technology	3	3
2	BTY2302	Emerging Technologies	2	2
3	BTY2303	Critical Analysis of Classical Papers	2	2
4	BTY2304	Bioentrepreneurship	2	2
5	BTY2305	Intellectual Property Rights, Biosafety and Bioethics	2	2
6	BTY2306	Project Proposal Preparation and Presentation	2	2
7	BTY23S1	Seminar	1	1
8	BTY2307	Laboratory VI: Bioprocess Engineering and Technology	8	4
9	BTY2308	Laboratory VII: Bioinformatics	4	2
10	BTY2PR1	Dissertation	-	4
		Total	**26**	**24**
		SEMESTER IV		
1	BTY2PR2	Dissertation	-	20
2	BTY24EX	Elective II	2	2
		Total	**2**	**22**
		TOTAL CREDITS		**96**

RECOMMENDED LIST OF ELECTIVES

S.No.	Code	Course Title	Hrs	Credits
1	BTY22E1	Biological Imaging	2	2
2	BTY22E2	Computational Biology	2	2
3	BTY22E3	Drug Discovery and Development	2	2
4	BTY22E4	Environmental Biotechnology	2	2
5	BTY24E1	Microbial Technology	2	2
6	BTY24E2	Nanobiotechnology	2	2
7	BTY24E3	Protein Engineering	2	2
8	BTY24E4	Vaccines	2	2

EVALUATION

Theory Courses:

Internal Assessment : 40 marks
End Sem. Exam : 60 marks
Total : 100 marks

Requirement for pass in the course:

1. Minimum 50% (ie. 30 marks out of 60 marks) in the End Semester Examination
2. Minimum 50 marks out of 100 marks (Internal Assessment + End Semester Examination)

Internal Evaluation – 40 Marks

S. No.	Item	Marks
1	90 min Written Test – 2 x 15	30
2	Seminar/Assignment/Quiz	05
3	Attendance	05
Total		**40**

Question Paper Pattern for Internal Evaluation

S. No.		Item	Marks
1	Part A – 10 marks (MCQ)	Answer ALL Questions 1 x 10 = 10	10
2	Part B – 20 marks (Essay)	Answer any FOUR Questions 5 x 4 = 20 (4 questions from SIX questions)	20
Total			**30**

End Semester Examination (3 Hrs) – 60 marks

Question Paper Pattern for End Semester Examination

S.No.		Item	Marks
1	Part A – 10 marks (MCQ)	Answer ALL Questions 1 x 10 = 10	10
2	Part B – 15 marks (Short notes)	Answer ALL Questions 3 x 5 = 15	15
3	Part C – 35 marks (Essay)	Answer any FIVE Questions 7 x 5 = 35 (5 questions from SEVEN questions)	35
Total			**60**

Practical Courses: Assessment of the practical courses shall be done for 100 marks by continuous internal assessment on the basis of the students' performance in the laboratory classes, on-time submission of results/observation/records, attendance, and written/viva-voce examinations.

Attendance: In each semester, the minimum attendance for a student to get eligible for appearing in the end semester examination is 75%. Upon failing the minimum requirement, the student shall abide by the University norms for eligibility.

Summer Internship: Assessment of the Summer Internship (SI) shall be done for 100 marks. Out of 100 marks, the Supervisor under whom SI was done will evaluate for 50 marks and SI/training evaluation committee of the department shall evaluate for 50 marks; out of which 25 marks will be for the report and 25 for the presentation.

Project/Dissertation: Assessment pattern of the Project (Phase I & II) is given below.

	Supervisor/Guide	Review	Total Marks
Internal Assessment	20	20 (2 x 10 = 20)	40
End Sem. Assessment	30	30	60
Total			**100**

- Review of the project shall be done by the Department Project Review Committee comprised of the Supervisor, one senior faculty member and one faculty member nominated by HoD.

BIOCHEMISTRY

BTY2101
Semester I
3 Credits

COURSE OUTCOME (CO)

CO1 Understand the structures and functions of biomolecules (PO: 1)
CO2 Apply biochemical principles with specific emphasis on different metabolic pathways (PO: 2,3)
CO3 Gain fundamental knowledge in biochemistry (PO: 1)
CO4 Able to distinguish macromolecules from small molecules (PO: 4)
CO5 Predict the molecular basis of various pathological conditions from the perspective of biochemical Reactions (PO: 3,4,5)

UNIT I: CHEMICAL BASIS OF LIFE AND PROTEINS: 7Hrs

Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies.

UNIT II: PROTEIN STRUCTURE: STRUCTURE-FUNCTION RELATIONSHIPS: 4Hrs

Amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.

UNIT III: ENZYME KINETICS: 5Hrs

Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

UNIT IV: GLYCOBIOLOGY: 2Hrs

Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins.

UNIT V: STRUCTURE AND FUNCTIONS OF DNA & RNA: 2Hrs

Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

UNIT VI: LIPIDS, DNA & RNA: 8Hrs

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown,

roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation.

UNIT VII: ROLE OF VITAMINS & COFACTORS IN METABOLISM: 12Hrs

Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling.

REFERENCES:

1. Stryer, L. (2002). Biochemistry. New York: Freeman.
2. Lehninger, A. L. (2004). Principles of Biochemistry (4th ed.). New York, NY: Worth.
3. Voet, D., & Voet, J. G. (2004). Biochemistry (4th ed.). Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890. doi:10.1038/nature02261.
5. Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

CELL AND MOLECULAR BIOLOGY

BTY2102
Semester I
3 Credits

COURSE OUTCOME (CO)

CO1 Understand various biological processes (PO: 1)
CO2 Acquire knowledge about basic cell structures, and membrane dynamics (PO: 1,2)
CO3 Able to characterize various types of cells (PO: 3)
CO4 Develop the strategies to exploit the functioning of different types of cells and biomolecules (PO: 2,3)
CO5 Compare possibilities and limits of methods and techniques used in molecular biology (PO: 4,5)

UNIT I: DYNAMIC ORGANIZATION OF CELL: 6Hrs

Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.

UNIT II: CHROMATIN STRUCTURE AND DYNAMICS: 12Hrs

Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin- Writers,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, trancriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code translation product cleavage, modification and activation.

UNIT III: CELLULAR SIGNALLING, TRANSPORT AND TRAFFICKING: 3Hrs

Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.

UNIT IV: CELLULAR PROCESSES: 8Hrs

Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and transmembrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.

UNIT V: MANIPULATING AND STUDYING CELLS: 3Hrs

Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

UNIT VI: GENOME INSTABILITY AND CELL TRANSFORMATION: 8Hrs

Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.

REFERENCES:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
2. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.
4. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM; Sunderland.
5. 5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston (8th Ed.). Benjamin Cummings.
6. Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA: Benjamin/Cummings.

PLANT AND ANIMAL BIOTECHNOLOGY

BTY2103
Semester I
2 Credits

COURSE OUTCOME (CO)

CO1 Understand the principles, and applications of animal biotechnology, plant tissue culture (PO: 1,2)
CO2 Apply concepts of plant and animal genomics (PO: 2,3)
CO3 Differentiate between conventional and biotechnological methods of analysis of traits of plants and Animals (PO: 2,3)
CO4 Gain fundamental knowledge in animal and plant biotechnology and their applications (PO: 3,4,5)
CO5 Practice genetic transformation and molecular breeding of plants and animals (PO: 3,4,5)

UNIT I: PLANT TISSUE CULTURE AND ANIMAL CELL CULTURE: 10Hrs

Plant tissue culture: historical perspective; totipotency; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production. Animal cell culture: brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation and in vitro testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

UNIT II: PLANT GENETIC MANIPULATION: 10Hrs

Genetic engineering: Agrobacterium-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.

UNIT III: ANIMAL REPRODUCTIVE BIOTECHNOLOGY AND VACCINOLOGY: 8Hrs

Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species; Vaccinology: history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.

UNIT IV: PLANT AND ANIMAL GENOMICS: 4Hrs

Overview of genomics – definition, complexity and classification; need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype; genome projects and bioinformatics resources for genome research – databases; overview of forward and reverse genetics for assigning function for genes.

UNIT V: MOLECULAR MAPPING AND MARKER ASSISTED SELECTION: 8Hrs

Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; introduction to mapping of genes/QTLs; marker-assisted selection - strategies for Introducing genes of biotic and abiotic stress resistance in plants: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; detection of meat adulteration using DNA based methods.

REFERENCES:

1. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
2. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.
3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: An Introduction to Genetic Engineering. Oxford: Oxford University Press.
4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry & Molecular Biology of Plants. Chichester, West Sussex: John Wiley & Sons.
5. Umesha, S. (2013). Plant Biotechnology. The Energy and Resources.
6. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.

7. Brown, T. A. (2006). Gene Cloning and DNA Analysis: an Introduction. Oxford: Blackwell Pub.
8. Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
9. Slater, A., Scott, N. W., & Fowler, M. R. (2003). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford: Oxford University Press.
10. Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
11. Levine, M. M. (2004). New Generation Vaccines. New York: M. Dekker.
12. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press

MICROBIOLOGY

BTY2104
Semester I
2 Credits

COURSE OUTCOME (CO)

CO1 Understand microbial diversity, morphology, physiology and nutrition; methods for control of microbes and host-microbe interactions (PO: 1,2,3)

CO2 Able to analyze the role of microorganisms for human applications (PO: 3,4)

CO3 Demonstrate and evaluate interactions between microbes, hosts and environment (PO: 2,3,4)

CO4 Appreciate and demonstrate structural, physiological, genetic similarities and differences of major categories of microorganisms (PO: 2,3)

CO5 Identify and demonstrate how to control microbial growth (PO: 3,4,5)

UNIT I: MICROBIAL CHARACTERISTICS: 6Hrs

Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.

UNIT II: MICROBIAL DIVERSITY: 9Hrs

Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilic archae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.

UNIT III: CONTROL OF MICROORGANISMS: 3Hrs

Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

UNIT IV: VIROLOGY: 5Hrs

Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles –viroids and prions.

UNIT V: HOST-MICROBES INTERACTION: 5Hrs

Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.

REFERENCES:

1. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). Microbiology (5th ed.). New York: McGraw-Hill.
2. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's Microbiology. New York: McGraw-Hill.
3. Matthai, W., Berg, C. Y., & Black, J. G. (2005). Microbiology, Principles and Explorations. Boston, MA: John Wiley & Sons.

GENETICS

BTY2105
Semester I
2 Credits

COURSE OUTCOME (CO)

CO1 Understand relationship between phenotype and genotype in human genetic traits (PO: 1,2)
CO2 Describe fundamental molecular principles of genetics (PO: 1,2)
CO3 Able to predict how gene expression is regulated (PO: 3,4)
CO4 Apply genetic concepts to describe the basics of genetic mapping (PO: 3,4)
CO5 Compare possibilities and limits of methods and techniques used in virology diagnosis and reference (PO: 4,5)

UNIT I: GENETICS OF BACTERIA AND BACTERIOPHAGES: 10Hrs

Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.

UNIT II: YEAST GENETICS: 6Hrs

Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.

UNIT III: DROSOPHILA GENETICS AS A MODEL OF HIGHER EUKARYOTES: 4Hrs

Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.

UNIT IV: POPULATION GENETICS AND GENETICS OF EVOLUTION: 4Hrs

Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy- Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.

UNIT V: QUANTITATIVE GENETICS OF COMPLEX TRAITS (QTLS): 2Hrs

Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs.

UNIT VI: PLANT GENETICS: 2Hrs

Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.

REFERENCES:

1. Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett.
2. Pierce, B. A. (2005). Genetics: a Conceptual Approach. New York: W.H. Freeman.
3. Tamarin, R. H., & Leavitt, R. W. (1991). Principles of Genetics. Dubuque, IA: Wm. C. Brown.
4. Smith, J. M. (1998). Evolutionary Genetics. Oxford: Oxford University Press.

BASICS OF MATHEMATICS AND STATISTICS

BTY2106
Semester I
2 Credits

COURSE OUTCOME (CO)

CO1 Gain broad understanding in mathematics and statistics (PO: 1,2)
CO2 Exposed to essential contents of mathematics and statistics (PO: 1,2)
CO3 Able to approach to problem solving, on a diverse variety of disciplines (PO: 3,4)
CO4 Recognize importance and value of mathematical and statistical thinking (PO: 3,4)
CO5 Capable of applying various mathematical principles and statistical tools to describe biological systems (PO: 3,4,5)

UNIT I: ALGEBRA: 6Hrs

Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models etc.), introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, basics of trigonometric functions, Pythagorean theory, graphing and constructing sinusoidal functions, imaginary numbers, complex numbers, adding-subtracting-multiplying complex numbers, basics of vectors, introduction to matrices.

UNIT II: CALCULUS: 4Hrs

Differential calculus (limits, derivatives), integral calculus (integrals, sequences and series etc.).

UNIT III: MATHEMATICAL MODELS IN BIOLOGY: 4Hrs

Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modeling chemical reaction networks and metabolic networks.

UNIT IV: STATISTICS: 8Hrs

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

REFERENCES:

1. Stroud, K. A., & Booth, D. J. (2009). Foundation Mathematics. New York, NY: Palgrave Macmillan.
2. Aitken, M., Broadhursts, B., & Haldky, S. (2009) Mathematics for Biological Scientists. Garland Science.
3. Billingsley, P. (1986). Probability and Measure. New York: Wiley.
4. Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press.
5. Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley.

BASICS OF CHEMISTRY AND PHYSICS

BTY2107
Semester I
2 Credits

COURSE OUTCOME (CO)

CO1 Understand the essence of physico-chemical principles (PO: 1,2)
CO2 Enumerate basics of chemistry and physics essential for biologists (PO: 1,2)
CO3 Gain knowledge on various chemical and physical concepts and laws (PO: 2,3,4)
CO4 Appreciate physico-chemical principles underlying biological processes (PO: 2,3,4)
CO5 Able to apply current chemical and physical scientific theories in biological systems (PO: 3,4,5)

UNIT I: BASIC PHYSICS FOR BIOLOGISTS: 12Hrs

Physical quantities and their dynamics: definitions and dimensions; vectors & scalars, displacement, velocity, acceleration, kinematic formulas, angular momentum, torque *etc.* force, power, work, energy (kinetic & potential/electric charge separation, electromagnetic spectrum, photons *etc.*); springs & Hookes laws; elastic and inelastic collisions; Newton's law of motions (centripetal and centrifugal forces *etc.*); simple harmonic motions, mechanical waves, Doppler effect, wave interference, amplitude, period, frequency & wavelength; diffusion, dissipation, random walks, and directed motions in biological systems; low Reynolds number - world of Biology, buoyant forces, Bernoulli's equation, viscosity, turbulence, surface tension, adhesion; laws of thermodynamics:

Maxwell Boltzmann distribution, conduction, convection and radiation, internal energy, entropy, temperature and free energy, Maxwell's demon (entropic forces at work in biology, chemical assemblies, self-assembled systems, role of ATP); Coulomb's law, conductors and insulators, electric potential energy of charges, nerve impulses, voltage gated channels, ionic conductance; Ohms law (basic electrical quantities: current, voltage & power), electrolyte conductivity, capacitors and capacitance, dielectrics; various machines in biology *i.e.* enzymes, allostery and molecular motors (molecules to cells and organisms).

UNIT II: BASIC CHEMISTRY FOR BIOLOGISTS: 12Hrs

Basic constituents of matter - elements, atoms, isotopes, atomic weights, atomic numbers, basics of mass spectrometry, molecules, Avogadro number, molarity, gas constant, molecular weights, structural and molecular formulae, ions and polyatomic ions; chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenious equation, Maxwell Boltzmann distributions, rate determining steps, catalysis, free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds (ionic, covalent, Van der Walls forces); electronegativity, polarity; VSEPR theory and molecular geometry, dipole moment, orbital hybridizations; states of matter - vapor pressure, phase diagrams, surface tension, boiling and melting points, solubility, capillary action, suspensions, colloids and solutions; acids, bases and pH -Arrhenious theory, pH, ionic product of water, weak acids and bases, conjugate acid-base pairs, buffers and buffering action *etc*; chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; redox reactions and electrochemistry - oxidation-reduction reactions, standard cell potentials, Nernst equation, resting membrane potentials, electron transport chains (ETC) in biology, coupling of oxidative phosphorylations to ETC; theories of ATP production and dissipation across biological membranes; bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).

REFERENCES:

1. Baaquie, B. E. (2000). Laws of Physics: a Primer. Singapore: National University of Singapore.
2. Matthews, C. P., & Shearer, J. S. (1897). Problems and Questions in Physics. New York: Macmillan Company.
3. Halliday, D., Resnick, R., & Walker, J. (1993). Fundamentals of Physics. New York: Wiley.
4. Ebbing, D. D., & Wrighton, M. S. (1990). General Chemistry. Boston: Houghton Mifflin.
5. Averill, B., & Eldredge, P. (2007). Chemistry: Principles, Patterns, and Applications. San Francisco: Benjamin Cummings.
6. Mahan, B. H. (1965). University Chemistry. Reading, MA: Addison-Wesley Pub.
7. Cantor, C. R., & Schimmel, P. R. (2004). Biophysical Chemistry. San Francisco: W.H. Freeman.

LABORATORY I: BIOCHEMISTRY & ANALYTICAL TECHNIQUES

BYT2108
Semester I
4 Credits

COURSE OUTCOME (CO)

CO1 Remember various methods of analysis of biomolecules (PO: 1,2)
CO2 Elaborate concepts of biochemistry with easy to run experiments (PO: 2,3)
CO3 Understand the principle of measurements using instruments with experiments in biochemistry (PO: 3,4)
CO4 Familiarize with basic laboratory instruments (PO: 3,4)
CO5 Utilize set of experimental methods in biochemistry in a problem-oriented manner (PO: 4,5)

1. Preparing various stock solutions and working solutions that will be needed for the course.
2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
5. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of the institution's choice).
   a) Preparation of cell-free lysates
   b) Ammonium Sulfate precipitation
   c) Ion-exchange Chromatography
   d) Gel Filtration
   e) Affinity Chromatography
   f) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method
   g) Generating a Purification Table (protein concentration, amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification)
   h) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis
   i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
6. Experimental verification that absorption at OD260 is more for denatured DNA as compared to native double stranded DNA. reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size.
7. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments)
8. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
9. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.

LABORATORY II: MICROBIOLOGY

BTY2109
Semester I
2 Credits

COURSE OUTCOME (CO)

CO1 Provide practical skills on basic microbiological techniques (PO: 1,2)
CO2 Apply various techniques to preserve bacterial cultures (PO: 2,3,4)
CO3 Perform antimicrobial sensitivity tests (PO: 3,4)
CO4 Determine bacterial load of different samples (PO: 3,4,5)
CO5 Able to isolate, characterize and identify common bacterial organisms (PO: 3,4,5)

1. Sterilization, disinfection and safety in microbiological laboratory.
2. Preparation of media for cultivation of bacteria.
3. Isolation of bacteria in pure culture by streak plate method.
4. Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus, Streptococcus, etc.*
5. Preparation of bacterial smear and Gram' s staining.
6. Enumeration of bacteria: standard plate count.
7. Antimicrobial sensitivity test and demonstration of drug resistance.
8. Maintenance of stock cultures: slants, stabs and glycerol stock cultures
9. Determination of phenol co-efficient of antimicrobial agents.
10. Determination of Minimum Inhibitory Concentration (MIC)
11. Isolation and identification of bacteria from soil/water samples

REFERENCES:

1. Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company.
2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins and Lyne's Microbiological Methods (8th ed.). Arnolds.
3. Tille, P. M., & Forbes, B. A. Bailey & Scott's Diagnostic Microbiology. Cantor, C. R., & Schimmel, P. R. (2004). Biophysical Chemistry. San Francisco: W.H. Freeman.

LABORATORY III: PLANT AND ANIMAL BIOTECHNOLOGY

BTY2110
Semester I
2 Credits

COURSE OUTCOME (CO)

CO1 Formulation of plant tissue culture and animal cell culture media (PO: 1,2)
CO2 Learn the importance of callus and cell suspension cultures, organogenesis and embryogenesis (PO: 2,3)
CO3 Able to understand the response of culture medium related to secondary metabolite production (PO: 3,4)
CO4 Demonstrate genomic DNA isolation and its quantification from plants and animals (PO: 4,5)
CO5 Able to perform cloning and genetic transformation methods invoked in plants and animals (PO: 4,5)

PLANT BIOTECHNOLOGY

1. Prepare culture media with various supplements for plant tissue culture.
2. Prepare explants of Valleriana wallichii for inoculation under aseptic conditions.
3. Attempt *in vitro* andro and gynogenesis in plants *(Datura stramonium)*.
4. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (available material).
5. Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.
6. Generate an RAPD and ISSR profile of *Eremurus persicus* and *Valleriana wallichii*.
7. Prepare karyotypes and study the morphology of somatic chromosomes of *Allium cepa, A. sativum, A. tuberosum* and compare them on the basis of karyotypes.
8. Pollen mother cell meiosis and recombination index of select species (one achiasmate, and the other chiasmate) and correlate with generation of variation.
9. Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometeric methods.
10. Perform PCR amplification of 'n' number of genotypes of a species for studying the genetic variation among the individuals of a species using random primers.
11. Study genetic fingerprinting profiles of plants and calculate polymorphic information content.

ANIMAL BIOTECHNOLOGY

1. Count cells of an animal tissue and check their viability.
2. Prepare culture media with various supplements for plant and animal tissue culture.
3. Prepare single cell suspension from spleen and thymus.
4. Monitor and measure doubling time of animal cells.
5. Chromosome preparations from cultured animal cells.
6. Isolate DNA from animal tissue by SDS method.
7. Attempt animal cell fusion using PEG

GENETIC ENGINEERING

BTY2201
Semester II
3 Credits

COURSE OUTCOME (CO)

CO1 Endowed with strong theoretical knowledge of genetic engineering technology (PO: 1,2)
CO2 Understand the applications of genetic engineering technology in biological research (PO: 2,3,4)

CO3 Know the different cloning strategies employed in genetic engineering (PO: 3,4)

CO4 Apply most appropriate recombinant-DNA techniques and other contemporary techniques to make a gene functional (PO: 4,5)

CO5 Able to take up biological research as well as placement in the relevant biotech industry (PO: 4,5)

UNIT I: INTRODUCTION AND TOOLS FOR GENETIC ENGINEERING: 6Hrs

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.

UNIT II: DIFFERENT TYPES OF VECTORS: 7Hrs

Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

UNIT III: DIFFERENT TYPES OF PCR TECHNIQUES: 7Hrs

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.

UNIT IV: GENE MANIPULATION AND PROTEIN-DNA INTERACTION: 7Hrs

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

UNIT V: GENE SILENCING AND GENOME EDITING TECHNOLOGIES: 13Hrs

Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems e.g. fruit flies (Drosophila), worms (C. elegans), frogs (Xenopus), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.

REFERENCES:

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
4. Selected papers from scientific journals, particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

IMMUNOLOGY

BTY2202
Semester II
3 Credits

COURSE OUTCOME (CO)

CO1 Understand the structural features of components of immune system as well as their function (PO: 1)
CO2 Evaluate usefulness of immunology in different pharmaceutical applications (PO: 2,3)
CO3 Identify proper method to elicit immune response to protect from infection (PO: 3.4)
CO4 Emphasis on development of immune system and mechanisms by which our body elicits immune Response (PO: 3,4)
CO5 Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses (PO: 3,4,5)

UNIT I: IMMUNOLOGY: FUNDAMENTAL CONCEPTS AND OVERVIEW OF THE IMMUNE SYSTEM: 5Hrs

Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.

UNIT II: IMMUNE RESPONSES GENERATED BY B AND T LYMPHOCYTES: 8Hrs

Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system..

UNIT III: ANTIGEN-ANTIBODY INTERACTIONS: 8Hrs

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

UNIT IV: VACCINOLOGY: 8Hrs

Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering: chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine

UNIT V: CLINICAL IMMUNOLOGY: 8Hrs

Immunity to infection: bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.

UNIT VI: IMMUNOGENETICS: 5Hrs

Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex

REFERENCES:

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.
2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.
3. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.
4. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
5. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
6. Parham, P. (2005). The Immune System. New York: Garland Science.

BIOINFORMATICS

BTY2203
Semester II
2 Credits

COURSE OUTCOME (CO)

CO1 Understand principles and framework of various biological databases (PO: 1,2)
CO2 Develop an understanding of basic theory of these computational tools (PO: 2,3)
CO3 Gain working knowledge of these computational tools and methods (PO: 3,4)
CO4 Appreciate their relevance for investigating specific contemporary biological questions (PO: 3,4)
CO5 Critically analyse and interpret results of their study (PO: 4,5)

UNIT I: BIOINFORMATICS BASICS: 5Hrs

Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.

UNIT II: DNA SEQUENCE ANALYSIS: 5Hrs

DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.

UNIT III: MULTIPLE SEQUENCE ANALYSIS: 5Hrs

Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

UNIT IV: PROTEIN MODELLING: 5Hrs

Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein

completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.

UNIT V: PROTEIN STRUCTURE PREDICTION AND VIRTUAL LIBRARY: 6Hrs

Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction; elements of in silico drug design;Virtual library: Searching PubMed, current content, science citation index and current awareness services, electronic journals, grants and funding information

REFERENCES:

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.
5. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.

GENOMICS AND PROTEOMICS

BTY2204
Semester II
2 Credits

COURSE OUTCOME (CO)

CO1 Structure and organization of genes and other elements in a genome (PO: 1,2)

CO2 Acquire knowledge of fundamentals of genomics and proteomics their applications in various applied areas of biology (PO: 2,3)

CO3 Significance of studying global gene expression profile (PO: 3,4)

CO4 Importance of comparing any two or more genomes (PO: 3,4,5)

CO5 Able to understand functional aspects of genomics and proteomics and their role in biological process (PO: 2,3)

UNIT I: BASICS OF GENOMICS AND PROTEOMICS: 3Hrs

Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.

UNIT II: GENOME MAPPING: 4Hrs

Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, in situ hybridization, comparative gene mapping.

UNIT III: GENOME SEQUENCING PROJECTS: 3Hrs

Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.

UNIT IV: COMPARATIVE GENOMICS: 5Hrs

Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.

UNIT V: PROTEOMICS: 5Hrs

Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases.

UNIT VI: FUNCTIONAL GENOMICS AND PROTEOMICS: 5Hrs

Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.

REFERENCES:

1. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
2. Liebler, D. C. (2002). Introduction to Proteomics: Tools for the New Biology. Totowa, NJ: Humana Press.
3. Campbell, A. M., & Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.

MOLECULAR DIAGNOSTICS

BTY2205
Semester II
2 Credits

COURSE OUTCOME (CO)

CO1 Understand recent advances in molecular biology and various facets of molecular medicine (PO: 1,2)

CO2 Able to apply many aspects of modern medicine including pre- or post-natal analysis of genetic diseases (PO: 2,3)

CO3 Identify individuals predisposed to disease ranging from common cold to cancer (PO: 3,4)

CO4 Develop modern molecular techniques for detecting/monitoring diseases (PO: 3,4)

CO5 Utilize various facets of molecular procedures that could be employed in early diagnosis and prognosis of human diseases (PO: 3,4,5)

UNIT I: GENOME BIOLOGY IN HEALTH AND DISEASE: 4Hrs

DNA, RNA, Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs.

UNIT II: GENOME: RESOLUTION, DETECTION & ANALYSIS: 5Hrs

PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF-MS; Bioinformatics data acquisition & analysis.

UNIT III: DIAGNOSTIC METABOLOMICS: 2Hrs

Metabolite profile for biomarker detection the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms.

UNIT IV: DETECTION AND IDENTITY OF MICROBIAL DISEASES: 4Hrs

Direct detection and identification of pathogenic-organisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics.

UNIT V: DETECTION OF INHERITED DISEASES: 4Hrs

Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: Fragile X Syndrome: Paradigm of new mutational mechanism of unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in growing number of familial cancer syndromes.

UNIT VI: MOLECULAR ONCOLOGY: 5Hrs

Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.

UNIT VII: QUALITY ASSURANCE AND CONTROL: 1Hr

Quality oversight; regulations and approved testing

REFERENCES:

1. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
2. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill.
3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology:
4. Principles and Applications of Recombinant DNA. Washington, DC: ASM Press.
5. Coleman, W. B., & Tsongalis, G. J. (2010). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press.

RESEARCH METHODOLOGY AND SCIENTIFIC COMMUNICATION SKILLS

BTY2206
Semester II
2 Credits

COURSE OUTCOME (CO)

CO1 Understand history and methodologies of scientific research (PO: 1,2)
CO2 Able to choose right topic for research (PO: 1,2)
CO3 Appreciate scientific ethics through case studies (PO: 3,4,5)
CO4 Apply relevant methodologies to present research papers (PO: 3,4,5)
CO5 Gain knowledge on understanding effective lab practices and scientific communication and appreciate scientific ethics (PO: 3,4,5)

UNIT I: HISTORY OF SCIENCE AND SCIENCE METHODOLOGIES: 8Hrs

Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

UNIT II: PREPARATION FOR RESEARCH: 2Hrs

Choosing a mentor, lab and research question; maintaining a lab notebook.

UNIT III: PROCESS OF COMMUNICATION: 5Hrs

Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences; Presentation skills – formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its

importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

UNIT IV: SCIENTIFIC COMMUNICATION: 9Hrs

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 nonblind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

REFERENCES:

1. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
2. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist.

LABORATORY IV: MOLECULAR BIOLOGY AND GENETIC ENGINEERING

BTY2207
Semester II
4 Credits

COURSE OUTCOME (CO)

CO1 Know the hands-on experience with the plasmids, cloning vectors for the recombinant DNA research work (PO: 1,2)

CO2 Explain the basic principles and practice in molecular cloning, design and genetic transformation (PO: 2,3)

CO3 Grow experimental knowledge of molecular biology and genetic engineering (PO: 3,4,5)

CO4 Enable to begin a career in industry as well as in research laboratories (PO: 3,4,5)

CO5 Gain hands on experience in gene cloning protein expression and purification (PO: 3,4)

1. Concept of lac-operon:
   a) Lactose induction of B-galactosidase.
   b) Glucose Repression.
   c) Diauxic growth curve of E.coli
2. UV mutagenesis to isolate amino acid auxotroph
3. Phage titre with epsilon phage/M13
4. Genetic Transfer-Conjugation, gene mapping
5. Plasmid DNA isolation and DNA quantitation
6. Restriction Enzyme digestion of plasmid DNA
7. Agarose gel electrophoresis
8. Polymerase Chain Reaction and analysis by agarose gel electrophoresis
9. Vector and Insert Ligation
10. Preparation of competent cells
11. Transformation of E.coli with standard plasmids, Calculation of transformation efficiency
12. Confirmation of the insert by Colony PCR and Restriction mapping

13. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in E.coli, SDS-PAGE analysis
14. Purification of His-Tagged protein on Ni-NTA columns
    a) Random Primer labeling
    b) Southern hybridization.

REFERENCES:

1. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

LABORATORY V: IMMUNOLOGY

BTY2208
Semester II
3 Credits

COURSE OUTCOME (CO)

CO1 Understand the basic immunological techniques (PO: 1,2)
CO2 Demonstrate an understanding of experiments related to immunology (PO: 2,3)
CO3 Able to analyze the role of the immune system for human applications (PO: 3.4)
CO4 Conduct investigations in immunology for translational applications (PO: 3,4,5)
CO5 Utilize the skill sets required to extrapolate findings for human applications with appropriate experimental tools (PO: 3,4,5)

1. Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgY from chicken egg.
6. SDS-PAGE, Immunoblotting, Dot blot assays.
7. Blood smear identification of leucocytes by Giemsa stain.
8. Separation of leucocytes by dextran method.
9. Demonstration of Phagocytosis of latex beads and their cryopreservation.
10. Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
11. Demonstration of ELISPOT.
12. Demonstration of FACS.

BIOPROCESS ENGINEERING & TECHNOLOGY

BTY2301
Semester III
3 Credits

COURSE OUTCOME (CO)

CO1 Give an account of important microbial/enzymatic industrial processes (PO: 1,2)
CO2 Estimate yield and production rates in a biological production process, and also interpret data (PO: 1,2)
CO3 Carry out stoichiometric evaluations and specify models of their growth (PO: 3,4)
CO4 Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research (PO: 3,4,5)
CO5 Analyze and interpret data, and apply the laboratory skills to solve complex bioprocess (PO: 3,4,5)

UNIT I: BASIC PRINCIPLES OF BIOCHEMICAL ENGINEERING: 4Hrs

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

UNIT II: STOICHIOMETRY AND MODELS OF MICROBIAL GROWTH: 4Hrs

Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

UNIT III: BIOREACTOR DESIGN AND ANALYSIS: 8Hrs

Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters

UNIT IV: DOWNSTREAM PROCESSING AND PRODUCT RECOVERY: 8Hrs

Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

UNIT V: FERMENTATION ECONOMICS: 4Hrs

Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.

UNIT VI: APPLICATIONS OF ENZYME TECHNOLOGY IN FOOD PROCESSING: 4Hrs

Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions e.g. starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

UNIT VII: APPLICATIONS OF MICROBIAL TECHNOLOGY IN FOOD PROCESS OPERATIONS AND PRODUCTION, BIOFUELS AND BIOREFINERY: 4Hrs

Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery

REFERENCES:

1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.
4. Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York:
5. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.

EMERGING TECHNOLOGIES

BTY2302
Semester III
2 Credits

COURSE OUTCOME (CO)

CO1 Understand new technologies that current experimental researchers are employing (PO: 1,2)
CO2 Probe complex system biology questions in life-sciences (PO: 1,2)
CO3 Learn theoretical basis and understanding of latest technologies in biotechnology (PO: 1,2,3)
CO4 Able to learn about various applications of these technologies (PO: 3,4,5)
CO5 Exposed to new principles and to appreciate current-day research tool-kit better (PO: 3,4,5)

UNIT I: OPTICAL MICROSCOPY METHODS: 8Hrs

Basic Microscopy: Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy: what is fluorescence, what makes a molecule fluorescent, fluorescence microscope; optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording color; three CCD elements with dichroic beamsplitters, boosting the signal.

Advanced Microscopy: Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers & solid-state, primary beamsplitter; beam scanning, pinhole and signal channel configurations, detectors; pixels and voxels; contrast, spatial sampling: temporal sampling: signal-tonoise ratio, multichannel images. nonlinear microscopy: multiphoton microscopy; principles of two-photon fluorescence, advantages of two-photon excitation, tandem scanning (spinning disk) microscopes, deconvolving confocal images; image processing, three-dimensional reconstruction; advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; Beyond the Diffraction Limit: Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM).

UNIT II: MASS SPECTROSCOPY: 4Hrs

Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.

UNIT III: SYSTEMS BIOLOGY: 3Hrs

High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modeling and designing testable predictions.

UNIT IV: STRUCTURAL BIOLOGY: 3Hrs

X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, smallangle X-ray scattering, Atomic force microscopy.

UNIT V: CRISPR-CAS: 6Hrs

History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.

UNIT VI: NANOBODIES: 4Hrs

Introduction to nanobodies, combining nanobody with phage-display method for development of antibody against native proteins, nanobody as a tool for protein structure-function studies, use of nanobodies for molecular imaging, catabolic antibodies using nanobodies.

REFERENCES:

1. Campbell, I. D. (2012). Biophysical Techniques. Oxford: Oxford University Press.

2. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). Methods in Molecular Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press.
3. Phillips, R., Kondev, J., & Theriot, J. (2009). Physical Biology of the Cell. New York: Garland Science.
4. Nelson, P. C., Radosavljević, M., & Bromberg, S. (2004). Biological Physics: Energy, Information, Life. New York: W.H. Freeman.
5. Huang, B., Bates, M., & Zhuang, X. (2009). Super-Resolution Fluorescence Microscopy. Annual Review of Biochemistry, 78(1), 993-1016. doi:10.1146/annurev. biochem.77.061906.092014.
6. Mohanraju, P., Makarova, K. S., Zetsche, B., Zhang, F., Koonin, E. V., & Oost, J. V. (2016). Diverse Evolutionary Roots and Mechanistic Variations of the CRISPR-Cas Systems. Science, 353(6299). doi:10.1126/science.aad5147.
7. Lander, E. (2016). The Heroes of CRISPR. Cell, 164(1-2), 18-28. doi:10.1016/j. cell.2015.12.041.
8. Ledford, H. (2016). The Unsung Heroes of CRISPR. Nature, 535(7612), 342-344. doi:10.1038/535342a.
9. Jinek, M., Chylinski, K., Fonfara, I., Hauer, M., Doudna, J. A., & Charpentier, E. (2012). A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity. Science, 337(6096), 816-821. doi:10.1126/science.1225829.
10. Hamers-Casterman, C., Atarhouch, T., Muyldermans, S., Robinson, G., Hammers, C., Songa, E. B., Hammers, R. (1993). Naturally Occurring Antibodies Devoid of Light Chains. Nature, 363(6428), 446-448. doi:10.1038/363446a0.
11. Sidhu, S. S., & Koide, S. (2007). Phage Display for Engineering and Analyzing Protein Interaction Interfaces. Current Opinion in Structural Biology, 17(4), 481-487. doi:10.1016/j.sbi.2007.08.007.
12. Steyaert, J., & Kobilka, B. K. (2011). Nanobody Stabilization of G Protein-Coupled Receptor Conformational States. Current Opinion in Structural Biology, 21(4), 567-572. doi:10.1016/j.sbi.2011.06.011.
13. Vincke, C., & Muyldermans, S. (2012). Introduction to Heavy Chain Antibodies and Derived Nanobodies. Single Domain Antibodies, 15-26. doi:10.1007/978-1-61779- 968-6_2.
14. Verheesen, P., & Laeremans, T. (2012). Selection by Phage Display of Single Domain Antibodies Specific to Antigens in their Native Conformation. Single Domain Antibodies, 81-104. doi:10.1007/978-1-61779-968-6_6.
15. Li, J., Xia, L., Su, Y., Liu, H., Xia, X., Lu, Q. Reheman, K. (2012). Molecular Imprint of Enzyme Active Site by Camel Nanobodies. Journal of Biological Chemistry J. Biol. Chem., 287(17), 13713-13721. doi:10.1074/jbc.m111.336370.
16. Sohier, J., Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U. Galleni, M. (2013). Allosteric Inhibition of VIM Metallo-β-Lactamases by a Camelid Nanobody. Biochemical Journal, 450(3), 477-486. doi:10.1042/bj20121305.
17. Chakravarty, R., Goel, S., & Cai, W. (2014). Nanobody: The "Magic Bullet" for Molecular Imaging? Theranostics, 4(4), 386-398. doi:10.7150/thno.8006.

CRITICAL ANALYSIS OF CLASSICAL PAPERS

BTY2303
Semester III
2 Credits

COURSE OUTCOME (CO)

CO1 Familiarize students with classic scientific literature (PO: 1)
CO2 Appreciate how groundbreaking discoveries were made without, necessarily, use of high-end Technologies (PO: 1)
CO3 Analyse about various applications of emerging technologies (PO: 2,3)
CO4 Exercise of hypothesis building and methods of addressing the hypothesis with readily available Technology (PO: 3,4,5)
CO5 Learning and developing skills on latest technologies in the field of biotechnology (PO: 4,5)

How does the Course Module work? Students may be divided in groups and each group may be responsible for one classical paper. Each week there may be a 1.5 hour presentation cum discussion

for each of the papers. At the end of the semester each student will be asked to write a mini-review (2-3 pages long) on any one classical paper, other than the one he/she presented/discussed.

A list of sixteen classic papers and some suggested reference materials:

MOLECULAR BIOLOGY

1. Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid fraction isolated from Pneumococcus type III. Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58.
   Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.
2. Independent functions of viral protein and nucleic acid in growth of bacteriophage Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56.
   Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.
3. Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8
   Note: In this one page paper Watson and Crick first described the structure of DNA double helix Study help - Watson_Crick_Nature_1953_annotated
4. Transposable mating type genes in Saccharomyces cerevisiae James Hicks, Jeffrey N. Strathern & Amar J.S. Klar; Nature 282, 478-483,1979
   Note: This paper provided evidence for 'cassette hypothesis' of yeast mating type switches i.e. interconversion of mating types in yeast (S. cerevisiae) occurs by DNA rearrangement.
5. Messelson & Stahl experiment demonstrating semi-conservative replication of DNA. Meselson M and Stahl FW.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82
   Note: The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology"
6. In vivo alteration of telomere sequences and senescence caused by mutated Tetrahymena telomerase RNAs Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn; Nature 344, 126-132, 1990
   Note: This paper demonstrates that the telomerase contains the template for telomere synthesis

CELL BIOLOGY

1. A protein-conducting channel in the endoplasmic reticulum Simon SM AND Blobel G.; Cell. 1991 May 3;65(3):371-80
   Note: This paper demonstrates the existence of a protein conducting channel Study help - A brief history of Signal Hypothesis
2. Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15
   Note: In this groundbreaking paper Randy Schekman's group used a mutagenesis screen for fast sedimenting yeast mutants to identify genes involved in cell secretion
3. A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45
   Note: Using another yeast mutation screen Schekman lab identifies Sec61, a component of ER protein Conducting Channel (PCC) Suggested reference paper - A biochemical assay for identification of PCC.
4. Reconstitution of the Transport of Protein between Successive Compartments of the Golgi Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):405-16
   Note: This paper describes setting up of an in vitro reconstituted system for transport between golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP etc.
5. A complete immunoglobulin gene is created by somatic recombination Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1-14
   Note: This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.
6. A novel multigene family may encode odorant receptors: a molecular basis for odor recognition Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87
   Note: This paper suggests that different chemical odorants associate with different cell-specific expression of a transmembrane receptor in Drosophila olfactory epithelium where a large family of odorat receptors is expressed.

7. Kinesin walks hand-over-hand Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8
   Note: This paper shows that kinesin motor works as a two-headed dimeric motor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.

DEVELOPMENTAL BIOLOGY/ GENETICS

1. Mutations affecting segment number and polarity in Drosophila Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980
   Note: This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well.
2. Information for the dorsal--ventral pattern of the Drosophila embryo is stored as maternal mRNA Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 20-26;311(5983):223-7
   Note: This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes
3. Hedgehog signalling in the mouse requires intraflagellar transport proteins Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7
   Note: One of the architects of original fly mutagenesis screens conducted a mouse mutagenes screen which identified a gene Kif3a as a major component of hedgehog signaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of cillia in it.

Suggested Reference paper - Design and execution of a embryonic lethal mutation screen in mouse.

BIOENTREPRENEURSHIP

BTY2304
Semester III
2 Credits

COURSE OUTCOME (CO)

CO1 Understand how to manage and develop life science companies and projects (PO: 1)
CO2 Gain entrepreneurial skills & project proposal preparation (PO: 2)
CO3 Able to build up a strong network within the industry (PO: 3,4)
CO4 Identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres (PO: 3,4,5)
CO5 Gain entrepreneurial skills, understand the various operations involved in venture creation (PO: 3,4,5)

UNIT I: INNOVATION AND ENTREPRENEURSHIP IN BIO-BUSINESS: 8Hrs

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

UNIT II: BIO MARKETS - BUSINESS STRATEGY AND MARKETING: 8Hrs

Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

UNIT III: FINANCE AND ACCOUNTING: 8Hrs

Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

UNIT IV: TECHNOLOGY MANAGEMENT: 8Hrs

Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

REFERENCES:

1. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion.
2. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., & Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
4. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
5. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

INTELLECTUAL PROPERTY RIGHTS, BIOSAFETY AND BIOETHICS

BTY2305
Semester III
2 Credits

COURSE OUTCOME (CO)

CO1 Understand the rationale for and against IPR and especially patents (PO: 1,5)

CO2 Familiarize with broad outline of patent regulations (PO: 1,5)

CO3 Appreciate ethical aspects related to biological, biomedical, health care and biotechnology research (PO: 2,3,5)

CO4 Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research (PO: 1,3,5)

CO5 Learn biosafety and risk assessment of products derived from biotechnology and regulation of such Products (PO: 4,5)

UNIT I: INTRODUCTION TO IPR: 5Hrs

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

UNIT II: PATENTING: 5Hrs

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.

UNIT III: BIOSAFETY: 5Hrs

Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.

UNIT IV: NATIONAL AND INTERNATIONAL REGULATIONS: 5Hrs

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).

UNIT V: BIOETHICS: 5Hrs

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology – Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

REFERENCES:

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
4. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
5. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
6. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies, MIT Press
7. World Trade Organisation. http://www.wto.org
8. World Intellectual Property Organisation. http://www.wipo.int
9. International Union for the Protection of New Varieties of Plants. http://www.upov.int
10. National Portal of India. http://www.archive.india.gov.in
11. National Biodiversity Authority. http://www.nbaindia.org
12. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf
13. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9
14. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). An Overview of General Features of Risk Assessments of Genetically Modified Crops. Euphytica,164(3), 853-880. doi:10.1007/s10681-007-9643-8
15. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.
16. Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/guidelines1.asp
17. Alonso, G. M. (2013). Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure "Fit for Purpose" Risk Assessments. Retrieved from http://biosafety.icgeb.org/inhousepublicationscollectionbiosafetyreviews.

PROJECT PROPOSAL PREPARATION & PRESENTATION

BTY2306
Semester III
2 Credits

COURSE OUTCOME (CO)

CO1 Formulate a scientific question (PO: 1,2)
CO2 Present scientific approach to solve the problem (PO: 1,2,3)
CO3 Interpret, discuss and communicate scientific results in written form (PO: 3,4,5)
CO4 Gain experience in writing a scientific proposal (PO: 3,4,5)
CO5 Learn how to present and explain their research findings to the audience effectively (PO: 3,4,5)

UNIT I: PROJECT PROPOSAL PREPARATION: 12Hrs

Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven. Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources. Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

UNIT II: POSTER PRESENTATION: 8Hrs

Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.

UNIT III: ORAL PRESENTATION: 10Hrs

At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

LABORATORY VI: BIOPROCESS ENGINEERING & TECHNOLOGY

BTY2307
Semester II
4 Credits

COURSE OUTCOME (CO)

CO1 Provide hands-on training to students in upstream and downstream unit operations (PO: 1)
CO2 Explain major steps in industrial production of bioproducts (PO: 1,2)
CO3 Execute theoretical aspects of bioprocess into practice (PO: 1,2)
CO4 Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research (PO: 2,3,4)
CO5 Analyze and interpret data, and apply the laboratory skills to solve complex bioprocess (PO: 4,5)

1. 1. Basic Microbiology techniques
   a) Scale up from frozen vial to agar plate to shake flask culture.
   b) Instrumentation: Microplate reader, spectrophotometer, microscopy.
   c) Isolation of microorganisms from soil samples.
2. Experimental set-up
   a) Assembly of bioreactor and sterilization.
   b) Growth kinetics.

c) Substrate and product inhibitions.

d) Measurement of residual substrates.

3. Data Analysis

   a) Introduction to Metabolic Flux Analysis (MFA).

4. Fermentation

   a) Batch.

   b) Fed-batch.

   c) Continuous.

5. Unit operations

   a) Microfiltrations: Separation of cells from broth.

   b) Bioseparations: Various chromatographic techniques and extractions.

6. Bioanalytics

   a) Analytical techniques like HPLC, FPLC, GC, GC-MS etc. for measurement of amounts of products/substrates.

REFERENCES:

1. 1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.
4. Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.

LABORATORY VII: BIOINFORMATICS

BTY2308
Semester II
2 Credits

COURSE OUTCOME (CO)

CO1 Describe contents and properties of most important bioinformatics databases (PO: 1,2,3)

CO2 Perform text- and sequence-based searches and analyze and discuss results in light of molecular biological knowledge (PO: 1,2,3)

CO3 Explain major steps in pairwise and multiple sequence alignment (PO: 3)

CO4 Explain principle and execute pairwise sequence alignment by dynamic programming (PO: 4,5)

CO5 Predict secondary and tertiary structures of protein sequences (PO: 4,5)

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modelling of proteins.
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target prediction tools.

DISSERTATION PHASE 1 & 2

BTY2PR1& 2
Semester III & IV
24 Credits

COURSE OUTCOME (CO)

CO1 In-depth knowledge of the chosen area of research (PO: 1,2)
CO2 Adapt to the research environment and understand how projects are executed in a research Laboratory (PO: 2,3)
CO3 Capability to critically and systematically integrate knowledge (PO: 3,4)
CO4 Identify issues that must be addressed within framework of specific thesis (PO: 4,5)
CO5 Competence in research design (PO: 4,5)

PLANNING & PERFORMING EXPERIMENTS:

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

THESIS WRITING:

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

RECOMMENDED ELECTIVES

BIOLOGICAL IMAGING

BTY2E21
Semester II
2 Credits

COURSE OUTCOME (CO)

CO1 Understand various imaging techniques used in biomedical science (PO: 1)

CO2 Able to compare and analyse advantages and disadvantages of various imaging techniques (PO: 1,2,3)

CO3 Learn to increase their resolution to improve qualitative and quantitative improvement in their performance (PO: 2,3)

CO4 Enlighten the perspectives and complexities of imaging techniques used in biomedical research (PO: 2,3)

CO5 Gain knowledge and skill on various imaging techniques for biomedical applications (PO:4,5)

UNIT I: WIDEFIELD FLUORESCENT MICROSCOPY: 3Hrs

One of the most basic techniques for live-cell imaging is widefield fluorescent microscopy. Standard inverted research grade microscopes can yield valuable results if you are imaging adherent cells, large regions of interest (such as organelles) or very thin tissue sections (less than 5 micrometer). In widefield, a CCD camera is usually used to capture images and the epi-fluorescence illumination source can be a mercury lamp, xenon lamp, LED's, etc. Each of light sources require carefully matched interference filters for specific excitation and emission wavelengths of your fluorophore of interest. With widefield microscopy, your specimen is only exposed to excitation light for relatively short time periods as the full aperture of emission light is collected by the objectives. Widefield fluorescence microscopy can be used in combination with other common contrast techniques such as phase contrast and differential interference contract (DIC) microscopy. This combination is useful when performing live-cell imaging to examine general cell morphology or viability while also imaging regions of interest within cells.

UNIT II: CONFOCAL LASER SCANNING MICROSCOPY (CLSM): 3Hrs

CLSM has ability to eliminate out-of-focus light and information. It is also possible to obtain optical serial sections from thicker specimens. A conjugate pinhole in optical path of confocal microscope prevents fluorescence from outside of focal plane from being collected by photomultiplier detector or imaged by camera. In CLSM, a single pinhole (and single focused laser spot) is scanned across specimen by scanning system. This spot forms a reflected epi-fluorescence image back on original pinhole. When specimen is in focus, fluorescent light from it passes through pinhole to detector. Any out-of-focus light is defocused at pinhole and very little of this signal passes through to detector meaning that background fluorescence is greatly reduced. The pinhole acts as a spatial filter for emission light from the specimen.

UNIT III: SPINNING DISC CONFOCAL MICROSCOPY (SDCM): 5Hrs

This method utilises a 'Nipkow Disc' which is a mechanical opaque disc which has a series of thousands of drilled or etched pinholes arranged in a spiral pattern. Each illuminated pinhole on disc is imaged by microscope objective to a diffraction-limited spot on region of interest on specimen. The emission from fluorophores passes back though Nipkow disc pinholes and can be observed and captured by a CCD camera. The effect of spinning disc is that many thousands of points on specimen are simultaneously illuminated. Using SDCM to examine a specimen means that real-time imaging (30-frames-per-second or faster) can be achieved, which is extremely useful if you are looking at dynamic changes within living cells over a wide spectrum of time-scales.

UNIT IV: LIGHT-SHEET FLUORESCENCE MICROSCOPY (LSFM, OR SPIM): 2Hrs

This method enables one to perform live-cell imaging on whole embryos, tissues and cell spheroids in vivo in a gentle manner with high temporal resolution and in three dimensions. One is able to track cell movement over extended periods of time and follow development of organs and tissues on a cellular level. The next evolution

of light-sheet fluorescence microscopy, termed lattice light-sheet microscopy as developed by Eric Betzig (Nobel Prize Laureate 2014 for PALM super-resolution microscopy) will even allow live-cell imaging with super-resolved in vivo cellular localization capabilities.

UNIT V: SUPER-RESOLVED FLUORESCENCE MICROSCOPY: 8Hrs

Super-Resolution in a Standard Microscope: From Fast Fluorescence Imaging to Molecular Diffusion Laws in Live Cells; Photoswitching Fluorophores in Super- Resolution Fluorescence Microscopy; Image Analysis for Single-Molecule Localization Microscopy Deconvolution of Nanoscopic Images; Super-Resolution Fluorescence Microscopy of the Nanoscale Organization in cells; Correlative Live-Cell and Super- Resolution Microscopy and Its Biological Applications; SAX Microscopy and Its Application to Imaging of 3D-Cultured Cells; Quantitative Super-Resolution Microscopy for Cancer Biology and Medicine.

UNIT VI: RE-SCAN CONFOCAL MICROSCOPY: 4Hrs

Structured Illumination Microscopy; Correlative Nanoscopy: AFM Super-Resolution (STED/STORM) ; Stochastic Optical Fluctuation Imaging.

REFERENCES:

1. Rajagopal Vadivambal, Digvir S. Jayas. (2015). Bio-Imaging: Principles, Techniques, and Applications. ISBN 9781466593671 - CAT# K20618.
2. Alberto Diaspro, Marc A. M. J. van Zandvoort. (2016). Super-Resolution Imaging in Biomedicine. ISBN 9781482244342 - CAT# K23483.
3. Taatjes, Douglas, Roth, Jürgen (Eds.). (2012). Cell Imaging Techniques Methods and Protocols. ISBN 978-1-62703-056-4.

COMPUTATIONAL BIOLOGY

BTY2E22
Semester II
2 Credits

COURSE OUTCOME (CO)

CO1 Understand the theory and practical experience of essentials to aid for all Omics drug design Program (PO: 1)

CO2 Advance required database extraction, integration, coding for computational tools and methods necessary for all Omics (PO: 2,3)

CO3 Create hypothesis for investigating specific contemporary biological questions (PO: 2,3)

CO4 Critically analyze and interpret results of their study with respect to whole systems (PO: 3,4,5)

CO5 Develop an understanding of the basic theory of these computational tools (PO: 3,4,5)

UNIT I: INTRODUCTION TO COMPUTATIONAL BIOLOGY BASICS AND BIOLOGICAL DATABASES: 4Hrs

Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases.

UNIT II: PAIRWISE AND MULTIPLE SEQUENCE ALIGNMENTS: 5Hrs

Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification.

UNIT III: GENOME ANALYSIS: 6Hrs

Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop

improvement. Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies.

UNIT IV: STRUCTURE VISUALIZATION: 3Hrs

Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD.

UNIT V: MOLECULAR MODELLING: 6Hrs

Significance and need, force field methods, energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: ab initio, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein interactions.

UNIT V: MOLECULAR MODELLING: 6Hrs

Significance and need, force field methods, energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: ab initio, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein interactions.

UNIT VI: STRUCTURE-BASED DRUG DEVELOPMENT: 6Hrs

Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extraprecision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings.

UNIT VII: LIGAND-BASED DRUG DEVELOPMENT: 6Hrs

Quantitative structure activity relationships; Introduction to chemical descriptors like 2D, 3D and Group-based; Radar plots and contribution plots and Activity predictions, Pharmacophore modeling, Pharmacophore-based screenings of compound library, analysis and experimental validation.

REFERENCES:

1. 1. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
3. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
4. Campbell, M & Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education.
5. Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library.
6. Gasteiger, J. & Engel,T. (2003), Chemoinformatics: a Textbook, Wiley Online Library.

DRUG DISCOVERY AND DEVELOPMENT

BTY2E23
Semester II
2 Credits

COURSE OUTCOME (CO)

CO1 Understand the basics of drug and drugable target (PO: 1)

CO2 Gain knowledge on various methods of drug designing (PO: 1,2)

CO3 Describe the general steps involved in drug discovery (PO: 1,2,3)

CO4 Explain the methods of target and lead identification and validation in drug discovery (PO: 3,5)

CO5 Know about ADME, Drug-Drug Interactions, Drug-Food Interactions, Drug toxicity and safety (PO: 4,5)

UNIT I: TARGET IDENTIFICATION AND MOLECULAR MODELLING: 7Hrs

Identification of target or drug leads associated with a particular disease by a number of different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Conceptualizing the automation of the HTS process and the importance of bioinformatics and data processing in identification of lead compounds; Rational drug design, based on understanding the three-dimensional structures and physicochemical properties of drugs and receptors; Modelling drug/ receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases.

UNIT II: LEAD OPTIMIZATION: 5Hrs

Identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity; Understanding structure activity relationship; Structure modification to increase potency and therapeutic index; Concept of quantitative drug design using Quantitative structure–activity relationship models (QSAR models) based on the fact that the biological properties of a compound are a function of its physicochemical parameters such as solubility, lipophilicity, electronic effects, ionization, stereochemistry, etc.; Bioanalytical assay development in support of in vitro and in vivo studies (LC/MS/MS, GC/MS and ELISA).

UNIT III: PRECLINICAL DEVELOPMENT: 5Hrs

Principles of drug absorption, drug metabolism and distribution - intestinal absorption, metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/ PD/TK studies; Scope of GLP, SOP for conduct of clinical & non clinical testing, control on animal house, report preparation and documentation Integration of non-clinical and preclinical data to aid design of clinical studies.

UNIT IV: DRUG MANUFACTURING: 4Hrs

Requirements of GMP implementation, Documentation of GMP practices, CoA, Regulatory certification of GMP, Quality control and Quality assurance, concept and philosophy of TQM, ICH and ISO 9000; ICH guidelines for Manufacturing, Understanding Impurity Qualification Data, Stability Studies.

UNIT V: CLINICAL TRIAL DESIGN: 4Hrs

Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation.

UNIT V: FUNDAMENTALS OF REGULATORY AFFAIRS AND BIOETHICS: 4Hrs

Global Regulatory Affairs and different steps involved, Regulatory Objectives, Regulatory Agencies; FDA guidelines on IND and NDA submissions, Studies required for IND and NDA submissions for oncology, HIV, cardiovascular indications, On-label vs. off-label drug use GCP and Requirements of GCP Compliance, Ethical issues and Compliance to current ethical guidelines, Ethical Committees and their set up, Animal Ethical issues and compliance.

REFERENCES:

1. Krogsgaard-Larsen et al. Textbook of Drug Design and Discovery. 4th Edition. CRC Press.
2. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
3. Nally, J. D. (2006) GMP for Pharmaceuticals. 6th edition. CRC Press
4. Brody, T. (2016) Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines. Academic Press.

ENVIRONMENTAL BIOTECHNOLOGY

BTY2E24
Semester II
2 Credits

COURSE OUTCOME (CO)

CO1 Understand the nature of various problems in environment (PO: 1)
CO2 Apply biotechnology to solve problems in water, air and soil environment (PO: 2,3)
CO3 Analyze the impact of pollution to environment (PO: 2,3)
CO4 Create mitigation methods for environmental problems (PO: 4,5)
CO5 Acquire biotechnological skills for abating environmental problems (PO: 4,5)

UNIT I: INTRODUCTION TO ENVIRONMENT: 6Hrs

Introduction to environment; pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology.

UNIT II: BIOREMEDIATION: 6Hrs

Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ).

UNIT III: ROLE OF MICROORGANISMS IN BIOREMEDIATION: 6Hrs

Application of bacteria and fungi in bioremediation: White rot fungi vs specialized degrading bacteria: examples, uses and advantages vs disadvantages; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration phytostabilization).

UNIT IV: BIOTECHNOLOGY AND AGRICULTURE: 11Hrs

Bioinsecticides: Bacillus thuringiensis, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (e.g. Trichoderma, Pseudomonas fluorescens); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.

UNIT V: BIOFUELS: 4Hrs

Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.

REFERENCES:

1. G. M. Evans and J. C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.
2. B. Ritmann and P. L. McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science.
3. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.

4. J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), Biofiltration for Air Pollution Control, CRC Press.
5. H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.
6. H. S. Peavy, D. R. Rowe and G. Tchobanoglous, (2013), Environmental Engineering, McGraw-Hill Inc.

MICROBIAL TECHNOLOGY

BTY2E41
Semester IV
2 Credits

COURSE OUTCOME (CO)

CO1 Understand application of microbial biotechnology for the welfare of mankind (PO: 1,2)
CO2 Apply microbial biotechnology to solve problems in different sectors (PO: 2,3)
CO3 Analyze the potential of different biotechnological tools for industrial purposes (PO: 2,3)
CO4 Create a model to address the emerging problem using modern biotechnological tools (PO: 3,4,5)
CO5 Acquire skills in the area of modern biotechnological tools (PO: 4,5)

UNIT I: INTRODUCTION TO MICROBIAL TECHNOLOGY: 8Hrs

Microbial technology in human welfare; Isolation and screening of microbes important for industry – advances in methodology and its application; Advanced genome and epigenome editing tools (e.g., engineered zinc finger proteins, TALEs/TALENs, and the CRISPR/Cas9 system as nucleases for genome editing, transcription factors for epigenome editing, and other emerging tools) for manipulation of useful microbes/ strains and their applications; Strain improvement to increase yield of selected molecules, e.g., antibiotics, enzymes, biofuels.

UNIT II: ENVIRONMENTAL APPLICATIONS OF MICROBIAL TECHNOLOGY: 6Hrs

Environmental application of microbes; Ore leaching; Biodegradation - biomass recycle and removal; Bioremediation - toxic waste removal and soil remediation; Global Biogeochemical cycles; Environment sensing (sensor organisms/ biological sensors); International and National guidelines regarding use of genetically modified organisms in environment, food and pharmaceuticals.

UNIT III: PHARMACEUTICAL APPLICATIONS OF MICROBIAL TECHNOLOGY: 6Hrs

Recombinant protein and pharmaceuticals production in microbes – common bottlenecks and issues (technical/operational, commercial and ethical); Attributes required in industrial microbes (Streptomyces sp., Yeast) to be used as efficient cloning and expression hosts (biologicals production); Generating diversity and introduction of desirable properties in industrially important microbes (Streptomyces/Yeast); Microbial cell factories; Downstream processing approaches used in industrial production process (Streptomyces sp., Yeast).

UNIT IV: FOOD APPLICATIONS OF MICROBIAL TECHNOLOGY: 7Hrs

Application of microbes and microbial processes in food and healthcare industries – food processing and food preservation, antibiotics and enzymes production, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors); Nonrecombinant ways of introducing desirable properties in Generally recognized as safe (GRAS) microbes to be used in food (e.g., Yeast) - exploiting the existing natural diversity or the artificially introduced diversity through conventional acceptable techniques (mutagenesis, protoplast fusion, breeding, genome shuffling, directed evolution etc.).

UNIT V: ADVANCES IN MICROBIAL TECHNOLOGY: 8Hrs

Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Limits of microbial genomics with respect to use in human welfare; Metagenomics and metatranscriptomics – their potential, methods to study and applications/use (animal and plant health, environmental clean-up, global nutrient cycles & global sustainability, understanding evolution), Global metagenomics initiative - surveys/projects and outcome, metagenomic library

construction and functional screening in suitable hosts – tools and techniques for discovery/identification of novel enzymes, drugs (e.g., protease, antibiotic) etc.

REFERENCES:

1. Lee, Y. K. (2013). Microbial Biotechnology: Principles and Applications. Hackensack, NJ: World Scientific.
2. Moo-Young, M. (2011). Comprehensive Biotechnology. Amsterdam: Elsevier.
3. Nelson, K. E. (2015). Encyclopedia of Metagenomics. Genes, Genomes and Metagenomes: Basics, Methods, Databases and Tools. Boston, MA: Springer US.
4. The New Science of Metagenomics Revealing the Secrets of Our Microbial Planet. (2007). Washington, D.C.: National Academies Press.
5. Journals: (a) Nature, (b) Nature Biotechnology, (c) Applied microbiology and biotechnology, (d) Trends in Biotechnology, (e) Trends in Microbiology,
   (f) Current opinion in Microbiology, (g) Biotechnology Advances,
   (h) Genome Research)
6. Websites: http://jgi.doe.gov/our-science/

PROTEIN ENGINEERING

BTY2E42
Semester IV
2 Credits

COURSE OUTCOME (CO)

CO1 Understand methods and strategies commonly used in protein engineering (PO: 1)
CO2 Analyse structure and construction of proteins by computer-based methods (PO: 1)
CO3 Describe structure and classification of proteins (PO: 2,3)
CO4 Analyse purity and stability of proteins and explain how to store them in best way (PO: 2,3)
CO5 Explain the uses of proteins for industrial and academic purposes (PO: 3,4,5)

UNIT I: INTRODUCTION TO PROTEIN ENGINEERING: 5Hrs

Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc. Protein engineering with unnatural amino acids and its applications.

UNIT II: STABILITY OF PROTEIN STRUCTURE: 5Hrs

Methods of measuring stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UV CD; Fluorescence; UV absorbance; ORD; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation.

UNIT III: APPLICATIONS: 5Hrs

Forces stabilizing proteins – Van der waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, etc., Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens etc., Application to devices with bacteriorhodopsin as an example; Engineering antibody affinity by yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery.

UNIT IV: COMPUTATIONAL APPROACHES: 5Hrs

Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles vis-à-vis those from mesophiles; Protein design, Directed evolution for protein engineering and its potential.

UNIT V: CASE STUDIES: 1Hr

Case Studies.

REFERENCES:

1. Edited by T E Creighton, (1997), Protein Structure: a Practical Approach, 2nd Edition, Oxford university press.
2. Cleland and Craik, (2006), Protein Engineering, Principles and Practice, Vol 7, Springer Netherlands.
3. Mueller and Arndt, Protein Engineering Protocols, 1st Edition, Humana Press.
4. Ed. Robertson DE, Noel JP, (2004), Protein Engineering Methods in Enzymology, 388, Elsevier Academic Press.
5. J Kyte; (2006), Structure in Protein Chemistry, 2nd Edition, Garland publishers.

NANOBIOTECHNOLOGY

BTY2E43
Semester IV
2 Credits

COURSE OUTCOME (CO)

CO1 Grasp the functional principles of nanobiotechnology (PO: 1,2)
CO2 Apply knowledge to practical nanobiotechnological applications (PO: 2,3)
CO3 Critically analyze methods and techniques in nanobiotechnology (PO: 2,3,5)
CO4 Design novel self-assembling nanostructures and nanodevices (PO: 2,3,5)
CO5 Develop essential skills for laboratory work and data analysis in nanobiotechnology (PO: 4,5)

UNIT I: INTRODUCTION TO NANOBIOTECHNOLOGY: 5Hrs

Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

UNIT II: NANO – FILMS: 5Hrs

Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

UNIT III: NANO – PARTICLES: 5Hrs

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

UNIT IV: APPLICATIONS OF NANO – PARTICLES: 5Hrs

Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

UNIT V: NANO – MATERIALS: 5Hrs

Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.

UNIT VI: NANO – TOXICITY: 5Hrs

Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment.

REFERENCES:

1. GeroDecher, Joseph B. Schlenoff, (2003); Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); Bionanotechnology: Lessons from Nature; Wiley-Liss
3. Neelina H. Malsch (2005), Biomedical Nanotechnology, CRC Press
4. Greg T. Hermanson, (2013); Bioconjugate Techniques, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.

VACCINES

BTY2E44
Semester IV
2 Credits

COURSE OUTCOME (CO)

CO1 Exposed to current developments in different areas of vaccines (PO: 1,2)
CO2 Develop fundamental concepts of human immune system and basic immunology (PO: 1,2)
CO3 Differentiate and understand immune responses in relation to infection and vaccination (PO: 2,3)
CO4 Able to understand requirement and designing of different types of vaccines (PO: 3,4,5)
CO5 Appreciate importance of conventional and new emerging vaccine technologies (PO: 4,5)

UNIT I: FUNDAMENTALS OF IMMUNE SYSTEM: 6Hrs

Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection.

UNIT II: IMMUNE RESPONSE TO INFECTION: 9Hrs

Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated) responses; Cell mediated responses: role of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.

UNIT III: IMMUNE RESPONSE TO VACCINATION: 8Hrs

Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.

UNIT IV: VACCINE TYPES & DESIGN: 3Hrs

History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.

UNIT V: VACCINE TECHNOLOGIES: 4Hrs

New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).

REFERENCES:

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology: the Immune System in Health and Disease. USA: Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). Kuby Immunology. New York: W.H. Freeman.
3. Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.
4. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.