Master of Science in Molecular Biology and Biotechnology (MBBT)

(Programme Code: MSCMBBT)

Program Educational Objectives (PEOs), Program Outcomes (POs) and Learning Outcomes (LOs)/ Course Outcomes (COs)

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Department of Molecular Biology and Biotechnology
Tezpur University Tezpur, Assam, India

Preamble

MSc in Molecular Biology and Biotechnology is a four semesters programme which encompasses theory and practical in different areas of Molecular Biology and Biotechnology. It also contains a research component through one semester project work to enhance the depth of knowledge and to develop research skills. The programme consists of 88 credits in total, of which theory component bears 50 credits and practical component is of 38 credits.

1. Introduction

MSc in Molecular Biology and Biotechnology (MBBT) is a DBT (Department of Biotechnology, Govt. of India) supported programme. Students are admitted through DBT conducted all India level entrance examination. Admitted students are awarded fellowship as per DBT guideline. The syllabus followed is as per the DBT approved syllabus. The course is an interdisciplinary programme aimed at developing skills to understand the complex biological phenomena at the molecular level. The course will enable the students to apply the gained knowledge and skills to develop sustainable technologies for better future. On completion of the course graduates will be competent to take up research in future or any other jobs in academia or biotech industries.

2. Qualification descriptors for the graduates

Knowledge and Understanding

i) In dept knowledge and understanding in Molecular Biology and Biotechnology
ii) In dept knowledge and understanding Biochemistry and Immunology
iii) In dept knowledge and understanding Cell biology and Microbiology

Skill and Technique

i) Graduates will be skilled in Molecular biology
ii) Graduates will be skilled in Recombinant DNA technology
iii) Graduates will be skilled in Bioprocess and microbial technology

Competence

i) Graduates will be competent to critically analyze biological problem
ii) Graduates will be able to carry out research in diverse areas of Molecular Biology and Biotechnology.
iii) Graduates will be empowered to take up bio-entrepreneurship initiatives
iv) Graduates will develop competence for employment in academia and/or in biotech industries.

3. Graduates Attributes

i) Graduates with knowledge and understanding in Molecular Biology and Biotechnology.
ii) Graduates with skilled human to contribute to the cutting-edge research in modern biology.
iii) Graduates trained in modern areas of molecular biology and biotechnology to contribute to the society through biotechnological approaches/interventions.

4. Program Outcomes (POs)

PO1: Graduates will gain fundamental knowledge in Molecular Biology and Biotechnology.

PO2: Graduates will be familiarize with the contemporary research in the field of Molecular Biology and Biotechnology as well as other related subjects

PO3: Graduates gain the applied knowledge of molecular biology and biotechnology for research and development.

PO4: Graduates will gain knowledge in molecular biology and biotechnology for academic and Biotech industry placement

PO5: Graduates will gain basic and applied knowledge to enable them for start-ups/bio-entrepreneurship.

5. Programme structure

Total Credits: 88

Structure of the curriculum

Course category		No of courses	Credits per course	Total Credits
I.	Core courses	6	3	18
II.	Core Courses	6	2	12
III.	Elective courses	7	3	3
IV.	Elective courses	1	2	2
V.	Project	1	20	20
	Total credits			88

6. SEMESTER-WISE SCHEDULE

SEMESTER I

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	BT 441: Biochemistry	3	0	0	3	3
	BT 443: Cell Biology	3	0	0	3	3
	BT 478: Microbiology	3	0	0	3	3
	BT 447: Molecular Genetics	3	0	0	3	3
	BT 453: Lab-I Biochemistry and Analytical Techniques	0	0	3	6	3
	BT 455: Lab-II Microbiology	0	0	3	6	3
	BT 449: Basics of Mathematics and Statistics	2	0	0	2	2
	BT 451: Basics of Chemistry and Physics	2	0	0	2	2

SEMESTER 2

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	BT 440: Molecular Biology	3	0	0	3	3
	BT 442: Immunology	3	0	0	3	3
	BT 444: Developmental Biology	3	0	0	3	3

	BT 448: Genomics and Proteomics	3	0	0	3	3
	BT 450: Lab-III Molecular Biology	0	0	3	6	3
	BT 452: Lab-IV Immunology	0	0	3	6	3
	BT 446: Bioinformatics	2	0	1	5	3
	BT 454: Biophysical methods and emerging technologies	2	0	0	2	2

SEMESTER 3

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	BT 457: Genetic Engineering	3	0	0	3	3
	BT 461: Bioprocess Engineering and Technology	3	0	0	3	3
	BT 471: Lab-V Genetic Engineering	0	0	3	6	3
	BT 473: Lab-VI Bioprocess Engineering and Technology	0	0	3	6	3
	BT 459: Molecular Diagnostics	2	0	0	2	2
	BT 469: Intellectual Property Rights, Biosafety and Bioethics	2	0	0	2	2
	BT 475: Critical analysis of classical papers and scientific communication skills	0	1	1	2	2
Electives	BT 463: Plant Biotechnology BT 465: Animal Biotechnology BT 467: Microbial Biotechnology BT 477: Computational Biology BT 479: Nanobiotechnology BT 499: Environmental Biotechnology	3	0	0	3	3

SEMESTER 4

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	BT 462: Project	0	0	40	40	20
Elective	BT 466: Bioentrepreneurship	2	0	0	2	2

7. Mapping of course with Program Outcomes (POs)

Course title	PO1	PO2	PO3	PO4	PO5
BT 441: Biochemistry	x	x	-	-	-
BT 443: Cell Biology	x	x	-	-	-
BT 478: Microbiology	x	x	x	x	-
BT 447: Molecular Genetics	x	x	x	x	-
BT 453: Lab-I Biochemistry and Analytical Techniques	x	x	x	x	-
BT 455: Lab-II Microbiology	x	x	x	x	x
BT 449: Basics of Mathematics and Statistics	x	x	-	-	-
BT 451: Basics of Chemistry and Physics	x	x	-	-	-
BT 440: Molecular Biology	x	x	-	-	-
BT 442: Immunology	x	x	-	-	-
BT 444: Developmental Biology	x	x	-	-	-
BT 448: Genomics and Proteomics	x	x	x	x	-
BT 450: Lab-III Molecular Biology	x	x	x	x	x
BT 452: Lab-IV Immunology	x	x	x	x	x
BT 446: Bioinformatics	x	x	-	-	-
BT 454: Biophysical methods and emerging technologies	x	x	x	x	-
BT 457: Genetic Engineering	x	x	x	x	-
BT 461: Bioprocess Engineering and Technology	x	x	x	x	x
BT 471: Lab-V Genetic Engineering	x	x	x	x	x
BT 473: Lab-VI Bioprocess Engineering and Technology	x	x	x	x	x
BT 459: Molecular Diagnostics	x	x	x	x	-
BT 469: Intellectual Property Rights, Biosafety and Bioethics	x	x	x	x	-
BT 475: Critical analysis of classical papers and scientific communication skills	x	x	x	x	-
BT 463: Plant Biotechnology	x	x	x	x	x
BT 465: Animal Biotechnology	x	x	x	x	x
BT 467: Microbial Biotechnology	x	x	x	x	x
BT 477: Computational Biology	x	x	x	x	x
BT 479: Nanobiotechnology	x	x	x	x	x
BT 499: Environmental Biotechnology	x	x	x	x	x
BT 462: Project	-	-	x	x	x
BT 466: Bioentrepreneurship	x	x	x	x	x

1. Evaluation plan:

- Understanding of subject is constantly evaluated through discussion and cross questioning.
- Examinations of specific duration (1 Hr/2 Hr)
- Assignment on critical problems related to specific subject.
- Constant assessment during laboratory courses and practical records.
- Individual and group oral presentations.
- Research paper presentation in seminar.
- Project work and report writing.
- Presentation (oral/poster) of project work.
- Research ability and research findings through project work
- Viva voce

2. DETAILED SYLLABUS

Semester I

BT 441: Biochemistry **L2-T1-P0-CR3**

Course outcome

CO1: *Ability to understand the composition of living matters*.
CO2: *Ability to understand and determine the structure of amino acid, protein, carbohydrate and lipids*
CO3: *Ability to understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.*

Course content

Unit I: Chemical basis of life
Composition of living matter; Water properties, pH, ionization and hydrophobicity; Emergent properties of biomolecules in water; Biomolecular hierarchy; Macromolecules; Molecular assemblies; Structure-function relationships

Unit II Structure and function of Amino acids:
Structure and functional group properties; Peptides and covalent structure of proteins; Elucidation of primary and higher order structures; Evolution of protein structure; Structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; Tools to characterize expressed proteins.

Unit III: Enzyme catalysis
General principles of catalysis; Enzyme characterization and Michaelis-Menten kinetics; Relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; Single substrate enzymes, Allosteric enzymes. Two-substrate kinetics and pre-steady state kinetics; Allosteric enzyme kinetics; Enzyme inhibition kinetics; Immobilization of enzymes. Kinetics of immobilization, external mass transfer resistance, Damköhler number, Effectiveness factor

Unit IV: Structure and function of carbohydrates and lipids
Sugars - mono, di, and polysaccharides; Suitability in the context of their different functions-cellular structure, energy storage, signaling; Glycosylation of other biomolecules - glycoproteins and glycolipids; Lipids - structure and properties of important members of storage and membrane lipids; lipoproteins. Biological membrane transport, membrane dynamics

Unit V: Bioenergetics
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-F0ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; 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.

Text books

1. Voet and J.G.Voet, Biochemistry, 3rd edition, John Wiley, New York, 2004.
2. D L Nelson and M M Cox, Lehninger Principles of Biochemistry, 7th edition, Macmilan 2017.
3. L. Stryer, Biochemistry, 5th edition, W.H. Freeman and Company, 2002.

Suggested readings

1. Thomas M Devlin (2010) Text of Biochemistry with Clinical Correlations, Wiley-Liss

BT 443: Cell Biology **L3-T0-P0- CR3**

Course outcomes

CO1: *Ability to understand three fundamental aspects in biological phenomenon: a) what to seek; b) how to seek; c) why to seek?*
CO2: *Ability to know about cells, organelles and biomolecules.*
CO3*: Ability to understand the various biological processes deeper and inclusive.*

Course content

Unit I: Techniques in Cell Biology

Advanced Microscopy: Confocal and immunofluorescence microscopy, FISH. Scanning and transmission microscopes, fixation and staining techniques for EM. Techniques for detection of Cancer.

Unit II: Cellular Division

Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis. Cell death: different modes of cell death and their regulation. Cell Cycle misregulation and cancer. Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, virus-induced cancer, metastasis

Unit III: Interaction of the cell with its environment

General principles of cell communication: cell-cell communications, cell-environment communications. Role of different adhesion molecules: Desmosomes, Hemi-desmosomes, Gap junctions, Tight Junctions, Plasmodesmata . Organelle Interconnectivity and communications.

Unit IV: Cell Organelles

Structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; endoplasmic reticulum and Golgi apparatus, lysosomes, cellular cytoskeleton, mitochondria, and chloroplasts. Nucleus, nucleolus and chromosomes. Organelle Interconnectivity and communication of Mitochondria with the endomembrane system.

Unit V: Cellular signaling

Signalling in normal cells: G-protein mediated signalling, RTK signalling, Ca^{++} signalling, Insulin Signalling, Ras-MAPK signalling, Wnt signalling. Hedgehog signalling, Toll-like receptor signaling Signalling pathways in Apoptosis and Cancer.

Textbooks

1. Karp G., Cell and Molecular Biology: Concepts and Experiments, 7th Edition (John Wiley & Sons, Inc., 2013).
2. Scott, M. P. et al, Molecular Cell Biology, 6^{th} Edition (W. H. Freeman, 2007).
3. Alberts, B. et al., Molecular Biology of the Cell, 5th Edition (Garland Publishing, 2008).

Suggested Readings

1. Pecorino, Lauren. Molecular biology of cancer: mechanisms, targets, and therapeutics. 4th Edition (Oxford university press, 2012.)

BT 478: Microbiology **L3-T0-P0- CR3**

Course outcome

CO1: *Ability to identify the major categories of microorganisms and analyze their classification, diversity, and ubiquity.*

CO2: *Ability to identify and demonstrate the structural, physiological, and genetic similarities and differences of the major categories of microorganisms.*

CO3: *Ability to control microbial growth, evaluate the interactions between microbes, hosts and environment*

Course content

Unit I: Microbial characteristics

Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; antimicrobial resistance.

Unit II: Microbial diversity

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: C**ontrol of microorganisms**

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

Unit IV: Virology

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

Host-pathogen interaction; symbiosis (Nitrogen fixation and ruminant symbiosis); microbial communication system; bacterial quorum sensing; microbial biofilm; prebiotics and probiotics**,** microbiome

Unit VI: Environmental microbiology

Ecological impact of microbes; microbes and nutrient cycles; microbial fuel cells

Textbooks

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.

Suggested Readings

1. Matthai, W., Berg, C. Y., & Black, J. G. (2005). *Microbiology, Principles and Explorations*. Boston, MA: John Wiley & Sons.

BT 447: Molecular Genetics **L3-T0-P0 -CR3**

Course outcome

CO 1: *Ability to understand the fundamental molecular principles of genetics.*
CO 2: *Ability to establish the relationship between phenotype and genotype in human*
CO 3: *Ability to do mapping and understand how gene expression is regulated.*

Course content

Unit I: Genetics of bacteria and bacteriophages

Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosome 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

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

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: Human Molecular Genetics

Nomenclature of human genes and mutations, types of mutations, Phenotype, Genotype, Pedigree analysis- construction and analysis of monogenic diseases/disorders (Autosomal-dominant and recessive, X linked-dominant and recessive, Mitochondrial, multifactorial inheritance/complex traits, SNPs-Types & application, Y chromosome, Fluorescence In-Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH), Linkage analysis, GWAS.

Unit V: Population genetics and genetics of evolution

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

Unit VI: Quantitative genetics of complex traits (QTLs) & Plant genetics

Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs, Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.

Textbooks

1. Pierce, B. A. Genetics: A Conceptual Approach. 5th Edition, W.H. Freeman publication. 2013. ISBN-13: 978-1464109461
2. Tamarin R H. Principles of Genetics, 7th Edition, Mcgraw Higher Ed Publishers, 2010. ISBN: 9780070486676.

Suggested Readings

1. Smith, J. M.. Evolutionary Genetics. Oxford: Oxford University Press. 1998. ISBN-13: 978-0198502319.
2. Strachan, T and Read, A. P, Human molecular genetics, 4th Edition, Garland Publishing, 2010. ISBN-13: 978-0815341499.
3. Edward S. T. Michael. C, M. F. Smith, Essential medical genetics, 6th Edition, Wiley-Blackwell publications, 2011. ISBN: 978-1405169745.
4. Susan Elrod, Schaum's Outline of Genetics, Fifth Edition (Schaums Outline Series), McGraw-Hill Education; 5 edition, 2010. ISBN-13: 978-0071625036.

BT 449 Basic of Mathematics and Statistics L2-T0-P0- CR2

Course outcome

CO1: *Ability to understand the relation between mathematics and statistics.*
CO2: *Ability to recognize the importance and value of mathematical and statistical thinking.*
CO3: *Ability to solve problems of biology and other biological related disciplines.*

Course content

Unit I: Algebra

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:

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

Unit III: Mathematical Models in Biology

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 III: Statistics

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.

Textbooks

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.

Suggested Readings

1. Billingsley, P. (1986). Probability and Measure. New York: Wiley.
2. Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press.
3. Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences.New York: Wiley.

BT 451 Basic Chemistry and Physics **L2-T0-P0- CR2**

Course outcome

CO1: *Ability to understand the physical theories in biological systems.*
CO2: *Ability to understand the chemical principles underlying all biological processes.*

Course content

Unit I: Basics Physics for Biologist

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: Basics Chemistry for Biologist

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).

Textbooks

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.

Suggested Readings

1. Mahan, B. H. (1965). *University Chemistry*. Reading, MA: Addison-Wesley Pub.
2. Cantor, C. R., & Schimmel, P. R. (2004). *Biophysical Chemistry*. San Francisco: W.H. Freeman.

BT 453 Lab I Biochemistry and Analytical Techniques L0-T0-P3- CR3

Course outcome

CO1: *Ability to recognize and demonstrate the principles of laboratory instruments used in biochemical experiments.*
CO2: *Ability to perform biochemistry experiments.*
CO3: *Ability to interpret the results of biochemical experiments.*

Course content

Detail Syllabus

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 Enzyme Kinetic Parameters: Km, Vmax and Kcat.
6. Experimental verification that absorption at OD_{260} 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.

Practical Book

1. An Introduction to Practical Biochemistry Paperback – 1 Jul 2017 David Plummer (Author). Publisher: McGraw Hill Education; 3 edition (1 July 2017) ISBN-10: 9780070994874
2. Biochemical Methods by S. Sadasivam (Author) Publisher: New Age International Pvt Ltd Publishers; Third edition (1 January 2018). ISBN-10: 8122421407

BT 455 Lab II Microbiology **L0-T0-P2- CR2**

Course outcome

CO1: *Ability to isolate, characterize and identify common bacterial organisms.*
CO2: *Ability to determine bacterial load of different samples and preserve bacterial cultures.*
CO3: *Ability to perform antimicrobial sensitivity test and determine the mechanism of antibiotic action.*

Course content

Detail Syllabus

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:
5. *Bacillus, E. coli, Staphylococcus, Streptococcus, etc.*
6. Preparation of bacterial smear and Gram's staining.
7. Enumeration of bacteria: standard plate count.
8. Antimicrobial sensitivity test and demonstration of drug resistance.
9. Maintenance of stock cultures: slants, stabs and glycerol stock cultures
10. Determination of phenol co-efficient of antimicrobial agents.
11. Determination of Minimum Inhibitory Concentration (MIC)
12. Isolation and identification of bacteria from soil/water samples.

Practical books

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*

Semester II

BT 440 Molecular Biology **L3-T0-P0- CR3**

Course outcome

CO1: *Ability to know the three fundamental aspects in biological phenomenon: The central dogma*

CO2: *Ability to know the molecular basis of replication, transcription and translation.*

CO3: *Ability to know various biological processes in molecular level.*

Course content

Unit I: Nucleic acid structure and function

Introduction to molecular biology, chemical nature of the genetic material: Avery et al experiment; Hershey and Chase experiment; DNA double helix: endo- and exo sugars, syn- and anti- conformation of N-bases, W-C and Non-W-C base pairing, roll, slide and twist in DNA DNA supercoiling: Super coiling, superhelical density, Lk, Wr and Tw, topoisomerases, Genome complexity: DNA re-association kinetics, Cot curve, C-value paradox, repetitive and unique sequences.

Unit II: DNA to Chromosome

Introduction to genomes of bacteria, eukaryotes, organelle and viruses: linear and circular chromosomes, single stranded and doubles stranded DNA/RNA viral genome, Organization DNA into chromosomes: DNase I sensitive regions, heterochromatin and euchromatin, DNA methylation (e.g. X chromosome inactivation)

Unit III: Replication,

DNA replication: Chemistry of replication, DNA polymerases, synthesis of leading and lagging strands DNA replication in prokaryotes and eukaryotes: initiation, elongation and termination; regulation of replication, segregation of chromosomes to daughter cells

Unit IV: DNA repair and recombination

Errors in DNA and repair: pyrimidine dimer, nick and gap in DNA, AP sites, base mispairing; photolyase; mismatch, base excision and nucleotide-excision repair mechanisms, SOS response. translation DNA synthesis, regulation of Y-family of polymerases in bacteria and eukaryotes, Non-homologous end joining (NHEJ), Homologous recombination, Holliday model, double strand break repair model, gene conversion, mating type switching in yeast, site specific recombination, FLP/FRT and Cre-Lox recombination, transposition- DNA transposons and retroposons and mechanism.

Unit IV: Transcription and RNA processing

Prokaryotic transcription: RNA polymerase, promoters, sigma factors, initiation, elongation and termination (Rho-dependent and independent), Eukaryotic transcription: types of RNA polymerases, promoters and enhancers, transcription factors, TBP and TAFs, RNA modification: splicing, alternative splicing, capping, polyA addition, editing, rRNA processing, base modification, tRNA processing and modifications

Unit V: Translation

Genetic code, Translation initiation, elongation, termination, ribosome recycling in prokaryotes and eukaryotes, IRES in eukaryotes Codon anticodon interaction, ribosome profiling, co-translational protein folding

Unit VI: Regulation of gene expression

Transcriptional regulation in bacteria: regulation of lac and trp operons in bacteria, regulation by sigma factors, anti-sigma factors, anti-sense RNA, two component regulatory system in bacteria, Concept of eukaryotic gene regulation RNA in gene regulation: RNA binding proteins, RNA stability, UTR mediated gene regulation, Riboswitch, RNA interference , nonsense and nonstop mediated decay, transportPost translational gene regulation: covalent modification of proteins: phosphorylation, methylation, acetylation adenylation, arginylation,

Textbooks

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:
3. W.H. Freeman. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). *Lewin's Genes XI*.

Suggested Readings

1. Burlington, MA: Jones & Bartlett Learning. Cooper, G. M., & Hausman, R. E. (2013). *The Cell: a Molecular Approach* (6th Ed.).

BT 442 Immunology **L3-T0-P0- CR3**

Course outcome

CO1: *Ability to design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses.*

CO2: *Ability to determine the immune responses during infection (viral or bacterial) by looking at cytokine profile.*

CO3: *Ability to apply the knowledge of vaccinology and clinical immunology in different pharmaceutical companies.*

Course content

Unit I: Fundamental concepts and overview of the immune system

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

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

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

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

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

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.

Textbooks

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). *Kuby Immunology*. New York: W.H. Freeman. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). *Clinical Immunology*. London: Gower Medical Pub.
2. Paul, W. E. (2012). *Fundamental Immunology*. New York: Raven Press
3. Parham, P. (2005). *The Immune System*. New York: Garland Science.

Suggested Readings

1. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). *Janeway's Immunobiology.* New York: Garland Science.
2. Goding, J. W. (1996). *Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology*. London: Academic Press.

BT 444 Developmental Biology **L3-T0-P0- CR3**

Course outcome

CO1: *Ability to understand processes like embryonic development: gametogenesis, fertilization, differentiation and patterning events leading to organization of tissues/organs in plant and animal.*

CO2: *Ability to understand the multicellular levels of biological organization*

CO3: *Ability to understand various developmental process of biological systems.*

Unit I: History of Developmental Biology and Developmental genetics

Historical perspective and different techniques in developmental biology. An overview of model organisms. Developmental events and genetics, Genes in early development, control of gene expression and cell signaling. Early embryonic development: Gametogenesis, Fertilization, Cleavage I, Cleavage II, Gastrulation I, Gastrulation II.

Unit II: Embryogenesis and Patterning of body plan

Embryogenesis in animals: Embryogenesis and early pattern formation in animal, cell lineages and developmental control genes in *C. elegans*. Laying of body axis planes, Axis formation and anterior/posterior patterning in amphibians/ C. elegans/ mouse and Drosophila (maternal effect genes, segmentation, zygotic genes, Hox genes), Sex determination in Drosophila.

Unit III: Cell differentiation

Differentiation of Specialized Cells: Stem cell differentiation and cell fate determination, cell adhesion and migration and morphogenesis; Blood cell formation; Differentiation of cancerous cells and role of protooncogenes.

Unit IV: Plant Embryonic Development, Differentiation and Patterning

Embryogenesis in plant: Development of Male and Female Gametophyte. Embryogenesis. Axial and Radial patterning in plants. Developmental control genes in a model plant (*Arabidopsis*). Organization of Shoot Apical Meristem (SAM) and Root Apical Meristems (RAM). Floral meristems and development. Leaf Ontogeny.

Unit V: Factors influencing Plant Development:

Light Signaling: Photomorphogenesis and Skotomorphogenesis. Role of Micro RNAs. Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

Textbooks

1. Plant Physiology & Development by Lincoln Taiz, Eduardo Zeiger, Ian M. Møller, and Angus Murphy, (2014) 6th Edition, Sinauer Associates Inc.

BT 446 Bioinformatics **L2-T0-P1-CR3**

Course outcome

CO1: *Ability to use computational tools for bioinformatics*
CO2: *Ability to investigate specific contemporary biological questions using bioinformatics.*
*C*O3: *Ability to critically analyze and interpret the results of their study using computational tools.*

Course content

Unit I: 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

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

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:

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:

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.

Textbooks

1. Lesk, A. M. (2002). *Introduction to Bioinformatics*. Oxford: Oxford University Press.
2. Pevsner, J. (2015). *Bioinformatics and Functional Genomics*. Hoboken, NJ.: Wiley-Blackwell.
3. Bourne, P. E., & Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss.

Suggested Readings

1. Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Baxevanis, A. D., & Ouellette, B. F. (2001). *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins*. New York: Wiley-Interscience.
3. Lesk, A. M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics.* Oxford: Oxford University Press.

BT 448 Genomics and proteomics **L3-T0-P0- CR3**

Course outcome

CO1: *Ability to understand the fundamentals of genomics and proteomics, transcriptomics and metabolomics.*

CO2: *Ability to do genome sequencing and mapping to understand the evolutionary process and compare between organisms*

CO3: *Ability to understand the biological systems using genomics, transcriptomics and proteomics.*

Course content

Unit I: Basics of Genomics and Proteomics

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

Unit II: Genome mapping

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 project

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

Unit IV: Comparative Genomics

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

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

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.

Textbooks

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.

Suggested Readings

1. Campbell, A. M., & Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.

BT 454 Biophysical methods and emerging technologies L2-T0-P0- CR2

Course outcome

CO1: *Ability to understand the theoretical basis of some of the latest technologies in the area of biotechnology.*
CO2: *Ability to know the applications of these technologies.*
CO3: *Ability to apply these technologies for project and research.*

Course content

Unit I: Microscopy:
Principles and application of electron microscopy, optical microscopy, phase contrast and fluorescence microscopy. Confocal microscopy, FRET, FRAP, TIRF.

Unit II: Spectroscopy:
UV, Visible, Photoluminescence; and Raman Spectroscopy; Theory and application of Circular Dichroism; FTIR, MS, NMR, PMR, ESR and Plasma Emission spectroscopy. Mass Spectroscopy: 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: Chromatography
Chromatographic methods for macromolecule separation – Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC

Unit IV: Electrophoretic
Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary gel electrophoresis; 2D-gel Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis.

Unit V: Structural Biology
X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, small-angle X-ray scattering, Atomic force microscopy.

Unit VI: Emerging technologies
CRISPR-CAS: History of its discovery, development of applications for in vivo genome engineering for genetic studies, Nanobodies: 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 etc

Textbook

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. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 1. 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.

Suggested Readings

1. Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th
2. Edition, Cambridge University Press, 2000. 4. D. Holme& H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.

BT 450 Lab III Molecular Biology **L0-T0-P3-CR3**

Course outcome

CO1: *Ability to isolation of vectors and cloning of gene into vectors for protein expression and purification.*
CO2: *Ability to apply these practical knowledge and experience in biotech industries.*
CO3: *Ability to fundamental and applied research in the field of biology.*

Course content

1. Plasmid DNA isolation and DNA quantitation: Plasmid minipreps
2. Restriction digestion
3. Preparation of competent cells.
4. Restriction Enzyme digestion of DNA
5. Agarose gel electrophoresis
6. Purification of DNA from an agarose gel
7. DNA Ligation
8. Transformation of E.coli with standard plasmids
9. Polymerase Chain reaction using standard primers

Practical books

1. Microbiology Laboratory Manual, 5th Edition, James G. Cappucciino and Natalie Sherman
2. Molecular Cloning A Laboratory Manual 1 3rd Edition, J. Sambrook, E.F Fristsch and T. Maniatis
3. Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis

BT 452 Lab IV Immunology **L0-T0-P3--CR3**

Course outcome

CO1: *Ability to conduct immunological experiments.*
CO2: *Ability to conduct different antigen and antibody interactions.*
CO3: *Ability to isolate different lymphocyte cells etc. and use them in respective research work.*

Course content

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.

Practical books

1. Molecular Cloning A Laboratory Manual 1 3rd Edition, J. Sambrook, E.F Fristsch and T. Maniatis
2. Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis

Semester III

BT 457 Genetic Engineering L3–T0–P0-CR3

Course outcome

CO1: *Ability to isolate gene from any organism and amplify using PCR.*
CO2: *Ability to clone gene in cloning and expression vectors and transform them in suitable host.*
CO*3: Ability to express the recombinant protein in different host.*
CO4: *Ability to do gene silencing and editing.*

Course content

Unit I: Introduction and tools for genetic engineering

Overall impact of genetic engineering in modern society; Tools required for genetic engineering experiments –host strains; restriction endonucleases, restriction mapping, restriction-modification methylases; DNA and RNA ligase,DNA ligation using: cohesive-ended and blunt-ended DNA fragments; linkers, adaptors; homopolymeric tailing, nucleic acids modifying enzymes;. Methods for protein-DNA, protein-RNA and protein-protein interactions (co-immunoprecipitation, pull-down assay, mammalian two-hybrid and yeast-two hybrid assay) .

Unit II: Nucleic acid hybridisation methods

Radioactive and non-radioactive labelling of nucleic acids and proteins, southern, northern, western, south-western, far western, eastern, colony, fluorescence in situ hybridisation (FISH) and detection of chromosomal abnormalities.

Unit III: Polymerase chain reaction and its application

Principles of PCR: primer design; fidelity of thermostable DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR; site-specific mutagenesis *in vitro* and *in vivo*; methods of mutation detection (SSCP, DGGE, RFLP). PCR in molecular diagnostics (viral and bacterial detection).

Unit IV: **Molecular vectors and expression systems**

Plasmids; Bacteriophages; M13 vectors; pUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Ti plasmid and Ri plasmid based vectors Construction of cDNA and genomic DNA libraries ; library screening methods Transformation, transduction and transfection methods. Expression vectors. Overexpression of recombinant protein in bacteria, Baculovirus, yeast and mammalian cells; Inclusion bodies formation and strategies to overcome; purification of recombinant proteins.

Unit V: Application of Genetic engineering

Gene silencing techniques: siRNA and miRNA construction of shRNA vectors; methods to generate transgenic animals and plants; DNA and protein microarrays genome editing technologies; ZFNs, TALEN, Cre-Lox and CRISPR/Cas9) system): Gene therapy;

Textbooks

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.

Suggested Readings

1. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub. 4. Selected papers from scientific journals, particularly Nature & Science.
2. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

BT 459: Molecular Diagnostics **L3-T0-P0--CR3**

Course outcome

CO1: *Ability to demonstrate various molecular procedures*

CO2: Ability to apply the knowledge of genomics, proteomics and metabolomics that could be employed in the early diagnosis and prognosis of human diseases.

Course content

Unit I: Genome biology in health and disease

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

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

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

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

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

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

Quality oversight; regulations and approved testing.

Textbooks

1. Coleman, W. B., & Tsongalis, G. J. (2010). *Molecular Diagnostics: for the Clinical Laboratorian*. Totowa, NJ: Humana Press.

Suggested Readings

1. Campbell, A. M., & Heyer, L. J. (2006). *Discovering Genomics, Proteomics, and Bioinformatics*.
2. San Francisco: Benjamin Cummings. 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: Principles and Applications of Recombinant DNA*. Washington, DC: ASM Press.

BT 461: Bioprocess Engineering and Technology L3-T0-P0- CR3

Course outcome

CO1: *Ability to isolate and grow microorganism which have industrial relevance.*
CO2: Ability to do stoichiometric calculations for growth and yield by microrganisms.
CO3: Ability to operate fermenters for bio-based products.

Course content

Unit I: Basic principles of biochemical engineering

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

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

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

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

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

Mechanism of enzyme function and reactions in process techniques; enzymaticbioconversions 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

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

Textbooks

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.

Elective I

BT 463: Plant Biotechnology L3-T0-P0- CR3

Course outcome

CO1: Ability to to manipulate plants using biotechnological tools.
CO2: Ability to use biotechnological intervention in plant for benefit of human being
CO3: Ability to conduct experiments like tissue culture, genetic transformation and molecular breeding of plants

Course content

Unit I: Plant tissue culture
Historical perspective; totipotency; organogenesis; Somatic embryogenesis; tissue culture media- nutrients and plant hormones, sterilization techniques; initiation and maintenance of callus and suspension cultures; single cell clones, applications of tissue cultures micropropagation.

Unit II: **Somaclonal variation**
Androgenesis and embryogenesis, their applications. Protoplast culture and somatic hybridization - isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production. Synthetic seed production

Unit III: **Genetic engineering**
Agrobacterium-plant interaction; Ti and Ri plasmids: disarmed Ti plasmid, opines and their significance; Molecular mechanism of T-DNA transfer; Genetic transformation - *Agrobacterium*-mediated gene delivery; cointegrate and binary vectors and their utility; screenable and selectable markers; characterization of transgenic plants.

Unit V: Other **methods of gene transfer into plants**
Direct gene transfer - PEG-mediated, electroporation, particle bombardment, alternative methods, chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing (ZFN, CRISPR/Cas, TALEN)

Unit VI: Application of transgenics
Insect resistance, virus resistance, abiotic stress tolerance, longer shelf life (including strategies for suppression of endogenous genes), male sterility, enhanced nutrition (golden rice), edible vaccines, phytoremediation, synthetic biology- production of biochemicals for healthcare (Phytopharmaceuticals) and industry

Unit VII: Omics technologies
Genomics, Transriptomics, Metablomics; genome sequencing strategies, Bioinformatics tools and genome annotation, forward and reverse genetic strategies; gene, promoter and enhancer traps for gene discovery, differential gene expression analysis- microarray and RNAseq. VIGS and RNAi.

Textbooks

1. Slater, A., Scott, N. W., & Fowler, M. R. (2008). *Plant Biotechnology: an Introduction to Genetic Engineering*. Oxford: Oxford University Press.

2. Slater, A., Scott, N. W., & Fowler, M. R. (2003). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford: Oxford University Press.

Suggested Readings

1. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons.
2. Umesha, S. (2013). *Plant Biotechnology.* The Energy And Resources.

BT 465: Animal Biotechnology **L3-T0-P0- CR3**

Course outcome

CO1: Ability to manipulate animal using biotechnological tools
CO2: Ability to improve the quality and yield of animals using biotechnological interventions.
CO3: Ability to do experiments related to genetic transformation and molecular breeding of animals.

Course content

Unit-I: Animal Cell Culture:
Brief history of animal cell culture; Basic requirement for animal cell culture; Cell culture media, serum and reagents; Culture of mammalian cells; tissue and organs; Primary and secondary cell culture; Continuous cell lines; Suspension culture; Common cell culture contaminants; Application of animal cell culture for toxicity study and production of vaccines and pharmaceutical proteins; Stem cells and their application.

Unit-II: 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; cryopreservation of embryos; embryo transfer technology.

Unit-III: Diagnostic methods:
Radio immunoassays; Immunoblotting; nucleic acid probe hybridization; PCR, Real time PCR; Nucleic acid sequencing; Molecular diagnostics of pathogen in animals.

Unit-IV: 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-V: Animal genomics:
Different methods of characterization of animal genomes; SNP, STR, QTLs, RFLP, AFLP, RAPD; Genetic basis for disease resistance in animals; Gene knock out technology and Animal models for human genetic disorders.

Unit-VI: DNA forensics:
Immunological and nucleic acid based methods for identification of animal species; detection of adulteration in meat using DNA based methods; identification of wild animal species using DNA based methods using different parts including bones, hair, blood, skin and other parts of the confiscated by anti poaching agencies; Human forensics; bio-terror agents; Bio-crimes and Bio-terrorism.

Textbooks

1. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.
2. Glick, B.R., & Pasternak, J.J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.; ASM Press.

Suggested Readings

1. Pinkert, C. (2006). Transgenic Animal Technology, Academic Press.

2. Masters, John R.W. (2000). Animal Cell Culture – A Practical Approach, Oxford University Press.
3. Gordon, I. (2005). Reproductive Technologies in Farm Animals. Oxford. CAB International.

BT 467: Microbial Technology **L3-T0-P0- CR3**

Course outcome

CO1: *Ability to conduct experiments in microbial technology.*
CO2*: Ability to apply the knowledge of microbial technology for cleaning environment.*
CO3: *Ability to apply the knowledge of microbial technology in food and pharmaceutical industries.*

Course content

Unit I Introduction to microbial technology

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

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

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

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); Non-recombinant 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

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.*

Textbooks

1. Lee, Y. K. (2013). *Microbial Biotechnology: Principles and Applications*. Hackensack, NJ: World Scientific.
2. Moo-Young, M. (2011). *Comprehensive Biotechnology*. Amsterdam: Elsevier.

Suggested Readings

1. Nelson, K. E. (2015). Encyclopedia of Metagenomics. *Genes, Genomes and Metagenomes: Basics, Methods, Databases and Tools*. Boston, MA: Springer US.
2. *The New Science of Metagenomics Revealing the Secrets of Our Microbial Planet*. (2007). Washington, D.C.: National Academies Press.
3. 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)
4. Websites: http://jgi.doe.gov/our-science/

BT 477: Computational Biology **L3-T0-P0-CR3**

Course outcome

CO1: *Ability to use computational tools in biological systems.*

CO2: *Ability to investigate specific contemporary biological questions using computational tools.*

CO3: Ability to design experiment or develop appropriate tools for understanding biological system.

Course content

Unit I: Introduction to computational Biology basics and biological databases

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

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

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

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

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

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. Extra-precision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings.

Unit VII: Ligand based drug development

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.

Textbooks

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.

Suggested Readings

1. Lesk, A. M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics*. Oxford: Oxford University Press.
2. Campbell, M & Heyer, L. J. (2006), *Discovering Genomics, Proteomics and Bioinformatics*, Pearson Education.
3. Oprea, T. (2005). C*hemoinformatics in Drug Discovery*, Volume 23. Wiley Online Library.
4. Gasteiger, J. & Engel,T. (2003), *Chemoinformatics: a Textbook*, Wiley Online Library.

BT 479: Nano Biotechnology **L3-T0-P0-CR3**

Course outcome

CO1: Ability to design and synthesize various nano materials.
CO2: Ability to apply the nano materials in various biotechnological applications.

Course content

Unit I Introduction to nanobiotechnology

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

Unit II Nano – films

Thin films; Colloidal nanostructures; Self Assembly, Nano vesicles; Nano spheres; Nanocapsules and their characterization

Unit III Nanoparticles

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 Application of nanoparticles

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

Unit V Nanomaterials and Nanotoxicity

Nanomaterials for catalysis, development and characterization of nanobiocatalysts, Introduction safety and basics of nanotoxicity, Models and assays for Nanotoxicity; Containment of nanomaterials

Textbooks

1. GeroDecher, Joseph B. Schlenoff, (2003); Multilayer Tin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA
2. Greg T. Hermanson, (2013); Bioconjugate Techniques, (3rd Edition); Elsevier

Suggested Readings

1. David S. Goodsell, (2004); Bionanotechnology: Lessons from Nature; Wiley-Liss Neelina H. Malsch (2005), Biomedical Nanotechnology, CRC Press

BT 462: Environmental Biotechnology **L3-T0-P0-CR3**

Course outcome

CO1: Ability to understand the basic microbiological, molecular and analytical methods used in environmental biotechnology.

CO2: Ability to use the tools of biotechnology in environmental applications.

Unit I: 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

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 Microorganism in Bioremediation

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

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: 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.

Textbooks

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.

Suggested Readings

1. J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), Biofiltration for Air Pollution Control, CRC Press.
2. H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.

BT 469: Intellectual Property Rights, Biosafety and Bioethics L3-T0-P0-CR3

Course outcome

CO1: Ability to establish the intellectual property rights of any material.
CO2: Ability to protect products derived from biotechnology research and issues related to application and obtaining patents.
CO3: Ability to assess the risk of products derived from recombinant DNA research.
CO4: Ability to release genetically modified organisms in the environment as per the guidelines.
CO5: Ability to compile as per the national and international regulations related to biological, biomedical, health care and biotechnology research

Course content

Unit I: Introduction to IPR

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

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

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

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

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.

Textbooks:

1. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy*. New Delhi: Tata McGraw-Hill Pub.
2. Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.

Suggested Readings

1. 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/
2. *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI*Complete Reference to Intellectual Property Rights Laws*. (2007). Snow White Publication

BT 471: Lab V Genetic Engineering **L0-T0-P3-CR3**

Course outcome

CO1: Ability to isolate gene and clone in cloning and expression vectors.
CO2: Ability to transform and express recombinant protein in expression host.
CO3: *Ability to isolate and characterize the recombinant protein.*

Detail syllabus

1. Amplification of gene of interest by Polymerase Chain Reaction and analysis by agarose gel electrophoresis
2. Restriction digestion of insert and vector; Ligation of digested insert and vector
3. Transformation of recombinant vector into expression host and confirmation of the insert by Colony PCR and Restriction mapping
4. Induction of expression host using IPTG and over expression of recombinant protein,
5. Purification of His-Tagged protein on Ni-NTA columns. Concept of soluble proteins and inclusion body formation in *E. coli*, SDS-PAGE analysis

Practical book:

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

BT 473: Lab VI Bioprocess Engineering and Technology L0-T0-P3-CR3

Course outcome

CO1: Ability to investigate, design and conduct experiments, analyze and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems.
CO2: Ability to apply the skills and knowledge in solving problems typical of bio industries and research.

Course content

1. Basic Microbiology techniques
   Isolation of microorganisms from soil samples and Scale up from agar plate to shake flask culture.
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. Unit operations a) Microfiltrations: Separation of cells from broth. b) Bioseparations: Various chromatographic techniques and extractions.
5. Bioanalytics
   Analytical techniques like HPLC, FPLC, GC, GC-MS etc. for measurement of amounts of products/substrates.

Textbooks:

1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.
2. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York:M. Dekker.

Suggested Readings

1. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.

BT 475: Critical analysis of classical papers and scientific communication skills **L0-T1-P1-CR2**

Course outcome

CO1: Ability to familiarize students with classic literature to make them appreciate how ground-breaking discoveries were made without, necessarily, use of high-end technologies.
CO2: Ability to conceptualize hypothesis and develop methods of addressing the hypothesis with readily available technology.
CO3: Ability to deliver scientific communication.

Course content

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

Cell Biology

1. A protein-conducting channel in the endoplasmic reticulum Simon SM AND Blobel G.; Cell. 1991 May 3;65(3):371 80
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
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
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
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
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
7. Kinesin walks hand-over-hand Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8

Developmental Biology/ Genetics

1. Mutations affecting segment number and polarity in *Drosophila* Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980
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

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

Semester IV

BT 462: Project **L0-T0-P40-CR20**

Course outcome

CO1: *Ability to formulate a scientific question and present scientific approach to solve the problem.*
CO2: *Ability to interpret, discuss and communicate scientific results in written form.*
CO3: *Ability to write scientific proposal.*

Students are allowed to choose their projects based on the research topics provided by the faculty members. The choice of research topic is based on CGPA of their previous semester.

Mode of Assessment:

Assessment will be done by thesis evaluation, viva voce and final presentation (oral/poster).

BT 466: Bioentrepreneurship **L2-T0-P0-CR2**

Course outcome

CO1: *Ability to identify scope for entrepreneurship in biosciences.*
CO2: *Ability to begin a career in entrepreneurship.*
CO3: *Ability to build up a strong network within the industry.*

Course content

Unit I: Innovation and entrepreneurship in bio-business

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

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

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

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).

Textbooks:

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.

Suggested Readings

1. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
2. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.