Course Content of
Biological Sciences

AcSIR-Biology Cluster

1. CSIR-CCMB
2. CSIR-CDRI
3. CSIR-CFTRI
4. CSIR-CIMAP
5. CSIR-CSMCRI
6. CSIR-IGIB
7. CSIR-IHBT (New Syllabus &Two new course added)
8. CSIR-IICB
9. CSIR-IICT
10. CSIR-IIIM
11. CSIR-IITR
12. CSIR-IMTECH
13. CSIR-IMMT (New Course Added)
14. CSIR-NBRI
15. CSIR-NCL
16. CSIR-NIEST
17. CSIR-NIIST

CCMB

100 level courses

Course number	Course content
BIO-CCMB-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-CCMB-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-CCMB-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-CCMB-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research,

	Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	Course content
BIO-CCMB-2-001	**Biotechniques and Instrumentation** (compulsory) i. General Instrumentation: handling, care, usage and safety (this includes spectrophotomers, rotors, cuvettes, etc). ii. UV spectroscopy: stead-state and time-resolved fluorescence spectroscopy iii. Vibrational spectroscopy: basic principles and applications in biology iv. Magnetic resonance spectroscopy v. Atomic force microscopy vi. Confocal and fluorescence microscopy vii. Analytical ultracentrifuge viii. Calorimetry (isothermal titration and differential scanning calorimtry) ix. Surface Plasmon Resonance x. Chromatography
BIO-CCMB-2-002	**Biology of Macromolecules** Introduction to biological Macromolecules, The need for polymeric macromolecules for the living cell, Information content (general ideas on Shannon's information theory), Non-covalent forces (electrostatic, hydrophobic, hydrogen bonding, etc.), Properties of water in relation to macromolecular conformation Problem of protein folding, Introduction to protein folding, Levinthal's paradox and necessity for folding pathways, discussion on folding pathways (framework, hydrophobic collapse, nucleation-condensation-propagation, zigzag puzzle models and experimental evidence in support and against for these models), Current view of protein folding, Folding surface and funnel, Assisted protein folding, Need for assistance in protein folding *in vivo,* Differences between in vitro and in vivo folding, Discovery of molecular chaperone, classification of chaperone and brief description of functions of GroEL, Methods for investigating protein folding, Fluorescence and circular dichroism, Basic principles and applications Structure-function relationship : why structure?, Overview of different methods of structure determination, Retrieving, visualizing and understanding macromolecular structures, Correlation between structure and function Protein architecture, Organization of protein structure, Supersecondary structural elements, Ramachandran plot, Structure determination by X-ray crystallography, Globular proteins, Identification of folds and classification, Examples of structure-function relationship Macro-Molecular interactions, Various models of ligand-protein interactions (simple as well as complex binding models), Analysis strategies (Scatchard and Klotz plots), co-operativity in biology and Hill plot, Methodology and principles for estimation of binding stoichiometry; classical (gel filtration, equilibrium dialysis, stopped flow) as well as advanced methods (absorption, CD, fluorescence, NMR, ITC, SPR etc)., Thermodynamics of interaction and principles of ligand design, Protein-protein interactions Enzymes, Enzyme kinetics, Why study enzyme kinetics? Single substrate, bisubstrate reactions, Determination of Km. Enzyme inhibition – Reversible and irreversible inhibition, Competitive, Non-competitive and uncompetitive inhibition. Independent identical and non-identical substrate binding sites on enzymes, allosteric regulation. Reactions on enzymes and rate enhancements, Transient state stabilization, Transition state analogues and catalytic antibodies.
BIO-CCMB-2-003	**Biology of Inheritance** Prokaryotic genetics Mutagenesis, DNA repair, applications of mutagenesis, mechanisms of gene transfer including conjugation & transduction, and Recombination & mapping. Applications and uses of transposable elements, gene regulation, virulence functions

	and horizontal gene transfer. Eukaryotic genetics Mendelian principles; Segregation and linkage; Recombination and mapping; Gene interactions, forward and reverse genetics. Bayesian methods of risk assessment; consanguinity in humans and model genetic systems; chromosome rearrangements and their effects on gene expression in Drosophila and Neurospora.
BIO-CCMB-2-004	**Biology of Infection** Bacterial Pathogenesis (7 Lectures): Introduction to Bacterial Pathogens, Bacterial Virulence Mechanisms, Mycobacterial Pathogenesis Pathogenesis of Parasites (7 Lectures): Introduction to Parasite Biology, Pathogenesis of Malaria Viral Pathogenesis I (7 Lectures), Introduction to Virology , Molecular Mechanisms of Viral Infections Viral Pathogenesis II (7 Lectures): Inflammation Biology, Cellular Invasion by Viruses, Cellular Detection of Pathogens
BIO-CCMB-2-005	**Genomics: Information flow in Biological Systems** Overview of human genome (4 lectures): Nuclear genome (2 lectures), Mitochondrial genome (2 lectures) Genome mapping (4 lectures): Markers and methods for genome mapping (2 lectures), Linkage analysis (1 lecture), Genome-wide association studies (1 lecture) Genome sequencing (5 lectures): Different methods and applications (2 lectures), Human genome project (1 lecture), Next generation sequencing (2 lectures) Molecular Basis of human diseases (6 lectures): Molecular epidemiology (1 lecture), Autosomal (1 lecture), X-linked (1 lecture), Y-linked (1 lecture), Mitochondrial (2 lectures) Molecular Phylogenetics (4 lectures) Methods for phylogenetic analysis (2 lectures): Origin and migration of modern human (1 lecture), Role of India in early human migration (1 lecture) Pharmacogenomics (2 lectures): Genome variation and drug response (1 lecture), Pharmacogenomics: Indian Scnario (1 lecture) DNA profiling (3 lectures): Evolution of DNA fingerprinting technology (2 lectures), DNA fingerprinting in medicolegal and forensic applications (1 lecture)
BIO-CCMB-2-006	**Protein science and proteomics** Experimental aspects of protein characterization with emphasis on techniques currently used b. Approaches to studying protein conformation in solution c. Holistic approach towards proteomics d. Theoretical methods for studying dynamics of proteins
BIO-CCMB-2-009	**Plant-Microbe Interaction** i. Over view – 1 lecture ii. Plant pathogen virulence functions (bacterial, fungal, and viral) – 8 lectures iii. Host-resistance mechanisms (elicitor and effector triggered immunity) – 5 lectures iv. Plant-symbiont interactions (plant interactions with bacteria and fungi) – 10 lectures v. Plant growth promoting rhizobacteria and biocontrol – 3 lectures vi. Summary – 1 lecture
BIO-CCMB-2-017	**Epigenetics and Chromatin Organization** *I. Transcription and Gene Expression 10 lectures* (1) Details of the process of transcription in eukaryotes Promoter structure and function: the role of cis-regulatory elements that affect gene function locally and globally (1 lecture), The structure, function, and regulation of

	general transcription factors, RNA polymerases (1 lecture), Transcriptional initiation, elongation, and termination (3 lectures) (2) Gene Activation (2 lectures) DNA-protein Interaction, Gene-specific factors: Activators and repressors (3) Post transcriptional processing and regulation (2 lectures) connections between RNA processing and upstream events in transcription, integration of transcriptional and translational response mechanisms to external stimuli (4) Genome-wide approaches (1 lecture): New surprises, Pervasive transcription *II. Chromatin organization 3 lectures* (1) Nucleosome structure (2) Nucleosome positioning (3) Chromatin Assembly: Nucleosome assembly, Fiber folding *III. Epigenetic Regulatory Mechanisms 15 lectures* Transcriptional repression/anti-repression mechanisms (1) Chromatin remodeling (1 lecture) (2) Variation in conservation: Histone variants (1 lecture) (3) Histone Code: covalent modifications (4 lectures): Writing and erasing the Histone code, Reading the Histone code, Functional correlates of epigenetic marks (4) Genome-wide studies (1 lecture): Nucleosome landscape of species, Cross-talks between epigenetic markings (5) Cross-talk between transcription and chromatin (1 lecture) (6) Involvement of RNAi and non-coding small RNAs in gene silencing and genome defense (Lectures by AJ Rachel): Small RNAs: History, discovery and RNAi, miRNAs, piRNAs (3 lectures); and Noncoding RNAs (2 lectures) (7) DNA Methylation and Heterochromatinization (2 lectures by AJ Rachel)
BIO-CCMB-2-022	**Stem cells, regeneration and aging** Pluripotency- in the context of embryo, adult and reprogramming. Molecular basis of pluripotency, self renewal and nitch, role of epigenetic changes, stem cells in tissue and organ development. Methods in stem cell research- isolation, characterization and maintenance of human and murine stems cells, derivation of induced pluripotent cells, in vitro differentiation towards derivation of specific lineages. Importance of regeneration, model organisms, molecular mechanisms, role of stem cells in regeneration, regeneration in higher vertebrates, tissue engineering and other techniques in regenerative medicine. Apoptosis, programmed cell death, importance of stress and ROS in apoptosis, stem cell theory of ageing, role of telomeres. Stem cells in cancers.
BIO-CCMB-2-101	**Self organizations in biology** (10 lectures): What is so *unique* about membrane organization ? What holds the membrane together ? The hydrophobic effect Membrane dynamics — the key to membrane function: time scales — how to monitor membrane dynamics: spectroscopic approaches ? Lipid-protein interactions Membrane proteins: receptors and signaling Membrane domains: platforms for organization ? Evolving role of membranes in pathogenecity II.(4 lectures): Lipid structures (2 lectures) Primacy of membranes in biology, chemistry, distribution, crystal structure of lipids Lipid phase transitions (1 lecture) Biological role of phase transitions, fusion. Emergent properties of lipids (1 lecture) Long range order, heterogeneity and membrane shape control

300 level courses

Course number	Course content
BIO-CCMB-3-001	**Seminar Course (compulsory)** History of science with emphasis on Indian contribution: Seminar by students
BIO-CCMB-3-007	**Nanobiology** Nanoparticle synthesis – various methods including bottoms-up and top-down approaches; Property of Band-gap in materials The significance of nano size, multiplexing and multilayering. Optical properties and nanoparticle shape dependence. Tool used for nano-technology Basic principle of different types of tools (such as nano-lithography, TEM, AFM and other x-ray base detections techniques) will be discussed and their relevance to biological system characterization. Application of nano-technology for development of functional materials for biological applications. Different types of interactions at nano-scale will be discussed to understand and modulate biological response by designing nanostructures and functions. In this lecture basics of micro fluidics systems will also be discussed which create new opportunities for the spatial and temporal control of micro environment for biological applications.
BIO-CCMB-3-101	**Brain and behaviour** I. Overview of the Nervous System and functioning of Neurons at structuralanatomical level, cellular level, molecular level; II. Techniques and tools in understanding Brain and Behaviour, at system lev III. Circuitry level approach to understand Brain and Behavio a. Chemosensory circuit (perception of odour and pheromones), b. Reward circuit (Addiction, Depression, anxiety & related Mood Disorders), c. Learning and memory circuit (Cognitive disorders and mental retardation) IV. Environmental perturbations affecting Brain and Behavior Change in environment affects the gene functions, and also brain and behaviour, via epigenetic mechanisms; Environmental perturbations in early stage of life affect circuit development and maturation and have implications to pervasive CNS disorders in adulthood; V. Biology of Neurodegeneration and Repair (Molecular Biology of Adult Neurogenesis, Neural Progenitor or stem cells)
BIO-CCMB-3-102	**Genome organization** I. Overview of genomes, 1 lecture i. The new science of genomics, major questions and potentials (1 lecture) II. Packaging of genome and higher order regulation of gene expression, 9 lectures i. Chromatinization of genome (2 lectures) ii. Structural and functional domains in genome(2 lectures) iii. Structural basis of epigenetic cellular memory (3 lectures) iv. Chromosomal position effect (1 lecture) v. Nuclear architecture and genomic packaging (1 lecture)

	III. High throughput techniques and tools in analysis of genome organization (4 lecture) i. Epigenome mapping (2 lectures) ii. Bioinformatic tools of comparative genomics (2 lecture)
BIO-CCMB-3-103	**NMR Micro-imaging and Spectroscopy** Introduction: Zeeman Interaction, Chemical Shift, Coupling Constants, Relaxation, Nuclear Overhouser Effect, etc. Heteronuclear NMR and Simplification of NMR: Techniques for Improving Sensitivity, Editing in NMR, etc. In Vivo NMR Spectroscopy: Water Suppression, Localization, Outer Volume Suppression, STEAM, etc. Image Construction Using NMR: Slice Selection, Frequency and Phase Encoding, Contrast in MRI: T1, T2, diffusion; functional MRI
BIO-CCMB-3-104	**Mass spectroscopy in biology** a. Historical introduction to mass spectroscopy b. Study of tissues to molecules by mass spectroscopy c. Limitations of mass spectroscopy
BIO-CCMB-3-105	**Conservation biology** Concepts, history, ethics, values and legal foundations Population genetics and biodiversity, threats to biodiversity, conservation genetics Interventions- Genetic management, conservation of populations and ecosystems, habitat management, origin and conservation of genetic diversity in agricultural plants and animals Sustainable development, climate change and conservation of biodiversity, economics of conservation
BIO-CCMB-3-106	**Drug Discovery** Journey of a drug from discovery to use Target identification and validation Assay development and screening methodologies Designing small molecule compounds (computational tools and mechanism-based) Moving from *in vitro* to *in vivo* testing: toxicity and bioavailability

CDRI

100 level courses

Course number	Course content
BIO-CDRI-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-CDRI-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-CDRI-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-CDRI-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research,

	Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	Course content
BIO-CDRI-2-001	**Biotechniques and Instrumentation** (compulsory) Immuno-techniques: ELISA, Immuno-fluorescence, Immuno-histochemistry, immuno-precipitation, ChIP, etc. Automation in Drug Discovery: High-Content and High-Throughput Screening High resolution microscopy Transmission and Scanning Electron Microscopy and Laser Scanning Confocal Microscopy. Gene Expression Analyses DNA Microarray and Proteomics Radiation biology Introduction to radiation biology, Scintillation counting, Autoradiography. Instrumentation Centrifugation, Transmission Electron Microscope, Scanning Electron Microscope, Laser Scanning Confocal Microscope, High Content Screening System, MALDI-MS.
BIO-CDRI-2-002	**Biology of Macromolecules** Introduction to Primary and secondary structures of proteins and nucleic acids; hydrogen bonding, ionic and hydrophobic interactions. Optical spectroscopy: Photons, chromophores, transition dipole moments, absorbance. Circular Dichroism, Fluorescence and surface plasmon resonance. Particles in a field: Applications of MS for complex proteins, electrophoresis and sedimentation. X-ray diffraction: Overview of theory. Scattering from a periodic lattice, reciprocal space, and symmetry. Phase problem, Patterson functions, molecular replacement, model building and refinement. Nuclear magnetic resonance: overview and practical aspects. Nuclear spin and coupling interactions, multi-dimensional experiments, determination of protein and nucleic acid structures, protein folding, dynamics, SAR by NMR. Cryo-EM: Applications of Cryo-EM on the architecture of molecular machines, organels and organisms. Bioinformatics: 3D structure modeling, visualization softwares, homology modeling, similarity searches, sequence alignment.
BIO-CDRI-2-004	**Biology of Infection** Bacterial (Tuberculosis):Overview of mycobacteria Organization of mycobacterial cell wall and its biosynthesis. Organization of mycobacterial genomes, plasmids and transposons. Mycobacterial infection and pathogenesis. Host response to mycobacterial infection (Immune response). Lab work: Mycobacterial staining, growth analysis, antibiotic tolerance. Virology: Introduction to Viruses (different types of viruses). Basics of Virus-host interaction. Progression of Viruses (viral DNA replication and gene expression). Host response to viral infection (anti-viral immunity). Drugs against viral infection. Lab work: in vitro viral infection. Parasite Biology: Malaria, Leishmania, Filaria Parasite interactions in vector and human host Pathogenesis Immune response to parasitic infection Diagnosis, Treatment and prophylaxis Drug targets and drug resistance

BIO-CDRI-2-006	**Protein Science and Proteomics** Amino Acids and Proteins Peptide backbone, side chains, polarity, Absorbance, Single letter codes etc. Protein Structure Primary, secondary, tertiary and quaternary structure, covalent modifications of the polypeptide chain, Forces that determine protein structure, Structural motifs in regulatory proteins: DNA-binding proteins, Zinc finger motif, Helix T urn Helix motif Basic Leucine Zipper motifs. Tools: Databank of protein sequences (*SWISS-PROT*), Basics of protein sequence alignment Protein Regulation Enzymes I: Mechanism of Catalysis Enzymes II: Kinetics & Regulation Protein Methods: Protein separation and purification Methods Protein Function Analysis The Life Cycle of a Protein: Folding to Destruction (Proteasomes and unbiquitination) Practical Training to protein separation/detection using Western blotting Introduction to Proteomics and its advantages over genomics 1D and 2D Gel Electrophoresis: pI, Isoelectric focussing, 2 dimensional gel Gel Staining methods and analysis Protein spot/Band processing for Mass spectrometric analysis Introduction to Mass spectrometers such as MALDI-TOF/TOF and electrospray mass spectrometer. Spectral Peak Annotation and Database search Shotgun Proteomics Protein quantification using Mass spectrometry: ITRAQ, ICAT and SILAC Practical Training for 1D and 2 D gel electrophoresis and subsequent Mass Spectrometric analysis of processed protein spot using MALDI-TOF/TOF
BIO-CDRI-2-008	**Xenobiotic Interaction and Response** Principles of Xenobiotic interactions Overview of various classes of xenobiotics Introduction to Regulatory Toxicology /Guidelines for Regulatory Toxicology Strategies for Toxicological evaluation of xenobiotics Organ specific histopathological response to xenobiotics Systemic effects of xenobiotic action (Hematology) Systemic effects of xenobiotic action (Neurotoxicology) Systemic effects of xenobiotic action (Immunotoxicology) Systemic effects of xenobiotic action (Genotoxicity) Systemic effects of xenobiotic action (Reproductive Toxicology) Systemic effects of xenobiotic action (Hepatotoxicity) Toxicokinetics Molecular Toxicology Biochemical mechanisms of xenobiotic action Computational Toxicology Xenobiotics of environmental origin and their effects Experimental systems in toxicology research: *in vitro* and *in vivo* Alternative systems in Toxicology Safe and responsible conduct of toxicology research
BIO-CDRI-2-011	**Molecular Therapeutics** Roadmap to New Drug Discovery and Development Drugs from Nature Molecular Mechanisms of Drug Action Adverse Drug Reactions Safety Pharmacology

	Molecular Pharmacokinetics of therapeutic agents Drug Absorption/Molecular permeability of therapeutic agents Pharmacogenomics and pharmacogenetics in therapeutic efficacy and molecular metabolism Molecular basis of drug interactions Targeted and controlled drug delivery system Laboratory Work
BIO-CDRI-2-012	**Cell Signaling** Principles of Cell Signalling and Biological Consequences Introduction: Overview of Pathways and Networks and GPCR Signalling G Protein–Coupled Receptors G Protein Effectors Ligand-Gated Ion Channels Regulation of Ion Channels by G Proteins Protein Kinases Protein Phosphatases Ras-MAPK Pathways Growth Factor and Receptor Tyrosine Kinases Cytokine Receptors and Jak-STAT Signaling Nuclear Transactivators and Repressors Nuclear Receptors Chromatin Remodeling Regulation of Complexes by Cytoskeletal Elements: Integrins as Force Transducers Linking Mechanical Stimuli and Biochemical Signals Apoptosis MicroRNA
BIO-CDRI-2-013	**Chemical Biology** Chemistry and life: Science at the Interface Chemistry-Biology Introduction to Chemical Biology : This lecture will provide a survey of major topics, technologies, and themes in Chemical Biology RNA interference: Including lectures on RNAi biological applications, siRNA- A tool in chemical biology and designing and synthesizing siRNAs Click Chemistry applications in Chemical Biology Fluorescent probes and fluorescent sensors for studying the biology Chemical Genetics: amelioration of biology through chemistry Semisynthesis of proteins and Protein ligation, native chemical ligation Unnatural amino acids as probes of protein structure and function
BIO-CDRI-2-017	**Epigenetics and Chromatin Organization** Nuclear ultrastructure, chromatin network and spatial organization in the nucleus DNA Replication (Origin recognition and initiation of DNA replication, mechanisms of replication, analyzing DNA replication origins and mechanisms) Transcriptional regulation (The transcription initiation complex: components, transcription factor, recruitment and regulation, regulatory DNA elements) Chromatin organization in prokaryotes and eukaryotes, chromatin assembly/disassembly and transcriptional control, epigenetic control of cancer Protein translation, post-translational modifications, retrotransport Organelle targeting and cellular transport of proteins Transport across membranes and signal transduction Ligand receptors, ion channels, signal transduction pathways

	Calcium signaling Molecular and cellular evolution Abiogenesis, mechanisms of evolution (random mutation, natural selection, genetic drift, endosymbiosis and current controversies Cell cycle regulation and apoptosis Maintenance and transition of the phases of the cell cycle, pathways of programmed cell death Molecular processes in development Gradients and cascades in embryo development
BIO-CDRI-2-018	**Homeostasis and feedback in biological systems** Levels of organization: Molecular, Cellular and Tissue Physiology Control and Regulation: Nervous and Endocrine Systems Overview of physiological adaptation Components of homeostasis & physiological feedback Regulation of homeostasis and adaptive mechanisms of glucose, water, pressure & volume, mineral & ion, acid-base (include oxygen-CO2 regulation), temperature Pathways affecting homeostasis Physiological Applications: Reproductive System and contraception
BIO-CDRI-2-020	**Molecular and Cellular Mechanisms of Defence** Cells and tissues of the immune system Innate immunity Effectors of adaptive immunity Antigen and antibody Complement system and inflammatory reaction Major Histocompatibility Complex Antigen processing, presentation Cytokines, chemokines and leukocyte trafficking Immunobiology of the pulmonary system Immune tolerance and autoimmunity Immunobiology and pathology of Malaria Immunobiology and pathology of Leishmania Immunobiology and pathology of Filaria Tumor immunology Transplantation immunology Vaccines
BIO-CDRI-2-136	**Dosage Form Design** Pre-formulation studies Formulation development of Tablets using different excipients, technology involved to develop different types of tablets. Problems associated with production of tablets and its evaluation parameters. Tablet coating Introduction to capsules, different size of capsules, excipient selection, different types of capsules, quality control parameters Sterile Products and admixtures: Development of injectable preparations, small volume and large volume parenterals, excipients used, Quality control parameters Solubilization: Solubility of drugs, drug solubilization in surfactant systems, different techniques for solubilization, hydrotropic solubilization etc. Poly-disperse systems: Development of suspension and emulsions. Stability issues, implications of particle size on stability and its quality control parameters Aerosols: Preparation, characterization and applications

300 level courses

Course number	Course content
BIO-CDRI-3-001	**Seminar Course (compulsory)** **History of science with emphasis on Indian contribution** **Seminar by students**
BIO-CDRI-3-002	**Cancer Biology** Cancer: The nature of cancer and class organization Hall Marks of Cancer: Evasion of Apoptosis, Limitless replicative potential, Sustained Angiogenesis, Inflammation Cancer: The Key Players (Carcinogens, tumor virology, oncogenes tumor suppressor genes, cell cycle regulation) Hypoxia and Angiogenesis in cancer Metabolism and cancer MicroRNAs and cancer Stem Cells and Cancer Chemoresistance & Radioresistance in Cancer Experimental approaches to understanding the origins, diagnosis, and treatment of cancer. Recent advances in the field and future prospects
BIO-CDRI-3-006	**Microbial Pathogenesis** Clinical spectrum of AIDS, Dengue, Tuberculosis, Malaria & Kala-azar *(Lectures in reference to Clinical symptoms, Diagnosis, Prophylaxis and Treatments*) Cellular and Host tropisms of Organisms and Pathological changes (*Lectures in reference to molecular bases of survival of the organisms in the hosts*) Metabolic and Enzymatic Pathways (*Lectures based on the molecules involved in virulence, diagnosis and drug targets*) Mechanism of Actions of Drugs and Drug Resistance (*Lectures highlighting present drugs, SDR, MDR, XDR and role of Hosts*) Delineations of Genomes and Proteomes of HIV, Plasmodium, *L. donovani* and *M. tuberculosis* (*Lectures based on Identification of important molecules involved in patho-biology of organisms, future drugs and Immunogens*) Laboratory Work: Culture of micro-organisms in laboratory and Infections *in vivo* and in *ex vivo*
BIO-CDRI-3-008	**Neurobiology** Introduction- Nervous System Anatomy of Neuron Physiology of Neuron –generation and propagation of AP Neuronal supportive cells – Glial cells Organization of CNS- Brain & Spinal Cord Neurotransmission Neuronal Synapse Neurotransmitters & Receptor Central Neurotransmitters Catecholamines (Epinephrine, Norepineprine & Dopamine) Acetylcholine 5-Hydroxytrytamine (5-HT) Histamine

	Inhibitory Amino Acid (GABA, Glycine & Benzodiazepines) Excitatory Amino Acid (Glutamate) Neuropeptides Endogenous Opioid System Autonomic Nervous System Sensory –Motor Reflexes Neurotransmitters & Diseases Neurotransmitter Mechanisms & Drug Design Experiments (In rodents): Recording of Gross behavior activities, Evaluation of Neuromuscular co-ordination & sensory reflexes
BIO-CDRI-3-136	**Transcription and Gene Regulation** Molecular Basis of transcription (RNA Polymerases and mechanism of transcription, positive and negative control of transcription, post transcriptional processing, CTD phosphorylation and function) Chromatin dynamics in gene regulation (DNA methylation, histone variants, nucleosome positioning, histone code, chromatin r Integration of transcription to translation, protein degradation Histone modification and signal transduction
BIO-CDRI-3-137	**Biol and Therapeutics of Life Style Disorders** Concept and introduction to the subject Introduction to disorders affecting central nervous system (*pathophysiology and therapeutics*) Introduction to disorders affecting cardiovascular system (*pathophysiology and therapeutics*) Biology of Inflammation and inflammatory disorders (*pathophysiology and therapeutics*) Pathophysiology and therapeutics of ulcers Energy metabolism and diabetes (*pathophysiology and therapeutics*) Obesity and syndrome X (*pathophysiology and therapeutics*) Laboratory work (*in vitro* and *in vivo* experiments)
BIO-CDRI-3-138	**Animal Models in Biomedical Research** Introduction to model systems, Origins of Animal Experimentations Laws, regulations and policies affecting the use of Laboratory animals Brief account of biology and diseases of commonly used Rodent models (Mouse, Rat, Hamster, Guinea pigs, Gerbils and Mastomys) Brief account of biology and diseases of different Non-Rodent models (Rabbit, Dog, nonhuman primates) Laboratory Animal Biosecurity (Prevention, containing and eradication) Planning and Execution of Animal Experiments Common Zoonotic Diseases and Prevention. Genetic manipulations and Transgenesis: Principles and methods. Transgenic and Knockout Models for specific diseases. Genetic Monitoring of Experimental Animals. Alternative Models (cell based, Yeast, Drosophila, C. elegans, Zebrafish), advantages and disadvantages. Animal handling, care and Laboratory animal Techniques (practicals).
BIO-CDRI-3-139	**Pharmacokinetics and metabolism** Introduction; Pharmacokinetics and its role in drug discovery and development; Drug absorption, distribution, metabolism and excretion; routes of drug administration; Plasma drug concentration time profile, Pharmacokinetic parameters Bioanalysis tools and techniques; Method development and validation; Regulatory considerations for pharmacokinetic and metabolic data for pre-clinical (e.g. IND) and clinical (e.g. NDA and ANDA) submissions.

	Bioavailability introduction; measurement of bioavailability; Biopharmaceutics classification system; Methods for enhancement of bioavailability. Absorption of Drugs; Mechanisms of drug absorption. Permeability/absorption models, Factors influencing absorption and bioavailability. Distribution of Drugs; Volume of distribution; Factors determining the distribution of drugs: perfusion, molecular size, solubility, protein binding; Significance of drug uptake by the lung; Binding of drug to tissue components. Drug Metabolism and its role in drug discovery and development; Drug metabolizing organs and enzymes. Reaction Phenotyping; Metabolite identification Phase I and Phase II metabolic reactions. Tools and Techniques for studying drug metabolism; Factors affecting metabolism. Pharmacogenetics and Pharmacogenomics; Reactive metabolites and metabolic toxicity; Metabolites in safety testing- need and criterions. Excretion of drugs-basic considerations; Renal and non-renal excretion of drugs. Clearance; Renal function, renal failure and dose adjustment in renal failure. Non-linear Pharmacokinetics; Causes of non-linearity; Michaelis Menten Equation Chronopharmacokinetics, Pharmacokinetic variations in paediatric, geriatric and obese populations Applications of pharmacokinetic principle: Design of dosage regimens, Individualization and Therapeutic Drug Monitoring (TDM). High Throughput approaches in pharmacokinetics and drug metabolism; Applications of computational/predictive tools in pharmacokinetics and drug metabolism; Drug-drug/Food-drug/herb-drug pharmacokinetic interaction studies.
BIO-CDRI-3-140	**Approaches to Drug Delivery** Conventional dosage forms- for per-oral and parenteral drug delivery Analytical approaches and method development for pharmaceutical analysis Storage stability under ICH and Schedule Y regimes Controlled release- Principles and strategies Oral controlled release systems Targeted drug delivery with special reference to colloidal particles. Cutaneous and Transdermal drug delivery Delivery of drugs by Pulmonary route Microparticles and nanoparticles for drug delivery Strategies for the delivery of biomacromolecules. Liposomes as drug delivery vehicles BCS system and applications of microemulsions for delivery of poorly soluble drugs. <u>Laboratory Work</u> Matrix-controlled release tablet Adhesive-dispersion transdermal Drug powder for inhalation Development of nanosuspension
BIO-CDRI-3-141	**An Intro to Drug Discovery & Development** Drug Discovery Approaches: Observation-based/Physiology-based (Phenotype),Target-based approach to drug discovery Areas of interest in drug discovery "Me Too" drugs, New chemical entities, Generics, Pro-drugs, Orphan drugs Milestones in Drug Discovery Technologies impacting each milestone Serendipity/Repositioning Target discovery/validation/druggability/introduction to proteomics and genomics Assay Development—in Vitro/Cell-based/in vivo Biological screening glossary Characteristics of hit/lead Screening techniques: HTS, NMR, X-ray, Virtual Sources of chemical libraries for screening/selection of molecules, natural products/privileged structure Target oriented and Diversity oriented synthesis Biologics Toxicity/PK studies/Formulation Bioinformatics in drug discovery

	IPR: IND/NDA Clinical trials Phase I/II/III

CFTRI

100 level courses

Course number	Course content
BIO-CFRTI-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-CFTRI-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-CFTRI-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-CFTRI-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research,

	Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	Course content
BIO-CFTRI-2-171	**Instrumental Techniques**
	Qualitative and quantitative analysis of carbohydrates, proteins, fats, vitamins, minerals and dietary fibre; Spectroscopy – principle and application in analysis of food constituents; Chromatographic methods for separation of proteins and determination of molecular mass and homogeneity; (vii) Isolation and purification of enzymes, assay of enzymes and enzyme kinetics; Elucidation of protein structure by physical chemistry methods; Assessment for biological activities associated with phytochemicals; Structural characterization of potent biomolecules by state-of-the-art instrumental methodologies – HPLC, GC/GLC, LC-MS, NMR and others; Animal and cell culture methods for evaluation of biological activities associated with active principles of diversified sources; Chemical and physical tests of packaging materials - migration tests for food grade packaging materials, water vapour and gas transmission rates of packaging materials for food storage; Determination of shelf life of packaged foods; Determination of additives & preservatives in foods and residue analysis in foods; Evaluation of physical and chemical properties of rice and cooking quality of rice; Parboiling of paddy and quality evaluation; Rheological characterization of dough and batter; Sensory profile of food ingredients and products – texture, aroma, flavor, consistency and overall acceptability; Aerobic and anaerobic culture methods for determination of microbial populations; Evaluation of food ingredients and products for microbial safety
BIO-CFTRI-2-172	**Basics of Food Microbiology**
	Historical development in microbiology; Developments in microscopy; Morphology, cytology and reproduction of bacteria, yeasts and molds; Microbial growth curve; Physical, chemical and biological factors influencing microbial behaviour; Recombination, Transduction, Transformation and Mutations in bacteria; Microbiology of fruits & vegetables; Cereals & cereal products; Meat & meat products; Poultry & eggs; Fish & fish products and milk & milk products; Major types of spoilage and pathogenic microbes and their characteristics; Foodborne infections and intoxications; Mycotoxins – characteristics, types and causative fungal species
BIO-CFTRI-2-173	**Significance of Food Preservation**
	Objectives of food processing; Composition of foods; Degree of perishability of unprocessed foods; Causes of quality deterioration and spoilage of perishable foods; Intermediate moisture foods; Principles and methods of blanching; Test for adequacy of blanching; Conventional methods of preservation – Dehydration, Canning, Freezing, Fermentation, Smoking, Pickling, Chemical preservatives and others; Methods of drying and their application to fruits & vegetables; Procedures and technological applications relating to storage of foods at low, chilling and

	freezing temperatures
BIO-CFTRI-2-174	**Thermal Processing of Foods**
	Principles and types of retorts; Thermal destruction of microorganisms – Determination of D, z & F_0 values; Heat resistance in microorganisms; Cooking, blanching, pasteurization and sterilization of foods; Heat penetration and inoculation pack studies
BIO-CFTRI-2-175	**Canning of Foods**
	Basic principles of canning; pH classification of foods; Tin plate containers including coating methods; Can fabrication; Aluminum cans; Canning of fruits & vegetables / meat products
BIO-CFTRI-2-176	**Controlled and Modified Atmosphere Storage of Foods**
	Basic principles; Minimally processed fruits & vegetables; Modified atmosphere packaging of selected fruits & vegetables; Controlled atmosphere packaging of selected fruits & vegetables; Quality and safety evaluation of MAP and CAP stored products
BIO-CFTRI-2-177	**Functional Preservatives**
	Chemical preservatives as effective antimicrobials and antioxidants; Qualitative evaluation of sulphur dioxide and benzoate in foods; Lactic acid bacteria as preservatives
BIO-CFTRI-2-178	**Hurdle Technology**
	Principles and application; Intrinsic and extrinsic factors as effective hurdles; Behaviour of microbial contaminants in food system; Shelf life determination
BIO-CFTRI-2-179	**Infestation Control and Grain Storage**
	Principles of food commodity storage; Biology of insect pests; Infestation detection and monitoring methods; Pesticides – Classification and chemistry; Controlled atmosphere for insect control and food protection; Pesticide residues in foods; Pesticides and health hazards

BIO-CFTRI-2-180	**Animal Products Technology**
	Raw and processed products of meat, fish and poultry; Abattoir design and slaughter methods; Hygienic meat production and carcass evaluation; Meat tenderization; Meat emulsions, sausages and comminuted meat products; Preparation of meat-based traditional food products – *tandoori* chicken, *kababs*, etc.; Quality and safety of animal products
BIO-CFTRI-2-181	**Spices and Plantation Products**
	Major constituents in pepper, ginger, chilli and turmeric; Analysis of spice oils and oleoresins; Flavour formulations; Tea – brewing and tasting; Coffee – characteristics, roasting and brewing; Cocoa beans – physical & chemical characteristics and chocolate making
BIO-CFTRI-2-182	**Microbial Fermentations**
	Microbial growth phase; Physical, chemical and biological factors influencing microbial survival and growth; Fermentative process – solid state and submerged; Design of working of batch, fed-batch and continuous fermenters; Process optimization (Lab. scale to Pilot scale) for higher yield and quality attributes; Downstream processing and quantitative profile of purified metabolites

300 level courses

Course number	Course content
BIO-CFTRI-3-001	**Seminar in topics of courses listed in level 300**
BIO-CFTRI-3-171	**Technology of Cereals and Pulses**
	Characteristics of wheat & its milled products – physical, chemical and rheological; Influence of ingredients, processing conditions and additives on quality attributes of bakery products; Physical & chemical characteristics of rice and rice-based processed products; Cooking quality of rice; Parboiling of paddy; Processed products of maize, sorghum and finger millet; Processing of pulses including cooking quality; Oilseeds as source of edible protein and oil; Extraction methods for edible oil – *ghanni*, expeller and solvent; Processing of oilseeds for protein concentrates and isolates
BIO-CFTRI-3-172	**Technology of Fruits and Vegetables**
	Maturity indices in fruits and vegetables; Post-harvest spoilage – microbiological and physiological; wax coating; fruit ripening; Measurement of texture & colour in fruits and vegetables; Canning of fruits and vegetables; Preparation of fruit juices/beverages – RTS, squashes, syrups, lime juice cordial; Tomato-based juice, puree, paste, ketchup and soup; Fruit juice concentrates and powders; Fruit & vegetable-based pickles; Preserves and candies; commercial cold storages and supply chain management
BIO-CFTRI-3-173	**Food Biotechnology**
	Basic concepts and food applications; Natural food colours and flavours; Recombinant DNA technology and genetic manipulation; Genetically modified organisms/foods – basic concepts and methods to achieve & identify target genes; Safety and applicability of modified foods and food ingredients; Anti-nutritional factors in cereals and pulses; Biotechnological approaches (enzymes/proteins & effective processing parameters)towards reducing/modifying anti-nutritional factors in foods and food ingredients
BIO-CFTRI-3-174	**Functional Foods**
	Definition and applicability; Basis to identify functional components in varied sources; Characterization of bioactives from edible sources with defined functional attributes and elucidation of their structure-function relationship; Benefits of identified functional attributes in food ingredients and prepared foods; Legal requirements and regulations for functional foods; Effect of food processing parameters on defined functional attributes

BIO-CFTRI-3-175	**Nutraceuticals**
	Definition, terminologies and scope; Plant, animal (marine & sea foods) and microbial based nutraceuticals and their characteristics; Structure-function relationship of defined & characterized nutraceuticals; Potential nutraceuticals (one or two) and their benefits in selected (two each) fruits, vegetables, pulses, cereals, algae (including marine), herbs, spices, plantation crops, desirable microbes and sea foods; Legal requirements and regulations for nutraceuticals; Effect of food processing parameters on defined nutraceuticals
BIO-CFTRI-3-176	**Dietary Supplements**
	Definition, characteristics and scope; Status in selected countries across the globe; Intake of dietary supplements and positive health benefits; Performance and functionality; Interaction with one or more functions of human health; Technological suitability of supplements in food processing; Legal requirements and regulations for usage of dietary supplements
BIO-CFTRI-3-177	**Convenience and Wellness Foods**
	Major bioactive constituents in pepper, ginger, chilli and turmeric; Cocoa bean fermentation and cocoa based products; Citrus peel oil, fruit pectin and vinegar; Protein isolates and hydrolysates from pulses (oilseeds) and their biological activities; Millets and minor legumes as potential source of bioactives and nutritionals; Emerging trends – frozen dough and healthy bakery foods; Cured meat products; Fermented (including traditional) meat and fish products; Ready-to-prepare (cook) foods based on cereals and legumes; Ready-to-eat shelf stable thermally (retorting) processed foods
BIO-CFTRI-3-178	**Prebiotics and Probiotics**
	Microorganisms and human health; Prebiotics – definition, nomenclature and significance; Non-digestible higher polysaccharides; Categories of prebiotics; Interaction between prebiotics and microbiota; Probiotics – definition, nomenclature, selection criteria and attributes; Probiotic microorganisms – lactic acid bacteria, bifidobacteria, yeasts; Protocols for commercial probiotic preparations; Health and therapeutic attributes; Safety of probiotics and food applications; Molecular characterization of benefitical attributes associated with probiotics and prebiotics
BIO-CFTRI-3-179	**Fermented Foods and Beverages**
	Lactic, acetic, alcoholic and mixed fermentations; Microbial production of polysaccharides, vitamins, amino acids, colours and flavours with one example for each category of products; Milk-based fermented foods – cheese and fermented milks (including Indian traditional foods); Fermented foods based on cereals &

	pulses, meat and vegetables
BIO-CFTRI-3-180	**Sensory Profiling of Foods**
	Introduction to sensory perception; Physical and chemical sensory scores – quantitative descriptive analysis; Food flavourings; Taints and off-flavours; Instrumental analysis of food flavours; Texture and colour measurements; Packaging materials and their interactions with food constituents; Instrumental and statistical methods in sensory analysis; Requisites of sensory panel, consumer test ranking and Hedonic data analysis
BIO-CFTRI-3-181	**Microbial Kinetics**
	Kinetics of microbial growth and death; Bioreactors for microbial cultures and their metabolites; Scale-up process and requisite equipments and process controls; Optimized parameters in fermentation process – composition & sterilization of nutrient medium, aeration, temperature and other influencing parameters
BIO-CFTRI-3-182	**Food Safety**
	Microbial contaminants – spoilage & pathogenic bacteria and fungi; Microbial toxins; Limiting factors for survival/growth of pathogenic and spoilage microorganisms; Other food contaminants – heavy metals and residues of pesticides & antibiotics; Food regulations – national and international; Quality systems in food chain – ISO 9001, 14001, 17025 and 22000
BIO-CFTRI-3-183	**Food Based Nutritional Significance**
	Nutrition and human health; Macro- and micro-nutrients in food ingredients; Influence of food processing parameters on the efficacy of nutrients; Nutrition related metabolic disorders; Dietary strategies in health and disease management; Health benefits from plant and animal derived bioactive molecules including spice principles; Food based approach and community nutrition; Recommended dietary intake for nutrients and balanced diets in Indian scenario
BIO-CFTRI-3-184	**Food Chain Establishment**
	Food plant management – definition and scope; Food plant design & machineries – Regulatory requirements; Concept of hygiene & sanitation in food plant design; Management and its role in planning and coordination; System analysis – basic principles and methodologies; Market research and promotional avenues; Financial aspects and inventory control; Demand and supply in food industry; Computer applications in food processing sector – database, operating systems, networking and others; Intellectual Property Rights and Patents; Scientific documentation of Research outputs

CIMAP

100 level courses

Course number	Course content
BIO-CIMAP-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-CIMAP-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-CIMAP-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-CIMAP-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research,

	Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	Course content
BIO-CIMAP-2-001	**Biotechniques and Instrumentation** (compulsory) Chromatography, Mass spectrometry and Protein identification, Protein interactions : Isothermal calorimetry, Analytical ultracentrifuge, Surface Plasmon resonance, Fluorescence spectroscopy, FACS, Imaging: Electron microscopy, Confocal microscopy, Atomic force microscopy, Single molecule imaging and structure determination of protein complexes, In vivo imaging, RNA/ DNA quantitation (capillary based methods), DNA and protein microarray, NMR, X-Ray crystallography
BIO-CIMAP-2-002	**Biology of Macromolecules** Basic concept: life forms from prokaryotes to eukaryotes; molecules, building blocks;Water and Buffer systems; Nucleic acids and proteins; Lipids; Sugars; Anabolism and catabolism of building blocks and macromolecules
BIO-CIMAP-2-003	**Biology of Inheritance** Evolution, Mendel's Laws of Inheritance, Chromosome theory of inheritance, Co-dominance and incomplete dominance; pleiotropism, genotypic interactions, epistasis, mechanism of epistasis; Mitosis and Meiosis in plants, animal and human. Cell cycle and cell division. Linkage and mapping in eukaryotes; FISH / GISH, coincidence and interference. Concept of sex determination and patterns in plants and animals; sex chromosomes; Sex-linked, sex-limited and sex-influenced characters. Extra-nuclear inheritance: determining non-Mendelian Inheritance; maternal effects, cytoplasmic inheritance. Nature and components of variation, heritability and genetic advance, self incompatibility and male sterility system, role of mutations and chromosome modifications, induction of polyploidy and its significance, Genetic consequences of self and cross fertilization, mating systems, apomixes.
BIO-CIMAP-2-004	**Biology of Infection** Introduction to microorganisms, types of infection, development and manifestation, defence against infection, prevention of infections, resistance in infectious organisms.
BIO-CIMAP-2-005	**Genomics: Information flow in Biological Systems** Introduction to genomics; Cloning vectors (plasmids, cosmids, BAC, PAC, YAC) genomes and genes; genome organization; Techniques in genomics; Advance sequencing techniques and their application in genomics; DNA Sequence assembly; Application of genomics tools in genotype designing and drug discovery; Defining the genome: from size to functions; Chloroplast and mitochondrial genomes; Functional genomics and beyond.
BIO-CIMAP-2-006	**Protein Science and Proteomics** Introduction proteomics; Extraction of proteins; Separation of proteins; Organelle proteomics; Protein identification and characterization; Structural proteomics and computational analysis; Protein-protein interactions; Techniques for Proteome research; High throughput proteomic screening for novel bioactive peptides/proteins/enzymes
BIO-CIMAP-2-007	**Systems Biology** Central dogma of life, Concept of genome, transcriptome, proteome and metabolome; Comparasion of genomes/transcriptome/proteomes /metabolomes; Synteny; Gene

	expression subsets; Primary and secondary metabolism; Analytical tools for systems biology; Applications in plant research.
BIO-CIMAP-2-008	**Xenobiotic Interaction and Response** Toxicokinetics, general toxicology, phytotoxicology, environmental toxicology, adverse drug reaction, drug safety profiling and regulatory toxicology.
BIO-CIMAP-2-009	**Plant-Microbe Interaction** Plant growth promoting microbes; Microbial bio-inoculants; Nitrogen fixing microorganisms: mechanism of nitrogen fixation; Plant diseases and management, Biological control of pathogens; Role of microbial technology in agriculture.
BIO-CIMAP-2-010	**Plant Environment Interaction** Introduction to environment: classification, components of environment; Ecology and ecosystems; Symbiotic relationships; Plant responses to abiotic & biotic stresses; Plant - soil interactions.
BIO-CIMAP-2-011	**Molecular Therapeutics** General pharmacology, phytopharmacology, drug receptor interactions, *in-vitro* and *in-vivo* bioassays in drug discovery and development
BIO-CIMAP-2-015	**Crop Protection** Major pests of crops; Insect - plant relationship; Principles of insect physiology; Toxicology and pathology; Insecticide resistance and residue monitoring; Biopesticides and integrated pest management.
BIO-CIMAP-2-016	**Developmental Biology-Plants** Development and differentiation in plants: Physiological and biochemical basis; Genetic regulation of spatial and temporal development; Genetic regulation of plant growth and development, gametophyte development, fertilization and seed development, seed germination, seed adaptation in relation to environment; Effect of development on plant secondary metabolism.
BIO-CIMAP-2-017	**Epigenetics and Chromatin Organization** Introduction to epigenetics; Techniques in epigenetics; Epigenetics in plants evolution, adaptation and environmental stress, Chromatin structure; Organization of nucleosome and chromosomes; Molecular aspects of cell division and cell cycle. DNA replication in Prokaryotes and Eukaryotes. RNA transcription and processing; Transcriptional regulation in prokaryotes and eukaryotes; Protein synthesis, protein modifications and secretion; Regulation of protein synthesis; Transposable genetic elements, Types and mechanisms of transposition.
BIO-CIMAP-2-021	**Molecular Breeding of Plants** Introduction and techniques in molecular breeding; Morphological and Molecular markers, QTL analysis; Application of molecular breeding in plants; Development of

	mapping populations; Molecular mapping and gene tagging of important traits; Marker-assisted selection; Gene pyramiding.
BIO-CIMAP-2-024	Bioresources and Bioprospection Phyto-taxonomy principles and fundamentals; Biodiversity: principles, importance and characterization; Threats, conservation and gene banking; Remote sensing and GIS concepts and approaches; Bio prospection: principle, techniques and applications.
BIO-CIMAP-2-206	**Crop Production Systems** Sustainable agriculture: crop growth and yield, adaptation of plants to water variation; Soil fertility and nutrient management; IPNMS system; Precision agriculture; Agroforestry systems; Soil-plant-water relationship; Energy concepts; Physio-morphological behaviour of plants; Isotopes and radiation techniques; Metabolic and hormonal responses; Natural resource management.
BIO-CIMAP-2-207	**Intellectual Property Management**
BIO-CIMAP-2-208	**Applied and fundamental aspects of *In Vitro* Plant/Cell/Tissue/ Organ Culture** Introduction to Plant Cellular totipotency: Process and mechanism; Differentiation, morphogenesis and Somatic embryogenesis; Haploids: Androgenic and gynogenic; Endosperm culture, triploid production and its applications; Somaclonal variations; Somatic hybridization; *In vitro* production of commercially useful secondary metabolites; Scale up studies using bioreactors; Biotransformations.
BIO-CIMAP-2-209	**Crop Modelling and System Research** Systems-definition, input-output relationships, crop modelling-static descriptive and explanatory models, modelling techniques, Crop modelling- methods for water and nutrient stress effects, data requirement and limitations, Modelling crop-environment interaction, applications of simulation modelling in environmental impact assessment; Agro and post-harvest technology development and dissemination.

300 level courses

Course number	Course content
BIO-CIMAP-3-001	**Seminar Course (compulsory)**
BIO-CIMAP-3-003	**Cell and Tissue Engineering** Transgenic plants: Advances in producing transgenics, selection, identification, molecular analysis for confirmation and applications. Molecular farming: salient achievements and future prospects. Metabolic engineering for pathway modulations: propose and potentials. *Agrobacterium* as natural genetic engineer; molecular mechanism, controlling factors and advantages.
BIO-CIMAP-3-004	**Frontiers of Biology: Synthetic Biology** Molecular biology of metabolic processes in plants and microbes. Molecular regulators of metabolic pathways. Approaches of engineering metabolic pathways in heterologous systems (plants, microbes and insect cell lines)
BIO-CIMAP-3-005	**Advanced Bioinformatics** Databases and resources in Bioinformatics, Gene expression analysis, Sequence analysis and algorithms, Protein and nucleic acid properties, Taxonomy and phylogeny, Next generation sequencing, Structural Bioinformatics, Molecular modeling and simulations, Comparative and functional genomics, Modelling biological systems, Drug design, Advanced programming and scripting.
BIO-CIMAP-3-009	**Gene Environment Interaction** Recent advances in plant responses to biotic and abiotic stresses. Impact of environmental changes at molecular and cellular levels in plants.
BIO-CIMAP-3-010	**Advances in Gene Silencing** Gene silencing: Mechanism, techniques and applications; Antisense RNA technology, RNAi and VIGS; siRNA & miRNA : Biogenesis, translocations, Methods of isolation, characterization and application.
BIO-CIMAP-3-013	**Advances in Crop Disease Management** Genetic improvement of microbial bio control agents-metabolites, rhizosphere colonization, disease control; Mass multiplication of bio control agents, delivery systems, monitoring, commercial bio pesticides, quality control of bio control agents; Enzyme based formulations-status and problems; Molecular diagnostic methods, pathogen-derived resistance, genetic engineering approaches to develop disease resistant plants; Integrated disease management strategies.
BIO-CIMAP-3-014	**Integrated Pest Management** Trends in the development of Integrated Pest Management in national and international level, IPM Theory and Practice, economic threshold concept and economic consideration, Biological control agents, Integration of different methods of pest management, Cost-benefit ratios, case studies of successful IPM programmes

BIO-CIMAP-3-206	**Anti microbial agents and drug resistance** Classification of antimicrobial agents; mechanism of antimicrobial agents, mechanism of drug resistance, strategies for combating drug resistance
BIO-CIMAP-3-207	**Drug delivery and Pharmaceutical formulations** Introduction to pharmaceutical dosage forms, Conventional methods for drug delivery, Novel Drug Delivery Systems (NDDS)
BIO-CIMAP-3-208	***In-vitro* secondary metabolite production and biotransformation** Production of commercially useful secondary metabolites by callus/ cell suspension/ hairy root cultures: induction, kinetics of growth and product formation, optimization of physical/chemical factors, precursor-feeding, permeabilization, elicitation and immobilization for improved product recovery. Scale up studies using bioreactors for commercial production-general principles of bioreactors, design optimizations and downstream processing. Biotransformations using cell/hairy root cultures for generating pharmaceutical lead molecules.
BIO-CIMAP-3-209	**Plant Pathogenesis** Principles and concepts in host-pathogen relationship, recognition concept and infection for pathogens; role of enzymes, toxins, growth regulators in disease development; oxidative burst; phytoalexins, PR proteins, elicitors-defense strategies, signal transduction, systemic acquired resistance and induced systemic resistance, defense genes, hypersensitive reaction, programmed cell death, viral induced gene silencing, R-gene expression and transcription profiling
BIO-CIMAP-3-210	**Biology & Chemistry of Natural Products** Classification of plant metabolites – primary & secondary metabolites; various classes of secondary metabolites – Alkaloids, Terpenoids, Phenylpropanoids and their complexes; extraction procedures for natural products; structure elucidation methods for identification of new compound/NCEs; structural modification of natural products. Bioprospecting natural products.
BIO-CIMAP-3-211	**Biology of inflammation and diseases** Activated innate and adapted immune responses, Pathobiology of inflammation, inflammatory reactions in infectious and non-infectious disease conditions, auto-immune disorders
BIO-CIMAP-3-212	**Soil and crop management** Chemistry of soil fertility, principles and methods of soil and plant analysis, fertilizer and fertilizers use technology, mineral nutrition of plants, manures and fertilizers, development and management and of salt affected and other problematic soils, agrometrology, cropping and farming systems, allelochemicals interaction in plants and soils.

CSMCRI

100 level courses

Course number	Course content
BIO-CSMCRI-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-CSMCRI-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-CSMCRI-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-CSMCRI-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research,

	Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	Course content
BIO-CSMCRI-2-001	**Biotechniques and Instrumentation (compulsory)** Part-I Chromatographic Analysis: GLC, HPLC, HPTLC and Flash chromatography Part- II- Spectroscopic analysis: UV, AAS and Mass spectrometry Part- III – Microscopy Light Microscopy, Confocal Microscopy, SEM and TEM NMR Spectroscopy in Plant Metabolomics: Introduction & Scope of NMR Spectroscopy and Applications of NMR Spectroscopy in Plant Metabolomics Electrophoresis: agarose and polyacrylamide gel (native and denaturing), 2-D gel Centrifugation (high speed, ultra and differential centrifugation) Common Molecular Biology Techniques Chromatography: affinity, ion exchange, hydrophobic chromatography, size exclusion and reverse phase chromatography Proteomics- MALDI-MS/MS, LC-ESI-MS/MS Practical Chromatography Techniques Spectroscopy Techniques
BIO-CSMCRI-2-002	**Biology of Macromolecules** Structure and function of Cell and Cell organelles, Nucleic acids and proteins; Chromatin structure; Organization of nucleosome and chromosomes; Molecular aspects of cell division and cell cycle; DNA replication in Prokaryotes and Eukaryotes; RNA transcription and processing; Transcriptional regulation in prokaryotes and eukaryotes; Genetic code: Properties and codon usage patterns; Protein synthesis, protein modifications and secretion; Regulation of protein synthesis; Transposable genetic elements, Types and mechanisms of transposition; Chloroplast and Mitochondrial Genome Organization
BIO-CSMCRI-2-003	**Biology of Inheritance** Evolution, Mendel's Laws of Inheritance, Chromosome theory of inheritance, Co-dominance and incomplete dominance; pleiotropism, genotypic interactions, epistasis, mechanism of epistasis; Mitosis and Meiosis in plants, animal and human. Cell cycle and cell division. Linkage and mapping in eukaryotes; Coincidence and interference. Concept of sex determination and patterns in plants and animals; sex chromosomes; Sex-linked, sex-limited and sex-influenced characters. Extra-nuclear inheritance: determining non-Mendelian Inheritance; maternal effects, cytoplasmic inheritance. Nature and components of variation, heritability and genetic advance, self incompatibility and male sterility system, role of mutations and chromosome modifications, Genetic consequences of self and cross fertilization, mating systems, apomixes.
BIO-CSMCRI-2-005	**Genomics: Information flow in Biological Systems** Introduction to genomics; Techniques in genomics; Advance sequencing techniques and their application in genomics; Application of genomics study in plants
BIO-CSMCRI-2-006	**Protein Science and Proteomics** Introduction proteomics; Extraction of proteins for proteomics analysis; Separation of proteins for proteomics analysis; Organelle proteomics; Protein identification and characterization; Post-translational modifications; Structural proteomics and computational analysis; Protein-protein interactions; Techniques for Proteome research; High throughput proteomic screening for novel bioactive peptides/proteins/enzymes

BIO-CSMCRI-2-009	**Plant-Microbe Interaction** Plant growth promoting bacteria, mycorrhizae, actinorhiza, current advances in microbial bio-inoculants, latest concepts in taxonomy of nitrogen fixing microorganisms, plant growth promoting rhizobacteria, mechanism of nitrogen fixation, molecular basis for legume rhizobia interaction, nitrogen fixation in free living and associative bacteria, actinorhizal symbiosis, role of biotechnology in agriculture Concept, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control, types of biological interactions, operational mechanisms and its relevance in biological control, Factors governing biological control of pathogens, comparative approaches to biological control of plant pathogens by resident and introduced antagonists Economic impact of viral and viroid diseases, molecular characteristics, movement through plasmodesmata and vasculature, viral determinants involved in phloem transport of plant viruses
BIO-CSMCRI-2-010	**Plant Environment Interaction** Introduction to environment: classification, components of environment; Ecology and ecosystems; Symbiotic relationship; Introduction to abiotic stress; Plant responses to abiotic stresses; Introduction to biotic stress; Plant responses to biotic stress
BIO-CSMCRI-2-019	***In Vitro* Development and Morphogenesis in Plants** Introduction, Production of disease free quality planting materials; Somaclonal variations (concept and applications, visual, molecular and other screening methods); Haploids (anther, ovule culture and bulbosum technique, detection of haploids, applications); Endosperm culture, triploid production and its application; Protoplast culture, somatic hybrids and cybrids, selection strategies and applications; Secondary metabolites, hairy root culture, molecular farming, scale up studies using bioreactors; Ex situ conservation, short and long term storage of germplasm; Applications of tissue culture in commercialization; In vitro methods of crop improvement using transgenic technology and their Implications
BIO-CSMCRI-2-021	**Molecular Breeding of Plants** Introduction to molecular breeding; Techniques in molecular breeding; Morphological and Molecular markers, QTL analysis; Application of molecular breeding in plants., development of mapping populations (F_2, Back crosses, Recombinant Inbred Lines , Near Isogenic Lines and Doubled Haploid lines). Molecular mapping and gene tagging of important traits, Marker-assisted selection, Gene pyramiding. Antisense RNA technology. production of transgenic plants; gmos, biosafety issues.
BIO-CSMCRI-2-023	**Natural Resource Management** Sustainable agriculture, Soil fertility and productivity, SOM, Nutrients function, Dynamics of major plant nutrients, nutrient use efficiency, IPNMS system, Precision agriculture, Growth Analysis, Crop response function, Economics of Agroforestry systems
BIO-CSMCRI-2-027	**Bioresource Production Systems** Advances in Soil-plant-water Relationship: Energy concepts, Physio-morphological behaviour of plants, Soil physico-chemical properties, isotopes and radiation techniques, Metabolic and hormonal responses, Water use efficiency, Crop growth and yield, adaptation of plants to water variation

300 level courses

Course number	Course Content
BIO-CSMCRI-3-001	**Seminar Course (compulsory)** History of science with emphasis on Indian contribution: Seminar by students on any contemporary topic
BIO-CSMCRI-3-005	**Advanced Bioinformatics** Databases and resources in Bioinformatics, Gene expression analysis, Sequence analysis and algorithms, Next generation sequencing, Non-coding elements, Structural Bioinformatics, Programming and Scripting, Statistics
BIO-CSMCRI-3-009	**Gene Environment Interaction** Recent advances in plant responses to biotic and abiotic stresses. Impact of environmental changes at molecular and cellular levels in plants.
BIO-CSMCRI-3-010	**Advances in Gene Silencing and Epigenetics**
	Gene silencing: Mechanism of gene silencing in plants, Techniques in gene silencing, Application of gene silencing in plants; Introduction to small RNA; Biogenesis of small RNAs; Translocation of small RNAs in plants; Methods of small RNA isolation and characterization; Application of small RNAs in plants. Mechanism and applications of Epigenetics in plants
BIO-CSMCRI-3-011	**Microbial Diversity and Habitat Ecology** Current developments in microbial taxonomy, phenotypic microarrays, chemotaxonomy, nucleic acid and protein based methods, explorations for yet to be cultured microorganisms, metagenomics approach and recent topics on various groups of microorganisms, basis of adaptation to extreme environments, biotechnological applications of extremophilic microorganisms, industrially important extremophilic enzymes, assignments and discussions
BIO-CIMAP-3-014	**Integrated Pest Management** Trends in the development of Integrated Pest Management in national and international level, IPM Theory and Practice, economic threshold concept and economic consideration, Biological control agents, Integration of different methods of pest management, Cost-benefit ratios, case studies of successful IPM programmes
BIO-CSMCRI-3-241	**Fermentation Technology**
BIO-CSMCRI-3-242	**Salt tolerance mechanism in plants and Genetic manipulation** Gene resources: Salt responsive genes from halophytes; Gene cloning: Subtractive hybridization, RACE; Cloning vectors and their characteristics, Restriction digestion, ligation of DNA molecules; Recombinant selection and confirmation. Transcript profiling under salt stress, isolation of stress inducible promoter and their characterization, Plant transformation: Construction of expression vector, Methods of transformation-*Agrobacterium* mediated and Gene gun. Transgenic analysis: PCR approach, Southern blotting, Northern blotting.
BIO-CSMCRI-3-243	**Biology of marine macroalgae**

	The marine environment; Introduction to marine macroalgae, Classification, Molecular systematic & phylogeny and life histories; Seaweed communities and biotic interactions; Physiology: Nutrient uptake, assimilation and growth kinetics; Abiotic stress mechanisms; In vitro culture and micropropagation: media preparation and culture methods; Clonal propagation and selection of strains; Macroalgal diseases, control measures and defense system; Application of biotechnological interventions for genetic improvement; Cultivation of macroalgae; seaweed conservation; Economic importance of macroalgae and their products.
BIO-CSMCRI-3-244	**Wasteland biology and reclamation** Categories of wasteland in India, Land use capability classification, Principles and methods of soil, plant and water analysis, Dynamics of macro and micro-nutrients in soil, Soil fertility and productivity, Soil-plant-water relationship, Response of plants to various environmental stress, Wastelands vegetations, Microbial community structure, Plant-microbe interaction, Biofuel and non-traditional crops for wastelands, Sustainable agriculture and precision farming, Management of saline, sodic and other wastelands, Life cycle assessment for production systems

IGIB

100 level courses

Course number	Course Content
BIO-IGIB-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-IGIB-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-IGIB-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-IGIB-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research,

	Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	Course content
BIO-IGIB-2-005	**Genomics: Information flow in Biological Systems** *G. K. Chesterton said: "A building is akin to dogma; it is insolent, like dogma. Whether or no it is permanent, it claims permanence, like a dogma. People ask why we have no typical architecture of the modern world, like impressionism in painting. Surely it is obviously because we have not enough dogmas; we cannot bear to see anything in the sky that is solid and enduring, anything in the sky that does not change like the clouds of the sky."* Science moves forward by the demolishing of existing dogmas. Nowhere in biology is it more relevant today than our understanding of the genome and its complexity. The course will chart the changes in our understanding and appreciation of the human, and other, genomes. It will attempt to bring forth the latest concepts in dissecting the genome and revealing functional elements of evolutionary and regulatory importance.
BIO-IGIB-2-006	**Protein Science and Proteomics** • Proteins, sequence-folding relationship, evolution of sequence, silent mutations and folding, diseases of conformation. • Structure and conformation, techniques and challenges • Dynamic regulation of protein function • Why proteomics?, Basic principles, 1D and 2D gel electrophoresis, Differential in gel electrophoresis, Fractionation techniques used in proteomics, Peptide fragmentation, Quantitative proteomics using LC MS approach, Challenges in plasma proteomics
BIO-IGIB-2-276	**The host and the invaders: the eternal battle** The invader: survival stratagies of pathogens, virulence factors, sensing of environment and regulation of virulence gene expression, subversion of host defence mechanisms. The Host: host defence processes, involvement of immune cells and their mediators, abnormalities in host immune system and their implication in disease processes.
BIO-IGIB-2-277	**The nature of chemical and biological diversity** Molecular Diversity and Biosynthetic pathways, Multi-functional Enzymatic assemblies, Coevolution of the chemical and biological world within the organisms
BIO-IGIB-2-278	**Dynamic nature of biology** Dynamic regulation of biological processes enable the cell and in turn the organism to survive a changing environment and thrive. Regulation has multiple layers starting from genome structure to gene expression and function. The mechanisms of regulation and the consequences of breakdown of regulation such as disease and loss of viability will be discussed.

300 level courses

Course number	Course content
BIO-IGIB-3-276	**Playing with Genomes** The course will provide hands-on oppurtunity to assemble and annotate a genome.
BIO-IGIB-3-277	**Complex Disease Genomics** • Using the genome to unravel complex diseases • Looking for the needles in the haystack: Genome Wide Association Studies (GWAS) • The intimate but mysterious relationship between genotype and phenotype • Genetic differences & personalized medicine • Genetic differences and predictive power
BIO-IGIB-3-278	**Death & Disease: the cellular dilemma** • Cellular death, various forms and mechanisms • The why and wherefore of death • Death as a preventative for disease • When death pathways breakdown
BIO-IGIB-3-279	**The Micro-World** • Microbial diversity • Culturable and unculturable bacteria • Microbial community structure and dynamics • Microbial-Environmental Interactions • Human body as a microbial observatory Metagenomics and synthetic biology
BIO-IGIB-3-280	**Space and Time in Biological Systems** The different scales of time in biology How time is defined at the organismal and cellular level How time delays and periodicity is generted in biological systems How do network motifs regulate biological processes
BIO-IGIB-3-281	**Immortality: the everlasting quest** The ability to regenerate lost or damaged organs is a dream humans have had since the beginning of civilization. Although humans have very limited capacity for regeneration, there are a many organisms that can regenerate complete organs and at times their whole body. We will explore these magical organisms and distill what we have learnt from studies of such organisms. The discussion course will try to estimate what our challenges will be if stem cell biology has to meet its expectations. We will discuss the latest advances made in the field of stem cell biology and the extent of our present ability to convert somatic cells into stem cells and then lead them down particular pathways of differentiation. The need to understand development and cellular reprogramming to generate tissues of our

	choice from the pluripotent stem cells.
BIO-IGIB-3-282	**Electronics for Biologists** Revolution in electronics has transformed our lives over the last few decades. However, most of the complex electronic systems that we see today are constructed from a few basic electronic components. The aim of the course is two-fold: To explain and demonstrate how complexity arises out of a few basic electronic elements thereby encouraging students to draw parallels between complex biological systems and electronic systems. Secondly, students will learn how to create complex interactive objects and environments such as sensing platforms using open source Arduino microcontrollers. Basic principles of optics will also be introduced as a part of the course and participants will have an opportunity for hands-on exploration of common biological instruments such as microscopes, cell sorters and sequencers. The course has enough flexibility built-in so that students can design their own assignment projects and explore their areas interest.

IHBT

100 level courses

Course number	Course Content
BIO-IHBT-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-IHBT-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-IHBT-1-003	**Basic Chemistry** 1. **Chromatography and Analytical Techniques** Thin Layer Chromatography: Theory and Applications, High Performance Liquid Chromatography: Principles, Instrumentation, Choice of Column, Detector and Applications. Gas Chromatography: Principles, Instrumentation, Choice of Column, Detector and Applications. 2. **Principle of Green Chemistry** Need and Challenge of Green Chemistry; Definition and Principles of Green Chemistry; Example of Wasteful Reaction e.g., Fridel Craft Acylation; Improved Catalysis; Green and Brown Synthesis of Ibuprofen; Effect of Improved Synthesis

	of Sertraline on Waste. **3. Natural products and their applications in medicinal chemistry** Principles of Drug Design**:** Lipinski's rule of Fives, Pharmacophore, Isosterism, Bioisosterism, Lengthening Alkyl Chains. Drug Discovery Optimization & Development, Discovery of Lead Compound. Natural Product derived Drugs, Process of Drug Discovery from Plants, Reverse Pharmacology 4. **Phenolics** Classes of Polyphenols, Basic Nature and Carbon Skeleton, Occurrence, Distribution and Biosynthesis of Flavonoid Group, Steriochemistry of Flavonoids. Isolation, Identification and Characterization. Importance and role in Plants, Animals and Humans. **5. Terpenoids** Introduction, Distribution, Classification, Essential Oil, Monoterpenoids, Sesquiterpenoids, Diterpenoids, Triterpenoids, Sterol, their Biosynthetic Pathways and Isolation and Characterization **6. Alkoloids** Definition, Nomenclature, Occurrence, Isolation, General method of structure Elucidation, Role of alkaloids in plants, Physiological action.
BIO-IHBT-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research, Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	Course Content
BIO-IHBT-2-001	**Biotechniques** pH and Buffers in Biology, Chromatography, Electrophoresis, Mass spectrometry, Radioisotopes, Microscopy, Immunotechniques, Gene and genome technologies, Spectroscopy, Protein and proteomics, Techniques in Plant Physiology, Techniques in Microbiology, Techniques in cell and tissue culture
BIO-IHBT-2-002	**Biology of Macromolecules** Structure and function of Cell and Cell organelles, Nucleic acids and proteins; Chromatin structure; Organization of nucleosome and chromosomes; Molecular aspects of cell division and cell cycle; DNA replication in Prokaryotes and Eukaryotes; RNA transcription and processing; Transcriptional regulation in prokaryotes and eukaryotes; Genetic code: Properties and codon usage patterns; Protein synthesis, protein modifications and secretion; Regulation of protein synthesis; Transposable genetic elements, Types and mechanisms of transposition; Chloroplast and Mitochondrial Genome Organization Enzymes, Enzyme kinetics, Why study enzyme kinetics? Single substrate, bisubstrate reactions, Determination of Km. Enzyme inhibition – Reversible and irreversible inhibition, Competitive, Non-competitive and uncompetitive inhibition
BIO-IHBT-2-003	**Biology of Inheritance** Evolution, Mendel's Laws of Inheritance, Chromosome theory of inheritance, Co-dominance and incomplete dominance; pleiotropism, genotypic interactions, epistasis, mechanism of epistasis; Mitosis and Meiosis in plants, animal and human. Cell cycle and cell division. Linkage and mapping in eukaryotes; Coincidence and interference. Concept of sex determination and patterns in plants and animals; sex chromosomes; Sex-linked, sex-limited and sex-influenced characters. Extra-nuclear inheritance: determining non-Mendelian Inheritance; maternal effects, cytoplasmic inheritance. Nature and components of variation, heritability and genetic advance, self incompatibility and male sterility system, role of mutations and chromosome modifications, Genetic consequences of self and cross fertilization, mating systems, apomixes.
BIO-IHBT-2-004	**Biology of Infection** Host pathogen interaction Infection and infectious process and routes of transmission, Methods of transmission and role of vectors (Mosquitoes, Sand fly) Description and pathology of bacterial diseases Infections caused by Gram negative and Gram positive bacteria, Tuberculosis, Principles of antibiotic action mechanisms and molecular basis of antibiotic resistance Description and pathology of fungal diseases Infections caused by candida spp, Infections caused by filamentous fungi Description and pathology of parasitic infections e.g. Malaria and Leishmania General properties of viruses Structure and replication of DNA and RNA viruses, Virus-host interactions, Detection and Cultivation of viruses

	Description and pathology of viral infections Infections caused by Flavi-viruses, Pox viruses, herpes viruses, myxo and paramyxo viruses, adenoviruses and other respiratory viruses, hepatitis viruses, HIV Biology and pathogenesis involved in Flavi-viruses Immunology Innate and acquired immunity, Components of immune system, T-cell subsets and surface markers, antigen processing and presentation, Antigen-antibody interactions, Types of hypersensitivity reactions, Host response to viral infection (anti-viral immunity), antiviral compounds, Vaccines and vaccinations Techniques in diagnostic microbiology: Immunological techniques, Serological techniques, Nucleic acid techniques, Biological safety in handling pathogenic bacteria and viruses
BIO-IHBT-2-005	**Genomics: Information flow in Biological Systems** Introduction to genomics; Cloning vectors (plasmids, cosmids, BAC, PAC, YAC). Genome Organization: Nuclear, Mitochondrial and Chloroplast Genome, Techniques in genomics; Advance sequencing techniques and their application in genomics; Application of genomics study in plants Genome mapping: Markers and methods for genome mapping, Linkage analysis, Genome-wide association studies. Overview of Arabidopsis and rice genome.
BIO-IHBT-2-006	**Protein Science and Proteomics** Amino Acids and Proteins Peptide backbone, side chains, polarity, Absorbance, Single letter codes etc. Protein Structure Primary, secondary, tertiary and quaternary structure, covalent modifications of the polypeptide chain, Forces that determine protein structure, Structural motifs in regulatory proteins: DNA-binding proteins, Zinc finger motif, Helix T urn Helix motif Basic Leucine Zipper motifs. Tools: Databank of protein sequences (*SWISS-PROT*), Basics of protein sequence alignment Protein Regulation Enzymes I: Mechanism of Catalysis Enzymes II: Kinetics & Regulation Protein Methods: Protein separation and purification Methods Protein Function Analysis The Life Cycle of a Protein: Folding to Destruction (Proteasomes and unbiquitination) Introduction proteomics; Extraction of proteins for proteomics analysis; Separation of proteins for proteomics analysis; Organelle proteomics; Protein identification and characterization; Post-translational modifications; Structural proteomics and computational analysis; Protein-protein interactions; Techniques for Proteome research; High throughput proteomic screening for novel bioactive peptides/proteins/enzymes
BIO-IHBT-2-009	**Plant-Microbe Interaction** Principles and Concepts in Host-Pathogen Relationship, Recognition Concept and Infection for Pathogens and Non-Pathogens, Role of Enzymes, Toxins, Growth Regulators in Disease Development, Oxidative Burst, Phenolics, Phytoalexins, PR Proteins, Elicitors-Defense Strategies, Signal Transduction, Systemic Acquired Resistance and Induced Systemic Resistance Structural Genes, Defense Genes, Hypersensitive Reaction, Reactive Oxygen Species, Phytoalexins, Programmed Cell Death, Viral Induced Gene Silencing, R-Gene Expression and Transcription Profiling, Mapping and Cloning of Resistance Genes and Marker-Aided Selection, Gene Pyramiding.

	Economic Impact of Viral and Viroid Diseases, Molecular Characteristics, Movement through Plasmodesmata and Vasculature, Viral Determinants Involved in Phloem Transport of Plant Viruses.
BIO-IHBT-2-010	**Plant Environment Interaction** Introduction to environment: classification, components of environment; Ecology and ecosystems; Phenotypic plasticity and plant adaptation; Introduction to abiotic stress; Plant responses to abiotic stresses; Introduction to biotic stress; Plant responses to biotic stress
BIO-IHBT-2-015	**Crop Protection** Major pests of crops, insect host plant relationship, principles of insect physiology, toxicology and pathology, insecticide resistance and residue monitoring, insect pest management, biopesticides, principals of integrated pest management
BIO-IHBT-2-016	**Developmental Biology-Plants** Introduction to developmental biology of plants, genetic regulation of plant growth and development, gametophyte development, fertilization and seed development, seed germination, seed adaptation in relation to environment
BIO-IHBT-2-017	**Epigenetics and Chromatin Organization** Introduction to epigenetics; Techniques in epigenetics; Epigenetics in plants evolution, adaptation and environmental stress, Chromatin structure Organization of nucleosome and chromosomes; Molecular aspects of cell division and cell cycle. DNA replication in Prokaryotes and Eukaryotes. Transcriptional Gene Regulation: Operon Concept, Transcription Factors, Promoters, cis-regulatory elements and enhancers; Gene Silencing: Transcriptional gene silencing, Post transcriptional gene silencing; Small RNAs and their mechanism of regulation;RNA processing and Inron splicing
BIO-IHBT-2-019	***In Vitro* Development and Morphogenesis in Plants** Introduction, Production of disease free quality planting materials; Somaclonal variations (concept and applications, visual, molecular and other screening methods); Haploids (anther, ovule culture and bulbosum technique, detection of haploids, applications); Endosperm culture, triploid production and its application; Protoplast culture, somatic hybrids and cybrids, selection strategies and applications; Secondary metabolites, hairy root culture, molecular farming, scale up studies using bioreactors; Ex situ conservation, short and long term storage of germplasm; Applications of tissue culture in commercialization; In vitro methods of crop improvement using transgenic technology and their Implications
BIO-IHBT-2-021	**Molecular Breeding of Plants** Introduction to molecular breeding; Techniques in molecular breeding; Morphological and Molecular markers, QTL analysis; Application of molecular breeding in plants, Mapping populations (F_2, Back crosses, Recombinant Inbred Lines , Near Isogenic Lines and Doubled Haploid lines). Molecular mapping and gene tagging of important traits, Marker-assisted selection, Gene pyramiding, Association mapping, Genomic selections.
BIO-IHBT-2-	**Natural Resource Management**

023	Sustainable agriculture, Soil fertility and productivity, SOM, Nutrients function, Dynamics of major plant nutrients, nutrient use efficiency, IPNMS system, Precision agriculture, Growth Analysis, Crop response function, Economics of Agroforestry systems
BIO-IHBT-2-024	**Bioresources and Bioprospection** Phyto-taxonomy principles and fundamentals, Hotspots, Mega-diversity, Threat categorization, Conservation initiatives, Principles and Practices of Ecology, habitats, Biomes, Community and continuum, Community organization, Diversity, Succession, Productivity, Trophic organization and Plant invasion, Principles of remote sensing, Sensors, Platforms, Digital image processing, Introduction and component of GIS, GIS data types, GIS analysis.
BIO-IHBT-2-027	**Bioresource Production Systems** Advances in Soil-plant-water Relationship: Energy concepts, Physio-morphological behaviour of plants, Soil physico-chemical properties, isotopes and radiation techniques, Metabolic and hormonal responses, Water use efficiency, Crop growth and yield, adaptation of plants to water variation
BIO-IHBT-2-311	**Nutrigenomics** Nutrition and its importance in human health, nutrition and human genetic diversity, epigenomicc and nutrition, ethical issue and social implication, nutritional enrichment and quality improvement of food products, nutrient toxicity and safety assessment, national and International standards, regulations and recommendation for human nutrition
BIO-IHBT-2-312	**Advances in protected cultivation of flower crops** Crop introduction, structures, external factors influencing plant growth and flowering, propagation, growing media and bed preparation, plantation, varieties, deficiency and toxicity symptoms of major and micro-nutrients, fertigation, method of crop development, crop protection, yield, grading, and post-harvest handling.
BIO-IHBT-2-313	**Biofertiliser Technology** Plant Growth Promoting Bacteria, Mycorrhizae, Actinorhiza, Current Advances in Microbial Bio-Inoculants, Latest Concepts in Taxonomy of Nitrogen Fixing Microorganisms, Plant Growth Promoting Rhizobacteria, Mechanism of Nitrogen Fixation, Molecular Basis for Legume Rhizobia Interaction, Nitrogen Fixation in Free Living and Associative Bacteria, Actinorhizal Symbiosis, Role of Biotechnology in Agriculture.

300 level courses

Course number	Course Content
BIO-IHBT-3-001	**Seminar Course (compulsory)** Two parts- theory and practice Theory (1 class and one invited speaker): Understanding listeners ; organizing content; creating presentation; using visual aids; vocal impact; presentation skill; maintaining confidence and building positive image; and managing interactive session. Practice: Delivering seminar on a specific topic.
BIO-IHBT-3-002	**Cancer Biology** Introduction to cancer, cancer types and their prevalence, diseased and cancerous cell: morphological and microscopic features, important tumor markers, molecular basis of Key Players like carcinogens, tumor virology, oncogenes, tumor suppressor genes, cell cycle regulation in cancer development, role of genomic instability in cancer pathogenesis, Histone acetylases/deacetylases in cancer progression, Understanding of posttranscriptional and posttranslational modifications in cancer cell, angiogenesis and malignancy, stem cell biology & cancer stem cells, Hypoxia/ tumor cell microenvironment and important signaling pathways involved in cancer progression, Systems Biology in cancer, epigenetics in cancer, MicroRNAs and cancer, cell death: nacrosis and apoptosis. Discovery and clinical validation of a targets in cancer, Pharmacokinetic and Pharmacodynamic parameters of important anticancer drugs, tools, techniques & important parameters involved in screening new bioactive(s) as possible anticancer agent(s), Cell cycle regulators: Role as therapeutic targets in cancer, gene silencing and RNAi technology in cancer treatment. Role of Histopathological & Immunocytochemical techniques in cancer diagnostics and research, initiation and propagation of cancer cells in cell culture systems: Evaluation of important properties and their relevance with human biology, Pathways involved in cell differentiation/ immortalization in cancer. Aggressive tumors: Gleason score in pathology, Orthotropic and xenografted models: Importance and their limitations in understanding cancer
BIO-IHBT-3-003	**Cell and Tissue Engineering** Molecular mechanisms regulating metabolic pathways and cellular processes, Recombinant technology, optimization and upscaling of engineered cells /tissue for higher metabolite production
BIO-IHBT-3-004	**Frontiers of Biology: Synthetic Biology** Molecular biology of metabolic processes in plants and microbes. Molecular regulators of metabolic pathways. Approaches of engineering metabolic pathways in plants and microbes
BIO-IHBT-3-	**Advanced Bioinformatics**

005	Databases and resources in Bioinformatics, Gene expression analysis, Sequence analysis and algorithms, Next generation sequencing, Non-coding elements, Structural Bioinformatics, Programming and Scripting, Statistics
BIO-IHBT-3-007	**Nanobiology** Nanobiotechnology and nanomaterials, Nanomaterials synthesis, Characterizations of nanoparticles, Biomolecules- nanoparticle interaction, Applications in nanomedicines and nanodiagnostics.
BIO-IHBT-3-009	**Gene Environment Interaction** Recent advances in plant responses to biotic and abiotic stresses. Impact of environmental changes at molecular and cellular levels in plants.
BIO-IHBT-3-011	**Microbial Diversity and Habitat Ecology** Current developments in microbial taxonomy, phenotypic microarrays, chemotaxonomy, nucleic acid and protein based methods, explorations for yet to be cultured microorganisms, metagenomics approach and recent topics on various groups of microorganisms, basis of adaptation to extreme environments, biotechnological applications of extremophilic microorganisms, industrially important extremophilic enzymes, assignments and discussions
BIO-IHBT-3-013	**Advances in Crop Disease Management** Genetic improvement of microbial biocontrol agents-metabolites, rhizosphere colonization, disease control; Mass multiplication of biocontrol agents, delivery systems, monitoring, commercial biopesticides, quality control of biocontrol agents; Enzyme based formulations-status and problems Molecular diagnostic methods, pathogen-derived resistance, genetic engineering approaches to develop disease resistance plants, biosafety issues related to GM crops Integrated Disease Management and Integrated Pest Management strategies for control of viruses and their vectors RNAi silencing in plant disease management
BIO-IHBT-3-311	**Plant Viruses as Expression Vectors for Vaccines, Gene Silencing, Drug Delivery Vehicle** Protein expression/vaccine production; drug delivery; functional characterization of plant genes (VIGS vectors)
BIO-IHBT-3-312	**Dietary Supplements** Dietary supplements and their relation to nourishment, Nutraceutical and Functional food, bioactive molecules as dietary supplements, interaction between bioactive dietary supplement in specific diseases, *in vitro* cellular and molecular mechanism of bioactive molecules and safety assessment.
BIO-IHBT-3-313	**Advances in Phytogenetic Remodeling** Genetic basis of generation advancement, mating systems, apomixes and its applications, Inheritance of qualitative and quantitative characters, Response and aids to selection, Gene pool concept, plant introduction and role of plant

	genetic resources in plant improvement, domestication, Hybridization and selection methods for self and cross-pollinated plants, combining ability, genetic basis of heterosis and inbreeding, development of inbreds, Development of hybrids, self incompatibility and male sterility in crop plants and their commercial exploitation, development of synthetics and composites; improvement of asexually/clonally propagated plants, quality seed production, concept of plant ideotype, Plant breeders rights.
BIO-IHBT-3-314	**Special Tech for Phytogenetic Remodeling** Nature and classification of mutations; mutagens; factors affecting mutagenesis, Induction of polyploidy, role of mutation and polyploidy in plants; wide hybridization, barriers to crossability and methods to overcome, cell and tissue culture, micropropagation, *in vitro* screening for resistance to biotic and abiotic stresses, haploids and doubled haploids (DH) production, embryo culture and its applications, somaclonal variation; protoplast culture and protoplast fusion
BIO-IHBT-3-315	**Biometrical Appro to Phytogenetic Remodeling** Foundations of biometrical concepts; continuous variation - its nature and origin; polygene concept; scales and transformation; components of means and variance; heritability; prediction of response; mating designs; combining ability analysis using line x tester and diallel approach; genotype x environment interaction and stability analysis; genetic divergence; genotypic and phenotypic correlations; path-coefficients and discriminant function in plant selection
BIO-IHBT-3-317	**Viral Pathogenesis in Plants** Manipulation of host and insect vectors by viruses for their transmission; Replication, plant virus interactions and plant responses to biotic stress ; Mechanism of action of viral suppressors of RNA silencing; endogenous suppressors employed by plant viruses to overcome silencing; viral sRNA-mediated regulation of gene expression in compatible interactions, transcriptome and proteome dynamics in response to infection
BIO-IHBT-3-318	**Advances in protected cultivation of flower crops** Crop introduction, structures, external factors influencing plant growth and flowering, propagation, growing media and bed preparation, plantation, varieties, deficiency and toxicity symptoms of major and micro-nutrients, fertigation, method of crop development, crop protection, yield, grading, and post-harvest handling.
BIO-IHBT-3-319	**Advanced Insect Toxicology** Principals of insecticide toxicology; classification of pesticides, structure and mode of action of pesticides, degradation of pesticides by various agents, evaluation of insecticide toxicity, hazards of pesticides to human, joint action of insecticides, factors affecting toxicity of insecticides, insecticide compatibility, phytotoxicity, metabolism; pest resistance to insecticides, resistance management, pest resurgence. Safe handling of insecticides, diagnosis, and insecticide-poisoning treatment.
BIO-IHBT-3-320	**Integrated Pest Management** Trends in the development of Integrated Pest Management in national and international level, IPM Theory and Practice, economic threshold concept and

	economic consideration, Biological control agents, Integration of different methods of pest management. Cost-benefit ratios, case studies of successful IPM programmes.
BIO-IHBT-3-321	**Crop Modelling and System Research** Systems-definition, input-output relationships, crop modeling-static descriptive and explanatory models, modeling techniques, Crop modeling- methods for water and nitrogen stress effects, data requirement and limitations, Modeling crop-environment interaction, applications of simulation modeling in environmental impact assessment
BIO-IHBT-3-322	Types of Fermentation, Fermentation kinetics, Factors affecting fermentation process, Process parameter optimizations, Bioreactor Design and Function, Modes of Operation, Aeration and Agitation, Sterilization, Downstream Processing, and Industrial Fermentation.

IICB

100 level courses

Course number	Course Content
BIO-IICB-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-IICB-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-IICB-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-IICB-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research,

	Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	Course Content
BIO-IICB-2-001	**Biotechniques** 1.Chromatography : Different chromatographic techniques, HPLC 2.Centrifugation: Principles and uses, application in modern biology 3.Electrophoresis: Theory and hypothesis, SDS-PAGE, Western Blot, 2D gel electrophoresis 4.Mass spectrometry and Protein identification: Principles and theory, application in proteomics 5.Colorimetry : ITC, DSC, Determination of protein stability, analysis of binding properties 6.Surface Plasmon resonance: Techniques and its use in biology 7.Optical spectroscopy: Absorption, fluorescence, FT-IR, Raman and other techniques 8.FACS: Principles and application 9. Imaging: Electron microscopy, Confocal microscopy, Atomic force microscopy, In vivo imaging 10. NMR: 1D NMR, 2D NMR and application in structural biology 11. X-Ray crystallography: Basic theory and its application in structural biology
BIO-IICB-2-002	**Biology of Macromolecules** 1. Protein – Nucleic acid interactions 2. Synthesis and degradation of macromolecules 3. The folding process and structural background 4. Modular structures, Protein flexibility, Domain motions, Domain-swapping; and Large macromolecular complexes 5. Enzyme activity, receptor binding and regulation, binding specificity, catalysis and cooperativity in enzymes and receptors 6. Methods for the determination of macromolecules structure and interaction 7. Macromolecular function in transcription, translation, signaling and other fields of cell biology, integration and control mechanisms 8. Structure and evolution of important protein motifs and folds. [e.g. Coiled-coil proteins, helical bundles, signaling domains (sh2, sh2, pdz etc), Immunoglobulin-like proteins, kinases, TIM barrels, DNA/RNA binding motifs 9. Principles of macromolecular engineering 10. The most important metabolic pathways and regulation 11. Relation between sequence, structure and function 12. Biological structure databases 13. Computer modeling of secondary- and tertiary structure of proteins and nucleic acid based on sequence data 14. Enzyme/receptor-based drugs-rational drug design
BIO-IICB-2-004	**Biology of Infection** **Parasitology** 1. Malaria Parasite General nature of Apicomplexan parasite; Biology of malaria parasite; Antimalarial drugs; Mechanism of drug resistance; Drug target and new antimalarial development; Host –parasite interaction, mechanism of multi-organ failure 2. Leishmania Parasite Biology of Leishmania parasite;Anti-Leishmanial drug; Host-parasite interaction 3. Entamoeba Protozoa Life pattern and pathogenecity 4. Nemathelminths

	Ascaris Sp.; Biology and mechanism of pathogenesis *Filaria* Sp;Biology and mechanism of pathogenesis 5. Medical Parasitology Sanitation and parasite infection;Detection of parasite infection; Precautionary measure to prevent parasite infection; Origin of new strain; Parasite and malnutrition; Ecology of parasite and vectors **Bacteriology** 1. General basic characteristics and fundamental structure of bacteria, particularly structures important for pathogenicity and virulence in microbial infections, brief description of some major medically important bacterial pathogens involved in organ and system infections in humans, biological safety in handling pathogenic bacteria 2. Molecular laboratory diagnosis of infection, definition of bacteriostatic and bacteriocidal agents, principles of antibiotic action mechanisms and molecular basis of antibiotic resistance and its importance in healthcare 3. Bacterial growth and metabolism, molecular basis of survival mechanisms under various in vivo and in vitro stressful environments 4. Importance of different virulence factors, namely, exotoxins, endotoxin, secretion systems, invasive properties, antigenic variation and other mechanisms to avoid the immune system 5. Regulation of virulence gene expression, motility, chemotaxis etc., importance of bacterial two-component signaling systems; Role of different mobile genetic elements in evolution of pathogens
BIO-IICB-2-006	**<u>Protein Science and Proteomics</u>:** **Protein Science**: 1. Basic building blocks of protein and their composition, chemical behavior, properties. 2. Peptide bond, geometry and parameters; Backbone geometry and parameters, side chain geometry and parameters, Ramachandran plot. 3. Primary, secondary, tertiary and quaternary structures. 4. Protein structure stabilizing forces – hydrogen bond, electrostatic bond or salt bridges; hydrophobic forces 5. Protein folding, dynamics and thermodynamics. 6. Protein: from gene to function. 7. Protein and diseases. 8. Some important proteins in cellular functions. **Proteomics:** 1. Protein cloning, expression and purification. 2. Protein chromatography systems and purification procedures – HPLC, FPLC etc. 3. Bioinformatics of protein sequences – sequence analysis, comparison, alignment etc. 4. Mass spectrometry – introduction to mass spectroscopy, gel mass spectroscopy, LC-MS, LC-MS-MS, MALDI-TOF 5. Protein NMR, FTIR Raman, CD 6. Protein Crystallography.

BIO-IICB-2-012	**<u>Cell Biology and Cell signaling</u>** 1. Cell growth and division, including cell cycle: Phases of cell cycle, Regulation of cell cycle, Cell cycle check point, Cell growth 2. Intracellular sorting of proteins: Nuclear import and export mechanism; Organelle targeting; Transport of protein to cell surface; Soluble protein sorting 3. Cell adhesion, cell junction and Extra Cellular Matrix: Cell adhesion molecules; Cell Junction; Extracellular matrix; Cell-cell recognition 4. Cytoskeletal structure-function and related macromolecules: Cytoskeletal proteins; Role in vesicular movement; Cellular morphology and cytoskeletal protein; Drug modulating cytoskeletal 5. Signal transduction pathways: Extracellular signals; Intracellular signals; 2^{nd} Messengers; Signal transduction pathways 5. Cell death and proliferation: Programmed cell death; Cell renewal system; Mitochondria and apoptosis; ER-stress 6. Cellular starvation, stress and Autophagy: Oxidative and nitrosative stress; Stress response; Autophagic vacuole turnover; Cellular homeostasis 7. Metabolic disorder and signaling aberrations: Abnormal Signaling in Cancer; Signaling for diabetic complication Angiogensis; Signaling for failure in diabetes
BIO-IICB-2-026	**<u>Bioinformatics</u>** 1. Specialized and derived databases for bio-molecular sequences and structure: Genome Databases of model organisms, human, pathogenic microbes & human micro biome; RNA Fold database, Small molecule databases; Structural databases and Structural comparison databases like CDD, FSSP, DALI etc. 2. Functional genomics and whole genome data-mining techniques: Application of sequence-based/structure-based approaches to assignment of gene functions; Identification of Virulence Cassettes & other genome islands; Analysis of gene repertoire, repeat sequences, CpG islands etc.; Prediction of miRNA/siRNA sequences & their putative targets; Use of SNPs for identification of genetic traits 3. Gene expression and Mass spectroscopy data analysis: Analysis of DNA microarray data (especially clustering approaches) and correlation of gene expression data to biological processes. In silico tools for analysis of proteomics data (Tools available at ExPASy Proteomics server); Computational methods for identification of polypeptides from mass spectrometry data. 4. Biological Pathway and interaction network analysis: Databases on metabolic pathways such as KEGG, EMP; Databases and tools for analysis of protein-protein interactions 5. Molecular modeling and simulation: Basic concepts in molecular modeling; Computer representations of molecules with different surface rendering; Principles for fold recognition, 1D profiles and threading approaches; Principles of molecular dynamic simulation; Concepts of force fields: representations of atoms and atomic interactions, potential energy; Purpose & concepts in 3D structure comparison, algorithms such as FSSP, VAST and DALI

	6. Drug discovery and design: Drug discovery cycle; Drug discovery Vs design; Role of Bioinformatics in drug design;Target identification; Structure-based drug design; Modeling of target-small molecule interactions 7. Genome assembly & annotation: Contig Assembly, Prediction of Genes, Promoters & Splice sites 8. Taxonomy and Phylogenetic analysis: Basic concepts in systematic; Phylogenetic analysis algorithms such as Maximum Parsimony, UPGMA, Neighbor-Joining; Probabilistic models like Maximum likelihood algorithm. 9. Concept of important algorithms applied in bioinformatics: PSSM, HMM, NN, SVM, DP: 10. Concepts and application of advance statistical analysis in bioinformatics.
BIO-IICB-2-346	**<u>Molecular and Cellular Immunology</u>** 1. History of immunological ideas and cellular components of immune system Transplantation antigens: structure, function, genetics, transplantation 2. Phagocytosis and antigen presentation Fc receptor and scavenger receptor mediated phagocytosis, markers to follow phagocytosis, presentation of endogenous and exogenous antigens, cross-presentation 3. Antibody structure, antigen-antibody interactions, binding site, affinity, avidity, Fc functions, molecular biology of immunoglobulins; B cell triggering: Tcell-B cell Interactions 4. Humoral immune response and cytokines: Signaling through B cell receptors, plasma cell differentiation, proinflammatory / anti-inflammatory effects of cytokines, transcriptional control of cytokine synthesis 5. Structure of lymphoid organs, ontogeny of lymphoid cells; Complement system and disease : Classical and alternative pathways of complement activation, complement regulation and deficiencies 6. Immune response to parasitic infections : Cell mediated immunity: delayed reactions, immunodeficiency; Allergy, Arthus reaction, serum sickness, inflammation; Autoimmunity: regulation of immune response and autoimmune diseases; Tutorial

300 level courses

Course number	***Course Content***
BIO-IICB-3-001	**Seminar & Critical Appraisal**
BIO-IICB-3-002	**Cancer Biology :** 1. Cancer Immunology: The immunological status of adaptive and innate immune cells in cancer, cellular interactions between immune and cancer cells in tumor progression or rejection, immunological mechanisms, regulation and function involved in host responses to tumors, anti-tumor immunity, cancer-induced immune tolerance, immunosuppression, dysregulation of the immune system and poorer outcome in the disease 2. Cancer stem cells : Origin/Hypothesis/Concept ; Signaling pathways in cancer stem cells 3. Cell signaling in cancer : Description of major classes of cell signalling: cell death signalling, cell survival signalling and developmental/stem cell signalling; signal networking and chemotharapy 4. Oncogenesis and epigenetics in cancer :Oncogenes and their regulation in signaling aberration; Acetylation/methylation in DNA and histones; Silencing/De-silencing of gene expression 5. Metabolic Engineering in cancer; Metagenomics and cancer 6. Cancer biomarkers and diagnosis : Selection of clinical specimens, recent advancement for identification of biomarkers through different approaches like genomics, proteomics and glycomics in combination with molecular pathology with potential clinical value; Application of biomarkers for cancer staging and personalization of therapy at the time of diagnosis to improve patient care. 7. Cancer drug discovery : Identification of lead molecules, target identification in cancer cells; combined approaches (*in vitro*, *in vivo* and *in silico*) for validation, various steps involved towards successful drug discovery; immunotherapeutic approaches e.g. cancer vaccines, monoclonal antibodies, adoptive immune cell transfer etc. and combination strategies to treat malignancies 8. Angiogenesis and metastasis 9. Project writing
BIO-IICB-3-003	**Cell and Tissue Engineering** 1. Introduction 2. Cell & Tissues : Definition of cells, tissues and organs 3. Tissue culture: Propagation of somatic cells 4. Stem cells : Source, biology and therapeutics 5. Biology of blood and artificial blood 6. Biology of skin and artificial skin 9. Biomaterials: source and usage 10. Hybrid cells: theory and instrumentation 11. Tissue transplantation 12. Biomolecules: angiogenic factors, growth factors 13. Mouse genetics 14. Transgenics, Knock-out

BIO-IICB-3-006	**Microbial pathogenesis** 1. Parasitic pathogenesis : An introduction to protozoan parasites: *Entaemoeba histolytica*: Life cycle, morphology and pathogenesis. Kinetoplastidae: *Leishmania* and *Trypanosome* : morphology, life cycle, mode of infection and molecular biology (replication of KDNA and RNA editing). *Plasmodium* : morphology, life cycle and mode of infection. 2. Major malaria vectors of India: distribution, Bio-ecology, potentiality, present sustainability status, form and function. 3. Helminthes and Nematodes: General introduction. 4. Host parasite interactions: Vector biology and its importance in parasite transmission, antigenic variation, potential drug targets, virulence factors, mechanism of drug resistance, vaccine strategies and proteomic approaches. 5. Organelle variations in protozoa: Cytoskeleton, mitotic spindle, hydrogenosomes, glycosomes. 6. Bacterial pathogenesis: Modulation of host signaling pathways during bacterial infection ; Bacterial strategies to overcome host defense; Cell-cell communication in bacteria; Role of the microbiome in health and disease; In silico data mining tools for bacterial genomics
BIO-IICB-3-008	**Neurobiology:** 1. Introduction: Introduction to central and peripheral nervous system; Basic elements of nervous system (neuron, glia and fibers). 2. Developmental Neurobiology : Neural tube formation, migration, differentiation, axonal guidance, myelination, synaptic re-arrangement and pruning; factors like growth factors, interleukins, steroid super-family, etc. on brain morphogenesis 3. Developmental neurological diseases: Neural tube defect, Autism, Dyslexia, Schizophrenia etc. 4. Functional & Chemical Neuroanatomy: Anatomical organization of central nervous system in relation to regulation of functions - brain stem autonomic regulatory nuclei, cardiovascular & respiratory functions of medulla & pons; chemical organization of the central nervous system in relation to anatomy - basal ganglia, anatomy, chemistry and functions; forebrain limbic system – arousal, fear, stress and feeding; integration of sensory and motor systems – peripheral sensory pathways and receptors, pain, auditory & visual systems, motor cortex output & pathways; neurotransmitters, neuromodulators and synaptic transmission. 5. Neuronal Physiology: Electrical signaling; action potential; voltage gated and receptor gated ion channels 6. Neural signaling: Receptors, second messengers and signaling 7. Epigenetics in brain development and behaviors: Epigenetic inheritance, chromatin regulation and histone modifications, Specificity of DNA methylation response 8. Neural stem cells and differentiation: Neural stem cells characteristics; differentiation into specific neural cells; stem cells in the adult brain; migration of stem cells in response to injury.

	9. Research tools in neuroscience : Brain stereotaxy; patch clamp; LCDM: MRI; CT; PET; NMR-S, etc. 10. Overview of neurodegeneration : Basic mechanism of neuronal apoptosis such as extrinsic and intrinsic apoptotic pathways; protein aggregation, proteosomal dysfunction, aberrant cell cycle activation 11. Neurodegenerative diseases: Use of animal models of human dysfunctions; pathophysiology of dementia and movement disorders; causes and corrections; regenerative therapy; deep brain stimulation 12. Neurogenomics in development and diseases: Detection of genes for neurological disorders; the study of gene expression in the CNS; creation of transgenic models of neurological disorders.
BIO-IICB-3-346	**Genomics** 1. An introduction to transition from genetics to genomics Family Pedigree Karyotyping and Linkage Analysis DNA Sequence Analysis The Need for an Animal Model System Phenotypic heterogeneity in monogenic disorders The need for genomic information 2. Genome Sequence Acquisition How Are Genomes Sequenced? The lesson from Unicellular Genomes The lesson from Metazoan Genomes 3. Comparative Genomics in Evolution and Medicine Comparative Genomics Evolution of Genomes Genomic Identifications Biomedical Genome Research 4. Genomic Variation Human Genomic Variation Ethical Consequences of Genomic Variations 5. Genomic Expression Basic Research with DNA Microarrays Alternative Uses of DNA Microarrays Applied Research with DNA Microarrays Improving Health Care with DNA Microarrays 6. Whole Genome Perspective Why Can't We Cure More Diseases? Genomic Circuits in Single Genes Integrated Genomic Circuits 7. Genomics of Microbes and Microbiomes Genome architecture of microbes Dynamics of Microbial Diversity Metagenomics- DNA sequence from multiple organisms The Human microbiome
BIO-IICB-3-347	**Eukaryotic Gene Regulatory Mechanisms** In each module the study material will consist of a few original research articles covering some of the latest developments in the field, to be chosen by the instructors for open discussion in the class. Discussion may include one or more of the following topics. Students are expected to brush up their post graduate knowledge of these topics before attending the lectures.

	1. Chromatin Structures and Epigenetics Nucleosome assembly and the modification of nucleosomes and of DNA/ The assembly of chromatin into higher order structures/ Different aspects of heritable patterning of gene expression and the biological importance of epigenomes/ Mechanisms of inheritance as well as imprinting, X inactivation and the role of RNA in establishing silent chromatin/ The impact of chromatin structure on differentiation, cell plasticity and development. 2. Transcriptional Regulation and Gene Expression Regulatory interplay between transcription factors: Regulatory DNA sequences (promoters, enhancers, locus control regions) /General transcription machinery/ Transcription factors: cell-specific and ubiquitous regulatory factors/ Mechanistic aspects of transcription activation / Chromatin, histones, DNA methylation /Gene regulatory networks /Transcription factors in health and disease/ Transcription factors as the final integrators of signaling cascades. 3. Structure, Processing, Trafficking and Function of RNA Chemistry and structure of RNA/ major lectures of cellular RNAs (mRNAs, tRNAs, rRNAs, snRNAs, and the newly discovered small regulatory RNAs/pre-mRNA processing with emphasis on splicing and polyadenylation/ biogenesis of tRNA and rRNA/ biochemistry and function of RNA interference (RNAi) and microRNAs/ RNA trafficking in the cell/ RNA quality control and RNA degradation/regulated mRNA translation during development/ RNA-protein interactions and major lectures of ribonucleoprotein particles;RNA granules and bodies /evolution of RNAs: The RNA world/ 4. Translational Control and Post-translational Protein Modification The translational control: Codons and frame shifting, attenuation, phosphorylation, and transformation/the role of translational control in the regulation of cell growth and differentiation.
BIO-IICB-3-348	**Chemical Biology** An overview of Chemical Biology Protein-protein interactions and its inhibitors Ligands for protein surfaces Ligands for Nucleic Acid surfaces Chemical Genetics Synthetic and semi synthetic proteins Applications of chemical biology, enzyme based biosensors, catalytic antibody
BIO-IICB-3-349	**Synthetic & Systems Biology** 1. Synthetic Biology: Concepts, useful definitions, basic cellular and molecular biology, biological components and properties Enzyme kinetics, gene structure and control of gene expression Intrinsic and extrinsic noises Basic knowledge in network circuits like feedback loops, switches, oscillators, feed forward loops, pulse generators, logic and filter circuits Synthetic networks, example and applications Metabolic network structure and metabolic or pathway engineering, applications of synthetic biology in pathway engineering Whole genome synthesis and related areas 2. Systems Biology: Introduction to systems biology

	Philosophy of systems biology Emergent properties of the system Biological robustness Experimental approaches in systems biology Global approaches to data collection Designing single cell experiments Utility of model organisms in systems biology Application of microfluidic and nanotechnology devices Integration of information derived from various data types Mathematical and statistical modeling of biological systems Graph theory Logical steady state approach Flux balance analysis Multivariate statistics Few examples of biological systems Cell signaling network Immune system network Transcriptional network Metabolic network
BIO-IICB-3-350	**Understanding Glycan structure & their role in Chemical Biology** 1. Overview, as an introduction to the topic and to emphasize the importance of carbohydrates in food and nutrition and biology.Discussion on the structures, shapes and various sources of carbohydrates. This may complement course "MC-630 Structure and Function of Biomolecules" in certain respects. 2. Reactions of carbohydrates: Discussion on the relative reactivities of the hydroxyl groups; convergent synthesis of biologically active oligosaccharides, glycolipids and glycoproteins. Discussion on the chemical and enzymatic methods after highlighting the need for synthesis. 3. Carbohydrate Therapeutics: Discussion on various drugs (aminoglycoside antibiotics including glycopeptides, enediynes, macrolides, anthracyclines, etc., alkaloid, steroid and terpenoid. Glycosides: polyphenol glycosides etc.) that contains carbohydrate moiety (moieties) including polysaccharide therapeutics. 4. Polysaccharide vaccines: Carbohydrate microarray. Understanding glycan structures and their analogues. Carbohydrate dynamics. The role carbohydrate structures in normal and diseased states.
BIO-IICB-3-351	**Modern Drug Discovery & Design** 1. *In-silico* drug design, and docking studies. Fragment based drug design; Structure-activity relationship (SAR), Quantitative structure-activity relationship (QSAR); Concept of drug, classification of drugs, Molecular basis of drug action: basic ligand concept, agonist, antagonist, partial agonist. Chemistry & therapeutic uses of bio-active molecules . 2. Physicochemical properties Hydrophobicity, electronic effects, Steric factors, solvent accessible surface area; Stability

	3. Lead generation Diversity oriented synthesis, Combinatorial chemistry; Sources of drugs, lead modification, prodrugs and soft drugs. Peptidomimetics, anti-sense RNA, DNA, PNA, LNA. 4. Pharmacokinetics, Pharmacokinetics, Bioavailability, Pharmacodynamics, drug metabolizing enzymes, route of administration, route of excretion, halflife, analysis, bioanalytical methods in mass spectrometry, therapeutic window 5. Drug delivery systems. Nano-particle drug carrier, liposomes etc.; Recombinant DNA products (vaccine), peptide drugs etc.; MAb :anti-idiotype vaccines, therapeutic drug targeting, disease-specific antigens 6. Drug target identification: Qualification a drug target, Rationale and Approaches: (a) Forward Genetics and Reverse Genetic/Chemical Genetics; (b) Gene-network; (c) Trancriptomics; (d) Interactome 7. Drug target validation: In vitro/in vivo models; High Throughput Screening (HTS) Assay designing Chemical and genetic knock down studies 8. Lead optimization and targeting and clinical trial Qualification for clinical trial Preclinical studies for toxicity, Efficacy Human clinical trials for safety.

IICT

100 level courses

Course number	Course Content
BIO-IICT-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-IICT-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-IICT-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-IICT-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research,

	Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation
BIO-IICT-105	**COMMUNICATION AND WRITING SKILLS** English proficiency course syllabus will be decided by the collaborative university: English and Foreign Languages University (EFLU), formerly the **Central Institute** of English and **Foreign Languages** (CIEFL)
BIO-IICT-106	**LABORATORY SAFETY** Lab rules and safety, Pre and post lab responsibilities, chemical hazards, reading and understanding Material Safety Data Sheets (MSDS), Hazard Assessment, Non-chemical hazards, Chemical hazards, Safe laboratory practices, Safe chemical practices, Biosafety, disposal of chemical, biological and radioactive waste. Fire extinguisher types and uses**,** Information on First Aid procedures, emergency eyewash, safety shower, storage cabinets, fire safety, Accident and Emergency handling, etc.

200 level courses

Course number	*Course Content*
BIO-IICT-2-001	**BIOTECHNIQUES & INSTRUMENTATION (compulsory)** Principles and applications of Centrifugation, Chromatography, Electrophoresis and spectroscopy. Immuno-techniques: ELISA, Immuno-fluorescence, Immuno-histochemistry, immuno-precipitation, ChIP, etc. Automation in Drug Discovery: High-Content and High-Throughput Screening procedures.
BIO- IICT-2-013	**CHEMICAL BIOLOGY** Science at the Interface of Chemistry and Biology; Introduction to Chemical Biology to encompass a survey of major topics, technologies, and themes in drug discovery. Screening methods for the identification of lead molecules . Current screening methods in chemical biology including cell based and target based automated assays; Overview of drug delivery systems with special emphasis on lipid mediated targeted gene delivery systems; siRNA as a tool in chemical biology; Biological applications of RNAi. Small molecule mediators of cell signaling pathways.
BIO-IICT-2-015	**CROP PROTECTION** Major pests of crops; Insect - plant relationship; Principles of insect physiology; Toxicology and pathology; Insecticide resistance and residue monitoring; Biopesticides and integrated pest management.
BIO- IICT-2-251	**TECHNIQUES FOR IDENTIFYING NEWER PESTICIDE MOLECULES** Classification of evaluation (Agricultural pest and Public health important vectors), Larvicidal, Pupicidal, Insecticidal, Anti-feedant, Insect growth regulators. Xenobiotics exposure/effect assessment using alternate animal models, How to evaluate commercial products.
BIO- IICT-2-252	**TECHNIQUES FOR IDENTIFYING NEWER DRUG MOLECULES** An overview of the various screening methodologies including *in vitro* and *in vivo* models. Correlations between *in vitro* and *in vivo* experiments. Choosing a right model and its relevance to human disease. Principles of high throughput screening (HTS). An overview of ex vivo techniques with special reference to isolated tissue experiments. An overview of methods for identifying hit molecules from NCEs. *In vitro* cell culture based screening techniques in the area of diabetes.
BIO-IICT-2-253	**PROTEOMICS AND ITS APPLICATION** Introduction to Proteomics and its advantages over genomics. 1D and 2D Gel Electrophoresis: pI, Isoelectric focussing, 2 dimensional gel Staining methods and analysis. Protein spot/Band processing for Mass spectrometric analysis. Introduction to Mass spectrometry and application of MALDI-TOF/TOF and electrospray/ liquid chromatography - mass spectrometer. Spectral Peak Annotation and Database search. Shotgun Proteomics, Protein quantification using Mass spectrometry: ITRAQ, and SILAC. Application of chemical proteomicsin drug design, Practical Training for 1D and 2 D gel

	electrophoresis and subsequent mock practice for Mass spectrometric analysis of processed protein spot using MALDI-TOF/TOF
BIO- IICT-2-254	**PRINCIPLES OF PHARMACOLOGY AND TOXICOLOGY** A general introduction to Pharmacology and Toxicology, Topics include absorption, distribution, biotransformation, elimination and calculation of dosages, Experimental design and data analysis for Pharmacology and Toxicology, Interdisciplinary Toxicology, Routes of administration. General principles and the application of toxicological knowledge are discussed including clinical toxicology, forensic toxicology, and risk assessment, Determination of median lethal concentration (manual calculations) Anticancer drugs and environmental agents exert their cytotoxic effects through DNA damage, The biochemical principles and molecular mechanisms underlying the toxicity of drugs and foreign agents.
BIO- IICT-2-255	**ENVIRONMENTAL AND MICROBIAL TECHNOLOGY** Concepts of environmental Microbiology, Complexity of microbial world, Environmental Ecology and Eutrophication, Fundamentals of microbial nutrition, Overview of microbial metabolism, Microbial diversity, Microbes and climate change, Water microbiology, Biodegradation and bioremediation, Microbial biogeochemistry, Microbial biofilm and corrosion, Concepts of microbial reactors, Perception of bioenergy, Hazardous waste bioremediation Biotransformation.

300 level courses

Course number	***Course Content***
BIO-IICT-3-001	**Seminar course – compulsory**
BIO- IICT-3-007	NANOBIOLOGY **Prerequisite courses:** *214 and/or 241* Introduction to nanoscience and nanotechnology. Optical and electronic properties of nanoparticles. Morphologies [nanotubes and nanowires, fullerenes (buckyballs, graphene)] of nanoparticles. Semiconductor/quantum dots nanoparticles. Historical background of nanotechnology/nanoparticle in medicine. Several synthesis routes for nanoparticles (physical, chemical and biological) Several physico-chemical techniques (XRD, TEM, SEM, AFM, TGA, DSC, FTIR, UV-visible spectra etc.) and their basic principles for the characterization of nanoparticles. Surface functionalization of nanoparticles for development of nanoconjugates. Application of nanoparticles in various fields. Why nanotechnology is important in biology and medicine? Application of nanotechnology in therapeutics, diagnostics and drug delivery system. Different interaction of nanoparticales with biological system. *In vitro* and *in vivo* toxicity study of nanoparticles.
BIO-IICT-3-012	ENVIRONMENTAL TOXICOLOGY **Prerequisite courses:** *217 and/or 242* Environmental Toxicology in present and future perspective (01 lecture), Environmental hazards (physical, chemical and biological aspects), Origin, sources and types of toxicants/pollutants; Dispersal/movement of toxicants in environmental compartments Ecotoxicology : Conventional and alternate models in toxicity assessment; Assessment of toxicity of pollutants; Absorption, distribution and storage of toxicants; Dose response relationships; Biotransformation and elimination of toxicants; Mechanisms of action of toxicants; Gene-environment Interactions. Pollution monitoring and Risk assessment: Tools for detection; Fate and transport. Hazardous waste management: Regulation, approaches and strategies
BIO-IICT-369	ADVANCED PHARMACOLOGY **Prerequisite courses:** *239 and/or 241* An outline of basic ethics in animal experimentation. Common laboratory animals, handling and care, different routes of administration of drugs and euthanasia techniques. Breeding techniques, random and selective breeding. Dose calculations in animals. Animal models in pharmacology, general perspectives, selection of suitable species and strains for disease models. Detailed study of the animal models related to inflammation, arthritis and diabetes. In vitro cell culture techniques, cell counting and cell viability assays. Commonly used isolated tissue experiments, physiological salt solutions, and recording transducers. Basic principles of pharmacokinetics, Concepts related to absorption, distribution, metabolism and Elimination (ADME), Factors influencing absorption of drugs.
BIO- IICT-370	DISEASE MECHANISMS

	Prerequisite courses: *214 and/or 240* Hall Marks of Cancer; Mechanisms of carcinogenesis (oncogenes, tumor supressors, tumor virology, chemical carcinogens) and disease progression. Mechanisms of chemoresistance and alternative strategies to overcome; Current knowledge on tumor metastasis; Emerging trends in cancer therapeutics – role of micro RNA's and stem cells. Introduction to factors affecting cardiovascular diseases; Pathophysiology, epidemiology and current therapeutic interventions related to atherosclerosis, hypertension and diabetes. An overview of central nervous system and neurophysiology; Neurocircuitry - circuitry level approach to understand Brain and Behavior, chemosensory circuit, reward circuit, learning and memory circuit (Cognitive disorders and mental retardation). An overview of disease mechanisms with specific emphasis on target development and plausible therapeutic interventions pertaining to Parkinson's and Alzheimers disease. Biology of neurogenesis and Repair mechanisms (Molecular Biology of Adult Neurogenesis, Neural Progenitor or stem cells).
BIO- IICT-371	INDUSTRIAL/ APPLIED MICROBIOLOGY: **Prerequisite courses:** *242* Introduction Industrial and environmental microbiology; Intermediate microbial metabolism for exploitation of microbes; Microbial enzymology and kinetics, Intermediate microbial metabolism; Microbial transformations; Immobilization and applications; Microbial processes for waste water management; Microbial processes for Air pollution management; Anaerobic digestion of organic solids Microbial solid waste management; Microbial fermentation; Microbial Energy Engineering; Microbial energy engineering and Biorefinery.
BIO-IICT-372	PROTEIN SCIENCE AND STRUCTURAL BASED DRUG DESIGN AND DEVELOPMENT Prerequisite courses: 214 and/or 240 Biochemistry and engineering of proteins, protein structure, structural motifs in functional regulation, methods of structure determination by NMR and crystallography, enzyme inhibitor complexes, structure based inhibitor design, modeling and bioinformatics. Enzymes: Mechanism of Catalysis, Kinetics & Regulation Protein Methods: Protein separation and purification Methods Practical Training to protein separation/detection using Western blotting, Protein structure: methods of crystallization, X-ray data collection, structure determination and analysis.

IIIM

100 level courses

Course number	*Course Content*
BIO-IIIM-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-IIIM-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-IIIM-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-IIIM-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research,

	Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	*Course Content*
BIO-IIIM-2-001	**Biotechniques and Instrumentation** (compulsory) Principles and applications of centrifugation, spectrophotometery, fluorometery, densitometery, electrophoresis, PCR & RTPCR, blotting, immunoassays, flowcytometry, DNA sequencing & fingerprinting, Chromatography (GLC, HPLC, HPTLC, GCMS, LCMS), polarimetery, elemental analysis, NMR spectrometry, Mass spectrometry, Microscopy (Simple, electron and confocal), in vivo imaging, MALDI/TOF, Microarray,
BIO-IIIM-2-004	**Biology of Infection** Host-microbe interactions Normal microbial flora of human body and their interaction with the host, Infection and infectious process and routes of transmission, Methods of transmission and role of vectors (Mosquitoes, Sand fly) Description and pathology of bacterial diseases Infections caused by Gram negative bacteria, Infections caused by Gram positive bacteria, *Mycobacterium tuberculosis* Description and pathology of fungal diseases Infections caused by candida spp, Infections caused by filamentous fungi Description and pathology of parasitic infections Infections caused by protoza, Infection caused by helminthes General properties of viruses Structure and replication of DNA and RNA viruses, Virus-host interactions, Detection and Cultivation of viruses Description and pathology of viral infections Infections caused by Pox viruses, herpes viruses, myxo and paramyxo viruses, adenoviruses and other respiratory viruses, hepatitis viruses, HIV virus Principles of chemotherapy Best in class antibacterial and anti-fungal agents, Drug resistance in bacteria and fungi, Best in class anti-protozoal agents and protozoal drug resistance, Best in class anti-viral agents Immunology Innate and acquired immunity, Components of immune system, T-cell subsets and surface markers, Antigen-antibody interactions, Types of hypersensitivity reactions, autoimmune disorders and their underlying molecular mechanisms, Immunoprophylaxis- Vaccines Techniques in diagnostic microbiology Immunological techniques, Serological techniques, Nucleic acid techniques
BIO-IIIM-2-009	**Plant-Microbe Interaction** Introduction to plant microbe interactions Significance of plant diseases and pathology , Types of plant-microbe associations (pathogenic– bacteria, virus, fungi, and symbiotic) , Mechanisms of variability in pathogens, pathogenicity genes and mechanisms in pathogenic bacteria, biotrophic and necrotrophic fungi, Virus and Viroid genes involved in pathogenicity , Types of plant resistance to pathogens (R gene resistance, quantitative and monogenic), basal and induced defense mechanisms, pre-formed inhibitors of pathogens, gene for gene interaction in plant defense, , Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR), Recognition mechanism and signal transduction during plant - pathogen interaction Bacterial pathogenesis and mutualism Bacterial colonization of roots and leaves, Hydrolytic enzymes, Toxins and Secretion systems, Hypersensitive Response (HR) and eXchange Reaction (XR), Pathogenecity and avirulence factors, Microorganisms and rhizosphere microcosm dynamics, Signaling in Rhizobia-Legume symbiosis

	Viral pathogenesis Viral infection, gene expression and replication, Host resistance against viruses, Gene silencing, VIGS and viral suppressors of RNAi Fungal Pathogenesis and Mutualism Fungal Pathogenesis: An overview , Fungal pathogenecity and virulence factors, Fungal toxins, Arbuscular mycorrhizal fungi, Endophytic Fungi and their secondary metabolites Case studies in Plant-Microbe Interactions Agrobacterium & crown gall disease: molecular responses, chemical cross-talk and biotechnological importance, Rice-Magnaporthe grisea pathosystem, Arabidopsis thaliana – Xanthomonas compestris model Relevance to Drug Discovery Program Production of pharmacologically active secondary metabolites in response to biotic stress, Fungal endophytes as source of interesting bioactive molecules, Crown gall and human cancers, similar themes, similar cures?
BIO-IIIM-2-011	**Molecular Therapeutics** General pharmacology, phytopharmacology, drug receptor interactions, *in-vitro* and *in-vivo* bioassays in drug discovery and development
BIO-IIIM-2-012	**Cell Signaling** Cell-to-cell signaling: Signal transduction; Classification of intercellular communication; Signaling pathways from the plasma membrane to the nucleus; Unicellular and multicellular organism cell signaling; Signaling in plants: Similarities/Differences with mammalian system; ER-golgi signaling in unfolded protein responses; Second messengers & Calcium/calmodulin; cAMP in cell communication; Phosphatidylinositol-derived second messengers; Nuclear receptors; Identification and characterization of receptors; Pharmacological and molecular classification of receptors; GTPase switch proteins, protein kinases, adapter proteins; G-protein-coupled receptors, Receptor tyrosine kinases & mitogen-activated protein kinase cascade(s); Transcription factors as signal transducers; Kinase -proteases crosstalk in cellular signalling; Extracellular signaling molecules and their action; Signaling cascades in excitotoxicity with special reference to GABA & AMPA receptors; Special properties of the NMDA glutamate receptor; Signaling and endocrine functioning; Insulin signaling pathways; Hormone-regulated transcription factors; Antagonists at the nicotinic acetylcholine receptor; Cell fate determination: Role of growth factors; Pathways involved in cell differentiation and self renewal in mammalian system; Apoptotic signaling versus normal survival signalling; Major signaling cascades in cancer (β-catenin, Wnt signaling etc); Signaling involved in global protein translation and cancer progression; Hypoxic or stress mediated signaling in tumor microenvironment; Signaling mechanisms of neurodegeneration and neuroprotection; Signaling mechanisms of inflammation; Modulation of signaling pathways in stem cell by small amolecules.
BIO-IIIM-2-013	**Chemical biology** Basics in chemical biology How small molecules have been used to probe and modulate signal transduction pathways and major metabolic pathways, Signal transduction , Protein translation, Stressing mechanistic aspects of protein synthesis and folding *in vivo*, Cell Biology, Enzymes overview , Enzyme kinetics and enzymatic reactions Chemistry of Natural products NPs sources, classification, Isolation, identification, characterization or structural elucidation of the NP compounds Organic Synthesis Synthetic design, retro-synthetic analysis, synthetic methods, total syntheses Basics in spectroscopic techniques and stereochemistry Basics in Medicinal Chemistry and Bio-informatics Bio-informatics: Software based drug designing Medicinal Chemistry: Hit identification, lead generation and lead optimization by medicinal chemistry approach for drug discovery Target based drug design

	Introduction to Drug discovery Stages of drug discovery NCEs, IND filing, NDA, etc Drug targets Discovery & development

300 level courses

Course number	Course Content
BIO-IIIM-3-002	**Cancer biology** Introduction to cancer, Biochemical strategies for cancer detection: Recent technological advancements, Properties, cancer types and their prevalence: Relevant scientific associations, Important tumor markers: Potential role in search of novel markers in various cancers, Developments in oncogenic enzymology in understanding the cancer biology, Adhesive interactions: Biochemical toolbox of cancer cells, Cancer development & metastasis: Molecular Basis, Repetitive elements & genomic instability: Role in pathogenesis of cancer, Histone acetylases/deacetylases in cancer: Role in gene expression, Mutational analysis in cancer: Consequences & origin , Epigenomic basis of cancer: Role in initiation and development, Understanding of posttranslational modifications in cancer cell, Angiogenesis and malignancy, Stem cell biology & cancer, Important signaling pathways of cancer, DNA methylation machinery pathways for identification of new biomarkers , Carcinogenesis and apoptosis: Modulation by small molecules , Translation machinery and cancer progression , Stem cell fate determination: Importance of growth factors, Role of Histopathological & Immunocytochemical techniques in cancer, Aggressive tumors: Gleason score in pathology, Gene silencing and tumorgenesis, RNAi technology in cancer treatment, Pathways involved in cell differentiation/ immortalization in cancer, Initiation and propagation of cancer cells in cell culture systems: Evaluation of important properties and their relevance with human biology, Hypoxia/ tumor cell microenvironment and metabolic pathways in cancer, Pharmacokinetic and Pharmacodynamic parameters of important anticancer drugs, Discovery and clinical validation of a targets in cancer, Tools, techniques & important parameters involved in screening new bioactive(s) as possible anticancer agent(s), Cell cycle regulators: Role as therapeutic targets in cancer, Diseased and cancerous cell: Morphological and microscopic features, Orthotropic and xenografted models: Importance and their limitations in understanding cancer, Human tissue recombination models in cancer: Laser capture dissecting
BIO-IIIM-3-381	**Pharmacological screening, Hit identification and mechanism of action** Introduction to drug development , Selection of disease and test material, Drug Discovery using natural products , Drug Discovery using synthetic compounds , *In silico* biology in Drug development , Identification and validation of drug target , Assay development, Screening and Identification of lead compounds, Lead optimization and Formulation Development: Dr. P. N. Gupta , Mechanism of action , Case studies in Drug Discovery, IPR issues and Legal Affairs , IND filing and Regulatory guidelines
BIO-IIIM-3-382	**ADME** Pharmacokinetics and pharmacodynamics; Bioavailability; Drug Disposition: Absorption, Distribution; Drug Disposition: Metabolism, Elimination;
BIO-IIIM-3-383	**Toxicology** Principle of toxicology; Preclinical toxicology and mutagenesis; Systemic toxicology and teratology; Regulatory Pharmacology

IITR

100 level courses

Course number	*Course Content*
BIO-IITR-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-IITR-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-IITR-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-IITR-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research,

	Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	*Course Content*
BIO-IITR-2-001	**Biotechniques** Affinity chromatography, gel filtration chromatography, high performance liquid chromatography (HPLC), PCR, restriction fragment length polymorphism (RFLP), Agarose gel electrophoresis, Polyacrylamide gel electrophoresis (PAGE), two dimensional gel electrophoresis, MALDI-TOF, LCMS/ MS, ELISA, RNAi, blotting techniques, Microarray technology. Separation and characterization of biopolymers, UV/Visible Spectrophotometry, Co-immunoprecipitation, transfection, transgenics, Light microscopy, Fluorescence microscopy, fixation and staining techniques, Transmission electron microscopy (TEM), Scanning, electron microscopy (SEM), flow cytometry.
BIO-IITR-2-003	**Biology of Inheritance** Mutagenesis, DNA repair and applications of mutagenesis; Mechanisms of gene transfer including conjugation & transduction, and Recombination & mapping in prokaryotes; Applications and uses of transposable elements, gene regulation, virulence functions and horizontal gene transfer. Mendelian principles; Segregation and linkage; Recombination and mapping in eukaryotes; Gene interactions, forward and reverse genetics; chromosome rearrangements and their effects on gene expression.
BIO-IITR-2-008	**Xenobiotic Interaction and response** Introduction to the discipline of toxicology and basic concepts essential for understanding the action of exogenous agents on biological systems; Principles underlying the absorption, distribution, metabolism, and elimination of chemicals. Toxicokinetics, specific classes of toxic responses, and experimental methods used to assess toxicity; ethics in toxicological studies, Regulatory toxicology.
BIO-IITR-2-012	**Cell Signalling** [Introduction, historical perspective, classification]; Growth/ Differentiation/Apoptosis Leukocyte integrin/endothelial cells interaction; Receptor-ligand interactions/Cytokine signaling/G-protein-mediated signalling; Growth hormones/Receptor-mediated signalling; Neuronal signalling/Signaling in stem cells; Ion channels; Signaling in immune cells; Signaling aberration & Diseases [cancer, cardiovascular, diabetes]; Gene expression [Relevant transcription factors]; Cell regulatory mechanism [Role of p53, pRb, PTEN]; Nuclear Receptors & Signal transduction; Signal transduction pathways [Ras-MAPK, PI3K-AKT, p53, pRb; TGF-β, JAK-STAT, cAMP, Notch, Hedgehog and Wnt]; Signaling Crosstalks; Small group discussion [Literature review].
BIO-IITR-2-022	**Stem cells: Basics and future applications** Stem cells: the concept, types, development and plasticity; Isolation, purification, characterization, cultivation and differentiation of stem cells in laboratory conditions; Stem cell niche, homing, and migration; Genomics and proteomics of stem cells; Role of epigenetics to decide the fate of stem cells; Cellular and nuclear reprogramming to develop induced pluripotent stem cells; Therapeutic prospects of stem cells; Stem cells and biomaterial scaffolds for constructing tissues and drug delivery; Cancer stem cells: immunologic targeting; Applications of stem cells in toxicology studies; Ethical issues associated with stem cells.
BIO-IITR-2-416	**System Immunology** System Immunology: Integrated perspective on entities and players participating at different system levels to the immune function; Antibody Structure, Antigen-antibody interactions, Binding Sites, Affinity (Mathematical derivation) Avidity (Mathematical derivation); Major histocompatibility complex (organisation, function, inheritance & self restriction); Infection & Immunity (emphasis on TB, AIDS & Influenza); Signalling in immune cells and signalling aberration; Molecular Biology of

	CMI and delayed reactions; Complement System (different components, functions, regulation and biological consequences); Allergy and Inflammation, IgE (Hypersensitive reactions & Mediators); Organ specific and systemic Autoimmunity; Transplantation (immunologic basis and clinical manifestation of graft rejection; immune tolerance and xenotransplantation) **Practicals** Isolation of Lymphocytes from blood and leukocyte counting; In vitro lymphocyte culture; PFC assay, HA titre; Quantitative analysis of cytokines by Sandwich ELISA; PCR based Cytokine gene expression

300 level courses

Course number	*Course Content*
BIO-IITR-3-001	**Seminar** History of science with emphasis on Indian contribution: Seminar by students.
BIO-IITR-3-012	**Environmental Toxicology** Environmental Toxicology in present and future perspective; Environmental hazards (physical, chemical and biological aspects); Origin, sources and types of toxicants/pollutants; Dispersal/movement of toxicants in environmental compartments; Conventional and alternate models in toxicity assessment; Assessment of toxicity of pollutants; Absorption, distribution and storage of toxicants; Dose response relationships; Biotransformation and elimination of toxicants; Mechanisms of action of toxicants; Gene-environment Interactions Pollution monitoring and Risk assessment; Tools for detection; Fate and transport Hazardous waste management; Regulation, approaches and strategies; Mitigation of environmental pollutants; Physico-chemical and biological processes **Practicals** Xenobiotics exposure/effect assessment using alternate animal models; Case histories/studies and new concepts or topics will be interactively discussed; Case studies: real-life sites/ecological settings/industry in and around Lucknow
BIO-IITR-3-416	**Model systems in Toxicological Research** *In vitro*: Basics and principles of cell and tissue culture; primary cell cultures, cell lines, stem cells. *In vivo*: Bacteria, Yeast, Paramecium, Tetrahymena, *Caenorhabditis elegans*, Drosophila, Daphnia, Tubifex, Snail, Zebrafish, mammalian models. *In silico*: Basics of QSAR and modeling of macromolecules
BIO-IITR-3-417	**Food & Chemical Toxicology** Food and Chemical Toxicology: Uniqueness and Complexity; Toxicity of Metals; Toxicit Pesticides; Methods for detection and analysis of metals and pesticides in different matri Principles of drug induced toxicity; Cosmetic Toxicity; Protocols for identification of pro allergens: mucous membrane test, patch test; Nutraceuticals; Sea Food: Safety issues; F Toxins & Phytomedicine; Preparation and characterization of herbal extracts; Geneti Engineered Food/Crops; Food Contaminants and Adulterants; Analysis of food addit contaminants and adulterants; Food Borne Pathogens; Toxicity of Tobacco Related Produ Protocols for assessment of genotoxicity and carcinogenicity: Food Poisoning and I Safety: Prevention of Food Adulteration Act
BIO-IITR-3-418	**Target organ toxicity** Overview: Types of injury that may be produced in specific mammalian organs and organ systems by exposure to chemical toxicants; Neurotoxicity and its mechanisms: Concepts in neuropharmacology and neurophysiology; Neurogenesis; Neuro-behavioral toxicology; Chemical induced neurodegeneration and neuroprotection/ neuroregenration; Hepatotoxicity: Overview; Effect of xenobiotics on liver; Regulatory mechanism involved in hepatotoxicity; Nephrotoxicity: Renal structure and function; Chemical induced renal injury; Pulmonary toxicity: Structure and function of the respiratory system with emphasis on lungs; Systemic lung injuries; Immunotoxicity: Basics of the immune system; Mechanisms of immunotoxicity; Immunosensitization and allergy; Endocrine and reproductive toxicity: Teratogenicity; Reproductive organs and chemicals affecting reproduction; Endocrine system and chemical induced endocrine disruption
BIO-IITR-3-419	**Nanomaterial Toxicology** Basics of nanotechnology: Synthesis and characterization of engineered nanomaterials (ENMs); Sol gel, biological and ball milling methods for synthesis of ENMs and

	characterisation using electron microscopy (TEM, SEM), dynamic light scattering (DLS) and confocal microscopy; Safety assessment of ENMs – methods and challenges: Methods for assessment of toxicology of ENMs; preparation of nano-suspensions; exposure paradigm, cellular uptake, absorption and distribution; in silico approaches for macromolecule interaction with ENMs; Mechanism of toxicity of ENMs: Effect of size, shape and surface chemistry on cellular responses (oxidative stress, cytotoxicity, genotoxicity, immunotoxicity etc); Ecotoxicity of ENMs: Models and methods used for ecotoxicity assessment of ENMs; life cycle analysis of ENMs; Safe handling of ENMs and their disposal. **Practical** Preparation of nano-suspensions and their characterization Cellular uptake using flow cytometer Cytotoxicity assessment for ENMs
BIO-IITR-3-420	**Chemical Carcinogenesis and Chemoprevention** Chemical Carcinogenesis: Past, Present and Future, Genetic and Epigenetic Mechanism of Carcinogenesis, Models, Mechanism and Etiology of Cancer, Role of Oncogenes in Cancer Development, Cell Transformation and Apoptosis, Mutation and Cancer, Targeted Drug Delivery in Cancer Chemotherapy.
BIO-IITR-3-421	**Neurotoxicology** Introduction- Basic elements of central, peripheral and autonomic nervous system; Organization of CNS- Brain & Spinal Cord; Anatomy of Neuron and neuronal supportive cells – Glial cells; Physiology of Neuron –generation and propagation of AP; Central Neurotransmitters & Receptors: Catecholamines (Epinephrine, Norepineprine & Dopamine), 5-Hydroxytrytamine (5-HT), Acetylcholine, Histamine Inhibitory Amino Acid (GABA, Glycine & Benzodiazepines) Excitatory Amino Acid (Glutamate); Neurotoxicology: Basic concepts and principles; Developmental neurotoxicology; Neurotoxicology of metals, pesticides, solvents, monomers, natural agents; Neurobehavioal approaches to screen neurotoxicity; Assessment of neurotoxicity involving neuromorphological, neuropathological, neurophysiological and neuroimaging approaches; Assessment of neurotransmitters and neurotransmitter receptors: Usefulness in neurotoxicology; In vitro and in vivo models in neurotoxicology; Clinical neurotoxicology : basic principles; Neurotoxins and neurodegenerative disorders; Risk assessment and use of biological markers for neurotoxicity; Neuroprotective and regenerative approaches
BIO-IITR-3-422	**Genes and environmental diseases** An introduction to abiotic stress, effect of temperature and pollutants on the gene expression, recent advances in organismal responses to abiotic stresses; Current tools to measure environmental exposures/pollutants; Effect of environment and methods to detect genetic variation; Genes, environment and neurodegenerative diseases; Genes, environment and cancer; Genes, environment and asthma and allergy; Genes, environment and reproductive diseases

IMTECH

100 level courses

Course number	*Course Content*
BIO-IMT-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-IMT-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-IMT-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach
BIO-IMT-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research, Meaning of the Research, What constitutes a research topic? How to select a research

	topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	*Course Content*
BIO-IMT-2-001	**Biotechniques and Instrumentation** (compulsory) Instruments - Acquaintance and handling of instruments (For example: weighing balance, pH meter, centrifuges, HPLC, FPLC, PCR machine etc) Techniques in Biology - Handling of microbes and their basic characterization, Taxonomic characterization microbes and biochemical tests for characterization of a bacterium by Gram staining, MRVP test, Lactose fermentation, fatty acid profiling etc. Recombinant DNA technology - Concept of cloning, Plasmid DNA isolation, bacterial transformation with plasmid DNA, restriction digestion etc. - DNA sequencing: scope, application and troubleshooting. Protein expression and purification (concept of chromatography) Biochemical/Biophysical techniques - MALDI and its application. Steady state fluorescence spectroscopy and its use - Protein-DNA interaction: Electrophoretic mobility shift assay and use of phosphoimager - X-ray crystallography: Crystallization of proteins. Application of NMR. Cell Biology tools - Use of electron microscopy - Applications of confocal microscopy. Use of flowcytometer. Tools and techniques of Fermentation - Animal handling
BIO-IMT-2-002	**Biology of Macromolecules** Protein conformation - Protein crystallography - Protein-Protein interaction – enzymes Protein-Nucleic acids interaction - Cryo-EM – SAXS - Protein structure analysis - Macromolecular complexes - Membrane proteins - Classification of proteins - Structural bioinformatics
BIO-IMT-2-003	**Biology of inheritance** Classical and molecular genetics of bacteria - Molecular genetics and genome wide approaches in yeasts - Nucleic acids structure and topology - Central dogma and concepts on DNA transactions – Replication - Transcription & Transposition - DNA-protein contact probing - Molecular mechanisms and dynamics of replication Control - Licensing mechanisms – Telomeres - Transcriptional regulation and gene expression - Genetic Recombination - Chromatin structure and remodeling - The mechanisms of RNA interference - Ribozymes and riboswitches - Genome imprinting
BIO-IMT-2-004	**Biology of infection** Evolution of Bacterial Pathogens: a) Genetic basis of Virulence b) Techniques involved in identification of virulence genes c) Population Genetics of pathogen - Glycobiology paradigm in host-pathogen interactions. Delivery of Virulence factors through various transporter systems - Regulation of Virulence gene expression : a) One and Two component signal transduction, b) Quorum sensing mediated virulence expression c) Environmental signals (such as pH, osmotic stress, temperature, antibiotics, NO, host factor etc) mediated virulence traits Molecular pathogenesis of Bacterial pathogens, Protozoan pathogens (Malaria) and Fungal pathogens (Candida albicans). Model systems to understand the function of unique virulence factors
BIO-IMT-2-005	**Genomics: Information flow in Biological Systems** Introduction - Next-generation sequencing technologies - Strategies for large scale DNA sequencing - Library preparation and sequencing of a genome -

	Computational assembly of a genome – Information sources for genomics – Principles of sequence analysis - Annotation and analysis of a genome – Evolutionary concepts in genomics - Genomes and the protein universe - Genome properties - DNA Repeats in genomes – Phylogenomics - Introduction to comparative genomics - Comparative genomics - Population genetics - Case study – genomics approach – Metagenomics - Analysis of gene expression
BIO-IMT-2-006	**Protein Science and Proteomics** Protein Spectroscopy - Design Principles of Protein molecular machines - Translational and transcriptional - Unwinders and Degraders - Filters and Transporters - Post-translation modification - Therapeutic protein - Protein vehicles - Proteomics - Glycobiology - Nano-biotechnology
BIO-IMT-2-007	**Systems Biology** Introduction - Mathematical Tools for systems biology - Physico-chemical understanding of the system - Building kinetic and statistical mechanical model of biological processes - Modeling of gene expression - Systems biology of signal transduction - Autoregulation and kinetic proof readings in biology - Modeling of biological processes at multi-level
BIO-IMT-2-012	**Cell Signaling** Cell Signaling research – a historical perspective - Cell Signaling hardwires – kinases, phosphatses, GPCR, Small GTPase – Cell Signaling in prokaryotes – Two-component system – environment sensing, Nutrient sensing and stress response – quorum sensing and social behavior in prokaryotes – Cell signaling in Fungi – Pheromone response pathway, nutrient sensing, osmosensing signal transduction pathway – Cell signaling softwares – Control mechanisms in cell signaling – System level and genome scale understanding of signaling pathways – Cell signaling in Metazoan – Differentiation and disease, cell communication – Methods in cell signaling research – kinase, phosphatase, GTPase etc assay – use of inhibitors and non-hydrolysable analogs – use of dominant and recessive mutants – analog sensitization – multiplex western blotting – protein-protein and protein-ligand interactions – FRET and FRAP analysis – Applications of Fluorescence microscopy in cell signaling research
BIO-IMT-2-013	**Chemical Biology** Organic Chemistry and Biology - Chemical Biology and Computers - Lipid and Sugar Chemistry - Drug Discovery through screening - Enzyme Conformation-Activity
BIO-IMT-2-020	**Molecular and Cellular Mechanisms of Defence** Introduction to Immunology - Historical perspective of immunology - Immune organs - Immune cells - Innate immunity - Adaptive immunity - Cellular Immunology - T and B cell biology, antigen presenting cells, Major Histocompatibility Complex (MHC) - Signaling and effectors of immune system - Immunoglobulins, cytokines, chemokines and cell signaling - Disease and immunity - Immunology of infectious diseases, cancer, autoimmune disorder and hypersensitivity-mediated diseases - Recent trends in immunology - Reproductive immunology, immunodiagnostics and immunotherapy.
BIO-IMT-2-025	**Biodiversity**

	Universal tree of life: domains of life, bacteria, archaea and eukarya - Prokaryotic species concept: Characterization of prokaryotes – polyphasic taxonomy - Overview of microbial diversity, methods, and limitations in studying microbial diversity - Molecular phylogeny : different types of genes used for phylogenetic studies and their importance - Metagenomics and its applications - The world of fungi : Diversity, taxonomy, classification, preservation and their maintenance - Microbial life in the biosphere –interactions between the microorganisms and ecosystem, adaptations to the extreme environments - Phototrophic Bacteria: Methods of cultivation and applications - Microbial diversity – bio-prospecting, applications and economic importance - Anaerobic microbes – methods to cultivate the anaerobic microorganisms and their metabolism
BIO-IMT-2-026	**Bioinformatics** **Biological Databases -** Database- introduction and definition. Primary, secondary and tertiary databases. Type and kind of databases. Literature (PUBMED and MEDLINE). Nucleic acid and protein databases (GenBank, EMBL, SWISS PROT, UNIPROT etc.). Plants and Animal databases (Ensembl Genome project, Flybase, Maize GDB). Structural databases- PDB, PDBsum, NDB, CATH, SCOP etc. Motifs and Pattern Databases- PROSITE, Pfam, etc. RNA databases: RNABase etc. Carbohydrates and lipid databases- GlycoSuiteDB, LIPIDAT etc. Database Retrieval and deposition systems- SRS, Entrez, Bankit, etc. and AutoDep. Protein-Protein Interaction Networks and databases- DIP (Database of Interacting Proteins), BIND - Biomolecular Interaction Network Database, Yeast Interaction Database etc. siRNA/miRNA resources. File formats- GenBank, EMBL, fasta, free format etc. **Alignment of Sequences -** Sequence alignment-introduction and concepts; Sequence comparison using DOT matrix. Scoring matrices (Identity, Chemical, Substitution- PAM, BLOSUM); Local and global alignment concepts. Dynamic programming (Needleman-Wunch, Smith-Waterman algorithm). Similarity and percent identity score (open, extended gap penality). Multiple sequence alignment-introduction and concepts. Types of multiple sequence alignment techniques. Description of major software (MSA, CLUSTALW, PILEUP). Database Scanning and Sequence similarity searches. Algorithm of FASTA. Description of BLAST algorithm. Various BLAST programs (e.g., BLASTP, BLASTN). Concept of iterative search (PSI-BLAST and PHI-BLAST). Application of PSSM profile. **Sequencing and Annotation of Genomes -** Introduction to genomes. Sequencing techniques. Sequencing of whole genomes. Next Gen Sequencing. Assembling of Genomes from Short Reads. Concept of Metagenomics. Types of repeats and repeat finding techniques. Structure of genes. Prediction of gene in prokaryotic and eukaryotic genomes. Prediction of promoter prediction in *E.coli* and in eukaryotes. Description of major gene prediction methods. Comparison of genomes. Genome projects and sequence archive databases. **Phylogenetic Analysis -** Evolutionary analysis. Relationship of phylogenetic analysis to sequence alignment. Genome complexity. Concept of evolutionary trees. Methods-maximum parsimony method, distance methods, the maximum likelihood approach. Sequence alignment based on evolutionary model. Reliability of phylogenetic predictions. Complications from phylogenetic analysis - **Protein Structure Analysis -** Protein Structure –Introduction. Protein Structure analysis. Secondary structure assignments (DSSP). Protein Structure Comparison and alignment. Distance Matrices. Maximum Common Sub-graph Algorithm (PROCOR). Structural alignment algorithms (CE, VAST, DALI, SSAP etc.) - **Prediction of Protein Structure -** Protein structure prediction-concepts. Use of sequence patterns for protein structure prediction. Prediction of protein secondary structure from the amino acid sequence- Secondary structure Prediction methods: First, second, third and fourth generation methods like CHOU-FASMAN, GOR; Nearest neighbor methods like GOR-IV etc., Neural network methods like PHD, PSIPRED, JPRED. Hidden Markov Models like HMMER. Concepts, algorithms and their limitations. Evaluation of success of structure predictions. Benchmarking, CASP, CAFASP, EVA etc.- Protein three dimensional structure prediction- Introduction. Homology Modeling (method- SWISS-MODEL, MODELER, Fold recognition method-3-D PSSM, SAM, I-TASSER etc. *abinitio* method –Introduction and concepts - Basic principle 2D and 3D graphics and use of molecular graphics packages (e.g.

	Rasmol, MOLMOL, Chimera, Pymol, spdbviewer), Building small molecules using chemical information. Structure Visualization techniques (Software & Hardware) - **RNA Structure Prediction -** Importance of RNA structure. Features of RNA secondary structure. Development of prediction methods. Self complementary regions in RNA sequences. Minimum free energy method. MFOLD and use of energy plots. Covariation analysis in RNA sequences and its use in structure prediction. Mutual information content. Limitations of prediction - **Molecular Simulation and Docking -** Introduction to Molecular Modeling. What are models used for? Areas of application – Single molecule calculation, assemblies of molecules, Coordinate Systems. Potential energy surface - Molecular structure and internal energy. Molecular Potential Energy function. Empirical force field. Sources of force field data. Examples of important force fields - Energy Minimization-Concepts. First derivative techniques: steepest descent and conjugate gradients, Second derivative techniques: Newton-Raphson, Global Optimization (simulated annealing) - Molecular dynamics- Introduction, Molecular dynamics using simple models, Dynamics with continuous potentials. Constant Temperature and constant dynamics, Conformation searching, Systematic Search. - Conformational Analysis: Systematic Methods, Random search methods, distance geometry - Principles and methods of docking. docking problem. Scoring functions. Macromolecular docking-Concept. Practice and limitations of Computer assisted drug discovery process - **Computer Aided Subunit Vaccine Design** - Introduction to immunoinformatics. Concept of subunit vaccine: Endogenous and Exogenous antigen processing. Prediction of CTL epitopes (MHC Class I binders, Cleavage sites, TAP binders, Non-epitope MHC binders). Identification of T-helper epitopes and promiscuous MHC class II binders. Prediction of B-cell epitopes (linear and conformational epitopes). Role of innate immunity in adjuvant design; Integrative approach for epitope or peptide based vaccine – **Microarray -** Introduction, history and types of microarrays. Application of microarray. Affyemetrix Technology. Stanford/cDNA chip. Processing and analysis of images. Preprocessing of expression data. Normalization of data; Differential Gene expression. Expression based clustering of genes (Supervised, Unsupervised, K-means, Hierarchical). Prediction of function from expression data. Microarray databases.
BIO-IMT-2-451	**Biochemical Engineering** Bio-reactions and bioreactors – Introduction to bioprocess engineering – interaction of chemical engineering – biochemistry and microbiology, cell growth and product formation kinetics – mammalian cell culture – biocatalysis – immobilization of cells and enzymes – types of reactors – mass transfer and heat transfer – asepsis and sterilization – scale up and scale down of bioprocesses – Downstream processing – Principles of choosing a separation/ purification process – Intracellular and extracellular product recovery methods – bioprocess synthesis.

300 level courses

Course number	*Course Content*
BIO-IMT-3-001	**Seminar Course (compulsory)** History of science with emphasis on Indian contribution: Seminar by students
BIO-IMT-3-004	**Frontiers of Biology: Synthetic Biology** Introduction to synthetic biology – Biobricks/parts, devices, systems – Peptide and protein building blocks for synthetic biology – reconstruction of genetic circuits, logic gates – application of synthetic biology – in medicine, energy, environment etc – Future perspectives – Major ongoing and international initiatives – Methods for large scale reconstruction of parts/ metabolic pathways
BIO-IMT-3-005	**Advanced Bioinformatics** **Computer Software -** Concept of LAMP (Linux, Apache MySQL and PERL) learning. Introduction to Linux. Installation of Linux; Basic and advance Linux commands. Editors (vi, emacs). Software installation and configuration; Introduction to Apache. Configuration of Apache. Launching of web site using Apache; Introduction of HTML. Development of web sites; Concept of common gateway interface (CGI). Concept of FORMS in HTML. Introduction to MySQL. Development of Databases using MySQL. Introduction to PERL. Example PERL programs. Handing FASTA files. Program for calculating amino or nucleotide composition of sequences – **Algorithms -** Algorithms and techniques used for developing programs for biological problems. Quantitative matrices. Introduction to Machine Learning Techniques. Artificial Neural Network. Support Vector Machine. Hidden Markov Model. Example-based leanings. Major Software for implementing algorithms (SVM_light; SNNS; HMMER; Weka). **Introduction to R:** Introduction to R. Installation of R. Description of R environment. Using R interactively. Getting help with functions. Assigning variables. Arrays and vectors. Functions on vectors. Using R commands from terminal. Reading data from files. Programming in R. **- Bioinformatics Software for Annotation of Proteins -** Important of annotation of proteins. Classification of protein annotation methods. Protein Sub-cellular Localization (amino acid, dipeptide, split-amino acid composition). Prediction of Antigenic regions in proteins (motif, matrix and ANN based methods). Secondary structure prediction (probability, segment, evolutionary approaches). DNA/RNA interacting residues in proteins (binary, PSSM and composition based approaches). (**Note:** This course is designed for students interested in research in the field of bioinformatics particularly in developing prediction and classification programs/web-servers. Equal number of theory and practical classes shall be taken up in this course.)
BIO-IMT-3-	**Mycobacterium tuberculosis**

451	Introduction to TB & A historical prospective of TB - Diagnosis of TB- development of Tuberculosis Vaccines - Treatment of tuberculosis-Drugs under development - Experimental animal models of tuberculosis - Molecular evolution of Mycobacterium - Ultra-structure and Biochemistry of mycobacterial cell- Lipids of mycobacterium- Structure, biosynthesis and biological activity - Redox homeostasis in Mycobacterium - Latency of mycobacterium- An overview of latency and mechanisms involved in persistence - Hypoxia and NO-A window to persistence of mycobacterium - Mechanism of signal transduction in mycobacterium. Serine-threonine kinases and two component proteins of mycobacterium - Transcription machinery of mycobacterium-Sigma factors and their role in the virulence of mycobacterium - Experimental Genetics of Mycobacterium - Interaction of Mtb with macrophages - Immunopathology of TB
BIO-IMT-3-452	**Metagenomics** Introduction to metagenomics, challenges, functional applications - A typical metagenomic study - eg.human distal gut microbiome Metagenomic library preparation and sequencing - Metagenomicassembly basics - Metagenomic gene identification, metabolic reconstruction - Genome variations, Detecting genome variations in metagenomic data, Quasi species detection Community and comparative metagenomics - Amplicon sequencing and Gene Targeted (GT) metagenomics - Strategies for enrichment, functional screens - Bioprospecting metagenomes for novel enzymes - Metatranscriptomics and metaproteomics
BIO-IMT-3-453	**Advanced Biochemical Engineering** Bioreactions – Cell growth and product formation kinetics, growth associated, non-growth associated and mixed-growth associated product formation, cell growth and product formation models – quantitative review of biochemistry, metabolism and metabolic engineering, engineering aspects of microbial process and bioconversions – Bioreactors – Design of bioreactors – kinetic analysis, packed bed bioreactor, Fluidized bed batch, fed-batch and continuous culture – Bioprocess development – Exploitation of genetic engineering and bioprocess development, Plant cell culture, Mammalian cell culture, Enzyme technology – Downstream processing – Purification and separation technology, integrated bio separation schemes – Case studies – Production of protein pharmaceuticals as a paradigm of the application of biochemical engineering to advanced process development within the frame work of current business and regulatory requirements – Chemicals from biomass

NBRI

100 level courses

Course number	Course content
BIO-NBRI-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-NBRI-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-NBRI-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach

BIO-NBRI-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research, Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	*Course content*
BIO-NBRI-2-001	**Biotechniques and Instrumentation** (compulsory) Part-I Chromatographic Analysis: GLC, HPLC, HPTLC and Flash chromatography Part- II- Spectroscopic analysis: UV, AAS and Mass spectrometry Part- III – Microscopy Light Microscopy, Confocal Microscopy, SEM and TEM NMR Spectroscopy in Plant Metabolomics: Introduction & Scope of NMR Spectroscopy and Applications of NMR Spectroscopy in Plant Metabolomics Electrophoresis: agarose and polyacrylamide gel (native and denaturing), 2-D gel Centrifugation (high speed, ultra and differential centrifugation) Common Molecular Biology Techniques Chromatography: affinity, ion exchange, hydrophobic chromatography, size exclusion and reverse phase chromatography Proteomics- MALDI-MS/MS, LC-ESI-MS/MS Practical Chromatography Techniques Spectroscopy Techniques
BIO-NBRI-2-003	**Biology of Inheritance** What, why and how of this course Introduction, Scope of the course syllabus, Reading lists and handouts for students, Lottery for Term / Review paper topics In the beginning: Cell, chromosome, gene, hereditary units, hereditary materials, what is heredity? Unit of life – A cell and cellular basis for heredity: Why a cell divides? How it divides? Cell cycle, How does cell division impact heredity? Cell division – rules and parameters Chromosomal basis for heredity: Chromosome structures, its functions, chromosomes in cell division, chromosomes in heredity, Aneuploids, Polyploids Everyone had an opinion about heredity: Assorted theories for inheritance, Darwinism, Neo-Darwinism, Lamarckism Gregor Johann Mendel and his seminal contributions to our understanding of genetics and heredity: Where would we be if Mendel had not made his landmark contributions? Mendelism: Genes, determinants, alleles, Mendel's postulates, Laws of inheritance, their applications in real life, Universality or otherwise of these laws What happens when Mendelian laws are not followed / obeyed? Epigenetics, Transposition, Pleiotropy, Heterosis What happens when heredity rules go wrong? Inherited disorders, chromosome errors, single gene mutations, induced mutations Mechanisms of inheritance: Recombination, crossing over, chimerism, gene dosage, dominance and incomplete dominance, linkage and linkage disequilibrium, QTLs Does heredity in individuals differ from or impact on populations and communities? Population genetics, genetic communities, quantitative genetics Molecular genetics: Architecture of a Mendelian locus, its dissection and mapping, linkage, genetic and molecular mapping Why is study of genetics central to: Our understanding of evolution, populations, communities, ecology, recombinant DNA technologies? Students display their learning: Return of term / review papers, Seminars / Round-Table brainstorming How far did we succeed? Evaluation times are here again!!! Students to complete a test (30 min, MCQ with negative markings; 1/3 descriptive question); Students evaluate Faculty (15 min – Predesigned questionnaire);

	Valedictory and Closure of the Course (15 min)
BIO-NBRI-2-005	**Genomics: Information flow in Biological Systems** Introduction: From Sequence to function in the Age of genomics, Genome databases of various plants. Genome Organization: Nuclear, Mitochondrial and Chloroplast Genome Genome analysis: Cloning systems used in genomics, Sequencing and analyzing genome, Principles of Gene Annotation and prediction, tools and resources Genomes and transcriptomes of model organisms Small RNAs and their role in regulation of gene expression Functional genomics: Strategies to find important genes in the genome and their functional analysis Differential gene expression profiling methods (differential display, subtractive analysis, Microarrays, comparative transcriptomics) Comparative genomics and synteny (Multiple Sequence Alignments & Phylogenetic analysis) Practical Courses: Demonstration of microarray system Demonstration of 454 whole genome sequencing system Demonstration of *Sequnome* system
BIO-NBRI-2-009	**Plant-Microbe Interaction** Plant associated soil micro-organisms and microbial diversity Plant responses to PGPRs and pathogens Rhizosphere dynamics, effectors and signaling Plant microbe interaction in stressed conditions Molecular mechanisms of PGPRs and pathogens Application of Proteomics in plant microbe interaction Role of mutagenesis in plant microbe interaction Bioinoculants for nutrient and disease management Virus structure and morphology, plant virus diseases and symptomatology Transmission of plant viruses Replication and translocation of viral genomes Genome organization of viruses Practical Techniques for study of PGPRs and pathogens-I Techniques for study of PGPRs and pathogens-II Methodology for assay, detection and diagnosis Modern approaches of virus control
BIO-NBRI-2-010	**Plant Environment Interaction** Environment and Sustainable Development. Environment Pollution in National and Global Perspectives Sources of Air Pollutants and Plant Responses Sources and Fate of Pollutants in the Aquatic Ecosystems Responses of Plants to Water Pollution Sources and Behavior of Soil Pollutants Responses of Plants to Soil Pollutants Prevention and Mitigation of Air Pollution Prevention and Control of Water pollution Energy Resources and Conservation Plant adaptation to Environmental stress Environmental Degradation and Restoration Biomonitoring of Environmental contaminants Environmental Impact Assessment & Auditing Practical

	To study improvement in physico-chemical characteristics of waste water after treatment with aquatic plants, Physiological and Biochemical response of plants to toxic metals
BIO-NBRI-2-012	**Cell Signaling** Cell communication: Inter-organellar communication Nucleus-plastid-mitochondrion, Plasmodesmata, signal delivery systems. Membrane receptors, Protein kinases: Ion channels, G-protein-coupled receptors, Wall associated kinases, MAPK kinases, Ca^{++}-calmodulin system. Ethylene signalling: Plant two-component signaling systems Ethylene biosynthesis, ethylene signaling cascade ethylene responses in different tissues. Auxin signalling: Auxin receptors, Auxin-responsive gene expression, Proteolysis and auxin signalling. ABA signalling: Biosynthesis and Catabolism Pathways, Regulation of ABA synthesis and metabolism, ABA Signaling in seed maturation processes Proteolysis and protein interactions, ABA Signaling in Guard Cells, ABA as Antagonizing Signal to Light in Stomatal Movement. Cytokinins, Gibberellins: Cytokinin metabolism, Cytokinin signal transduction, Gibberellin metabolic pathway, Genes of GA Biosynthesis and regulation, Signal transduction pathway, Downstream transcriptional events induced by Gas, Sites of GA Signaling. Brassinosteroids, strigolactones, Signaling by JA, SA, polyamines: Biosynthesis, metabolism, signal transduction-mode of action Light signalling: Phytochrome-mediated responses-energy dependence, Structure of phytochromes, Phytochromes- mechanism of action, Phytochrome interacting factors, Phytochrome-regulated gene transcription Cross talk between signaling pathways
BIO-NBRI-2-016	**Developmental Biology-Plants** Root - Architecture and types, cell types, molecular basis of root development, lateral root formation, adventitious roots, root hairs, storage roots, gravitropism, hormonal control, root symbiosis, root apex Shoot - Shoot apical meristem, cell division,differentiation, xylogenesis, phloem, branching, secondary wood, molecular basis of development, hormonal control, cell growth, programmed cell death Leaf - Types, phyllotaxis, size and shape control, cell types, venation, plastid biogenesis, stomatal development, senescence Flower - Types, determinacy, ABC model, architecture, pigmentation, control of flowering time, photoperiod control, senescence, hormonal basis, scent, development of reproductive organs, pollination, apomixis Reproduction – Male and female gametophyte development, Pollination, fertilization, zygote, embryogenesis, Molecular basis, male sterility self incompatibility, somatic embryogenesis Fruit - Development, size control, ripening, parthenocarpy, molecular basis, hormonal control, climacteric fruits, abscission, sex determination Seed - Genetic control of seed development, seed structure, types of storage reserves, molecular basis, oil seeds, dormancy and germination, hormonal control, recalcitrance in seeds, photomorphogenesis, endosperm Secondary growth, cambium, trichomes, fibre, totipotency
BIO-NBRI-2-017	**Epigenetics and Chromatin Organization** Theory Epigenetics: DNA methylation and concept of epigenetics, Histone modifying enzymes and their role, Chromatin modifying matchinary, Chromatin architecture, Histone modifications, Hostone methylation, demethylation etc Transcriptional Gene Regulation: Operon Concept,, Transcription Factors and Classification, Promoters, cis-regulatory elements and enhancers, Pre-initiation complex and RNA Polymerase, transciprtion elongation and termination Gene Silencing: Transcriptional gene silencing, Post transcriptional gene silencing : Small RNA world and mechanism of regulation Post-transcriptional gene regulation: RNA processing, Inron splicing etc., Post-

	translational modifications of protein and their regulation Practical Nuclear Protein preparation, EMSA, Chromatin Immunoprecipitation and analysis
BIO-NBRI-2-018	**Homeostasis and feedback in biological systems** Light use and leaf gas exchange: Leaf anatomy, light interception and gas exchange, Chloroplasts and energy capture Carbon dioxide assimilation and respiration: Modes of photosynthesis, Photorespiration, Respiration and energy generation Gaining water and nutrients: root function: Root system architecture, Extracting water and nutrients from soil, Soil–root interface, Absorption of water and nutrients by roots Using water and nutrients: cell growth: Membrane transport and ion balance, Regulation of nutrient ion and Cell enlargement Vascular integration and resource storage: Long-distance transport of water and nutrients and Distribution of photoassimilates within plants, Phloem transport, Phloem loading, Phloem unloading and sink utilization Growth analysis: a quantitative approach: Concepts and techniques, Environmental physiology and Crop growth analysis
BIO-NBRI-2-021	**Molecular breeding of plants** Breeding strategies of self and cross pollinated crops Mode of reproduction in plants, pure line and mass selection, pedigree and bulk population, backcross, population improvement, Self incompatibility and male sterility and their use in hybrid seed production, recurrent selection Experimental designs in relation to plant breeding Randomized complete block design (RBD); latin square designs; augmented block design, Merits and limitations of different designs, Statistical and biometrical methods in plant breeding Analysis of Variance (ANOVA), Correlation, regression and path analysis, heritability, genetic advance, genetic gain, combining ability, heterosis and inbreeding depression, Tests of significance: Sampling distribution of mean and standard error; z and t-test, Chi- square test for goodness of fit, F test. Mutation and polyploidy breeding Selection of parents, mutagen treatment and handling of treated material, development of polyploids and their evaluation, Molecular Markers Overview of markers, Concept, Development methodology of AFLP, SSR, and SNP markers, Merits and demerits of different types of markers Mapping populations and phenotyping Types and developmental strategies (F2, RILs, DH lines), Merits and demerits of various types of mapping populations, Field experimental design and phenotyping Construction of linkage map Linkage map, marker polymorphism, genotyping, Data scoring, softwares and Linkage analysis, Germplasm characterization and Diversity Analysis Selection of markers, Genotyping, Data acquisition, Softwares, statistical methodologies and analysis Quantitative Trait Loci (QTLs) and QTL analysis Principle of QTL analysis,Genotyping, phenotyping, Methods to detect QTLs (Single markers, Simple and composite interval mapping), data acquisition, Softwares and analysis, Association mapping in plants Introduction, Choice of population, Analysis of population structure, Trait evaluation (phenotyping), Identification of marker/sequence polymorphism, Statistics of association mapping-Linkage disequlibrium (LD), measure of LD, factors affecting LD Marker Assisted Selection (MAS) Gene tagging by Bulk segreegent Analysis (BSA) and near isogenic lines (NILs), Gene pyramiding, advanced backcross QTL (AB-QTL) analysis, Breeding by

	Design, Effectiveness and efficiency of MAS over phenotypic selection, foreground and background selections; marker assisted hybrid (MAH) breeding; important examples of successful MAS. Practical Emasculation, pollination, Genotyping (PAGE and ABI DNA Analyzer), data scoring, polymorphism detection.
BIO-NBRI-2-025	**Biodiversity** Aims, objectives and dynamics of Plant biodiversity Bio-geographic regions of plant biodiversity in India and world Diversity within different plant groups Assessment of biodiversity through classical taxonomic methods Ecological methods for plant diversity inventorying Drivers of biodiversity loss Role of Biosphere Reserve, National Parks, Wild Life Sanctuaries, Sacred Grooves in biodiversity conservation Species distribution and endemism Biodiversity and its sustainable uses Biodiversity and traditional knowledge Development of plant databases and its management Biodiversity legal and policy instruments Biodiversity, ecosystem function and ecosystem processes Ecological niche Impact of climate change on plant biodiversity Practical work: Field visit and ecological methods to study biodiversity
BIO-NBRI-2-486	**Plant morphogenesis and regeneration** History and scope of plant tissue culture, concept of cellular differentiation Dedifferentiation, re-differentiation, totipotency and media composition. Plant Growth Regulators Auxin, cytokinin, GA, ABA, JA, ethylene signaling pathway Organogenesis and somatic embryogenesis: Fundamental aspects of morphogenesis, somatic embryogenesis and androgenesis, mechanisms, techniques and utility. Culture of different plant parts: Root, stem, leaf, meristem culture, ovary, ovule and nucellus culture, embryo culture, endosperm culture. Production of Haploids: Techniques for development of androgenic haploids, factors affecting anther culture, pollen culture, gynogenesis, applications of haploids. Somatic Hybridization: Protoplast isolation, fusion and culture, hybrid selection and regeneration, possibilities, achievements and limitations of protoplast research Application of Plant Tissue Culture: Clonal propagation, artificial seed production/ encapsulation somaclonal variation, production of secondary metabolites/natural products, automation in plant tissue culture, cryopreservation and germplasm storage Specific gene transfer: Direct and indirect methods, current status and limitations. Practical Laboratory organization and equipments, preparation and sterilization of media. Explant preparation, surface-sterilization, inoculation and subculture. Hardening and field transfer of tissue-raised plants, excised root culture, callus culture, encapsulation of seeds/somatic embryos.

300 level courses

Course number	*Course content*
BIO-NBRI 3-001	**Seminar Course (compulsory)**
BIO-NBRI 3-003	**Cell and tissue engineering** Genetic engineering of plant cells -Transgenic plants Methods of direct and *Agrobacterium* mediated gene transfer (Ti plasmid). Methods for DNA transformation: electroporation, microinjection, particle-gun technology. Strategies for crop improvement with special mention of biotic and abiotic resistant plants and value addition. Recombinase-directed chromosome engineering in plants Cre & lox system FLP& FRT system PhiC31 & aatP-attB system R and RS system/ParA& MRS system Production of pharmaceutically important drugs and therapeutics using genetic engineering Large scale production of secondary metabolites using cell and suspension cultures. Hairy root culture and Ri plasmid, Hairy root cultures as phytochemical factories and process of elicitation. Recombinant therapeutic protein production (medical molecular pharming) in plant cells/tissues. Metabolic Engineering of major metabolic pathways and products. Cloning and characterization of secondary metabolic genes. Bioengineering and other means to develop new plant products. Use of genetic engineering and molecular biology tools for Metabolic Engineering. Plant Cell reactors- type of reactors, comparison of reactor performances, Immobilized plant cell reactors. Practical Experiments Electroporation & particle-gun technology Molecular characterization of transgenic plants Hairy root induction and establishment Demonstration of bioreactor
BIO-NBRI-3-486	**Climate change and Plants** Sources of Green House Gases (GHGs) and their impact, Mitigation strategies of GHGs, Impact of elevated CO_2 and temperature on plants, Plant responses to O3 stress, Drought tolerance mechanism of plants, Crop simulation modeling, Carbon sequestration, Green technologies to combat climate change, Climate change and forest ecosystems, Climate change and plant diseases, Climate simulation modeling, Remote Sensing & GIS, FACE technology Practical Ozone monitoring techniques Methane efflux measurement Ambient Air Quality Monitoring
BIO-NBRI-3-487	**Bioremediation** Bioremediation: Principles and Applications Bacterial Remediation of Metal and Metalloid Contamination Fungal Bioremediation Mycorrhiza and Rhizoremediation Phycoremediation

	Biodegradation of Recalcitrant Organic Wastes Phytoremediation of Contaminated Water & Constructed Wetlands Phytoremediation of Contaminated Soils Phytoremediation and Role of Nutrient Management Role of Nanotechnology in Bioremediation Scope of Soil Carbon Sequestration in Degraded Soils Limiting Factors in Bioremediation Processes Practical Protocols/ Techniques of Soil Bioremediation using Microbes Protocols/ Techniques of Soil Phytoremediation Protocols/ Techniques of Phytoremediation for Aquatic Ecosystems Use of Soil Enzymology in Monitoring of Bioremediation
BIO-NBRI-3-488	**Environmental Biochem and Biotech** Advances in Environmental Biotechnology Physiology of toxic metal transport and accumulation by plants I Physiology of toxic metal transport and accumulation by plants II Biochemical basis of metal hyperaccumulation in plants Detoxification mechanisms of toxic organic compounds Transgenic microbes for pollution management Molecules and pathways associated with metal detoxification in plants. Gene mining for metal accumulation and transport Transgenic plants as hyperaccumulators of heavy metals. Transgenic crops for low accumulation of toxic metals. Metagenomics of polluted habitats. GM crops and their impact on Environment. Practical Element estimation by AAS, ICPMS Enzyme assays- Antioxidant enzymes. Measurement of non protein thiols/Phytochelatins Gene expression by heavy metals (Microarray/RTPCR).
BIO-NBRI-3-489	**Taxonomy and speciation** <u>Unit-I: Taxonomy of plants</u> History of plant taxonomy and classification of angiosperms International Code of Botanical Nomenclature Modern trends in Taxonomy: (a) Numerical taxonomy, chemo-taxonomy, cyto-taxonomy, and (b) Palynology, embryology, anatomy and palaeo-botany Relevance of Herbaria & Botanical Gardens Systematics of Pteridophytes and Gymnosperms (General characters, classification, important families) Systematics of non-vascular plants Plant descriptors, systematic of some selected families in Dicots & Monocots Methods and techniques in plant taxonomy and herbarium <u>Unit –II: Molecular Systematics and speciation</u> Species concept Speciation in plants Molecular Systematics: Concepts and applications Molecular markers in plant systematics Procedures for collecting and sampling of plant materials Molecular Phylogenetics Phylogenetic Inferences Phylogeography: concepts and case studies in plants
BIO-NBRI-3-490	**Plant Conservation and Reproductive Biology** <u>Conservation biology: principles and applications</u>

	Introduction to the science of conservation biology, Threats to plant diversity- Causes and consequences of Habitat fragmentation, destruction, over-exploitation, diseases, invasive aliens, pollution, and climate change Vulnerability to extinction Habitats, Species and Populations vulnerable to extinction, Examples and Case Studies Conservation at species and population levels: Population genetics and conservation I Measurement of genetic diversity, Population bottlenecks and maintenance of genetic diversity Population genetics and conservation II Gene flow, Reproductive/mating systems; -inbreeding and out -breeding depression Effective population size and management of genetic diversity Conservation biology of rare and endangered plants Concepts and practical approaches, Case studies, Designing framework for new case studies Conservation at Landscape and Ecosystems levels Methods and strategic approaches, Case studies Plant species loss: assessment of extinction risks IUCN Red lists: Criteria and Classification, National Red Lists, Biodiversity Hot spots Plant conservation methods and strategies *In situ* conservation, *Ex situ* conservation, Integrated conservation, Recovery, Reintroduction and Rehabilitation of endangered habitats and species, Case studies; visit to botanic garden, conservatories, gene banks, etc. Introduction to Plant Reproductive Biology Modes and mechanics of reproduction in plants Functional Mechanism of Sex gametes and Reproductive behaviour Ontogeny and development of sex gametes in cryptogams, Ontogeny and development of sex gametes in phaenerogams, Floral biology and phenology Reproductive Progression and Plant Breeding Intra and Inter gametophytic mating and sporophyte development , Nature of breeding system, homozygosity and heterozygosity, Reproductive success and origin of polyploid genotype Pollen and Pollination Biology Structural and developmental pattern of pollen, factors influencing pollen productivity (environment, genetic) and pollen syndrome, Pollination mechanism, plant-pollinator interactions , Pollen and pistil interaction Fertilization and Seed Biology Fertilization mechanism, embryo and endosperm development, Fruit biology, seed formation, dispersion and syndrome, Seed germination and seedling demography Abnormal Reproductive Behaviour in Plants Male sterility and self incompatibility, Polyembryony, parthenogenesis, parthenocarpy, Apogamy, apomixis, apospory Recent Trends in Reproductive Biology In vitro culture of pollen, spores, gametophytes, sporophytes, embryo and tissues, Physiological and molecular aspects of sex gamete expression, differentiation, development and floral induction , Production of androgenic plants and somatic hybridization Reproductive Biology and Threatened Plants Genetic load and reproductive barriers, Physiological and genetic infringement of reproductive barriers, Case study, visit to conservatory, fernery and moss houses etc .
BIO-NBRI-3-491	**Economic Plants and Pharmacology**
BIO-NBRI-3-492	**Floriculture and Agronomy**

NCL

100 level courses

Course number	*Course content*
Course number **BIO-NCL-1-001**	**Course content** **Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (5 lectures) (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach)

	Drug target, discovery and development (forward and reverse approach
BIO-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research, Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation
BIO-NCL-1-521	**Research Methodology** Good laboratory practices, Safety in the laboratory, First Aid in the laboratory, Maintenance of laboratory records, Scientific literature management, Communication skills (scientific writing and presentation), Intellectual property management & planning, Ethics in Science, Computer applications and tools, Statistical methods & Data analysis
BIO-NCL-1-522	**Analytical Tools and Instrumentation** Thermal methods (TG, DTG, DTA, TMA, DSC), X-ray methods (XRD, XRF, SAXS), NMR (^{1}H, ^{13}C) and other Spectroscopic methods (EPR, IR, UV, Fluorescence), Chromatographic methods (TLC, GC, LC), Mass spectroscopy, Electron Microscopy (SEM, TEM), Electron Probe Micro Analysis (EDS, WDS), Quantitative Analysis (AAS, ICP, CHN)
BIO-NCL-1-523	**Basic mathematics and numerical methods** Determinants and Matrices, Complex Variables, Vector analysis, Infinite Series, Special Functions, Differential Equations, Interpolation and Approximation, Numerical differentiation and Integration, Basic Linux, Introduction to Algorithms, basic programming, Shell and Shell Scripting, Network Computing and Parallel Computing, Matlab/Scilab/Octave/Gnuplot

BIO-NCL-1-524	**Basic Chemistry for Interdisciplinary sciences** Basics of inorganic, organic, physical and biochemistry, Nomenclature (IUPAC), molarity, molality and normality, types of bonding, Ionic, covalent and non-bonding interactions, Acids and bases, Atomic structure, periodic table and periodic properties, stoichiometry, chemical reactions and kinetics, solvent effects, functional groups in organic compounds, general named reactions and reaction mechanisms, carbohydrates, lipids, proteins, nucleotides, enzymes, photosynthesis
BIO-NCL-1-525	**Introduction to Nanoscience and Nanotechnology** **General considerations, Introduction, definitions, consequences of size reduction,** **Properties: structural, thermodynamic, optical, electrical and magnetic properties,** Methods of synthesis, Surface modifications, factors governing the stability and assembly, Characterization of nanomaterials, Applications of Nanomaterials
BIO-NCL-1-526	**Introduction to Chemical Biology** Amino Acids, Peptides & Proteins, The Chemistry of Carbohydrates, Nucleic acids, The Chemistry of Enzymes, Lipids, Fats & Steroids, Drug discovery, Drugs from Nature, Drug interaction
BIO-NCL-1-527	**Basic techniques in biology** Basic techniques in microbiology Basic techniques in plant tissue culture Basic techniques in plant molecular biology Basic techniques in animal cell culture Basic Entomological techniques Microscopy - Light and florescence Freeze drying, centrifugation, ultra-centrifugation, ultra-filtration, etc. Electrophoretic techniques (DNA/RNA/Protein-Native/denaturing) / IEF and Agarose / PAGE / Capillary electrophoresis Chromatography techniques (Ion exchange, Affinity, Gel filtration) Purification and characterization of biomolecules (Proteins & metabolites)

200 level courses

Course number	*Course content*
BIO-NCL-2-521	**Advanced Techniques in Biology** Sequencing of nucleic acids and proteins Functional characterization of biomolecules Advanced microscopy (TEM, SEM, Confocal, AFM, etc.) Biophysical techniques (UV, Fluorescence, CD) Spectrometry (GC-MS, LCMS) High performance chromatography (HPLC, FPLC) Tracer techniques NMR for biomolecules Proteomics (2D, MALDI-TOF, ESI, Database search, de novo sequencing) Microarray analysis Techniques in molecular biology (PCR, RT-PCR, Sequencing, Southern, Northern, etc.) Gene cloning and over-expression: identification of genes, designing primers, selecting vectors and cloning, expression in cells, solubilization of inclusion body, protein purification, site-directed mutagenesis Immunological techniques- Antigen-Antibody reaction, ELISA, RIA, *In situ* hybridization, immunoblotting, Western blotting, etc. Techniques in structural biology: crystallization and X-ray structure determination Bioinformatics tools and databases
BIO-NCL-2-522	**Introduction to infectious diseases** Human microbiome and normal flora Pathogens responsible for human infectious diseases i. Virus: classification, biology and diseases caused / Specific case studies will be discussed ii. Bacteria: classification, biology and diseases caused / Specific case studies will be discussed iii. Protozoans: classification, biology and diseases caused / Specific case studies will be discussed iv. Fungal: classification, biology and diseases caused / Specific case studies will be discussed v. Worm: classification, biology and diseases caused / Specific case studies will be discussed Virulence mechanisms Host pathogen interaction and overview of host immune response against specific pathogens Overview on veterinary pathogens Epidemiology / Transmission / preventive strategies Diagnostic methods and techniques against infectious diseases Drugs / Drug resistance / Drug discovery Vaccines Infectious disease studies in the 'post genomic era'. Overview of genome sequencing efforts, and highlight the importance of genome information in helping to under the biology and disease caused by specific pathogens. Discuss the role of genomics in epidemiology, diagnosis and drug discovery Special focus on neglected tropical diseases.
BIO-NCL-2-523	**Mathematics and statistics for biologists** Introduction to algebra and geometry Trigonometry: Ratios of single and compound angles, their relations, inverse function. Complex numbers: algebra and geometrical interpretation

	Matrices and determinants: algebra, inverse of matrix, elementary transformations and solving equations Vectors: algebra, coordinate system, unit vectors, direction cosines, vector operations, products. Eigen value and eigen vectors Coordinate transformations and rotation about a general direction Calculus: continuity and limit of functions, derivatives, integrals, differential equations, Fourier transform, applications. Biostatistics: introduction Probability distributions (normal, binomial and Poisson), Sampling techniques, Correlation and Regression, Null hypothesis, Confidence intervals, Significance levels Experimental Design and Methods of sampling, Basic and Two-Way ANOVA
BIO-NCL-2-524	**Structure determination and analysis of biomolecules** Introduction to the structure of biomolecules: DNA, RNA, sugar, lipid, protein Conformation of biopolymers, energetics of folding Crystallization of Proteins: Principles and techniques, preparation of heavy atom derivatives, Freezing protein crystals for storage and data collection. Single crystals: Three-dimensional structure determination using protein crystallography, Arrangement of molecules in crystals, Lattice, symmetry, unit cell, point groups, space groups. Diffraction: X-ray diffraction, Laue an Bragg equations, reciprocal lattice, structure factor equation, Fourier transform, phase problem, diffraction data collection, indexing, systematic absences Structure determination: Solution to phase problem using direct methods, molecular replacement, Patterson method, isomorphous replacement and anomalous scattering, phasing of protein reflections, accuracy of phasing and refinement of phases, electron density and model fitting, Refinement: methods for structure refinement, structure validation, structure deposition, database. Fiber diffraction and small angle scattering Biophysical and spectroscopic techniques: NMR, Fluorescence, Circular Dichroism.
BIO-NCL-2-525	**Concepts in Microbiology** Topics Architecture of Bacterial cell Architecture of Fungal cell Taxonomy of bacteria Taxonomy of fungi Bacterial genetics Fungal genetics Microbial diversity Fungi from different environments Strain improvement Whole cell & enzyme immobilization Secondary metabolites Morphological and physiological characterization of microorganisms
BIO-NCL-2-526	**Concepts in Plant Biotechnology** Structural genomics including genome architecture, gene structure, large insert libraries and classical genome sequencing, next generation sequencing, physical mapping Functional genomics including differential expression (microarray technology, real time and digital PCR), over expression, gene silencing (miRNA and siRNA), mutation, transposable elements, Genome-wide technologies (Transcriptomics,

	TILLING, SAGE, etc.) Molecular markers including concept, properties, classes, advantages and applications, population development Plant cell, tissue and organ culture Plant transformation methods including tissue culture and non tissue culture based, Agro bacterium mediated co-cultivation, particle bombardment, plant vectors, promoters and analysis Endophytes and their applications Phytoremediation
BIO-NCL-2-527	**Advances in Nanoscience and Nanotechnology** Low-dimensional structures: Quantum wells, Quantum wires, and Quantum dots, Nano clusters & Nano crystals, fullerenes, carbon nano tubes and graphene, Nano Composites, synthesis and characterization techniques, Properties at Nano Scales and comparison with bulk materials, fabrication techniques, general applications, nanomaterials in biology.
BIO-NCL-2-528	**Advances in Chemical Biology** Amino Acids, Peptides & Proteins: Structure and functions of peptides and proteins, Design of poly peptides, Peptide hormones and their pharmaceutical significance, Peptide mimetics as therapeutics The Chemistry of Carbohydrates: Glycosylation methods, Oligosaccharide synthesis and biosynthesis, Sugar derivatives and reactions, Glycoconjugates and glycomimetics Nucleic acids: Structural aspects of nucleic acids, Building blocks of nucleic acids , Structure & function of DNA and RNA, Nucleic acid mimetics & their therapeutic applications. The Chemistry of Enzymes: Enzymes: Classification & Nomenclature, The Mechanism of Enzyme action, Enzymes as Catalysts Lipids, Fats & Steroids: Chemical synthesis & biosynthesis, Drug discovery , Basic principles of medicinal chemistry, The process of drug discovery and combinatorial chemistry, Case studies in drug discovery, Drugs from Nature: Introduction to natural products chemistry, Natural products based drug discovery, Naturally occurring antimalarials, anticancer and anti-microbial agents.
BIO-NCL-2-529	**Advanced Biomaterials** Definition of biomaterials, Surface property requirements of biomaterials, Types of materials used in medicine, Synthesis and surface characterization, Biology of wound healing, foreign body response and tissue remodeling, Molecular and cellular interactions of materials with biological environment, Degradation and long term fate of materials used in medicine, Requirements of biomaterials for biomedical implants, surface coatings, wound dressings, sutures, cardiovascular devices, ophthalmology, dentistry, orthopedics and cosmetic surgeries, Applications in drug delivery and tissue engineering, Standard protocols for testing the efficacy and efficiency of biomaterials, The regulatory environment for biomaterials, Some concepts for design development of common biomaterials.

300 level courses

Course number	*Course content*
BIO-NCL-3-521	**Molecular recognition and molecular interactions in structural biology** Databases and tools used in structural biology Enzyme kinetics, active site and inhibition Metabolism of DNA and RNA: Replication, recombination, transcription Ribosome structure and mechanism of protein synthesis. Protein folding, degradation and prediction of protein conformation Protein-DNA interaction: case study of transcription factors and student assignment. Protein-carbohydrate interactions: case study of lectins and student assignment. Structural studies of genetic diseases and student assignment. Proteins as enzymes: case study of proteases and student assignment. Proteins as enzymes: carbohydrate digesting enzymes and assignment. Protein superfamily: Ntn hydrolases and assignment. Molecular recognition: case study of antigen-antibody interactions and student assignment. Virus structures. Membrane proteins and student assignment Protein evolution: globins and cytochromes and student assignment Cell signaling and cell-cell interactions and student assignment Cell motility and transport and student assignment Structure based drug design: case study. Structural genomics, proteomics and metabolomics
BIO-NCL-3-522	**Advances in Microbiology and Microbial Technology** Fungal morphogenesis Microbial diversity: Metagenomics/Functional genomics Evolution of bacteria Evolution of fungi Host-pathogen interaction Microbial and plant lectins Signal transduction Programmed cell death Metabolic Engineering Synthetic biology Agriculture microbiology: Biofertilizer and Biocontrol agents Industrial enzymes Biotransformation Concept to commercialization Submerged and solid state fermentation Down stream processing Nanobiotechnology Single cell microbiology IPR Surface expression of enzymes
BIO-NCL-3-523	**Applications in Plant Biotechnology** Plant –pathogen/microbe/insect interactions, plant defense, defense proteins, such as AI, PI, lectins, defensins, etc. Abiotic stress tolerance in plants Plant genetic engineering for crop improvement with case studies, safety practices in handling GMOs

	Applications of molecular markers in linkage mapping, gene tagging, gene introgression, synteny mapping, Hybrid testing, germplasm analysis, DNA fingerprinting, MAS, map based cloning Identifying and mapping of QTLs including strategies of QTL mapping (SMA, SIM, CIM, MTIM), QTL x QTL and QTL x environment interactions, expression QTLs, Softwares used, Association mapping Biodiversity including genetic diversity, molecular diversity and taxonomy, DNA barcoding, population genetics, conservation of diversity and endangered species Metabolomics including plant secondary metabolites, functional molecules, metabolic engineering, analytical methods Molecular farming and Biotransformation Proteomics including recognition, sequencing, applications of proteomics in plant biotechnology, identification, differential analysis, intensity fading etc. Application of nano-biotechnology in plant sciences
BIO-NCL-3-524	**Beyond Genomes: Concepts in comparative and functional genomics** Overview of genome sequencing, assembly and annotation. Will discuss recent advances in genome sequencing technology and assembling short reads, gene finding and annotation. Accessing genome sequences and genomic-scale datasets: Genome browsers and databases *Genome wide experiments* 1. Gene expression and genetic variation analysis by microarray and sequencing. 2. Gene silencing / knock down techniques (micro RNA / siRNA) 3. Epigenetics / Histone modifications 4. Chemical genomics *Comparative genomics* 1. Synteny mapping *2.* Overview of phylogenetics, orthology (orthologs / paralogs), gene duplication and functional specialization. Case study – the human kinome *3.* Lateral gene transfer and functional specialization. Case study – the apicoplast organelle genome and function of apicomplexan parasite Metagenomics Population genetics Genome wide association studies (GWAS) and systems biology – integrating diverse datasets to understand biological functions and disease mechanisms Genomics and Drug discovery. The druggable genome concept. The EnCODE and 1000 genome projects Case study on current status of select genomes (humans / mouse / Arabidopsis / *Plasmodium* species / *Mycobacterium* species)
BIO-NCL-3-525	**Chemistry and biology of Heterocycles** Privileged heterocycles, Electronic properties, reactivity (electrophilicity and nucleophilicity), Synthetic methodologies, Biological properties of Natural products and drug candidates, Biosynthesis, Dimeric compounds and related stereochemistry

NEIST

100 level courses

Course number	*Course content*
BIO-NEIST-1-591	**Research Methodology** Introduction to research concept, identification, selection and formulation of research problem, justification, hypothesis, literature retrieval, survey, bibliography presentation, digital resource (internal), data collection, sampling techniques, collection, documentation, presentation and interpretation of data
BIO-NEIST-1-592	**Research communication** Communication skill, presentation of scientific finding & discussion, scientific manuscript writing, literature survey, online search tools- Biomed Central, Pub med, Scopus, Scifinder, Web of Science etc.
BIO-NEIST-1-593	**Bio-statistics** Basic concept of bio-statistics and its application, probability, Correlation, regression, F-distribution, Analysis of variance (ANOVA), Standard deviation, Use of computer software for data analysis etc.
BIO-NEIST-1-594	**Laboratory safety** Team work culture in laboratory, General Safety and lab-safety procedures, Chemical, electrical and UV safety, safe handling of toxic and hazardous chemicals, storage and disposal of chemicals etc. Common laboratory Instruments and applications: Principles and practices of instruments used in microbiology, biochemistry, molecular biology, genetics engineering, fermentation technology, bioremediation, plant biotechnology, ecology etc.

200 level courses

Course number	*Course content*
BIO-NEIST-2-591	**Biodiversity and Environmental Studies** (Compulsory Paper**)** Overview of Biodiversity and conservation: types of protected area, protected areas of N E India, Environmental and Forest policies and laws Scope of environmental studies, Environmental studies in a multidisciplinary approaches. Ecosystems – major types, structure and functions, productivity of ecosystems and sustenance.
BIO-NEIST-2-592	**Natural resources** Types of resources, basics of conservation, natural resources of N E India, Traditional knowledge with reference to natural resources and their application potential.
BIO-NEIST-2-593	**Advances in plant biology** Advances in plant biology, physiological and molecular responses of plant to abiotic stress, advances in mineral nutrition, photosynthesis and ecological adaptation.
BIO-NEIST-2-594	**Microbial biotransformation** Microbial biotransformation, biodegradation of petroleum, xenobiotics, bioremediation and phyto-remediation, production of microbial enzymes and fermentation, physico-chemical parameters for maximum enzyme production, enzyme purification, characterization and immobilization of enzymes, enzyme use for biotransformation, chiral synthesis.
BIO-NEIST-2-595	**Plant-Microbe interactions** Isolation, purification and characterization of microbes. DNA Finger printing, Electrophoresis, PCR, Real Time PCR, Reverse Transcriptase PCR, Sequencing of DNA, basic knowledge and application of bioinformatics etc. Molecular basis of plant-microbe interactions and application of microbes in industry and agriculture.

300 level courses

Course number	*Course content*
BIO-NEIST-3-591	**Microbial Biotechnology** Isolation, screening of microbes for industrial and agriculture application, production of bioactive metabolites for pharmaceutical and industrial lead/hits, DNA fingerprinting, DNA sequencing, Molecular characterization of genes and traits responsible for biological activity, enzyme production, isolation, purification, characterization and applications. Exploitation of microbes for bioremediation & biotransformation.
BIO-NEIST-3-592	**Advances in physiological and molecular responses to abiotic stress** Plant ecology and stress physiology with basic concepts and approaches applicable to all types of plants. Emphasis on the relationship between environmental parameters (radiation, temperature, water, nutrients), heavy metals, and their effect on development, membranes, phytohormones, carbon balance, and the use of stable isotopes in stress, physiological processes (photosynthesis, respiration, cellular and molecular responses, mineral nutrition), and plant responses (leaf expansion, partitioning of dry mass, water status, and transpiration). Integration of plant responses into models for better understanding and predict growth and yield.
BIO-NEIST-3-593	**Biodiversity and conservation** Concept and definition of Biodiversity, existing regulations, laws and NBA, Bio-profiling, in-situ- and ex-situ preservation, Bio-prospection and utilization, Methods and Approaches for value additions, Role and Relevance of Biodiversity, Technology development and dissemination, Ecology and socio-economic impact of local resources on stack-holders. Biotic and abiotic interaction, Impact of stress factors on Life forms, Climatic changes and agro biology, Adaptation Biology and Evolution, Ecotourism managements.
BIO-NEIST-3-594	**Eco-restoration** Ecology and nature of environmental degradation of ecosystems due to natural and manmade activity and different measures adopted for ecological restoration. Phenocopies and Ecotypes; genetic Assimilation and natural selection; Phenotypic Accommodation; Evolutionary considerations; Developmental mechanisms of phenotypic accommodation; Reciprocal accommodation, Niche construction
BIO-NEIST-3-595	**Ethnobotany and Traditional Knowledge** Ethnobotany, definition and scope, Role and relevance of Ethnobotany, Ethnobotany and medical botany, Interdisciplinary nature of Ethnobotany, Medical botany and drug development,Methods and approach of ethnobotany, Ethnobotany and plant taxonomy, Ethnobotany and bioprospection, Validation of Ethnobotanical knowledge, Cross cultural Ethnobotany, Plant folk medicines and NE India, Ethnobotany and biopiracy, Documentation and development of database.
BIO-NEIST-3-596	**Plant - Insect Interaction and Herbivore Managements** **Herbivore-Plant Interaction.** Tritrophic interactions of plant-insect & parasitodids,Plant defence Secondary plant metabolites, Botanical Pesticides

	past , present and future **Plant-Pollinator interactions.** Insect as pollinator- Honey bee & Butterfly as pollinator- Honeybee & crop production pollination Biology **Butterfly as environmental indicator.** Butterfly biodiversity, Host range, conservation **Herbivores- induced plant defence.** Induced biosynthesis of plant defense compounds-use of plant signal in agricultural crops- Transgenic plants. **Insect behaviour.** Manipulation of insect behaviour for insect pest management-Evolution of insect behavior **Novel methods of Insect-pest management.** IPM- Concept & Evolution, Ecology of pest- IPM of major pests, Resistance, Biocontrol/Biocides, Molecular approaches in Insect-pest Management.
BIO-NEIST-3-597	**Advances in Plant Microbes Interactions** **Biology and Ecology of Plant Pathogens and Endophytes.** Biology and ecology of major group of plant pathogens viz. fungi, bacteria, viruses, nematodes and mollicutes and endophytes. Concepts of plant diseases, etiology, microbial communities, virulence and resistance, population biology, disease development and epidemiology. **Genetics of Host Pathogen interaction and Mechanism of Host Defence.** Genes and plant diseases, genetics of resistance and pathogenicity, recognition mechanisms in host pathogen interaction. Pathogenesis and host defence, passive and active defence mechanisms- structural and biochemical defences, systemic acquired resistance. **Advances in Plant Disease Management.** Introduction to biology of the pathogens that cause plant diseases, disease diagnosis. Topics include principles and practices of plant disease management including physical methods, regulatory methods, biological and chemical methods, host resistance and integrated plant disease management (IPDM). **Biotechnology of Edible and Medicinal Mushroom.** Prospects of edible and medicinal mushrooms , biochemistry of mushroom fructification, nutritive and medicinal values, spawn and spawn preparation, agrotechnology , pest and diseases **,**genetic improvement.
BIO-NEIST-3-598	**Advance Plant Physiology** **Overview of Essential Concepts.** Plant and cell Architecture, Energy and Enzymes **Transport and Translocation of Water and Solutes.** Water and Plant Cells, Water Balance of the Plant, Mineral Nutrition, Solute Transport. **Biochemistry and Metabolism.** Photosynthesis: The Light Reactions, Photosynthesis: Carbon Reactions, Photosynthesis: Physiological and Ecological Considerations, Translocation in the Phloem, Respiration and Lipid Metabolism, Assimilation of Mineral Nutrients, Plant Defences: Surface Protection and Secondary Metabolites.

	Growth and Development. Signal Transduction, Cell Walls: Structure, Biogenesis, and Expansion, Growth, Development, and Differentiation, Phytochrome, Blue Light, Responses: Stomatal Movements and Morphogenesis, Growth Hormones, the Control of Flowering, Stress Physiology
BIO-NEIST-3-599	**Insect Biotechnology** **Insect Biotechnology.** Isolation of protein/hormone from insects, insect tissues, *In Vitro* and *In Vivo* assays, Radiochemical Assays for detection of Hormones, Metabolism of Proteins, carbohydrates and silk protein biosynthesis, enzymes kinetics, microbial protein based products and process.
BIO-NEIST-3-601	**Molecular and cell biology** Introduction to Molecular Biology, Historical background (Vital force theory, the scientific approach, classic experiments), Physico-chemical approach to biology,(Schrodinger's book, theory of the chemical bond, crystallography), Biomolecules and replication (DNA, RNA, protein, background to their discovery and analysis, roles played in biology, replication machinery in prokaryotes and eukaryotes, problem of packaging genetic information)., Flow of genetic information (Central dogma, adaptor hypothesis, operon concept, transcription, translation), Gene expression and control (Operon, cistron, polycistronic/monocistronic messages, transcriptional control, RNA processing, chromosomal histone modification, cell cycle), Evolution (organismal,bacterial, molecular, Darwin to Oparin, Hardy- Weinberg law, analysis of evidence, C-value paradox in eukaryotes, cot value), Cells and Biomolecules, Prokaryotic and eukaryotic cells overview and comparisons, Techniques for the study of cell structure and function (Histology, staining, karyotyping, freeze fracture, microscopy, FISH, flow cytometry, patch clamp, live cell imaging, probing with toxins), Microbial and phage genetics, (Discovery of the genetic material, Classic experiments in microbial and phage genetics - phage lysogeny, restriction and modification, bacterial conjugation, transformation, transduction) Cell components (cell wall, membrane, nucleus, mitochondria, chloroplasts, lysosomes, vacuoles, cytoskeleton), Protein sorting and secretion, biotechnological considerations (Golgi and ER, targeting of proteins, use of principles in high-expression systems)
BIO-NEIST-3-602	**Molecular Markers and Breeding** **Genome Organization** Organellar genome and Nuclear Genome: Unique sequences, Repeat DNA sequences, Classification of Repeat DNA (Tandem repeats, Interspersed repeats, Micro-satellites, Mini-satellites, midi-satellites, VNTRs), The dynamic genome: Polymorphisms and Sources of Genetic variation, Oveview of Genetic Markers: Phenotypic Markers, Biochemical markers, DNA based markers Molecular marker and DNA fingerprinting techniques: Concepts, classification and methodologies: Hybridization based markers (viz. Restriction Fragment Length Polymorphism, Oligonucleotide fingerprinting), PCR based markers (viz. DNA Amplification Fingerprinting, Arbitrarily Primed PCR, Randomly Amplified Polymorphic DNA, SSRs, STMS, SCARs, Inter-SSRs, Multiple Arbitrary Amplicon Profiling, Amplified Fragment Length Polymorphism, electively Amplified Microsatellite Polymorphic Loci, Inter retrotransposon amplified polymorphism, retrotransposon-microsatellite amplified polymorphism, Diversity Array Technology (DArTs), SNPs and SNP based assays for high-throughput genotyping, EST based markers, Sequencing by Hybridization (SBH), Molecular Markers and Assessment of genetic diversity: Principles of Numerical taxonomy, binary matrix to phenetic dendograms, Structure analysis, Case Studies and examples, Molecular Markers for genome mapping: Principles of Genetics: Laws of inheritance, Linkage and crossing-over, Recombination analysis Genotyping Concepts for

	Genetic mapping Construction of genetic linkage maps for gene and QTL mapping, positional cloning for gene identification, Introduction to linkage mapping software packages and interfaces Breeding by design: Marker Assisted Selection (MAS), gene introgression and pyramiding, BSA Genotyping for Physical mapping: Fingerprinting for BAC assembly, Types of Mapping populations in Plants: F2 populations, RILs (recombinant inbred lines), Backcross lines, NILS (Near Isogenic Lines), HIF (Heterogenous Inbred Families), AILs (Advanced Intercross Lines), Other Application of Molecular Markers: Genotyping tools as plant variety protection, hybrid purity tests, diagnostics (transgenics, forensics) Other Mapping tools and Methodologies: Introduction to Cytogenetic maps, Radiation Hybrid Maps, HAPPY mapping, Physical Maps, Comparative/Synteny mapping.
BIO-NEIST-3-603	**Functional Genomics** **Gene Expression and the transcriptome analysis** **Medium throughput techniques.** Northern, Quantitative RT-PCRs, RACEs, cDNA-AFLP, Inventories for gene discovery and annotation: EST databases, full-length cDNA /ORF clones **Hi through put-genome wide Analytical Platforms.** Microarrays: Whole Genome arrays, cDNA arrays and Tiling Arrays: Concept, designing, fabrication, probing, and data analysis, Applications: Global gene expression profiling, discovery of novel genetic pathways and targets, Genotyping for DNA polymorphism, Mapping genome wide epigenetic states, alternative splicing, miRNA microarrays, ChIPchips for identifying DNA binding sites. **Hi through put-genome wide Profiling Platforms.** Serial Analysis of Gene Expression, Digital Northerns, Massively Parallel Signture Sequences, Roche's 454-FLX Sequencer, Solexa/Illumina's 1G Genome Analyser **Proteomics and integrative genomics.** Protein separation and 2-D PAGE, Mass Spectrometry and protein identification: N-terminal sequencing, MALDI – TOF, LC-MS/MS, Tandem-MS/MS. SELDI-TOF, ICAT, I TRAQ, MUDPIT, Protein interaction maps, analysis of cellular constituents, metabolomics. **Reverse genetics-Navigating from structure to Function** **Mutant analysis.** Forward versus reverse genetic approaches, Mutagens and methodologies for Reverse genetic systems: Random and Targeted mutagenegis, Insertional Mutatagenesis viz. T-DNA tagging, Ac/Ds system for Transposon Tagging, TILLING, Deleteagene, Activation mutagenesis (Gene traps, Enhancer Traps and Promoter Traps), mis-expressions (*viz* ectopic expression, two component systems for tissue specific gene expression), RNAi based Silencing Techniques (viz. Antisense RNA, co-suppression, artificial miRNA, tissue or stage specific knockouts) Zinc-finger nucleases, Homologous Recombination, Genome-wide Mutant Libraries and resources. **Genetic screens for molecular genetic analysis**. Enhancer, suppressor and dominant modifier screens, Core-collections and germplasm resources for Reverse Genetics **Natural Genetic Variation**. Discovery of novel genes and alleles, Case studies from Rice and Arabidopsis **Elucidation of molecular genetic Pathways and Processes.** Flowering Time Control and flower development in *Arabidopsis,* Stress response and SOS pathways in *Arabidopsis, Caenorhabditis elegans and Drosophila development,* AtGenExpress: Transcriptome atlas of Arabidopsis thaliana-Case Study
BIO-NEIST-3-604	**Plant Biotechnology Management and Regulatory Issues** **Introduction to Legal System** Constitution, Statutes, Rules, Regulations, Judicial System, Judicial Review,

	Administrative set up. International Law, Sources, Treaties **Principles of Regulation** **Competing Models of Risk Assessment,** Models of risk consideration: Scientific rationality trajectory and Social rationality trajectory. **Risk Analysis Framework** Risk Assessment, Risk Management and Risk Communication. **The Concept of Precaution in Regulation** Precautionary principle and precautionary approach Country **Comparisons about Approaches to Biotechnology Regulation** The U.S. and E.U. approaches on *Biotechnology research, Intentional introduction into environment, GM Food, labelling etc.* **Multilateral Agreements.** Convention on Biological Diversity, Cartagena Protocol on Biosafety, WTO Agreements, *Codex Alimentarius*, Plant Genetic Resources for Food and Agriculture. **Regulatory Systems in India.** Environment Protection Act, 1986 Rules for the manufacture, use, import, export and storage of hazardous micro-organisms, genetically engineered organisms or cells. Institutional Structure, Powers and Functions Relevant Guidelines and Protocols. Other relevant laws Plant Quarantine order Biological Diversity Act Protection of Plant Varieties and Farmer's Rights Act Drugs and Cosmetics Act, Policy and the rules Seed Policy DGFT Notification Recent Initiatives Draft National Biotechnology Regulatory Bill 2008 **IPRs** **Introduction.** A Brief history of IP protection, Rationale for IPR, Types of IPRs, Patents, Copyright, Trademarks, Trade Secrets, Plant, Variety protection, Geographical Indications, Farmer's, Rights, Traditional Knowledge **Patents and Agricultural Biotechnology.** Patentability criteria, Relevant Case law, Indian Patent Act, 1970, TRIPS, Amendments to Indian Patents Act (2005), **IP applications and Procedures** Patent drafting, Patent and prior art searches etc. **Management of IPR Assets,** Licensing and contracts, Negotiations, Valuation of patents, IPR Enforcement

NIIST

100 level courses

Course number	*Course Content*
BIO-NIIST-1-O01	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-NIIST-1-002	**Computation/bioinformatics** Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet Introduction to Word, Powerpoint and Excel Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-NIIST-1-003	**Basic Chemistry** Thermodynamics Solutions and Ions Chemical bonding and molecular structure Chemical Kinetics Stereochemistry Introduction to drug discovery (Medicinal chemistry approach) Drug target, discovery and development (forward and reverse approach

BIO-NIIST-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research, Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

Course number	*Course Content*
BIO-NIIST-2-001	**Biotechniques and Instrumentation** (compulsory) General Instrumentation: handling, care, usage and safety. Concepts of spectroscopy and use of UV-VIS spectrophotometers, Concepts of centrifugation, use of centrifuges, Electrophoretic equipments-ID and 2D electrophoresis and data analyses, Blotting techniques, Immuno-cytochemisty, ELISAs, PCR – equipment and techniques, RT-PCR, QPCR, chromatographic techniques- GC, LC and HPLC, Microscopy- Bright Field, Dark field, Phase contrast, fluorescence and confocal imaging, Electron microscopy, Concepts of DNA and protein sequencing and equipment for sequencing, Equipments for high-throughput assays – Micro-titer plate readers and multimode readers, ultra-filtration equipment.
BIO-NIIST-2-006	**Protein Science and Proteomics** Amino Acids and Proteins; Peptide backbone, side chains, polarity, Absorbance, Single letter codes etc. Protein Structure-Primary, secondary, tertiary and quaternary structure, covalent modifications of the polypeptide chain, Forces that determine protein structure, Structural motifs in regulatory proteins: DNA-binding proteins, Zinc finger motif, Helix Turn Helix motif Basic Leucine Zipper motifs. Tools: Databank of protein sequences (*SWISS-PROT*), Basics of protein sequence; alignment; Protein Regulation Enzymes I: Mechanism of Catalysis; Enzymes II: Kinetics & Regulation Protein Methods: Protein separation and purification Methods;Protein Function Analysis Practical Training to protein separation/detection using Western blotting; 1D and 2D Gel Electrophoresis: pI, Isoelectric focussing, 2 dimensional gel; Gel Staining methods and analysis Protein spot/Band processing for Mass spectrometric analysis Introduction to Mass spectrometers such as MALDI-TOF/TOF and electrospray mass spectrometer. Spectral Peak Annotation and Database search Shotgun Proteomics
BIO-NIIST-2-256	**Basics and Applied Microbiology** Isolation, Culture and Preservation of Microorganisms Streak plate method; pour plate method, pH, temperature and oxygen requirements. Cultivation of anaerobic bacteria, Isolation of soil algae. Aseptic handling of microbes including Sterilization (autoclaving). Culture Media: Solid and broth cultures shake cultures. Specific media for different group of microorganisms. Inoculum development, Methods of culture preservation- Refrigeration, Freezing, preservation in soil, freeze drying (Lyophilization, Principles of freeze drying- Predrying, ampoule preparation, harvesting the cultures, Primary drying, secondary drying, opening of ampoules Sterilization – concepts and methods Identification and classification of microbes- Colony characters, Staining methods, Biochemical tests, physiological tests and polyphasic approach. Classification based on extreme conditions like thermophiles, Alkaliphiles and halophiles Methods in applied microbiology Screening, primary, secondary, enrichment cultures Industrial Microbiology- Production of microbial Metabolites- organic acids, amino acids, antibiotics, enzymes, biopolymers. Microbial assisted processes, Immobilization techniques and processes

	employing immobilized whole cells. Strain improvement- Classical and modern techniques. Agricultural Microbiology – Role of microbes in plant health, plant-microbe interactions, Biofertilizers, Biopesticides, PGPR.
BIO-NIIST-2-257	**Basic Molecular Biology** *Nucleic Acid Techniques -I* Isolation of DNA (genomic, plasmid, bacterial, fungal, plant and mammalian), total RNA and mRNA. Gene cloning -prokaryotic and eukaryotic; Cloning strategies – shot gun cloning, PCR cloning, cDNA cloning. Cloning vectors –plasmids, viral vectors, phagemids, cosmids, fosmids, BAC vectors, YAC vectors, shuttle vectors, and expression vectors. Common host organisms used for genetic engineering. Construction of genomic and cDNA libraries. Gene transfer techniques-chemical transformation, electroporation, virus mediated transfer, Agarose gel electrophoresis for DNA separation, Denaturing gels for RNA *Nucleic acid Techniques II* PCR, RT-PCR, qPCR techniques and applications. Primer design – manual and using software, design of degenerate primers. DNA sequencing, primary analyses of sequences, nucleic acid databases searches, sequence deposition and access. Applications of nucleic acid base specificity in research – hybridizations, microarray techniques; Probes in nucleic acid detection –radioactive and non radioactive. Genomics –Functional, Comparative; High throughput analyses – Microarrays, Metagenomics, Applications of genomics.
BIO-NIIST-2-258	**Bioprospecting and Biochemical Pharmacology** *Cellular organization and interaction* i. Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes. ii. Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle. iii. Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways. iv. Cellular communication: General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins. *Molecular Processes* i. DNA replication, repair and recombination: ii. RNA synthesis and processing: iii. Protein synthesis and processing: iv. Control of gene expression at transcription and translation level *Methods in Research* i. Molecular biology methods: Isolation and purification of RNA , DNA (genomic and plasmid) and proteins, different separation methods; analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, isoelectric focusing gels; RFLP, RAPD, AFLP techniques, PCR and RT-PCR. ii. Histochemical and Immunotechniques: Antibody generation, detection of molecules using ELISA, RIA, western blot, immune precipitation, flow cytometry and immune-fluorescence microscopy, detection of molecules in living cells, *in situ* localization by techniques such as FISH and GISH, HPLC, Ultra centrifugation. *Chemistry of Natural Products* i. Secondary Metabolites/ Alkaloids: Occurrence, isolation, classification

	and properties of alkaloids, structure determination, synthesis and physiological activities of ephedrine, nicotine, atropine and morphine. Terpenoids: occurrence, isolation, geraniol, citral, amyrin. ii. Phenolic compounds: Classification and properties. iii. Therapeutics: Bioactive principles in herbs, plants with hepatoprotective, hypoglycemic, anticancer, antibacterial, antiviral and antimalarial, anti-inflammatory properties. iv. Free radicals: Types, sources, importance, production, free radicals induced damages, lipid peroxidation, measurement of free radicals, disease caused by radicals, reactive oxygen species, antioxidant defence system, enzymic and nom-enzymic antioxidants, role of antioxidants in prevention of diseases ,phytochemicals as antioxidants.
BIO-NIIST-2-259	**Fundamentals of Food processing** *Thermal Processing of Foods* Principles, Classification - Cooking, blanching, pasteurization, sterilization, evaporation, extrusion, drying, Equipments and Applications *Separations and concentration methods in food processing* General Principle and application, Evaporation, Membrane processing, Reverse osmosis, Nanofiltration, Ultrafiltration, pervaporation, freeze drying , Extraction- liquid-liquid & solid liquid, Super critical extraction, Osmotic dehydration, Sedimentation, Equipments and Applications *Separations and concentration methods in food processing* General Principle and application, Evaporation, Membrane processing, Reverse osmosis, Nanofiltration, Ultrafiltration, pervaporation, freeze drying , Extraction- liquid-liquid & solid liquid, Super critical extraction, Osmotic dehydration, Sedimentation, Equipments and Applications *Size reduction and its application in food industry* Size reduction, Size measurement, Dry and wet grinding, Slicers/dicers, Pulpers and granulators, Milling equipments, Size separation *Food Emulsions* Basics and examples, Homogenizers and colloid mills- Principles, types and applications *Mixing and Kneading* Basics, Equipment and Applications *Advances in Food processing* Minimal processing, Hurdle technology,High pressure technology, Irradiation, Microwave, Cryogenics, Ohmic heating, Pulsed electric heating, ultrasound processing, Equipments and Applications *Basic packaging Machinery* Can sealing, Bottle washing, Filing and sealing, Powder fillers, Liquid fillers, Foam – fill and seal systems *Sterilization techniques* Basics, Techniques and Applications *Maintenance of Food Plant & Equipment* Maintenance of food plant and equipment, pumps, valves and conveyers
BIO-NIIST-2-260	**Cell biology and Tissue Engineering** *Cellular organization* Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes. iCell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle. Cell signaling *Basic Cell culture* Types of cells grown in culture, work area and equipment, preservation and storage, maintenance, safety considerations, cell culture methods, determination of cell counts and viability, Cell based assays *Animal cell culture*

	Basic principles of cell culture, Preparation of culture lab, maintenance of aseptic conditions, biology of cells in culture, choice of materials, Generals methods of cell culture and parameters, monolayer culture, suspension culture, immobilized cultures, Cell line preservation and authentication: cell freezing, quantitation of recovery, authentication, Cytotoxicity and cell viability assays: specific techniques, end points, assay comparisons, protocols, interpretation, Flourescence in situ hybridization, Genetic modification: Basics of Transfection, microcell mediated chromosome transfer, irradiation fusion gene transfer, Stem cell identification, isolation and culture, Senescence, apoptosis and necrosis, Animal cell culture and drug designing.

300 level courses

Course number	*Course Content*
BIO-NIIST-3-001	**Seminar course** (compulsory)
BIO-NIIST-3-005	**Introductive Bioinformatics** *Introduction to bioinformatics*-Historical perspectives. Introduction to data mining, internet and bioinformatics, applications of data mining to bioinformatics problems and applications of bioinformatics. *Sequence Alignments* - Pair wise sequence alignments – Global and Local, Methods of alignment, Algorithms for sequence comparisons – Smith Waterman, Needlman and Wunsch , Dynamic Programming, Scoring matrices and gap penalties. Multiple sequence alignments – scoring multiple sequence alignments, methods for multiple sequence alignments. Tools for sequence alignment – web based and local – BLAST, Clustal W, BLOCKS. Phylogenetic prediction and analysis – methods, gene prediction. *Biological databases and their interfaces*-Types of databases, nucleotide database- Genebank, EMBL, PDBJ, Genes, Entrez. Protein sequence databases – Swiss Prot/ TrEMBL; Sequence motif/domain databases – Pfam, PROSITE; Protein sequence databases - PDB, CATH, SCOP. *Protein classification and structure prediction* - Conserved domains, motifs, structure function relationships, viewing protein structure; Protein sequence alignments, use of sequence pattern for structure prediction, prediction of secondary structures – tools, tertiary structure prediction by homology modeling. *Applications of Bioinformatics* - Phylogenetic analysis, Comparative genomics – functional genomics, Drug discovery, Gene expression analyses.
BIO-NIIST-3-011	**Microbial Diversity and Ecology** Microbial Taxonomy and Diversity: Bacteria, Archea and their broad classification; Eukaryotic microbes: Yeasts, molds and protozoa; Viruses and their classification; Molecular approaches to microbial taxonomy. Role of microbial life in the evolution and ecology of the biosphere, application of classical ecological concepts to microbial populations and communities, Underlying principles that drive microbial population structure in the environment, Community function and dynamics at both the molecular and the organismal level, Abiotic and biotic interactions within microbial communities, Ecophysiology and thermodynamic constraints on microbial community structure, Molecular and genomic tools for understanding the physiology and ecology of microbial communities, Microbial metabolism and biogeochemical cycling. Microbial interactions with the Environments: Interactions of microorganisms with their physical and chemical environment, biogeochemical cycles, Interactions with the biotic environment: symbiosis, competition, parasitism, predation, Interactions within microbial communities: quorum sensing, syntrophy, antibiotics, Interactions of microorganisms with algae and plants, Interactions of microorganisms with animals and humans. Methods in Microbial Ecology: Pure culture techniques, principles of microbial, nutrition, enrichment culture techniques for isolation of microorganisms. Characterization of microbial communities: PCR, sequencing, molecular fingerprints, Characterization of microbial communities: culture-based methods, biomarkers, cell stains, Characterization of microbial communities by culture independent molecular methods, Methods of extracting total bacterial DNA /RNA from a habitat: FISH, real-time PCR, DGGE, T-RFLP, SSCP, functional Clone library (metagenomics), pyrosequencing. Software tools in Metagenomics, Newer approaches for exploring

	uncultivable bacteria, methods in Taxonomy of Bacteria (including archae, bacteria,) and Fungi: Morphological Methods, Chemotaxonomy, Genetic Methods ,Methodology of rRNA, Methodology of identification of unknown pure cultures: Strategy and methods.
BIO-NIIST-3-381	**Bioprocess Technology** *Introduction to Bioprocess Technology;* Introduction, microbial metabolites an overview (primary and secondary), Factors on growth and product formation, raw materials and media formulation, microbial growth curve and growth kinetics, sterilization, death kinetics. *Fermentation Technology* Types of Fermentation (submerged and solid state fermentation), Batch, fed batch and continuous modes of fermentation, Fermentation kinetics, Factors affecting fermentation process, Process parameter optimizations using statistical tools *Bioreactors* Introduction, Bioreactor configurations, design features, Sterile operations, Types of bioreactors (stirred tank, fluidized bed, packed columns, airlift etc), Bioreactors for submerged fermentation, Bioreactors for SSF, concepts of mass transfer, heat transfer, Engineering aspects in bioreactor designing. *Downstream Processing* Unit operations in downstream processing, concentration –filtration, flocculation, precipitation, chromatography techniques, dialysis, reverse osmosis, ultra filtration, electrophoresis, electrodialysis, crystallisation, drying, monitoring downstream process and process integration. *Industrial Microbiology* Characteristics of industrial micro organisms , Industrial applications of microbial biotechnology (production of organic acids, enzymes, amino acids, antibiotics etc), Industrial strain improvement, classical mutations, protoplasmic fusion, auxotrophic mutants, role of metabolic engineering in industrial biotechnology
BIO-NIIST-3-382	**Enzymology & Enzyme Technology** *Introduction to Enzymology*- Introduction to enzymes, modes of action, Classification and nomenclature of the enzymes- Oxidoreductase, Transferase, Hydrolase, Lyase, Isomerase, Ligase. *Production and purification of enzymes*- Industrial production of enzymes - Production methodology, Optimization of culture medium and production conditions, techniques used for enzyme homogenization, Down-stream processing. Techniques for enzyme assays- Spectrophotometric method, colorimetric method, fluorescence method, manometric method, viscometric method. Purification methods, Concentration of enzyme - Salting out using ammonium sulfate, fractionation using organic solvents, fractionation using non-ionic polymers, fractionation using polyelectrolyte etc, Dialysis, ultra-filtration., Chromatographic separation of enzymes – Adsorption chromatography, ion-exchange chromatography, affinity chromatography, gel filtration chromatography, chromatofocusing. Techniques for protein separation- paper electrophoresis, gel electrophoresis, capillary electrophoresis, isoelectric focusing. Crystallization of enzymes. *Characterization of enzymes*- Determination of temperature and pH optima, Determination of molecular weight of enzyme- gel filtration chromatography, PAGE, other methods. Enzyme inhibitors – competitive inhibition, non-competitive inhibition, mixed type of inhibition, uncompetitive inhibition. *Kinetics of enzyme reaction*- Concept of ES complex, active site, specificity, Mechanism of enzyme reaction, measurement of reaction velocity, Different plots for the determination of K_m & V_{max} and their

	physiological significances. Importance of K_{cat}/K_m. Kinetics of zero & first order reactions. Significance and evaluation of energy of activation. Michaelis pH functions & their significance. Michaelis & Menten equation for uni-substrate reactions, Lineweaver–Burk plot, Hanes–Woolf plot, Scatchard equation. *Immobilization of enzymes and industrial applications of enzymes*- Methods of immobilization- carrier binding method, physical adsorption method, ionic binding, covalent binding, cross linking method, entrapping method, microencapsulation. Industrial applications of enzymes – Food and baking industry, Textile industry, Leather industry, Detergent industry, paper and pulp industry, animal feed industry, therapeutic and diagnostic applications, enzymes in biofuel industry.
BIO-NIIST-3-383	**Biodegradable polymers** Biodegradable polymers – Historical outline, Classification (natural and synthetic biopolymers). Important polyesters that have been commercialised and under commercialization such as PHA, PHB, PLA and others. Biopolymers-microbial production, Production processes, downstream processing Methods for characterisation of polymers (TLC, FTIR, GPC, Viscometric methods, NMR), structure, physio-chemical properties, Life cycle assessment biopolymer and applications. Production processes for biopolymer, Chemical modifications and its significance. Biotic and abiotic degradation of biopolymers. Microbial deterioration (aerobic and anaerobic). Biodegradability testing. Role of enzymes in biodegradation. Factors affecting biodegradation. Application of biopolymers- biodegradable plastics, tissue engineering, drug delivery.
BIO-NIIST-3-384	**Metabolic Engineering** Review of cellular metabolism (Transport processes, fuelling reactions, biosynthesis, growth energetic) Review of cellular stoichiometry. Regulation of metabolic pathways: Levels of regulation of enzymatic activity (overview of kinetics, reversible and irreversible inhibitions, allosteric enzymes and cooperativity) – regulation of enzymes concentration (Control of transcription and translation – example with respect of lacoperon and catabolite repression)- Global control-regulation of metabolic networks (Branch point classification, coupled reactions and global currency metabolities and energy regulation) Metabolic engineering in practice: Concept of directed cellular energy utilization – analytical and synthetic elements of metabolic engineering – targets of metabolic engineering. Metabolic Pathway analysis (Typical case study: Lysine Biosynthesis) Strategies for redirecting branched and linear pathways: (Alteration of feed back regulation; limiting accumulation of end product feedback resistant mutants, alteration of permeability). Metabolic Flux Analysis: Concept and utility of MFA – Theory – case studies – over determined systems – experimental determination of MFA by isotope labeling – applications of MFA: Case studies- concept & fundamentals of metabolic control analysis (Basic concept only). Application of pathway manipulations: Strategies for overproduction of primary metabolites. Strategies for overproduction of secondary metabolites (precursor effects, prophophase idiophase relationship,

	enzyme induction, feedback regulation.) Bioconversions: (ME concepts applied in process decisions for enhanced bioconversion). Examples of pathway manipulations: Enhancement of product yield (alcohol, amino acids)– extension of substrate ranges (lignocelluloses utilization) – extension of product spectrum (antibiotic, biopolymers) - improvement of cellular properties (alteration of metabolism, enhanced efficiency and yield, genetic stability).
BIO-NIIST-3-385	**Natural Product Chemistry** *Structure, Bonding & Nomemclature* Lewis structures, orbital hybridization, configuration and stereo chemical notation, conformational analysis, systematic IUPAC nomenclature. *Functional Groups* Preparation, reactions, and interconversions of alkanes, alkenes, alkynes, dienes, alkyl halides, alcohols, ethers, epoxides, sulfides, thiols, aromatic compounds, aldehydes, ketones, carboxylic acids and their derivatives, amines *Reaction Mechanisms* Nucleophilic displacements and addition, nucleophilic aromatic substitution, electrophilic additions, electrophilic aromatic substitutions, eliminations, Diels-Alder and other cyclo additions *Reactive Intermediates* Chemistry and nature of carbocations, carbanions, free radicals, carbenes, benzynes, enols Resonance, molecular orbital theory, catalysis, acid-base theory, carbon acidity, aromaticity, antiaromaticity. *Natural products* i. Carbohydrates-glucose- The structure and configuration of glucose-Anomeric forms of monosaccharides-glycosides-Disaccharides: cellobiose, maltose, gentibiose, trehalose ii. Polysaccharides-starch, cellulose, hemicellulose, modification of cellulose, Extraction, separation and quantification methods iii. Polyketides- biosynthesis-Acetyl Coenzyme-A, Orsellinic acid - structure iv. Lipids:,Fatty acids, structure, reactions, extraction methods, saturated and unsaturated fatty acids oleic, linoleic, linolenic, PUFA, waxes, phospholipids v. Terpenoids-general –isolation methods- isoprene rule, biosynthesis ,monoterpenes alpha-pinene, beta-pinene, cineole, citrals, geraniol,sesquiterpenes, caryophyllenes, zingiberene, humulenes, nerolidols, farnesols, oxides of caryophyllene, diterpenes - abeitic acid, triterpenoids- sqalenes and carotenoids-beta carotene, capsanthins vi. Alkaloids: Biosynthesis structure, general classification, sources, isolation methods, properties-piperine, coniine, quinine vii. Steroids-general-cholesterol and sitosterols, isolation methods viii. Phenyl propanoids- biosynthesis general characteristics-coniferyl alcohol ix. Aminoacids – assay, isolation methods, alpha aminoacids-reactions, essential amino acids, Peptides& proteins –primary structure of peptides-assay x. Saponins-general, isolation methods, sources, properties, polyketides -general structure, properties, isolation techniques xi. Vitamins-general, classification, sources,V-A,V-B complex,V-C, structures, dietary importance, Assay for V-C,V-A and V-E
BIO-NIIST-3-386	**Cardiovascular Disease Biology** Pathophysiology of various heart diseases. Biochemical changes associated with myocardial infarction (MI) viz., oxidative stress, Lipid peroxidation and metabolic changes associated with MI. Risk factors associated with myocardial infarction. Biochemical risk

	factors, modifiable risk factors and non modifiable risk factors Physiology of cardiac function, Cardiac hypertrophy, various types of cardiac hypertrophy, pathophysiology. Molecular basis of cardiac hypertrophy, Ishcmeia/reperfusion injury Signaling pathways in cardiac hypertrophy, calcineurin-NFAT pathway, Cyclic GMP/PKG-1 pathway, G-protein coupled receptors, Gq/G11 signaling, Histone deacetylases, MAPK pathways Various systems involved in the pathophysiology of cardiac hypertrophy viz., Na/H Exchanger, Renin angiotensin system (RAS), Atrial natriuretic peptide (ANP), Nitric oxide, Tumor necrosis factor (TNF-alpha), Peroxisome proliferators activated receptor). Drugs that affect cardiac function, Cardiac angiogenesis, calcium transient in hypertrophy, calcium overload Thrombosis, Platelets and Anti-Platelet Therapy in Cardiovascular Disease: Molecular Mechanisms, Blood Coagulation and Atherothrombosis, Thrombosis and Thrombolytic therapy. Drugs that act on the coagulation cascade
BIO-NIIST-3-387	**Molecular Biology of Diabetes** Introduction to Diabetes Mellitus, Preclinical and Clinical Methods for Evaluating Antidiabetic Activity of Plants, in vitro Models for Assessing Antidiabetic Activity, Plant metabolites and other Antioxidant Polyphenols in alleviating diabetic complications Insulin Secretion in Type II Diabetes, cellular effects of insulin, insulin signalling pathways, regulation mechanisms Cellular Effects of Elevated Glucose Concentrations, regulation by Insulin and an Insulinomimetic Approach to Lowering Blood Glucose Levels, Insulin resistance, its importance in diabetes and tissues affected, Obesity and its link to diabetes Metabolic Aspects of Glycogen Synthase Activation and its role in the pathogenesis of Insulin Resistance and Hypoglycemia, the distinction between 'Glucose set point', 'Glucose Threshold'and 'Glucose Sensor' is critical for understanding the role of the Pancreatic β-Cell in Glucose Homeostasis Mechanisms of Diabetic Complications, Oxidative Stress and Advanced Glycosylation End Products and Diabetic Retinopathy Drugs currently used in the treatment of Diabetes its proposed mechanism of action and reported side effects, therapeutic potential of recombinant gene transfer studies
BIO-NIIST-3-388	**Environmental Technology** *Waste Characterization* Organic and inorganic pollutants, Chemical oxygen demand (COD), Biological oxygen demand (BOD), Suspended solids (SS), Mixed liquor suspended solids (MLSS), Volatile suspended solids (VSS), Nutrient load, Total nitrogen (TN), Ammonia-nitrogen (NH4-N), Total phosphorus (TP), Microbial load, drinking water standards, discharge limits, Persistent organic pollutants, Ambient air quality, Air quality monitoring, VOC emission factor. *Biological Waste Water Treatment* Biological wastewater treatment, waste air treatment, biofilters, anaerobic digestion, composting, aerobic, anoxic and anaerobic wastewater treatment, combined treatment systems, soil remediation, phytoremediation, constructed wet lands, lake remediation *Process parameters in engineered biological systems* Batch, Fed-batch and continuous bioreactors, Sequence-batch reactor (SBR), Fluidized bed and packed bed bioreactors, Photo-bioreactor, Up-flow anaerobic sludge blanket reactors (UASB), Flocculated and granular sludge, Hydrolic retention time (HRT), Solid retention time (SRT), Pollutant loading rate, Microbial growth kinetics *Molecular Microbial Analysis*

	Microbial community analysis in waste treatment systems, Molecular markers for microbial diversity analysis, Fluorescent microscopy, Whole cell fluorescent in-situ hybridization (FISH), PCR, DGGE/TGGE, rep-PCR, 16S DNA sequence analysis and phylogenetic analysis, protein profiling.
BIO-NIIST-3-389	**Biomass to fuels** To recognize the diversity of plants, plant parts and plant structures that provide raw material for biofuel production. To understand basic principles of plant light energy conversion to chemical energy and carbon fixation. C3 and C4 plants. To examine the basic chemistry and biochemistry involved in the conversion of sugars to liquid alcohol Ecological dimensions of biofuels Impact of biofuels in global climate change and food production Case Study: Corn, cellulosic and sugar cane ethanol pros and cons Starch-Corn-ethanol: Resources and energy consumed by the industry: water, fertilizer and pesticides. Biorefineries & distribution, transport and green house gas emissions, denaturation with gasoline, distribution Cellulose stocks for biofuel, mill residues, forest residues, and agriculture waste. Cellulose-ethanol pathway starting from degradation of the plant cell wall, pretreatments to make biomass more accessible to enzymatic attack, hydrolysis of cellulose to glucose and conversion to ethanol. Lignin problem
BIO-NIIST-3-390	**Biochemical Engineering** Introduction to Engineering calculations. Energy and Material Balances Unit operations and unit processes: historical and more recent developments in chemical engineering; Process variables and degrees of freedom; Differential and integral balances; Lumped and distributed balances; Balances in systems involving physical changes Steady state energy and material balances Balances in reacting systems; Balances in systems involving recycle, purge, and bypass; Computer aided calculations; Generalization to unsteady state balances Introduction to transport phenomena: Momentum transfer Viscosity; Molecular theory of Gases and Liquids; Shell balance: Falling film, Circular tube; Equations of Change for isothermal systems: Continuity, Motion, Energy, Substantial derivatives; Unidirectional flows: Pipe flow, Variable viscosity falling film, Couette viscometer, Rotating Sphere; Unsteady flows: Startup Plate flow, Parallel plates etc Introduction to transport phenomena: Heat & Mass transfer Thermal conductivity and mechanism of energy transport; Shell energy balances and temperature distributions in solids and laminar flow; Diffusivity and the mechanisms of mass transport; Concentration distributions in solids and laminar flow; Equations of change for multicomponent systems; Introduction to the concept of heat and mass transfer coefficients; Dimensional Analysis Reactor Engineering- Bioreactor configurations

IMMT

100 level courses

Course number	Course Content
BIO-IMMT-1-001	**Biostatistics** Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression Basic probability distributions: Binomial, Normal, Chi-squares. Estimation of parameters: method of moments, maximum likelihood Testing of hypotheses: (a) parametric tests: t-test, z-test, chi-squares test, ANOVA (b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov
BIO-IMMT-1-002	**Computation/bioinformatics** Computers: Introduction to computer. History of computers: Evolution, Generation of computers (I, II, III, IV, V). Classification of computers (Notebook, Personal Computers, Workstation, Mainframes, Minicomputers, Microcomputers, Supercomputers) – comparison with memory, power, cost, size - then and now. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer- Central Processing Unit, Arithmatic Logrithmic Unit etc., Introduction to operating systems: Characteristics and Types of Operating system like DOS, windows XP/NT/VISTA/7, LINUX, Installation, portability and programming of these operating systems. Introduction to Computer Viruses. Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication (ISDN, Cable Modem), Communication Media (Coaxial Cables, Fiber Optics etc.), Optical vs. copper networking, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls,. Network Applications, Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet, World Wide Web, Advantages of Web, Web Terminology, Accessing the Internet, Dedicated Access, Dial – up access, Concepts of Domain, Concept of Web Browser, Internet Services, Internet Tools. Telnet/SSH, FTP, E-Mail (Using web E-Mail, client-mail, IMAP/POP configurations) Chat, newsgroups etc. MS-Word: Introduction to word, Introduction to parts of window (title bar, menu bar, tool bar, ruler, status bar), Creating, opening, saving and printing a document, Editing a document, Copy move and replace the text, text formatting, Page Setup, Margins, Gutters, text alignment, Line spacing, Page break, header and footers, spell checking. Creation and Manipulation of tables, Mail Merge, insert objects MS-Powerpoint: Introduction, Power Point Elements, Exploring Power Point Menu: opening and closing menu, working with dialog box, adding text, title. Moving and resizing text, starting a slide show, opening, saving and printing a slide show. Work with slide master. Views: Slide view, sorter view, notes view, online view, Formatting Text, Enhancing Text by using bullets, fonts style, font size, effect and color. Displaying slide show and adding multimedia and objects. MS-Excel: Introduction, format of electronic worksheet, adding data in worksheet, cell

	addressing, saving, opening and printing a worksheet, Ranges and different type of ranges, applying formula, copying formula, various mathematical function, statistical function and date functions, charts. Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics. Introduction to databases, Type and kind of databases, Applications and limitations Literature Search Databases: e.g. PUBMED, MEDLINE Nucleic acid and protein databases: GenBank, EMBL, DDBJ, SWISS PROT, UNIPROT. Animal and plant databases: Ensembl Genome project TIGR database, Maize GDB etc. Biotechnological databases: EST, STS, GSS, HTG SNP Motifs and Pattern Databases: PROSITE, Pfam, BLOCKS, PRINTS etc. Databases for species identification and classification: GBIF, ICTV, taxonomy browser at NCBI etc. Structural databases: PDB, PDBsum, NDB, SCOP, CATH etc. Database Retrieval and deposition systems: SRS, Entrez, Bankit, Seqin, Webin, AutoDep. Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.
BIO-IMMT-1-003	**Basic Chemistry** Thermodynamics (2 lectures) Solutions and Ions (2 lectures) Chemical bonding and molecular structure (2 lectures) Chemical Kinetics (2 lectures) Stereochemistry (3 lectures) Introduction to drug discovery (Medicinal chemistry approach) (2 lectures) Drug target, discovery and development (forward and reverse approach (2 lectures)
BIO-IMMT-1-004	**Research Methodology, Communication/ethics/safety** Philosophy and structure of scientific thoughts, Objective and Motivation of Research, Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure Research methodology, communication, ethics, safety Asking the right questions: Originality, Depth, Precision can co-exist Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it Study design: Recognizing and minimizing bias Experiment design: Sometimes less is more and the importance of controls Good lab practices: Record keeping, organizing data, organizing the lab space Data interpretation; objectivity, quantification, double blind studies and necessity of statistics Comunicating your data:writing up your research

	Comunicating your data: presenting your findings Radiation safety Chemical and Biosafety Intellectual property rights What is ethics, the different interpretations & historical instances of unethical science Case studies: Data fraud/ plagiarism and Human Ethics violation Write a 2-page scientific review on a topic of choice + might have 5 min presentations by students on aspects of 'History of Science' Introduction to IGIB & TCGA facilities (Visit & 2 hour discussions on principles & applications of Clinic Genomics, Genome Sequencers, Mass Spec, Confocal, Microarray, AFM, EM)

200 level courses

Course number	Course Content
BIO-IMMT-2-001	**Biotechniques and Instrumentation** (compulsory) **Separation and characterization** Principles and applications of centrifugation: high speed, ultra and differential centrifugation. Chromatography: affinity, ion exchange, hydrophobic chromatography, size exclusion and reverse phase chromatography, GLC, HPLC, HPTLC, GCMS, LCMS and Flash chromatography **Microscopy** Microscopy and Imaging: Light Microscopy, Bright and dark field, phase contrast, Fluorescence, Confocal, atomic force, transmission electron and scanning electron microscopy, cryo-EM, Surface Plasmon Resonance **Spectroscopy** Spectrophotometry: UV-Visible, absorption and emission spectrophotometry, AAS and Mass spectrometry, NMR Spectroscopy, stead-state and time-resolved fluorescence spectroscopy. Vibrational spectroscopy, circular dichroism and dynamic light scattering, Magnetic resonance spectroscopy **Techniques in Molecular biology** DNA/RNA isolation, plasmid isolation, designing of primers, RFLP, RAPD, ISSR, PCR, Realtime PCR, agarose, polyacrylamide and 2D-PAGE, poly/mono-clonal antibodies, ELISA, blotting and hybridization techniques, DNA sequencing. Cloning: vectors, expressing cloned genes.
BIO-IMMT-2-002	**Materials Characterization Technique (Compulsory)** Size and surface area analysis; Interaction of X-rays with matter, diffraction techniques and applications; Optical principles of microscopy; electron diffraction, imaging (various contrasts), determination of crystal structure, burgers vector, electron beam-specimen interactions and other applications of Transmission Electron Microscopy; Applications of Scanning Electron Microscopy and, Electron Probe Micro-Analyser; Principles of Quantitative Microscopy: Overview of other characterization techniques such as Auger electron spectroscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy.

BIO-IMMT-2-003	**Biology of Biology of Macromolecules** **Cell Biology** Basic concept: life forms from prokaryotes to eukaryotes, Structure and function of Cell and Cell organelles, Nucleic acids and proteins; Molecular aspects of cell division and cell cycle, Chromatin structure; Organization of nucleosome and chromosomes, Chloroplast and Mitochondrial Genome Organization. Bacterial and Algal genome organization **Biomolecules and pathways** Basic macromolecular structure: DNA, RNA, protein, lipids and carbohydrates, Synthesis and degradation of macromolecules, Relation between sequence, structure and function, protein folding and flexibility, important metabolic pathways and regulation **Enzymology** Enzyme activity, kinetics, Single substrate, bisubstrate reactions, Determination of Km. Enzyme inhibition: Reversible and irreversible inhibition, Competitive, Non-competitive and uncompetitive inhibition, receptor binding and regulation, allosteric regulation. **Genomics and proteomics** DNA replication in Prokaryotes and Eukaryotes, Genetic code: RNA transcription and processing, Transcriptional regulation in prokaryotes and eukaryotes, Protein synthesis, protein modifications and secretion, Regulation of protein synthesis, Biological structure databases, Computer modelling of proteins and nucleic acid based on sequence data
BIO-IMMT-2-004	**Plant Environment Interaction** Introduction to environment: classification, components of environment; Ecology and ecosystems; Symbiotic relationships; Plant responses to abiotic & biotic stresses; Plant - soil interactions. Environment and Sustainable Development.Environment Pollution in National and Global Perspectives, Environmental pollution and its effect on plants, Sources and Fate of Pollutants in the Aquatic Ecosystems, Energy Resources and Conservation, Plant adaptation to Environmental stress, Environmental Degradation and Restoration, Biomonitoring of Environmental contaminants, Environmental Impact Assessment & Auditing
BIO-IMMT-2-005	**Microbes and Environment** Environmental (soil, water and air) pollution – source, effect and fate Management of pollutants Environment monitoring methodologies Control of pollutants Microbes and polluted environment Biogeochemical cycling Microorganisms in biodeterioration Microbial bioremediation

	Metabolic networks of microbial systems Biosensors – reporter and marker genes Geomicrobiology Microbial cell as a factory Synthetic biology Systems biology .
BIO-IMMT-2-006	***In Vitro* Development and Morphogenesis in Plants** Introduction, Production of disease free quality planting materials; Somaclonal variations (concept and applications, visual, molecular and other screening methods); Haploids (anther, ovule culture and bulbosum technique, detection of haploids, applications); Endosperm culture, triploid production and its application; Protoplast culture, somatic hybrids and cybrids, selection strategies and applications; Secondary metabolites, hairy root culture, scale up studies using bioreactors; Ex situ conservation, short and long term storage of germplasm; Applications of tissue culture in commercialization; In vitro methods of crop improvement using transgenic technology and their Implications
BIO-IMMT-2-007	**Biodiversity** Aims, objectives and dynamics of Plant biodiversity Bio-geographic regions of plant biodiversity in India and world Diversity within different plant groups Assessment of biodiversity through classical taxonomic methods Ecological methods for plant diversity inventorying Role of Biosphere Reserve, National Parks, Wild Life Sanctuaries, Sacred Grooves in biodiversity conservation Species distribution and endemism Biodiversity and its sustainable uses Biodiversity and traditional knowledge Development of plant databases and its management Biodiversity legal and policy instruments Biodiversity, ecosystem function and ecosystem processes Ecological niche Impact of climate change on plant biodiversity Practical work: Field visit and ecological methods to study biodiversity

300 level courses

Course number	Course Content
BIO-IMMT-3-001	**Seminar Course (compulsory)** Two parts- theory and practice Theory (1 class and one invited speaker): Understanding listeners ; organizing content; creating presentation; using visual aids; vocal impact; presentation skill; maintaining confidence and building positive image; and managing interactive session. Practice: Delivering seminar on a specific topic.
BIO-IMMT-3-002	**Biomaterials (Compulsory)** Requisites of biomaterials and structure-property relation: metals, ceramics & polymers; Surface chemistry, surface & interfaces, cohesion and adhesion; Surface chemistry and physics of selected metals, polymers and ceramics; Property requirement of biomaterials; Concept of biocompatibility; Cell material interactions and foreign body response; Assessment of biocompatibility of biomaterials; Important biometallic alloys; Ti-based, stainless steels, Co-Cr-Mo alloys; Bioinert, Bioactive and bioresorbable ceramics; Processing and properties of different bioceramic materials with emphasize on hydroxyapatite; Synthesis of biocompatible coatings on structural implant materials; Microstructure and properties of glass-ceramics; Biodegradable polymers; Design concept of developing new materials for bio-implant applications
BIO-IMMT-3-003	**Genome and gene regulation** **Genome anatomy** Genomes of prokaryotes and eukaryotes, genetic organization of the prokaryotic genome, operons (*lac, mal, ara, trp*). genetic and physical maps: RFLP, SSLP, SNPs, restriction mapping, FISH, STS. Chromatin modifications and genome expression, genome replication, Molecular phylogenetics, Gene location, experimental techniques for gene isolation **Studying DNA** DNA structure, Enzymes for DNA manipulation: DNA polymerase, nucleases, Restriction endonucleases, ligases, End-modification enzymes. DNA cloning, cloning vectors, Mutation, repair and recombination, Polymerase chain reaction, DNA sequencing. **Transcriptomes** Transcription complex, Bacterial RNA polymerase, promoter sequences, Coding and non-coding RNA, synthesis of bacterial and eukaryotic RNA,

	mapping of end of transcripts, transcriptional regulation, termination of transcription, sythesis and processing of non-coding RNAs, degradation of mRNAs, S1 mapping, primer extension, Run-on and run-off transcription **Proteomes** Ribosome structure, initiation, elongation and elongation of translation, protein folding, proteolytic cleavage, chemical modification, protein degradation, purifying and studying proteins, DNA-protein interactions, Gel mobility shift, DNase footprinting, Flowcytometry MALDI-MS/MS/TOF, LC-ESI-MS/MS
BIO-IMMT-3-004	**Microbial Diversity and Habitat Ecology** Introduction to microbial lineages Techniques of studying culturable and unculturable microbes Methods in microbial taxonomy Microbial phylogeny Structure and function of microbial communities Genomic methods to identify microbial structure-function relationship Methods of studying uncultured microbes Plant-microbe interactions Mineral-microbe interaction Microbial metagenomics Environmental sampling and statistical analysis Instrumentation in microbial diversity study Latest sequencing technologies Assignments and discussions
BIO-IMMT-3-005	**Biology & Chemistry of Natural Products** Classification of metabolites - primary & secondary metabolites, Various classes of secondary metabolites - Alkaloids, Terpenoids, Steroids, Saponins, Flavonoids, Tannins etc., Extraction procedures for natural products, Purification and Isolation of pure compounds by chromatographic techniques, Structural elucidation of known/new compounds/NCEs by spectroscopic techniques, Structural modification of natural products
BIO-IMMT-3-006	**Bioremediation** Principles and Applications, Bacterial Remediation of Metal and Metalloid Contamination, Bioremediation through Fungi and Mycorrhiza, Biodegradation of Recalcitrant Organic Wastes, Phytoremediation of Contaminated Water, soil & Constructed Wetlands, phytoremediation and Role of Nutrient Management, Role of Nanotechnology in Bioremediation Scope of Soil Carbon Sequestration in Degraded Soils, Limiting Factors in Bioremediation, Processes, Biodiversity, Climate change research, Microbe-Plant interactions, Eco-restoration and Remediation technologies, **Environmental pollution and importance of microbes:** Microbial diversity in

	different Ecosystem, Constructed wetlands for treatment of Wastewaters, Microbial diversity in different Ecosystem, Resource recovery from waste, Bio-energy Environmental Biotchnology **Environmental Management:** Waste management through Eco-friendly approaches, Concept and dynamics of ecosystem, biogeochemical cycles; Types of ecosystems, Community structure and organisation Practical Protocols/ Techniques of Soil Bioremediation using Microbes Protocols/ Techniques of Soil Phytoremediation Protocols/ Techniques of Phytoremediation for Aquatic Ecosystems Use of Soil Enzymology in Monitoring of Bioremediation
BIO-IMMT-3-007	**Mineral Bioprocessing** Introduction to chemolithotrophic and heterotrophic nutrition of microbes. Chemical and electrochemical aspects of bioleaching. Understanding of role of microbes in biogeochemical cycles of Fe, Mn, Si, P etc. Bioleaching of valuable metals from ores/minerals. Role of microorganisms and their attachment to ore in bio-flotation and bio-beneficiation.
BIO-IMMT-3-008	**Taxonomy and Speciation** <u>Unit-I: Taxonomy of plants</u> History of plant taxonomy and classification of angiosperms International Code of Botanical Nomenclature Modern trends in Taxonomy: (a) Numerical taxonomy, chemo-taxonomy, cyto-taxonomy, and (b) Palynology, embryology, anatomy and palaeo-botany Relevance of Herbaria & Botanical Gardens Systematics of Pteridophytes and Gymnosperms (General characters, classification, important families) Systematics of non-vascular plants Plant descriptors, systematic of some selected families in Dicots & Monocots Methods and techniques in plant taxonomy and herbarium <u>Unit –II: Molecular Systematics and speciation</u> Species concept Speciation in plants Molecular Systematics: Concepts and applications Molecular markers in plant systematics Procedures for collecting and sampling of plant materials Molecular Phylogenetics Phylogenetic Inferences Phylogeography: concepts and case studies in plants

CLRI (Biological Sciences –Course Work)

100 level courses

(Minimum 4 credits required)

Course number	Course content	Credits
BIO-CLRI-1-001	**Biostatistics (Compulsory)**	**1-0-0-1**

Summarization of Data: measures of center, dispersion, skewness Dependence of variables: Correlation, linear regression, logistic regression
Basic probability distributions: Binomial, Normal, Chi-squares.
Estimation of parameters: method of moments, maximum likelihood
Testing of hypotheses:
(a) parametric tests: t-test, z-test, chi-squares test, ANOVA
(b) non-parametric tests: Mann-Whitney, Kruskal Wallis, Kolmogorov-Smirnov

BIO-CLRI-1-002 **Computation/bioinformatics (Compulsory)** **1-0-0-1**

Computers: Introduction, Evolution and Classification of computers. Fundamentals of computing. Bit and Byte, Introduction to types of Hardware and Software. Components of Computer. Introduction to operating systems. Introduction to Computer Viruses.
Network: Introduction. Network structure and architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols, transport protocol design. Types of network, Topologies of network, Router, Switch, Data Communication, Concept of Wireless networking, LAN, WAN, MAN, Security of the network, Fire-walls, Network Applications
Information Technology: Concepts of client Server Architecture, Concept of search Engine, Database search engines. Introduction to Internet
Introduction to Word, Powerpoint and Excel
Introduction to Bioinformatics: History of Bioinformatics, Genome sequencing projects, Human Genome Project, Applications of Bioinformatics.
Introduction to databases, Type and kind of databases, Applications and limitations. Literature Search Databases, Nucleic acid and protein databases, Animal and plant databases, Ensembl Genome project TIGR database, Biotechnological databases, Motifs and Pattern Databases, Databases for species identification and classification, Structural databases. Database Retrieval and deposition systems.
Web tools and resources for sequence analysis: Pairwise and multiple sequence Alignment, Sequence similarity search: BLAST, Pattern recognition, motif and family prediction, Restriction map analysis, primer design, Gene prediction, Phylogenetic Tree, Protein structure prediction and visualization.

BIO-CLRI-1-003 **Basic Chemistry (Compulsory)** **1-0-0-1**

Thermodynamics
Solutions and Ions
Chemical bonding and molecular structure
Chemical Kinetics
Stereochemistry
Introduction to drug discovery (Medicinal chemistry approach)
Drug target, discovery and development (forward and reverse approach

BIO-CLRI-1-004 **Research Methodology, Communication/ethics/safety (Compulsory)** **1-0-0-1**

Philosophy and structure of scientific thoughts, Objective and Motivation of Research,
Meaning of the Research, What constitutes a research topic? How to select a research topic?, Importance of literature review, Selection of appropriate methodology, Collection of data, Interpretation of data, Writing research paper, Paper presentation in scientific conference, Statistical methods, Importance of documentation, Procedure for Hypothesis Testing, Values and Ethical Problems, Criteria of Good Research, Good laboratory practice, Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure
Research methodology, communication, ethics, safety

Asking the right questions: Originality, Depth, Precision can co-exist
Formulating and refining the hypothesis: Those who do not learn from the past are condemned to repeat it
Study design: Recognizing and minimizing bias
Experiment design: Sometimes less is more and the importance of controls
Good lab practices: Record keeping, organizing data, organizing the lab space
Data interpretation; objectivity, quantification, double blind studies and necessity of statistics
Communicating your data: writing up your research
Communicating your data: presenting your findings
Radiation safety
Chemical and Biosafety
Intellectual property rights
What is ethics, the different interpretations & historical instances of unethical science
Case studies: Data fraud/ plagiarism and Human Ethics violation

200 level courses

(4 credits: 1 compulsory + 1 optional)

Course number	Course content	Credits

BIO-CLRI-2-001 Biotechniques and Instrumentation (compulsory) Theory and Practical 1-0-1-2

General Instrumentation: handling, care, usage and safety (this includes spectrophotomers, rotors, cuvettes, etc).
UV spectroscopy: stead-state and time-resolved fluorescence spectroscopy
Vibrational spectroscopy: basic principles and applications in biology
Magnetic resonance spectroscopy, ESR
Atomic force microscopy
Confocal and fluorescence microscopy
Analytical ultracentrifuge
Calorimetry (isothermal titration and differential scanning calorimtry)
Surface Plasmon Resonance
Chromatography
Single molecule spectroscopy

BIO-CLRI-2-002 Biomacromolecules 2-0-0-2

Introduction to biological Macromolecules, The need for polymeric macromolecules for the living cell, Non-covalent forces (electrostatic, hydrophobic, hydrogen bonding, etc.), Properties of water in relation to macromolecular conformation, peptide backbone, side chains, polarity, absorbance, single letter codes etc. Protein separation and purification methods, protein structure, primary, secondary, tertiary and quaternary structure, covalent modifications
DNA structure – Watson and crick model, forms of DNA, Conformation of nucleic acids (A-, B-Z-DNA), t-RNA, micro-RNA.
Lipids and Carbohydrates: Structure, function and classification.

BIO-CLRI-2-003 Cell Signalling 2-0-0-2

General principles of cell signaling,
G Protein-Coupled Receptor (GPCR) Signaling,
Growth Factor/ Receptor Tyrosine Kinases (RTKs),
Calcium and Cytokine signaling,
Wnt signaling, JAK/STATs , Ras, Mitogen-Activated protein Kinase (MAPK) pathways
Protein Kinases and Phosphatases, Ion channels.

BIO-CLRI-2-004 Chromatin Organisation 2-0-0-2

Chromatin structure; Organization of nucleosome and chromosomes; Molecular aspects of cell division and cell cycle. DNA replication in Prokaryotes and Eukaryotes. RNA transcription and processing; Transcriptional regulation in prokaryotes and eukaryotes; Protein synthesis, protein modifications and secretion; Regulation of protein synthesis; Transposable genetic elements, Types and mechanisms of transposition.

BIO-CLRI-2-005 Connective Tissue Biology 2-0-0-2

Extracellular matrix (ECM) proteins, lipids and glycoproteins,
Triple helix structure of collagen,
Functions of skin and other connective tissues

Types of collagen ,
Stability, crosslinking and Thermal properties ,
Biosynthesis of collagen,
Matrix metalloproteinases and action on ECM,
Biology of wound healing and other disorders

BIO-CLRI-2-006 Biomaterials 2-0-0-2

Physical properties of materials and their measurements
Biomaterial tissue interaction
Stabililisation of biomaterial
Metals, Polymers and biodegradable polymers
Cell addition and colonization of surfaces
Physico - chemical characterization of biomaterials,
Surface characterization
Design of composites and their application.
Bioceramics,
Tissue response to implants and biocompatibility
Biosensor technologies

BIO-CLRI-2-007 Computer Aided Drug Discovery 2-0-0-2

Use of molecular modeling to Discover and Design of Drugs, Molecular modeling in drug discovery; computer representation of molecules, chemical databases and 2D substructure searching, 3D Database searching,

Deriving and Using 3D pharmacophore, constrained systematic search, Ensemble distance geometry, Ensemble molecular dynamics and genetic algorithms, clique detection method for finding pharmacophore, maximum likelihood method, incorporating geometric futures in 3D pharmacophore.

Molecular Docking; Various types of docking techniques, Scoring functions, Applications of database searching and docking,

Molecular similarity and similarity searching, Molecular Descriptors, Quantitative structure- activitiy relationships, selecting compounds for QSAR analysis, various types of descriptors, Deriving QSAR equations, Cross validation, interpreting QSAR equation, Regression analysis, Partial Least squares, Principle component analysis, Molecular field Analysis, 2D-QSAR, 3D-QSAR and muti-dimensional QSAR approaches. Structure based methods to identify lead compound, de novo ligand design.

BIO-CLRI-2-008 Biochemical Engineering Principles 2-0-0-2

Basics of Microbiology – Structure of cells, important cell types; Chemicals of life – Sugars, polysaccharides, lipids, nucleotides and nucleic acids, amino acids and proteins; cellular organization.

Enzyme kinetics – Michelis-Menten kinetics, substrate activation and inhibition, multiple substrates, temperature and pH effects on enzyme reaction rates; applied enzyme catalysis; enzyme immobilization and kinetics; stoichiometry of cell growth and product formation.

Molecular genetics – gene expression, induction and repression, genetic code, protein synthesis; recombinant DNA technology; kinetics of microbial growth, substrate utilization, product formation; sterilization and thermal death kinetics; batch and continuous sterilization;

Transport phenomena - Gas liquid mass transfer in cell systems, basic mass transfer rates, measurement of k_La; Heat transfer aspects; Design and analysis of bioreactors, ideal reactors and

non-ideal mixing; multiphase bioreactors – CSTR, packed bed, bubble column, etc; animal and plant cell bioreactors; scale up criteria

Instrumentation and control – physical and chemical sensors; off-line analytical methods; process control; Downstream processing – filtration, centrifugation, sedimentation, extraction, precipitation; chromatography, membrane separations; Bioprocess economics; Biological waste water treatment.

BIO-CLRI-2-009 Enzyme and Fermentation Technology 2-0-0-2

Microbial metabolism – metabolic regulation, catabolic regulation, feedback regulation, permeability control; biosynthesis of primary and secondary metabolites; proteins – structure, characterization; factors important to enzyme fermentations.

Fermentation Kinetics – Microbial growth, chemical description; measurement of biomass – direct and indirect methods; Monod kinetics, nutrient utilization and product formation, yields and productivities; heat evolution; factors affecting microbial growth; medium formulation

Batch and continuous cultures, chemostat; multiple substrates and mixed cultures; chemostat with cell recycle, multi stage continuous culture; transient growth; product formation in continuous culture; catabolic products, microbial metabolites, enzyme production.

Kinetics and engineering of medium sterilization, kinetics of sterilization; batch and continuous sterilization; aeration and agitation, power requirements, types of fluids – Newtonian and non-newtonian; oxygen transfer efficiency;

Translation of laboratory, pilot and plant scale data; scale-up practices and methods; fermentation control; measurement of dissolved and gaseous oxygen and CO_2 concentration; intermediate sensors; mechanical disruption; precipitation of polymers; filtration, centrifugation, cell disruption, chromatography

BIO-CLRI-2-010 Gene Expression and Proteomics 2-0-0-2

Primer characteristics and Designing, Polymerase Chain Reaction - Semi-quantitative and quantitative PCR;

Experimental aspects of protein characterization with emphasis on techniques currently used, approaches to studying protein conformation in solution, holistic approach towards proteomics, theoretical methods for studying dynamics of proteins. Proteomics and its advantages over genomics,1Dand 2D Gel Staining methods and analysis Protein spot/Band processing for Mass spectrometric analysis, application of Mass spectrometers such as MALDI-TOF/TOF and electrospray mass spectrometer and sequencing.

300 level courses

(4 credits: 1 compulsory + 1 optional)

Course number	Course content	Credits
BIO-CLRI-3-001	**Seminar Course (compulsory)**	**2-0-0-2**

History of science with emphasis on Indian contribution: Seminar by students

BIO-CLRI-3-002	**Nanobiology**	**3-0-0-3**

Nanomaterial synthesis and characterization
Incorporation of nanoparticles in biomaterials,
Nanoparticles for therapeutic purposes
Multifunctional nanocomposites and nanobiocomposites.
Characterization of nanoparticles/nanocomposties
Use in targeting and imaging

BIO-CLRI-3-003	**Industrial Microbiology and Enzymology**	**3-0-0-3**

Introduction to Microorganisms, Growth & metabolism:
Microbial nutrients and physiology
Metabolic pathways and bioconversions:
Introduction to Enzymology:
Role of microbes in Industrial sector:

BIO-CLRI-3-004	**Cell Death and Diseases**	**3-0-0-3**

Cell cycle regulation,
Apoptosis, Autophagy, Necrosis
Morphology,
Mechanisms in cell death pathways,
Participation of organelles-ER, Mitochondria, cytoskeleton
Signaling Involved in Cell Survival & Death
Inflammation/Toll-like receptors/NF-kB signaling
Signalling cross-talk.

BIO-CLRI-3-005	**Approaches to Drug Delivery**	**3-0-0-3**

Sustained release drug delivery systems. (SRDDS)
Polymers for controlled drug delivery systems
Concepts and system design for the rate – controlled drug delivery
Parenteral controlled release drug delivery systems
Transdermal drug delivery systems (TDDS)
Controlled release oral drug delivery systems
Targeted drug delivery system

BIO-CLRI-3-006	**Computational Biology**	**3-0-0-3**

Concepts in molecular modelling: Introduction to Statistical Mechanics and Classical Mechanics.
Molecular mechanics: Potential energy surface, Born-Oppenheimer approximation, Features of molecular mechanics, force fields, Bonds structure and bending angles, Electrostatic Vander Waals

and non-bonded interactions, Hydrogen bonding in molecular mechanics, Derivatives of molecular mechanics energy function, Calculating thermodynamic properties using force field for metals and inorganic systems, Application of energy minimization.
Molecular dynamics and monte carlo simulation methods: Molecular Dynamics using simple models, Molecular Dynamics with continuous potentials and at constant temperature and pressure, Solvent effect in molecular Dynamics, conformational changes from Molecular Dynamics simulation, Analysis of molecular dynamics trajectory, Normal Model analysis, ANM, GNM, Coarse graining approaches: modeling of protein aggregation. Monte Carlo Method in various ensembles and its applications.

BIO-CLRI-3-007 Bioprocessing and Industrial Fermentations 2-0-0-2

Industrial microorganisms – Screening, isolation and preservation techniques; Measurement techniques for biomass – qualitative and quantitative; strain improvement /enrichment techniques - wild types, mutation, genetic engineering principles and techniques.
Screening of enzymes and metabolites; enzyme assays; Purification methods – ammonium sulphate precipitation, ultrafiltration, aqueous two-phase extraction, spray drying; chromatographic methods – Gas chromatography, Liquid Chromatography, Characterization of enzymes
Bioprocessing – Submerged fermentation - Medium preparation and sterilization; inoculum preparation; shake flask culture, ; principles of fermentations at laboratory, pilot scale and commercial scales; factors influencing growth and production; monitoring and control; Solid state fermentation – substrates and inoculum types; critical factors of influence; reactors and scale up; downstream processing; formulations.
Industrial fermentations – Single cell protein, enzymes – protease, lipase, tannase, cellulase, etc; organic acids – citric and lactic acids; ethanol, vinegar; secondary metabolites; high value products; food fermentations; enzymes in leather processing.
Technology aspects – Costing and economics of bioprocessing; IPR aspects; validation of processes; detailed project report preparation; marketing strategies.

BIO-CLRI-3-008 Cell and Tissue Engineering 2-0-0-2

Cell and Tissue culture,
Angiogenic factors and growth factors
Introduction to Tissue engineering, Artificial skin
Embryonic and adult stem cells, Induced pluripotency, Cancer stem cell
Stem cell differentiation, Therapeutics prospects, Ethics issues,
Implants
Basic principle of different types of tools (such as nano-lithography, TEM, AFM and other x-ray base detections techniques) will be discussed and their relevance to biological system characterization. Analytical electron microscopy.

BIO-CLRI-3-009 Nanomaterial Toxicology 2-0-0-2

Basics of nanotechnology
Synthesis and characterization of engineered nanomaterials (ENMs)
Sol gel, biological and ball milling methods for synthesis of ENMs and characterisation using electron microscopy (TEM, SEM), dynamic light scattering (DLS) and confocal microscopy.
Safety assessment of ENMs – methods and challenges
Methods for assessment of toxicology of ENMs; preparation of nano-suspensions; exposure paradigm, cellular uptake, absorption and distribution; in silico approaches for macromolecule interaction with ENMs.
Mechanism of toxicity of ENMs

Effect of size, shape and surface chemistry on cellular responses (oxidative stress, cytotoxicity, genotoxicity, immunotoxicity etc) Ecotoxicity of ENMs
Models and methods used for ecotoxicity assessment of ENMs;.life cycle analysis of ENMs.
Safe handling of ENMs and their disposal
Practical:
Preparation of nano-suspensions and their characterization
Cellular uptake using flow cytometer
Cytotoxicity assessment for ENMs

BIO-CLRI-3-010 **Byproduct Utilization** **2-0-0-2**

Nature and composition of tannery byproducts. Present methods of tannery waste management/ utilization. Recovery of organic and inorganic components from different types of biowastes generate at different unit operations.
Determination of proximate composition; protein molecular weight mapping. Microbial enzyme technology: production, characterization and application of enzymes in tannery for pollution abatement; Enzymatic treatment of tannery wastes and recovery of value added products for recycling/reuse etc. Development of collagen based biomaterials for biomedical application.

400 level courses (8 credits required)

Compulsory courses

Bio-CLRI-4-001	**Project proposal writing & presentation**	**0-0-4-2**
BIO-CLRI-4-002	**Review Article**	**0-0-4-2**
BIO-CLRI-4-003	**CSIR-800**	**0-0-8-4**