ANNEXURE I

Department of Biological Sciences
Aliah University, Kolkata

Draft Syllabus for 2-Years MSc in Botany (CBCS)

****Effective from 2021-22 onwards****

Programme Outcomes (POs):

PO-1: Core competency: Students will acquire core competency in the subject, and in allied subject areas.

PO-2: Analytical ability: The students will be able to demonstrate the knowledge in understanding research and addressing practical problems.

PO-3: Communication skills: Students will gain a standard communication skill and will be able to read and understand documents with in-depth analyses and logical arguments. Students will be well-versed in speaking and communicating their ideas or findings to a wider audience.

PO-4: Research ability: Application of various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyse the data to decipher the degree to which their scientific work supports their hypothesis.

PO-5: Critical Thinking and problem-solving ability: An increased understanding of fundamental concepts and their applications of scientific principles is expected at the end of the program. Students will become critical thinkers and acquire problem solving capabilities.

PO-6: Digitally equipped: Students will acquire digital skills and integrate the fundamental concepts with modern tools.

PO-7: Ethical and Psychological strengthening: Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.

PO-8: Team Player: Students will learn team workmanship in order to serve efficient institutions, industry and society.

PO-9: Independent Learner: Apart from the subject specific skills, generic skills, especially in programs of biological sciences, the program outcome would lead to gain knowledge and skills for further higher studies, competitive examinations and employment.

Programme Specific Outcomes (PSOs)

PSO-1: The students will be able to identify major groups of plants and compare the characteristics of lower (e.g. algae and fungi) and higher (angiosperms and gymnosperms) plants.

PSO-2: Students will be able to use the evidence based comparative botany approach to explain the evolution of organisms and understand the genetic diversity on the earth.

PSO-3: The students will be able to explain various plant processes and functions, metabolism, concepts of gene, genome and how an organism's function is influenced at the cell, tissue and organ level.

PSO-4: Students will be able to understand adaptation, development and behaviour of different forms of life.

PSO-5: The understanding of networked life on earth and tracing the energy pyramids through nutrient flow is expected from the students.

PSO-6: Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Botany.

PSO-7: Students will be able to understand about the modern tools and techniques for research and development including the development of genetically modified crops or other plants.

Department of Biological Sciences
Aliah University, Kolkata
Draft Syllabus for 2-Years MSc in Botany (CBCS)

The postgraduate Degree Programme namely 'Master of Science in Botany' of Aliah University will be consist of:

1. Core Course (CCT and CCP): [Total Paper: 13; Total Credit: 13x4=52]
Discipline specific compulsory basic course. Minimum *10 theory* papers (each of 4 credits i.e. totalling minimum 10x4 = 40 credit points) and *3 practical* papers (each of 4 credits i.e. totalling minimum 3x4 = 12 credit points) based on the 10 theory core course papers are mandatory.

2. Discipline Specific Elective Course (DET and DEP): [Total Paper: 4 ; Total Credit: 4x4=16]

Discipline specific elective courses (choice based) which are more advanced or specialized would be offered in the Semester- III and IV. 4 papers (2 theory and 2 practical) each of 4 credits totalling 4x4 = 16 credit points have to be chosen out of the 6 papers offered.

3. Generic Elective Course (GEC): [Total Paper: 2; Total Credit: 2x4=8]
Interdisciplinary elective course (choice based) to be opted from a discipline other than one's main discipline (s) of choice in the Semester-III and IV. 2 papers each of 4 credits totalling 2x4 = 8 credit points have to be chosen out of the 4 papers offered.

4. Aliah University Compulsory Course (AUC): [Non-credit]
There will be a Compulsory Course on "Elementary Arabic and Islamic Studies" having no credit points in Semester-I.

5. Ability Enhancement Compulsory Course (AEC): [Non-credit]
There will be a Compulsory Course on Disaster management/ Human Rights/ Value Education/ Yoga/ Soft Skills having no credit points in Semester-II.

6. Project and Dissertation (PRJ): [Total Paper: 1 ; Total Credit: 1x4=4]
Students have to work on a specific project and will write a dissertation on it followed by a presentation in Semester IV. (1 paper of 4 credit totalling 1x4 = 4 credit points).

List of Core Course Theory (CCT) Papers

1. BOTPGCCT01 : Systematics and Evolution
2. BOTPGCCT02 : Ecology and Conservation
3. BOTPGCCT03 : Cell Biology
4. BOTPGCCT04 : Principles of Biochemistry
5. BOTPGCCT05 : Plant Metabolism
6. BOTPGCCT06 : Plant Developmental Biology
7. BOTPGCCT07 : Biostatistics and Bioinformatics
8. BOTPGCCT08 : Molecular Plant Pathology
9. BOTPGCCT09 : Molecular Biology
10. BOTPGCCT10 : Plant Physiology

List Core Course Practical (CCP) Papers

1. BOTPGCCP01 : Core Course Practical I
2. BOTPGCCP02 : Core Course Practical II
3. BOTPGCCP03 : Core Course Practical III

List of Discipline Specific Elective Course (DET and DEP) Papers

1. BOTPGDET01 : Genetics
2. BOTPGDET02 : Genetic Engineering and Plant Biotechnology
3. BOTPGDET03 : Quantitative Genetics
4. BOTPGDEP01 : Discipline Elective Practical I
5. BOTPGDEP02 : Discipline Elective Practical II
6. BOTPGDEP03 : Discipline Elective Practical III

List of Generic Elective Course (GEC) Papers

(To be opted by the students of other disciplines)

1. BOTPGGEC01 : Developmental Biology
2. BOTPGGEC02 : Techniques and Ethics in Biology
3. BOTPGGEC03 : Bioentrepreneurship
4. BOTPGGEC04 : Phytochemistry

Semester-wise curriculum plan

Sl. No.	Course Title	Course Code	Credits	Marks
Semester I				
1	Systematics and Evolution	BOTPGCCT01	**4**	**50**
2	Ecology and Conservation	BOTPGCCT02	**4**	**50**
3	Cell Biology	BOTPGCCT03	**4**	**50**
4	Principles of Biochemistry	BOTPGCCT04	**4**	**50**
5	Core Course Practical I	BOTPGCCP01	**4**	**50**
6	*Elementary Arabic and Islamic Studies	PGAUC01*	**0**	**0**
	*PGAUC01: Ability Enhancement Compulsory Course			
Semester II				
7	Plant Metabolism	BOTPGCCT05	**4**	**50**
8	Plant Developmental Biology	BOTPGCCT06	**4**	**50**
9	Biostatistics and Bioinformatics	BOTPGCCT07	**4**	**50**
10	Molecular Plant Pathology	BOTPGCCT08	**4**	**50**
11	Core Course Practical II	BOTPGCCP02	**4**	**50**
12	*Disaster Management/ Human Rights and Value Education/ Yoga and Life Skills (Any one)	PGAEC01*	**0**	**0**
	*PGAEC01: Ability Enhancement Compulsory Course			
Semester III				
13	Molecular Biology	BOTPGCCT09	**4**	**50**
14	Core Course Practical III	BOTPGCCP03	**4**	**50**
15	*Discipline Elective Theory I	BOTPGDET01	**4**	**50**
16	*Discipline Elective Practical I	BOTPGDEP01	**4**	**50**
17	#Generic Elective Paper I	MICPGGEC01	**4**	**50**
*Discipline Elective- One Theory (BOTPGDET01) and One Practical (BOTPGDEP01) to be chosen out of 6 options # Generic Elective- One Paper (BOTPGGEC01) to be chosen out of 4 options by the students of other disciplines				
Semester IV				
18	Plant Physiology	BOTPGCCT10	**4**	**50**
19	**Discipline Elective Theory II	BOTPGDET02	**4**	**50**
20	**Discipline Elective Practical II	BOTPGDEP02	**4**	**50**
21	## Generic Elective Paper II	BOTPGGEC02	**4**	**50**
22	Project and Dissertation	BOTPGPRJ01	**4**	**50**
**Discipline Elective- One Theory (BOTPGDET02) and One Practical (BOTPGDEP02) to be chosen out of 6 options ## Generic Elective- One Paper (BOTPGGEC02) to be chosen out of 4 options by the students of other disciplines				
Total Credits / Total Marks			**80**	**1000**

Core Course Theory (CCT) Papers

Paper Code: BOTPGCCT01
Paper Title: Systematics and Evolution

Course Objective	Course Outcome
1. To catalogue and preserve the plant species collected from different sources. 2. To differentiate the variations among organisms and arrange them on the basis of their relationships or associations. 3. To provide scientific names to the taxa, so that one can record, store and retrieve them when needed. 4. To establish a set of rules to choose characters for arranging species into hierarchic classification. 5. To study the genetic and phylogenetic relationships among life forms. 6. To make extensive use of computers to analyze and differentiate the intra and interspecific relationships among organisms. 7. To investigate the evolutionary histories of organisms. 8. To study the environmental adaptations of organisms.	The student will be able to: 1. Understand the fundamental principles of systematic in which the plants are how to classify according to their characters and what are the theories which have to be followed for classification. International rules of nomenclature and classification is studied. 2. Understand the existing organic biodiversity of our earth. 3. Understand the differences between the species on the basis of different genetic markers. 4. Construct the phylogenetic tree. 5. Understand the patterns and processes of evolution above the species level.

Unit I: Concepts of Plant Taxonomy

Concept and objective of plant taxonomy; Plant Nomenclature: Principles of ICN, Type concept, Effective and Valid publication, Priority of publications, Author's citation and rejection of names, Taxonomic keys; Biocode and PhyloCode. Taxonomic Literature: Types, definition and Examples- Monographs, Manuals, Floras, Journals, and taxonomic websites; Genbank. Herbarium: Traditional and Digital Herbarium, Use of Herbaria; role of Botanic Gardens in the 21st Century.

Unit II: Angiosperms Classification

Recent systems of Angiosperm classification including APG-IV (2016); Systems of angiosperm classification: Outline and relative merits and demerits of (i) Bentham and Hooker (ii) Takhtajan (iii) Hutchinson and (iv) Cronquist; Application of GIS and GNSS (Remote sensing) in Botany.

Unit III: Biosystematics

Definition, methods, importance, categories and relationship with classical taxonomy; Taxonomic supportive evidences: Palynology, Embryology, Cytology and Phytochemistry; Numerical Taxonomy (Phenetic methods): Principles, Methods, Merits and Demerits. Taxonomic features, systematic phylogeny and economic importance of families: Magnoliidae, Asteridae, Alismatidae, and Liliidae (Sensu Cronquist, 1981). Concepts of palaeo-herbs and eu-dicots (tricolpates).

Unit IV: Molecular Plant Systematics

Plant genomes: nuclear, mitochondrial, chloroplast; Acquisition of molecular data, Sequence alignment; Analysis of protein and nucleotide sequence, molecular tools in phylogeny Phylogenetic analysis (parsimony, Maximum Likelihood, Neighbour-Joining); DNA barcoding and its practical implications; Molecular Markers: Restriction site analysis (RFLPs), Isoenzymes, Simple sequence repeats (SSR) or Microsatellite DNA, Random amplified polymorphic DNA (RAPDs), Amplified fragment length polymorphism (AFLPs), Internal transcribed spacer, Inter simple sequence repeats (ISSR), Single nucleotide polymorphisms (SNPs)

Unit V: The Modern Synthesis

Evolutionary time scale: Eras, periods and epoch; Major events in the evolutionary time scale; Population genetics: Gene pool, allele and genotype frequency; Hardy-Weinberg Law; Neutral theory; Molecular clocks; Natural selection (stabilizing, directional and disruptive); Genetic drift; Adaptive radiation; Isolating mechanisms; Models of Speciation: Allopatric, Parapatric and Sympatric; Pattern of evolution: Convergent and Divergent evolution; Coevolution; Gene duplication and divergence.

Suggested Reading

1. Taxonomy of Vascular Plants - G.H. Lawrence
2. Flora of India (all vols.) - Botanical Survey of India
3. The Identification of Flowering Plant Families - P.H. Davis and J. Cullen
4. The Evolution and Classification of Flowering Plants - A. Cronquist
5. The Families of Flowering Plants (3rdEdn.) - J. Hutchinson
6. Plant Systematics - Michael G. Simpson, S.B. Jones and L.E. Luchsinger and Gurcharan Singh
7. Biodiversity – Principles and Conservation - U. Kumar and M.J. Asija
8. Molecular systematics and Plant Evolution. - P.M. Hollingsworth, R.M. Bateman and R.J. Gornall, Taylor and Francis, London.
9. Judd WS, Campbell CS, Kellogg EA, Stevens PA and Donoghue MJ (2002). Plant Systematics: A Phylogenetic Approach. Sinauer Associates, Inc., Massachusetts.
10. Nei M and Kumar S (2000). Molecular Evolution and Phylogenetics. Oxford University Press, New York.

Paper Code: BOTPGCCT02

Paper Title: Ecology and Conservation

Course Objective	Course Outcome
1. Understand the Structure and Functions of the ecosystem. 2. Knowledge of environmental pollution in relation to air, water and soil. 3. To understand climate change: Greenhouse gases, their sources, trends and role, Ozone layer and its depletion (Global warming, Sea level rise, UV radiation) acid rain, Bioindicator and biomarkers of environmental change. 4. To sensitize the students about the paramount role and importance of Nature. 5. To know the Biodiversity Concept, types and situation in India. IUCN categories. Strategies of conservation: In situ conservation & Ex situ conservation measures. 6. Knowledge of various acts related to Biodiversity conservation and protection and international conventions. 7. Judicious use of existing ecological resources for sustainable development. 8. Enables students to understand practical aspects of ecology and helps them to solve many contemporary ecological issues such as global warming, land degradation, habitat loss, desertification and pollution etc. 9. To examine the forces impacting ecosystems.	On completion of this course the students will be able to: 1. Demonstrate an understanding of key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors. 2. Analyse various types of ecosystems, correlate different ecosystems. 3. Comprehend the population characteristics, dynamics, growth models and interactions. 4. Understand the community characteristics, ecosystem development and climax theories. 5. Analyse the threat and suggest conservative measures. 6. Analyse environmental impact. 7. Monitor various physical, chemical and biological properties of soil water and air. 8. Apply the basic principles of ecology in wildlife conservation and management.

Unit I: Concept of Ecology

Introduction to ecology: level of organization, environmental concepts: Soil, atmosphere, light temperature, laws and limiting factors; adaptation and acclimatization: plants and animals; ecological amplitude; ecological species concept, ecotype, ecads, ecological equivalents & guilds; edges and ecotones.

Unit II: Ecosystem Ecology

Concept of ecosystem, production, food webs, energy flow through ecosystem; Transfer efficiencies: consumption, assimilation, production; Ecological pyramid: number, biomass, energy; mineral cycling (C, N, P); Controls on ecosystem function: bottom-up and top-down control; Types of ecosystems: freshwater and marine, estuary; Biomes: species, distribution, precipitation, temperature; Habitat and Niche: Concept; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

Unit III: Population Ecology

Characteristics of population: density, dispersion, demographics, survivorship curve; Population growth: exponential and logistic growth; Population regulation: density dependent and independent; concept of metapopulation; r and k strategies; population dynamics; estimation of population size; age structure; trade off; grime's triangle; Species Interactions: Types of intraspecific and interspecific interactions, mutualism, ammensalism, commensalism; Connell's experiment, Lotka Volterra model, Gause principle; Prey and Predation interaction: Defence-Mechanical & chemical; Avoiding predation- aposematic & cryptic coloration; Mimicry: Batesian and Mullerian

Unit IV: Community & Behavioural Ecology

Species richness & evenness; relative abundance; Simpson's and Shannon index; Species area and intermediate disturbance hypothesis; Succession: Type and mechanism; hydrarch and xerarch succession; model of succession; concept of climax; theory of island biogeography; Behavioural ecology: Altruism, inclusive fitness, reciprocal altruism, Hamilton's rule and kin selection; mating behaviour: sexual selection; optimal foraging theory; imprinting.

Unit V: Biodiversity

Concept, levels, importance of biodiversity, Global diversity hotspots, IUCN red list categories, General idea about Red Data Book, Megadiversity centres of world; Conservation: Objective, strategies & type of conservation, management, keystone species, indicator species, umbrella species, flagship species; Sustainable development, natural resource management in changing environment; Biodiversity protected areas in India; Biosphere reserves, resources and management, Effect of manmade alteration of environment on Biospheres; Molecular ecology, genetic analysis of single and multiple population, phylo-geography, conservation genetics, Modern tools and techniques to assess biodiversity.

Unit VI: Climate change

Environmental stresses and their management, greenhouse effect, stratospheric ozone, effect of ozone depletion, Kyoto protocol, Montreal protocol, acid and nitrogen deposition, coping with climatic variations, BOD, COD, biomagnification, eutrophication, threats to biodiversity.

Unit VII: Bioremediation

Bioremediation strategies; Major classes of contaminants; Uptake, biotransformation, detoxification, elimination and accumulation of toxicants. Factors influencing bioaccumulation from food and trophic transfer. Pesticides and other chemicals in agriculture, industry and hygiene and their disposal. Impact of chemicals on biodiversity of microbes, animals and plants. Bioindicator and biomarkers of environmental health, biodegradation.

Suggested Readings

1. Ecology-Peter Stiling, Second Edition-2015
2. Elements of Ecology-T. M. Smith and R.L. Smith-Eighth edition-2011
3. Campbell Biology-Urry et.al-Eleventh Edition-2016
4. Principles and Standards for Measuring Primary Production. 2007. Fahey, T.J. and Knapp, A.K. Oxford University Press, UK.
5. Ecological Modelling. 2008. Grant, W.E. and Swannack, T.M., Blackwell.
6. Fundamental Processes in Ecology: An Earth system Approach. 2007. Wilkinson, D.M. Oxford University Press, UK.
7. Principles of Terrestrial Ecosystem Ecology. 2011. Chaplin, F.S., Matson, P.A. and Virtuosic, P.M. Springer.
8. Environmental Chemistry. 2010. Stanley and Manahan, E. CRC, Taylor & Francis. London.
9. Freshwater Ecology: A Scientific Introduction. 2004. Closs, G., Downes, B. and Boulton, A. Wiley-Blackwell publisher, Oxford.

Paper Code: BOTPGCCT03
Paper Title: Cell Biology

Course Objective	Course Outcome
This course is designed to give the students 1. Basic idea of cell structure including macromolecules, membranes, and organelles. 2. Cell signalling, communication and cell transport 3. Cell division: process and regulation; and cell culture- types and methods 4. Cell culture: basic concepts and applications	On completion of this course the students will be able to: 1. Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles. 2. Students will understand different cellular components in cell signalling, communication and transport. 3. They will know the different types of cell culture and methods involved in it 4. Students will apply their knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation

Unit I: Structure of Cell

Plasma membrane: Structure and transport of small molecules; Protein and Small Molecule Trafficking: Receptor-mediated endocytosis; intra-cellular transport, lysosomes, organelle biogenesis; extra-cellular transport: biogenesis of membrane proteins, protein modification, glycosylation; pumps, channels and transporters; Extracellular matrix; Structure and organization of Microtubules, Intermediate filaments and Microfilaments

Unit II: Cell signalling

Hormones and their receptors, cell surface receptors, signalling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signalling pathways, bacterial and plant two-component systems, light signalling in plants, bacterial chemotaxis and quorum sensing.

Unit III: Cell cycle and cancer

Cell cycle and its regulation, Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, angiogenesis, interaction of cancer cells with normal cells, apoptosis, autophagy, anoikis; therapeutic interventions of uncontrolled cell growth. Stem cell: Embryonic stem cells (ESC) and adult stem cells (ASC).

Unit IV: Techniques in Cell biology and Cell culture

Microscopy, Cell fractionation, FACS, Introduction and historical background of animal cell culture. Types of cell culture. Basic characteristics of tissue culture media. Basic equipment and facilities in animal cell culture. Types of culture media and culture wares. Sterilization methods for culture wares and culture media. Maintenance of a cell line and storage of cells.

Suggested Readings

1. Cell and Molecular Biology: Concepts and Experiments, 6th edition (2009), Gerald Karp, Wiley. ISBN- 978-0470483374.
2. The Cell: A Molecular Approach, 6th edition (2013), Cooper and Hausman; Sinauer Associates, Inc. ISBN- 13:978-1605351551.
3. Essential Cell Biology, 7th edition (2009), Alberts, Bray, Hopkin, Johnson, Lewis, Raff, Roberts and Walter. Garland Science. ISBN-13:978-0815341291.
4. Molecular Cell Biology, 7th edition (2012), Lodish, Berk, Kaiser, Krieger, Bretscher, Ploegh, Amon and Scott. W. H. Freeman. ISBN-13: 978-1429234139

Paper Code: BOTPGCCT04
Paper Title: Principles of Biochemistry

Course Objective	Course Outcome
This course is designed to give the students 1. The understanding of acids, bases and buffers and their relevance in living systems. 2. The information about the structure and function of various biomolecules such as carbohydrate, protein (including their role as biocatalysts) and nucleic acids. 3. The knowledge about enzyme and catalysis 4. Use of various techniques involved in biochemical analysis.	After completion of the course, a student will be able to achieve these outcomes: 1. The students will learn about the chemical structures of carbohydrates, and their structural and metabolic role in cellular systems. 2. The students will learn about structure and function of lipids, circulating lipids and inflammatory lipid mediators etc. 3. They will also learn about primary, secondary, tertiary, quaternary structure of proteins. 4. The students will understand about the structure and function of nucleosides and nucleotides. 5. The students will learn about the enzymes and various enzymatic mechanisms in the biological system. 6. Students will learn the application of various techniques used in biochemical analysis.

Unit I: Introduction

Chemical basis of life; water; concepts of acid and base, reaction kinetics, pH, buffer; Biomolecular hierarchy; Macromolecules; Molecular assemblies: Stabilizing interactions.

Unit II: Carbohydrates

Definition, classification and structure of carbohydrates; Isomers; Sugar derivatives; Structure, occurrence, properties and functions of Disaccharides and Polysaccharides. Suitability in the context of their different functions- cellular structure; energy storage; signalling; Glycosylation of other biomolecules - glycoproteins and glycolipids.

Unit III: Amino acids and Proteins

Amino acids: structure and functional group properties and reactions; Peptides and covalent structure of proteins; Protein structure: Elucidation of primary and higher order. End group analysis and protein sequencing. Forces stabilizing protein structure; Structure-function relationships in model proteins like ribonuclease A; myoglobin; hemoglobin; chymotrypsin etc.; Tools to characterize expressed protein.

Unit IV: Nucleic acid

Structure, diversity and functions; DNA: Double helical structure, A-DNA, B- DNA & Z-DNA; The RNA world- Structure, types and roles of RNA; Nucleic acid Sequencing; G-Quadruplex.

Unit V: Lipids

Fatty acid: structure and functions; Lipids in the formation of membranes; Saponification structural lipids; Lipid functions: cell signals, cofactors, pigments; Lipoproteins.

Unit VI: Enzymes

General principles of catalysis; Quantitation of enzyme activity and efficiency; Enzyme characterization and Michaelis-Menten kinetics; Relevance of enzymes in metabolic regulation; activation; inhibition and covalent modification; Single substrate enzymes. Structure and function of Vitamins and coenzymes. Immobilized enzymes and their applications

Unit VII: Bioenergetics

Basic principles; Laws of thermodynamics, free energy, entropy, high energy bonds; Coupled processes.

Unit VIII: Basic Techniques in Biochemistry

Biomolecule purification by various types of chromatography, estimation by using colorimeter/spectrophotometer and characterization by spectroscopy and electrophoresis.

Suggested Readings

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W. H. Freeman
4. Berg JM, Tymoczko JL, Gatto Jr, GJ and Stryer L (2019) Biochemistry, 9th Edition, W. H. Freeman and Company
5. Nelson DL and Cox MM (2017) Lehninger Principles of Biochemistry, 7th Edition, W.H. Freeman and Company,
6. Voet, D. and Voet J.G (2005) Biochemistry 3rd edition, John Wiley and Sons.
7. Segel Irvin H (1997) Biochemical Calculations, 2nd Ed., John Wiley and Sons, New York.
8. Palmer, T (2001) Enzymes: Biochemistry, Biotechnology & Clinical chemistry, Horwood Pub. Co, Eng.

Paper Code: BOTPGCCT05
Paper Title: Plant Metabolism

Course Objective	Course Outcome
1. To understand the concept of metabolism and energetics 2. To understand the mechanism of metabolic pathways 3. In-depth analysis of various plant-based metabolic pathways 4. Concept of secondary metabolites and its applications	1. To identify and differentiate between various types of biomolecules 2. The students would be able to correlate between the concepts of metabolism and energetics 3. Delineation of metabolic pathways would help the students in understanding plants' response to various physiological and biological factors. 4. The students will be able to get a holistic picture of the various metabolic cycles and their relationship with the surrounding plant ecosystem. 5. The students will be able to understand mechanisms of biosynthesis of secondary metabolites and broad applications of the secondary metabolites

Unit I: Basic concepts of metabolism
Overview of metabolism and characteristics of metabolic pathways; Overview of organic reaction mechanisms- (1) group-transfer reactions; (2) oxidations and reductions; (3) eliminations, isomerization, and rearrangements; and (4) reactions that make-or-break carbon–carbon bonds; Experimental approaches to study metabolic pathways; Thermodynamics of high energy-yielding compounds; Thermodynamics of life.

Unit II: Carbohydrate metabolism
Photosynthesis: general concept of light reaction, action spectra for photosynthetic activity, light-harvesting antennas and photochemical reaction centres, mechanism of light reaction; organizational structure of photosynthetic apparatus and light-absorbing antenna systems; mechanism of electron transport, proton transport, and ATP synthesis; repair and regulation of the photosynthetic machinery; genetics, assembly, and evolution of photosynthetic systems; mechanism and regulation of Calvin-Benson cycle; C2 oxidative photosynthetic carbon cycle; Inorganic carbon-concentrating mechanisms- C4-carbon cycle and crassulacean acid metabolism (CAM); accumulation and partitioning of photosynthates (starch and sucrose)- biosynthesis and signalling of sucrose, formation and mobilization of starch. Respiration: overview of plant respiration; Glycolysis; Oxidative phosphate pentose pathway; Kreb's cycle; Glyoxylate cycle; Mitochondrial electron transport and ATP synthesis; alternative oxidase pathway.

Unit III: Lipid metabolism
Fats and oils as storehouses of energy; structural and functional lipids; fatty acid biosynthesis; glycerolipids synthesis; membrane lipids as precursors of cell-signalling molecules; biochemistry of storage lipids in germinating seeds.

Unit IV: Assimilation of mineral nutrients
Physical and biological nitrogen fixation, Ammonification, Nitrification, Denitrification. Biochemistry and genetics of nitrogen fixation and Ammonium assimilation; Amino acid biosynthesis and degradation; sulfur assimilation; phosphate assimilation; energetics of nutrient assimilation.

Unit V: Secondary metabolites and plant defences
Overview of secondary metabolites; Biosynthesis, structure and physiological, ecological, and biochemical significances of terpenes, phenolic phytochemicals, and nitrogen-containing compounds including alkaloids, cyanogenic glycosides, glucosinolates and non-protein amino acids; induced plant defences against insect herbivores; plant defences against pathogens, phytoalexins.

Suggested readings

1. Plant Biochemistry by Hans-Walter Heldt, 4th Ed., Academic Press, Elsevier
2. Plant physiology and development, Lincoln Taiz, Eduardo Zeiger, Ian Max Møller, Angus Murphy, Sinauer Associates Inc.
3. Biochemistry, Donald Voet and Judith G. Voet. Wiley publications
4. Lehninger Principles of Biochemistry, David L. Nelson and Michael M. Cox. Macmillan Learning

Paper Code: BOTPGCCT06
Paper Title: Plant Developmental Biology

Course Objective	Course Outcome
1. Understanding basic concepts of developmental biology 2. Knowledge about signal transduction in plant cells 3. Understanding gametogenesis, fertilization and early development in plants 4. Ulta-structure, biogenesis and expansion of plant cell wall 5. Morphogenesis and organogenesis in plants 6. Phytochrome and light control of plant development and role of signaling in flower development 7. In depth study of the structure, biosynthesis, transport, signal transduction pathways and function of plant hormones and their role in plant growth and development. 8. Knowledge about different types of plant senescence.	1. Students will learn the basic concepts of developmental biology including potency, specification, induction, competence, determination and differentiation and transgenics in analysis of development. 2. Understand basic components of signal transduction cascade, signal receptors and their location within plant cells. 3. Students will come to know about production of gametes, embryo sac development and double fertilization in plants as well as biochemistry of seed development and seed germination. 4. Composition of primary cell wall, synthesis of various cell wall components, pattern and rate of cell elongation. 5. Organization and development of shoot and root apical meristem, leaf development, floral meristem and floral development. 6. They will be acquainted with the knowledge of photochemical and biochemical properties of phytochrome as well as phytochrome induced responses. 7. Role of plant hormones including auxin, gibberellins, cytokinins, ethylene and abscisic acid in plant growth and development. 8. Leaf senescence regulation, systematic degradation of phototoxic chlorophyll, programmed cell death as a type of plant senescence will be understood.

Unit I: Basic concepts of developmental biology
Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

Unit II: Gametogenesis, fertilization and early development in plants
Production of gametes, cell surface molecules in sperm-egg; embryo sac development and double fertilization in plants; Sporophytic development of plant growth; embryogenesis, establishment of symmetry in plants: origin of polarity; identification of genes essential for embryo organization; GNOM proteins, MONOPTEROS, formation of tissue layers, differentiation of cortical and endodermal layers, intercellular movement of macromolecules during developmental processes; Biochemistry of seed development (including starch synthesis) and seed germination.

Unit III: Morphogenesis and organogenesis in plants
Meristematic tissues as foundations for indeterminate growth; Organization and development of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum.

Unit IV: Phytochrome and light control of plant development
Photochemical and biochemical properties of phytochrome; characteristics of phytochrome-induced responses; structure and function of phytochrome proteins; genetic analyses of phytochrome function; phytochrome signalling pathways; ecological functions of phytochromes; photo-physiology of blue-light responses;

regulation of blue light-stimulated responses; blue-light photoreceptors. Circadian rhythms; Photoperiodism; coincidence model; SDPs and LDPs; Vernalization: influence on flowering; role of signalling in flower development; discovery of Florigen.

Unit V: Plant hormones and their role in plant growth and development

Study of the structure, biosynthesis, transport, signal transduction pathways, effects, and functions of plant hormones including auxin, gibberellins, cytokinin, ethylene, abscisic acid, brassino-steroids.

Unit VI: Aging and senescence

Types of plant senescence; leaf senescence regulation; systematic degradation of phototoxic chlorophyll; Programmed cell death as a type of plant senescence.

Suggested readings

1. Plant Biochemistry by Hans-Walter Heldt, 4th Ed., Academic Press, Elsevier
2. Plant physiology and development, Lincoln Taiz, Eduardo Zeiger, Ian Max Møller, Angus Murphy, Sinauer Associates Inc.
3. Biochemistry, Donald Voet and Judith G. Voet. Wiley publications
4. Lehninger Principles of Biochemistry, David L. Nelson and Michael M. Cox. Macmillan Learning

Paper Code: BOTPGCCT07
Paper Title: Biostatistics and Bioinformatics

Course Objective	Course Outcome
1. To introduce students to the basic concepts of statistics, probability and probability distributions. 2. To teach them the different probability distributions and their application in statistical analysis 3. To familiarize them with various test of fit analysis methods. 4. To introduce the concept of database, in-silico tools for biological sciences 5. To expose them about the various stages of drug development.	After completion of the course the students would be 1. Well versed with sampling methods for biological sciences and their statistical analysis. 2. Able to analyze of data for test of fit analysisAb 3. le to access the various biological databases and retrieve the information 4. Enabled to analyze the data using different in-silico tools.

Unit I: Descriptive Statistics

a) Data in Biology: Development in biostatistics, samples and populations, techniques of sampling (random and stratified), sampling and non-sampling errors, variables in biology, univariate and bivariate frequency distributions.
b) Measures of Central Tendency: means, mode, median.
c) Measures of Dispersion: Range, standard deviation, coefficient of variance and covariance.
d) Measures of Skewness: Pearson's coefficients of skewness; coefficient of skewness using moments. Measures of Kurtosis.

Unit II: Probability and Probability Distributions

a) Probability: Basic concepts, addition and multiplication rules of probability, conditional probability
b) Probability Distributions: Probability mass function, probability density function and distribution function. Binomial distribution, Poisson distribution, normal distribution and exponential distribution along with their properties and relationships.

Unit III: Correlation and Linear Regression

a) Correlation Analysis: Scatter diagrams, Pearson's and Spearman's coefficients of correlation, coefficient of determination.
b) Regression Analysis: Method of least squares, equations of lines of regression and their applications in biostatistics.

Unit IV: Hypothesis Testing

a) Sampling distributions and standard error, null and alternate hypothesis, basic concept and illustrations of type I and type II errors, concept of confidence interval estimation.
b) Student's t-distribution: test for single mean, difference of means and paired t- test, chi-square distribution.

Unit V: Biological databases and genome browsers

Introduction to various databases and their classification (primary and secondary databases) e.g., NCBI, DDBJ, EMBL, ENSEMBL, UCSC and their uses

Unit VI: Sequence alignment

Local and global sequence alignments (Needleman-Wunsch and Smith-Waterman algorithms), pair-wise (BLAST and FASTA algorithms) and multiple sequence alignment (Clustal W) and its importance. s-value and e-value, p value.

Unit VII: Phylogenetic analysis

Basic concepts of phylogenetic analysis, rooted/uprooted trees, approaches for phylogenetic tree construction (UPGMA, Neighbor joining, Maximum parsimony, Maximum likelihood).

Unit VIII: Structure predictions for nucleic acids and proteins

Approaches for the prediction of RNA secondary and tertiary predictions, energy minimization and base covariance models, Basic approaches for protein structure predictions, comparative modeling, fold recognition/threading and *ab- initio* prediction

Unit IX: Overview of drug development

Drug life cycle, stages of drug discovery and strategic issues in drug discovery. Lead Generation; HTS, clinical trials, characterization of binding site, virtual screening, protein-ligand interactions, prediction of pharmacological properties, Lipinski's rule of five, concept of energy minimization and force fields, introduction to rational drug design using example, Introduction to drug databases

Suggested Readings

1. Bioinformatics: Sequence and Genome analysis, 2nd edition (2004), David W. Mount, Cold Spring Harbour Laboratory Press. ISBN-13: 978-0879697129.
2. Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition (2004), Andreas D. Baxevanis and B.F. Francis Ouellette, John Wiley and Sons. ISBN-13: 978-0471478782.
3. The Process of New Drug Discovery and Development, 2nd edition (2006), C.G. Smith and J.T. O"Donnell, Informa Healthcare, ISBN-13: 978-0849327797.
4. Cheminformatics (2003), J. Gasteiger, Thomas Engel; Wiley-VCH. ISBN: 9783527618279.
5. Molecular modeling - Principles and Applications, 2nd edition (2003), A. R. Leach, Pearson Education Limited, UK. ISBN 13: 9780582382107.
6. Cheminformatics in Drug Discovery (2006), edited by. T.I. Opera; Wiley Publishers, ISBN: 9783527604203.
7. Primer of Biostatistics, 7th edition (2011), Stanton Glantz, McGraw-Hill Medical. ISBN-13: 978-0071781503.
8. Biostatistics: A Foundation for Analysis in the Health Sciences, 10th edition (2013), Wayne W Daniel and Chad L. Cross, Wiley. ISBN-13: 978-1118302798.
9. Principles of Biostatistics, 2nd edition (2000), Marcello Pagano and KimberleeGauvrean, Thompson learning. ISBN-13: 978-0534229023.
10. Biostatistical Analysis, 5th edition (2009), Jerrold H. Zar, Pearson. ISBN-13: 978-0131008465.

Paper Code: BOTPGCCT08
Paper Title: Molecular Plant Pathology

Course Objective	Course Outcome
1. To understand recognition and specificity between plant and pathogen. 2. To know about plant responses to biotic and abiotic stresses. 3. To learn occurrence, properties, isolation, purification, characterization, induction and functions of plant defence enzymes. 4. To get acquainted with different types of phytoalexin, their biosynthesis and role in plant defence and application in human health and control of diseases. 5. Genetic manipulation of industrially important fungi. 6. To understand the gene-for-gene concept in plant microbe interaction. 7. To know in depth genetic engineering of plants for disease resistance. 8. Molecular tools for identification and detection of mycorrhizae. 9. Provide an overview of commercialization of biocontrol agents.	1. Students will understand penetration, infection and invasion mechanisms for establishment of pathogens in host tissue along with molecular recognition and specificity in disease resistance and molecular detection of plant pathogens in soil, water and plant tissues. 2. Hypersensitive response and systemic acquired resistance as well as mechanism of biotic and abiotic stress tolerance. 3. Students will come to know the occurrence, isolation, purification, biochemical and immunological characterization, induction and possible functions of plant defence enzymes. 4. Isoflavonoid and terpenoid phytoalexins, their biosynthesis, detoxification mechanism, elicitation and manipulation for induced immunity in plants. 5. In depth knowledge for genetic improvement of edible mushroom and biocontrol fungi using recombinant DNA technology, choice of vectors for cloning and stabilization of transformants will be shared. 6. They will be acquainted with the knowledge of signal exchange and transduction mechanism for activation of plant defence against microbial attack. 7. Organization of genes controlling disease resistance, method of gene transfer and strategies for development of transgenics will be discussed. 8. Students will understand PCR cloning of genes from AM fungi, RAPD and TS analysis of orchid mycorrhizal fungi and analysis of gene expression of AM fungi. 9. Commercialization methods of biocontrol fungi, entomopathogenic fungi and plant growth promoting rhizobacteria.

Unit I: Recognition and Specificity between Host and Pathogen
Penetration, infection, invasion of host tissue, relationship between pathogen and host factor(s); Molecular recognition and specificity of host and pathogen in disease resistance; Molecular detection of plant pathogens in soil, water and plant tissues.

Unit II: Plant responses to biotic and abiotic stress
Mechanism of biotic and abiotic stress tolerance; Hypersensitive response (HR) and Systemic Acquired Resistance (SAR).

Unit III: Plant defence enzymes
Occurrence, properties, isolation, purification, biochemical and immunological characterization, induction, possible functions. Pathogenesis-related (PR) proteins.

Unit IV: Phytoalexins
Isoflavonoid and terpenoid phytoalexins: Biosynthesis; Role in plant defence and application in human health and control of diseases; Detoxification mechanisms; Elicitors of phytoalexins; Manipulation of phytoalexin synthesis in plants; Induced immunity in plants.

Unit V: Genetic manipulation of filamentous fungi
Strain improvement, recombinant DNA technology, choice of vectors for cloning, stabilization of transformants, application in genetic improvement of edible mushroom and biocontrol fungi.

Unit VI: Resistance genes
Gene-for-gene concept in plant-microbe interaction; Signal exchange and transduction mechanism for activation of plant defence against microbial attack; Signalling in plant disease resistance.

Unit VII: Genetic engineering of plants for disease resistance
Organization of genes controlling disease resistance, methods of gene transfer, strategies for development of transgenics

Unit VIII: Mycorrhizae
Molecular tools for identification and detection; PCR cloning of genes from AM fungi; RAPD and ITS analysis of Orchid mycorrhizal fungi; Genomic fingerprinting of ectomycorrhizal fungi; Analysis of gene expression in AM fungi.

Unit IX: Biocontrol agents
Commercialization of biocontrol fungi, entomopathogenic fungi and plant growth promoting rhizobacteria. Biocontrol fungi.

Suggested Readings

1. Molecular Plant Pathology - M. Dicinson. Bios Scientific Publishers, Taylor and Francis group, London and New York.
2. Molecular and cellular biology of filamentous fungi-Nick Talbot, Oxford University Press.
3. Plant Pathology- G. N. Agrios, Elsevier Publications.
4. Plant Pathology - Mehrotra and Agarwal, Tata McGrow Hill
5. Handbook of Phytoalexin Metabolism and Action – M. Daniel and R. P. Purkayastha Eds. Marcel Dekker, Inc. New York.
6. Molecular approaches for Plant Fungal Disease Management – H.P.singh, P.chowdappa, B.N.Chakraborty, A.R. Podile Eds.Westville Publishing House, New Delhi
7. Molecular Plant Pathology: A practical approach, Vol. I & II- S.J. Gurr, M. J. Mc Phersson and D. J. Bowles, Eds., Oxford University Press.

Paper Code: BOTPGCCT09
Paper Title: Molecular Biology

Course Objective	Course Outcome
1. Understanding the detailed molecular structure, organization, and function of genetic material of prokaryotes and eukaryotes. 2. To understand molecular mechanisms of cellular processes like DNA replication, Transcription, Post-transcriptional processes, Translation, and Post-translational processes etc. 3. Understanding the regulation of all the molecular processes. 4. Provide an overview of cell structure and function at the molecular level, including the flow of information from genes to proteins, and regulation of cellular processes in prokaryotes and eukaryotes.	1. Students will understand the scientific process, in the context of learning the fundamental biological and chemical 'facts' of molecular biology. 2. Students will gain skills required to effectively do scientific research. Students will learn to implement the scientific method by proposing hypotheses to explain biological phenomena, designing and conducting experiments to test these hypotheses, and critically interpreting the resulting data. 3. Explain that the growth, development, and behavior of organisms are activated through the expression of genetic information in context. 4. Students will be able to Describe and discuss the properties and biological significance of the major classes of molecules found in living organisms and the relationship between molecular structure and biological function 5. Represent and illustrate the structural organization of genes and the control of gene expression 6. Conceptualize and describe protein synthesis, modification, folding etc.

Unit I: Genetic material
The structure of DNA and RNA; Melting of DNA, Super-helicity, Comparative Organization and features of Microbial Genomes and Eukaryotic Genomes

Unit II: DNA replication
Arrangement of replicons in a genome, Various modes of replication, continuous, discontinuous synthesis, various replication Enzymes, Replication Fork and priming, leading and lagging strand, elongation, termination, Plasmid replication, specific features of replication in Prokaryotes and Eukaryotes, action of topoisomerases, Telomere maintenance and Chromatin Assembly, Single stranded DNA replication, Relationship between DNA replication and cell cycle, DNA copy number maintenance.

Unit III: Recombination and Repair of DNA
DNA repair and recombination, DNA Mismatch Repair, Double Strand Break Repair, Recombination as a molecular biology tool. CRISPR-Cas9, Principle, Variations involved and applications.

Unit IV: Transcription
Transcription machinery of prokaryotes, various transcription enzymes and cofactors, initiation, elongation and termination, sigma factors, Transcription machinery of eukaryotes, various forms of RNA polymerase and cofactors, initiation, elongation and termination, promoters, enhancers, silencers, activators, effect of chromatin structure, regulation of transcription.

Unit V: Post-transcriptional processes
RNA processing, splicing, capping and polyadenylation, rRNA and tRNA processing, RNA Editing; RNAi and miRNAs, Antisense RNA, Post-transcriptional gene regulation

Unit VI: Operon

Gene structure, concept of Operon, Lac and Trp operon, organization and role in regulation of expression

Unit VII: Translation
The genetic code and protein structure, Mechanisms of translation in prokaryotes, Mechanisms of translation in eukaryotes, initiation complex, ribosomes and tRNA, factors, elongation and termination, *in vitro* translation systems, polycistronic/monocistronic synthesis, Regulation of translation, RNA instability, inhibitors of translation, stringent response in bacteria.

Unit VIII: Post-translational processes
Protein modification, inteins and exteins, folding, chaperones, transportation; The Signal Hypothesis, proteasome.

Suggested Readings

1. Gene IX by Benjamin Lewin, Jones and Bartlett Publishers, Sudbury, Massachusetts, 2007.
2. Molecular Biology by R.F. Weaver, 4th edition, McGraw Hill. New York. USA, 2007.
3. Molecular Biology of the Gene by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick, 6th
   edition, Benjamin Cummings, San Francisco, USA, 2007.
4. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter, 5th
   edition, Garland Science, New York and London, 2007.
5. Biochemistry (5th edition) by J.M. Berg, J.L. Tymoczko, L. Stryer, W.H. Freeman and Company, New York, USA, 2008.
6. Current Protocols in Molecular Biology Edited by: Fred M. Ausubel; Roger Brent; Robert E. Kingston; David D. Moore; John A. Smith; Kevin Struhl, John Wiley and Sons, Inc. 2007

Paper Code: BOTPGCCT10
Paper Title: Plant Physiology

Course Objective	Course Outcome
1. Understanding of plant-water relationship. 2. Mechanism of water uptake by angiospermic plants 3. Impact of various biotic and abiotic factors on plant physiology. 4. Distribution of photosynthates from source to sink. 5. Impact of plant growth regulators on plant physiology. 6. Understanding the stress physiology in plants.	1. Students would be able understand the impact of water and mineral requirements on growth and development of diverse plants 2. Knowledge of the impact of plant growth regulators would help the students in growing plants in optimal conditions. 3. Mineral nutrition information would help the students in understanding both general and specific needs for plant breeding. 4. Understanding the concept of source-sink in plants would help in plant cultivation for specific requirements. 5. Knowledge of plants' response stress would help the students in maintaining healthy lineage of plant varieties.

Unit I: Overview of the plant structure:
Plant cells, tissue systems; independently dividing autonomous and semi-autonomous sub-cellular organelles; brief description of the plant cytoskeleton; Plant cell wall and membrane properties.

Unit II: Transport and translocation of water
Physicochemical Properties and biological significance of water; Diffusion and osmosis; concept and significance of water potential; water potential in plant cells; turgor pressure and its significance. Mechanism of water absorption by roots; mechanism of water transport through xylem; transport of water from leaves to atmosphere; soil-plant-atmosphere continuum.

Unit III: Transport and translocation of solutes in phloem
Active and passive transport mechanism; transport of ions across membrane barriers; membrane transport processes; membrane transport proteins; ion transport in roots; Pathways of translocation through various phloem cells; pattern of translocation; description of various materials that are translocated via phloem; rates of solute movement, pressure-flow model, and its various aspects; translocation of solutes in gymnosperms; Mechanisms of phloem loading via symplast and apoplast; phloem unloading and sink-to-source transition. Photosynthate distribution that includes allocation of sugars, and partitioning of sinks; transport of signalling molecules such as proteins and RNAs.

Unit IV: Physiological aspects of photosynthesis and respiration
Influence of leaf anatomy, leaf angle, and leaf movement on photosynthesis. Plant acclimatization of sun and shade environments; photosynthetic responses to light; photosynthetic responses to temperature; photosynthetic responses to carbon dioxide; studies on identification of various photosynthetic pathways; interlinking of photosynthesis and respiration. Respiration rates in various plant tissues and organs, role of various environmental factors that alter respiration rates; Electrochemical conductivity of photosynthetic pigments.

Unit V: Mineral nutrition
Essential nutrients, deficiencies, and plant disorders; treatment of nutritional deficiencies in plants; influence of soil texture, pH, microbes and development of root systems that assist in adsorption of mineral nutrients in plant roots. Mycorrhizal fungi and its mechanism of action on nutrient uptake in root cells

Unit VI: Stress physiology

Adaptations and phenotypic plasticity; Abiotic environment and its biological impact on plants- climate change, water deficit and flooding, imbalance of soil minerals (salt stress), extreme temperature stress, high light stress; developmental and physiological mechanisms that protect plants against environmental extremes; regulation and proteomics of stress tolerance. Seed dormancy- its mechanism, types and uses. Biochemistry of fruit ripening. Artificial seeds-preparation and uses.

Suggested readings

1. Plant Biochemistry by Hans-Walter Heldt, 4th Ed., Academic Press, Elsevier
2. Plant physiology and development, Lincoln Taiz, Eduardo Zeiger, Ian Max Møller, Angus Murphy, Sinauer Associates Inc.
3. Biochemistry, Donald Voet and Judith G. Voet. Wiley publications
4. Lehninger Principles of Biochemistry, David L. Nelson and Michael M. Cox. Macmillan Learning

Core Course Practical (CCP) Papers Content

Paper Code: BOTPGCCP01
Paper Title: Core Course Practical I

SECTION A Cell Biology

1. Isolation of mitochondria and their visualization with Janus green B
2. *In situ* visualization of microfilaments and microtubules by fluorescent labeling.
3. *In silico* analysis (sequence comparison) of mitochondrial and chloroplast genes for identification of the loci for interspecific discrimination.
4. Immunostaining of nuclei
5. Immunostaining of chloroplast.
6. Immunostaining of mitochondria.
7. Demonstration of
   a. cell culture media preparation
   b. visualization of cells in culture
   c. maintenance of cell culture

SECTION B Biochemistry

I. Basic and standardization Methods
1. Preparation of Acid & Alkali solutions and acid-base titration.
2. Concept of pH. Measuring pH of different solutions
3. Preparation of buffers: Acetate, Phosphate and Tris buffers.
4. pH meter titration of amino acids and separation of aliphatic, aromatic and polar amino acids by TLC

II. Estimation of macromolecules
1. Estimation of inorganic phosphate
2. Estimation of sugar (glucose)
3. Estimation of Amino acid (Tyrosine)
4. Estimation of Base (Guanine)

III. Estimation of macromolecules
1. Determination of Blue Value of Starch
2. Estimation of Proteins
3. Estimation of nucleic acids (DNA)

IV. Enzyme kinetics
1. An enzyme purification theme (such as E. coli alkaline phosphatase or any other enzyme.
   a) Preparation of cell-free lysates.
   (b) Ammonium sulfate precipitation.
   (c) Ion-exchange / Affinity / Gel filtration chromatography .
   (e) Assessing the purity of protein by PAGE.
   (f) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
   (g) Determination of Units and specific activity of an enzyme

Paper Code: BOTPGCCP02
Paper Title: Core Course Practical II

Section A: Systematics and Evolution

1. Seasonal collection of local flora, processing, Herbarium preparation.
2. Identification of plants by matching.
3. Working out of different angiospermic plants (fresh and dry), their identifications using literature and preparation of artificial keys.
4. Use of GPS and demonstration on the use of at least one remote-sensing software
5. Preparation of temporary and permanent pollen slides, description of common palynomorphs.
6. Preparation of identification keys.
7. Molecular phylogenetic analysis
8. Construction of a phylogram using the UPGMA analysis tool.
9. Field trip within and near-by areas; compilation of field notes and preparation of herbarium sheets of commonly available plants.

Section B: Ecology and Conservation

A. Habitat studies:

1. Physical and chemical characteristics of soil.
2. Physico-chemical properties of water.

B. Community/ecosystem studies:

1. Assessment of density, frequency and abundance of plants/ animals in a community using various techniques i.e., transect, quadrate etc.
2. Diversity index by Simpsons and Shannon
3. Decomposition of various organic matters and nutrient release mechanisms/role of arthropods and other micro- and macro-fauna in decomposition.
4. Understanding ecosystem succession by studying various stages of vegetation/community assemblages' development.
5. Application of molecular techniques in ecological study.
6. Insect diversity in soil.
7. Identification of aquatic organisms of different trophic levels and construction of food chain and food web.

C. Landscape studies:

1. Principles of GIS, GPS and RS technology.
2. Interpretation (visual and automated) of remote sensing information for landscape differentiation

D. Aquatic ecology studies:

1. Estimation of dissolved O2 of water.
2. Estimation of free CO2 in water.
3. Estimation of pH of water.
4. Quantitative counting of zooplankton

Section C: Bioinformatics and Biostatistics-

1. Sequence alignment using BLAST and Clustal W.
2. Phylogenetic analysis using PHYLIP.
3. Microarray analysis using Bioconductor.
4. Molecular format conversion and hands-on molecular visualization program for displaying, animating and analyzing large bio-molecular systems using 3-D graphics.
5. Homology Modeling using SPDBV, model structure refinement using SPDBV and model validation using What Check and Pro Check.
6. Comparing structures, mutations, studying interactions creating electrostatic potential diagrams.
7. Virtual screening and molecular docking using AUTODOCK.
8. Computer-based practicals using any statistical software like 'R'. MATLAB, SPSS, Spreadsheets, etc. to understand the following concepts:

a. Graphical data representation
b. Measures of central tendency and dispersion
c. Probability and probability distributions: binomial, Poisson and normal distribution

d. Correlation and linear regression analysis
e. Student's t- test, Chi-square test

Paper Code: BOTPGCCP03
Paper Title: Core Course Practical III

Section A: Plant metabolism

1. Determination of proteins during seed germination
2. Extraction, separation and determination of absorption spectra of plant pigments
3. Identification of Food Adulterants:
   a. Test for dilution of milk with water
   b. Test for starch in milk or milk products
   c. Test for Argemone oil in Mustard oil
   d. Test for common sugar in honey
   e. Test for khesari Dal in Besan of other Dal
   f. Test for coloured saw in turmeric powder
4. Estimation of Urease activity from Horse-gram
5. Determination of total Ascorbic acid from fruit juices by DNPH method
6. Estimation of Acid phosphatase activity from Potato
7. Estimation of proline content in plant sample
8. Estimation of starch content by Anthrone reagent

Section B: Plant Developmental Biology

1. Spectrophotometric estimation of Indole acetic acid in plant tissues
2. Determination of Gibberellic acid by half seed method
3. Microsporogenesis and development of male gametophyte (pollen) and pollinia.
4. Megasporogenesis and development of female gametophyte.
5. Observation on types of endosperms, dissection and isolation of endosperms.
6. Observation or stages of embryo development, dissection and isolation of developing embryos.
7. Effect of different concentration and combination of sucrose, boric acid on pollen germination and pollen tube growth.
8. Pollen-pistil interaction in angiosperms.
9. Seed germinability and viability test
10. Qualitative test for Unknown Secondary metabolites in plants (Alkaloids, terpenoids, flavonoids etc.)

Section C: Molecular plant pathology

1. Histopathological studies of fungal diseases of economically important crops.
2. Artificial inoculation of plants with pathogen(s) and disease assessment.
3. Comparison of soluble protein content between healthy and artificially inoculated plants.
4. Comparison of total and ortho dihydroxy phenol content between healthy and artificially inoculated plants.
5. Extraction and assay of Phenylalanine ammonia lyase (PAL) activity in plants following infection.
6. Extraction and assay of peroxidase activity in plants following infection
7. Isolation of fungal/plant DNA and its quantification by spectrophotometric method.

Discipline Specific Elective Course (DET and DEP) Papers

Paper Code: BOTPGDET01
Paper Title: Genetics

Course Objective	Course Outcome
1. Students will learn the basic principles of Mendelian inheritance. 2. Come to know the basics of genetics and classical genetics covering prokaryotic and higher eukaryotic domains 3. Learn the fine structure and molecular aspects of genetic material. 4. Understand the cause and effect of alterations in chromosome number and structure. 5. Understand how DNA encodes genetic information and the function of mRNA and tRNA 6. Students will be exposed to concepts of population genetics, quantitative genetics encompassing complex traits, clinical genetics and genetics of evolution. 7. Relate the conventional and molecular methods for gene manipulation in other biological systems.	On successful completion of this unit, students will be able to: 1. Understand and articulate the roles for inheritance/genetic mechanisms in human health & disease, and environment & society along with ethical issues associated with genetic knowledge; 2. Understand and describe key processes involved in the inheritance and expression of genes; 3. Analyse and interpret biological and evolutionary problems in terms of genetic/genomics concepts and be able to utilise modern genetic/genomic tools to conduct further investigation; 4. Clearly communicate genetic concepts so they are understood across a wide range of scientific disciplines; Apply the principles of Mendelian inheritance 5. Work effectively as independent researcher and in teams within a laboratory setting; and 6. Develop an awareness of genetic issues as they are viewed within society and across cultural boundaries.

Unit I: Basic concepts of inheritance
Overview of history of scientific progress leading up to modern-day genetics; concepts of inheritances, traits, genes, alleles, genotypes, phenotypes, dominance, recessive, monohybrid cross, dihybrid cross, testcross, backcross, standard genetic symbols; Mendel's laws of inheritances based on Mendel's experiments; Predicting outcome of genetic crosses by Punnett's square and Probability methods; Goodness-of fit Chi-Square test.

Unit II: Extensions and modifications of Mendel:
Chromosomal theory of inheritance; Incomplete dominance, codominance, penetrance and expressivity, lethal alleles, multiple alleles, pseudo alleles; Gene interactions with epistasis; Complementation tests; Sex-determination and sex-linked inheritance; Sex-influenced and sex-limited inheritance and expression of genes; Cytoplasmic inheritance; Genetic maternal effect; Genomic imprinting and epigenetics; Anticipation; Environmental effects on genotype expression; Pleiotropy.

Unit III: Gene mapping methods, Pedigree analysis and genetic testing
Pedigree analysis; Pedigree characteristics of autosomal recessive, autosomal dominant, X-linked recessive, X-linked dominant, and Y-linked traits; Concordance of twins; Genetic testing and karyotyping; Genetic diseases; Concept of linked genes and linkage group, recombinants and non-recombinants; Relation between crossing over and linkage; Recombination frequency; Concept of coupling and repulsion; Concept and construction of genetic maps, determination of gene orders; Interference and coefficient of coincidence; Lod scores; Physical gene mapping methods.

Unit IV: Microbial genetics

Brief introduction of microorganisms that are used as study models for genetics; Basic structures of bacterial and viral genomes; Gene transfers methods- conjugation, transformation and transduction; Gene mapping methods in bacteria; Benzer's mapping techniques.

Unit V: Gene mutations and alteration of chromosomes

Concept of gene mutation; Types of gene mutation, causal factors and detection techniques of gene mutation; Phenotypic effects of gene mutation; Concept of chromosomal mutation; Types of chromosomal mutations- rearrangements, aneuploids and polyploids; Transposition of genes.

Unit VI: Quantitative genetics

Concept of continuous and discontinuous inheritance; Types of quantitative characteristics; Polygenic inheritance; statistical methods in quantitative genetics; Concept of heritability- phenotypic variance, environmental variance and genetic variance; Types of heritability, calculation of heritability; Limitations of heritability; Quantitative Trait Loci (QTLs) mapping.

Suggested Readings:

1. Genetics: A Conceptual Approach, Benjamin A. Pierce. Macmillan learning, ISBN:9781319297145
2. Gene IX by Benjamin Lewin, Jones and Bartlett Publishers, Sudbury, Massachusetts, 2007.
3. Principles of Genetics, 6th edition (2011), Snustad DP and Simmons MJ, John Wiley and Sons, Inc; ISBN-13: 978-0470903599.
4. Concepts of Genetics, 10th edition, (2011). William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino; Pearson Education, ISBN-13: 978-0321724120.

Paper Code: BOTPGDET02
Paper Title: Genetic Engineering and Plant Biotechnology

Course Objective	Course Outcome
1. To add one or more desired traits that are not already found in that organism 2. To make as many identical copies of a beneficial gene possible and to make the genes express and form polypeptide products. 3. To change the genetic makeup of cells, including the transfer of genes within and across species boundaries to produce improved or novel organisms. 4. To alter the genetic structure of an organism by either removing or introducing DNA. 5. To fix severe genetic disorders in different organisms by replacing the defective gene with a functioning one. 6. To develop nutritionally enhanced foods, enabling sustainable agricultural production, and engineering plants for industrial and medical purposes. 7. To develop new varieties and traits include genetics and genomics, marker-assisted selection (MAS), and transgenic (genetically engineered) crops. 8. To improve plants for various reasons such as increasing yield and quality, heat and drought resistance, resistance to phytopathogens, herbicide and insect resistance, increasing biomass for biofuel production, and enhancing the nutritional quality of the crops.	The student will be able to: 1. Understand and recognize the biochemical, molecular and cellular structure of organisms and biological systems. 2. Understand the concepts, regulations and applications of the existing and emerging methods of biotechnology. 3. Understand the fundamental concepts of molecular biology like DNA chemistry, DNA replication and recombinant DNA techniques. 4. Understand the principle of different techniques and their applications. 5. Understand the basic Mendelian and non-Mendelian rules of heredity. 6. Define basic concepts in microbial biotechnology and ecology for biodegradation and bioremediation of pollutants, fermentation kinetics, primary / secondary metabolite excretion and ingredients for the food industry. 7. Extract data from specific databases using accession numbers, gene names, run simple analyses on genomic sequences, and identify features on the sequence such as coding regions, restriction enzyme sites, prediction of protein structure.

Unit I: Basics of DNA cloning

Tools of DNA cloning: Different enzymes and vectors used in genetic engineering. Simple cloning and cloning using linkers and adaptors. Selection and screening of clones.

Unit II: Polymerase Chain Reaction

Concept of PCR and various thermophilic enzymes used in PCR. Gradient PCR versus Touchdown PCR. Designing primers. DNA fingerprinting

Unit III: Construction of cDNA and genomic DNA libraries

Vectors used in the construction of cDNA versus genomic DNA libraries. Steps and enzymes involved in the construction of cDNA versus genomic DNA libraries. Screening libraries by colony hybridization and colony PCR. Screening expression libraries. Enrichment of clones in cDNA libraries by positive selection and subtractive hybridization.

Unit IV: Genome sequencing

DNA sequencing by Sanger's method – traditional and cycle sequencing. Next gen sequencing technologies. Mechanism of Pyrosequencing.

Unit V: Components of plant genetic engineering

Methods for analysis of differential gene expression in plants Enhancer trap, Promoter tagging, gene tapping gene tagging, Insertional mutagenesis, Activation tagging Tissue specific promoters, characterization of plant promoters Agrobacterium and Ti Plasmid based and physical DNA delivery methods.

Unit VI: Applications of plant genetic engineering

Analysis of transgenic plants. Approaches to marker-free transgenics developing herbicide resistance in crops: Target of herbicide action and Detoxification of herbicides. Engineering male sterility in crop plants. Genetic engineering of plants for Insect resistance: Bt toxins and use of protease inhibitors. Transgenic plants for disease resistance. Engineering plants for abiotic stress tolerance. Biopolymer Production through transgenic plants. Fatty acid modification and oleosin technology

Unit VII: Functional genomics

Validation of gene function Gene silencing, PTGS, RNai, Antisense technology, Applications. Chloroplast transformation, Molecular Pharming Biosafety, Bioethics and plant biotechnology Genome Editing tools-ZFNs and TALENs.

Suggested Readings

1. Molecular Biology by David P. Clarke, 1st edition; Elsevier Academic Press; 2005.
2. Molecular Cloning: A laboratory manual by Joseph Sambrook& David Russell, 3rd edition; CSHL press; 2001.
3. DNA Technology: The Awesome Skill by I. Edward Alcamo, 2nd edition; Harcourt Academic Press
4. Molecular Biology of the Gene by James Watson, Tania Baker, Stephen Bell, Alexander Gann, Michael Levine & Richard Losick , 6th Edition; CSHL Press; 2007.

Paper Code: BOTPGDET03
Paper Title: Quantitative Genetics

Course Objective	Course Outcome
1. To understand the concept of genetic variation. 2. To understand polygenic traits and its mathematical derivation. 3. Impact of genetics in evolution 4. To understand impact of heritability on various population types 5. To understand the concept of the outcome of linkage groups in the gene pool.	On successful completion of the course paper, the students would be able to 1. Correlate genetic outcomes of population types 2. differentiate between environmental factors and heritable factors 3. derive gene pool of any given population type 4. Identify various heritable diseases that a given population could be at risk.

Unit 1: Genetic Variations
Variation at the genetic level: DNA markers -VNTR, STR, microsatellite, SNP and their detection techniques - RFLP, genotyping, RAPD, AFLP etc.

Unit 2: Population Genetics
Organization and measure of genetic variation: Random mating population, Hardy-Weinberg principle, complications of dominance, special cases of random mating – multiple alleles, different frequencies between sexes (autosomal and X-linked).

Unit 3: Linkage Studies
Linkage and linkage disequilibrium

Unit 4: Gene Frequency
Sources responsible for changes in gene frequencies: Mutation, selection, migration and isolation; random genetic drift; insights into human migration, natural selection and evolution. Population substructure: Hierarchical population, Isolate breaking, Inbreeding, Assortative mating.

Unit 5: Quantitative traits
Quantitative Genetics: Johannsen's pure-line theory, multiple factor hypothesis, types of quantitative traits, components of phenotypic variation and genetic models for quantitative traits, concept of heritability, artificial selection and realized heritability.

Suggested readings

1. Genetics: A Conceptual Approach, Benjamin A. Pierce. Macmillan learning, ISBN:9781319297145
2. Gene IX by Benjamin Lewin, Jones and Bartlett Publishers, Sudbury, Massachusetts, 2007.
3. Principles of Genetics, 6th edition (2011), Snustad DP and Simmons MJ, John Wiley and Sons, Inc; ISBN-13: 978-0470903599.
4. Concepts of Genetics, 10th edition, (2011). William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino; Pearson Education, ISBN-13: 978-0321724120.

Paper Code: BOTPGDEP01
Paper Title: Discipline Elective Practical I

SECTION A: Molecular Biology

1. Isolation of plasmid DNA.
2. Isolation of genomic DNA.
3. Estimation of purity & concentration of DNA.
4. Amplification of DNA by PCR
5. Preparation of competent cells and determination of transformation efficiency
6. Restriction digestion analysis by agarose gel electrophoresis.
7. Ligation of DNA fragments.
8. Cloning of a DNA fragment
9. Alpha-complementation / Blue-white screening
10. Isolation of total protein and estimation by Bradford method.
11. Overexpression of proteins and analysis by SDS-PAGE
12. Purification of recombinant protein
13. Western Blotting analysis

SECTION B: Genetics

1. Observation of wild type and mutant phenotypes in eukaryotic organisms.
2. Preparation of culture media for *Drosophila* and study different stages of the life cycle of *any one eukaryotic organism.*
3. Verification of Mendelian laws through *Drosophila* / seeds – dominant, recessive and sex-linked.
4. Preparation of Barr body.
5. Karyotyping with the help of photographs (normal and abnormal karyotypes).
6. Pedigree charts of some common characters like blood group, color blindness and PTC tasting.
7. Study of polyploidy in onion root tip by colchicine treatment.

Paper Code: BOTPGDEP02
Paper Title: Discipline Elective Practical II

Section A: Plant Physiology

1. Isolation of chloroplasts and Estimation of chlorophylls from given plant sample
2. Determination of peroxidase activity in plant tissue
3. Determination catalase activity in plant tissue
4. Determination of protein under abiotic stress
5. Determination of pyridoxine of fruits / leaves
6. Effect of water stress on root metabolic activity
7. Determination of water potential of plant samples by Chardakov's method
8. Quantitative estimation of accumulated chloride ion in cell sap
9. Study of photolysis of water by demonstration of Hill reaction
10. Quantitative estimation of dissolved oxygen due to photosynthesis by Winkler's method
11. Effect of sodium azide on water uptake by plants.

Section B: Genetic engineering and Plant Biotechnology

1. DNA digestion by Restriction endonuclease
2. Isolation of plasmid DNA and restriction mapping
3. Preparation of culture media, autoclaving and sterilization
4. Culture of *E. coli* cells & plasmid isolation
5. Preparation of competent cells
6. Calcium chloride mediated transformation
7. Ligation of DNA
8. Restriction fragment length polymorphism
9. Random amplified polymorphic DNA
10. Estimation of DNA by Diphenylamine method
11. Isolation RNA from yeast cells.
12. Estimation of RNA BY Orcinol method.
13. Estimation of DNA and purity determination by UV absorption method.
14. Determination of melting temperature (Tm) of ds-DNA

Paper Code: BOTPGDEP03
Paper Title: Discipline Elective Practical III

1. Discussing Weedon et al. (2008) experiment on adult height.
2. Allelic frequency: concept and numerical.
3. Genotypic frequency: concept and numerical
4. Genetic drift: concept and numerical
5. Linkage: concept and numericals
6. Study of autoradiographs
7. Demonstration of Agarose gel electrophoresis
8. Effect of denaturation (heat/urea/guanidine chloride/BME) on UV absorption spectra of DNA.
9. Study of structural changes of nucleic acids at different pH/solvent/temperature using UV spectrophotometry.
10. Separation of nucleotides/amino acids using TLC.

Generic Elective Course (GEC) Papers

(To be opted by the students of other disciplines)

Paper Code: BOTPGGEC01
Paper Title: Developmental Biology

Course Objective	Course Outcome
1. The objective of this course is to provide a comprehensive understanding of the concepts of early development. 2. They will be able to develop a critical appreciation of methodologies specifically used to study the process of embryonic development in plants and animals. 3. They will learn about gametogenesis, fertilization, morphogenesis and organogenesis. 4. They will be familiarized with the genetics behind the development of embryos.	1. Students will be able to describe the concepts of early development. 2. They can recall the methodologies used to study the process of embryonic development in plants and animals. 3. They can elaborate the vital processes of life like gametogenesis, fertilization and morphogenesis. 4. They can describe the genetics behind the development of embryo

Unit I: Basic concepts of developmental biology
Production of gametes; Structure of the gametes- the sperm, the egg; Cell surface molecules in sperm-egg recognition in animals; fertilization; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis. Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

Unit II: Developmental genetics in animals
Genes for development in Drosophila: maternal effect genes and zygotic genes, coordinate genes, gap genes, pair-rule genes, segment polarity genes, homeotic genes, HOX genes; Genetic basis of ocular and neural development in Drosophila; programming and reprogramming in development; morphogen gradients and gene regulatory mechanisms. Epimorphic regeneration of reptile (salamander) limb; Morphallaxis regeneration in hydra; embryonic stem cells and their applications.

Unit III: Developmental genetics in plants
Approaches to study genes involved in plant development in Arabidopsis and maize; genetic control of phase changes in plant development; juvenile to adult plant; transition to flowering - vegetative to reproductive evocation, floral homeotic mutations in *Arabidopsis*, *Antirrhinum* and *Petunia*, gender expression in monoecious and dioecious plants; pollination and fertilization; gametophytic and sporophytic incompatibility.

Suggested Readings

1. Developmental Biology: Scott F Gilbert [Latest edition].
2. Essentials of Developmental Biology: JMW Slack [Latest edition]
3. Principles of Development: Louis Wolpert [Latest edition].
4. S.F. Gilbert, Developmental Biology, Sinauer Associates Inc. Massachusetts
6. B.I. Balinsky, An introduction to Embryology, Saunders College Publishing
7. Lewis Wolpert, Principles of Development, Current Biology Ltd., London, New York.

Paper Code: BOTPGGEC02
Paper Title: Techniques and Ethics in Biology

Course Objective	Course Outcome
1. To educate students about the properties and preparation of buffers, and various basic analytical techniques like dialysis, filtration, spectroscopy, fluorescence techniques, chromatographic techniques, centrifugation techniques and their applications in industrial and research fields. 2. The course is also meant to familiarize the students with radioactivity and the applications of radioisotopes in research. 3. Also, to familiarize students to some more advanced techniques used in biological research.	1. Students should be able to gather knowledge about the preparation? types, and uses of buffers used in biochemical studies. 2. They will be able to learn about the significance and applications of various techniques used in biotechnology-based industries and research labs. 3. Students should be able to know the principle, working and instrumentation of various chromatographic techniques in detail. 4. They will also be able to understand the details of principle, working and instrumentation of various electrophoretic techniques. 5. Students should be able to understand the theory and principle of centrifugation. They will be able to differentiate between different types of centrifuges. Also, they will be able to enumerate various applications of centrifugation techniques in research. 6. Students should be able to understand the different types of radiation emitted by radioisotopes and their measurement. They will know the applications of radioisotopes in biological research, medicine and diagnosis. Also, they will understand the research significance and measurement of less abundant non-radioactive isotopes. 7. Students should be able to understand the principle, methods and applications of protein crystallization. They will learn the theory, types, instrumentation and applications of various spectrometry.

Unit I: Separation Techniques
Different methods of protein precipitation: Precipitation using inorganic salts (salting out) and organic solvents, isoelectric precipitation, Dialysis, Ultrafiltration, Lyophilization.

Unit II: Centrifugation
Basic principles; Mathematics & theory (RCF; Sedimentation coefficient etc); Types of centrifuges - Microcentrifuge; High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

Unit III: Chromatography
Basic principles; Adsorption and partition chromatography; Partition coefficient; Performance parameters; Modes of chromatography; Different types of chromatography: Paper Chromatography, Thin Layer Chromatography; Gel filtration Chromatography, Ion Exchange Chromatography, Affinity Chromatography, Gas Liquid Chromatography; LPLC and HPLC; IMAC; Preparative and analytical applications.

Unit IV: Electrophoresis
Basic Principle; Paper electrophoresis; Gel electrophoresis; discontinuous gel electrophoresis; PAGE: SDS-PAGE, Native gels, denaturing gels, Isoelectric Focusing of proteins, 2D gel; Agarose gel electrophoresis; PFGE; Buffer systems in electrophoresis; Detection and identification (staining procedures); Molecular weight determination; Protein and nucleic acid blotting.

Unit V: Spectroscopy and Crystallography
Molecular spectroscopy; UV-Visible, Raman, IR spectroscopy; Fluorescence spectroscopy; FRET; Bimolecular

fluorescence complementation assay; Theory and application of Circular Dichroism; Mass spectrometry; NMR; PMR; ESR and Plasma Emission spectroscopy. Theory and application of X-Ray Crystallography.

Unit VI: Microscopy
Principles and applications of Microscopy; Fluorescence; Phase contrast; Confocal; Scanning and Transmission and Cryo- Electron microscopy.

Unit VII: Analysis of protein-DNA and protein-protein interactions
Gel retardation assay; DNA foot-printing by DNase I and chemical methods; Yeast one-hybrid assay, ChIP-chips. Yeast two hybrids, three-hybrids, split hybrids and reverse hybrids. Co-immunoprecipitations; GFP and FRET; Phage display.

Unit VIII: Radioisotopes
Radioisotopes and their use in biology and diagnostics; autoradiography; radioactive labeling of biological macromolecules.

Unit IX: Bioethics
Philosophy and Theories of Bioethics; Clinical ethics; Research Ethics.

Suggested Readings

1. Physical Biochemistry: Principles and Applications, 2nd edition (2009), David Sheehan, JohnWiley
2. Cell and Molecular Biology: Concepts and Experiments, 6th edition (2009), Gerald Karp, Wiley
3. Gene cloning and DNA analysis, 6th edition (2010), T.A. Brown. Wiley-Blackwell
4. Principles of Gene Manipulation and Genomics, 7th edition (2006), S.B. Primrose and R.M. Twyman. Blackwell Scientific
5. Human Molecular Genetics, 3rd edition (2003), Tom Strachan and Andrew Read; Garland Science Publishers
6. Immunology, 6th edition, (2006), J. Kuby, W.H. Freeman and Company, New York

Paper Code: BOTPGGEC03
Paper Title: Bioentrepreneurship

Course Objective	Course Outcome
The overall aim of the course is to give the students an insight into the field of bioentrepreneurship, i.e. business within the life sciences.	At the end of the course the student will be able to: 1. Explain the importance of embarking on self-employment 2. Understand company Law and commercial knowhow for biotechnological ventures 3. Identify issues in protection of biotechnology inventions 4. Adapt biosafety and bioethics principles 5. Demonstrate a general understanding of the central role that business development plays for the biomedical industry 6. Write, and critically review a business plan 7. Perform a basic market analysis in the life science sector 8. Analyse and critically assess a case study

Unit I: Introduction to Biotechnology
Biotechnology: definition, history, thrust areas; Elements of Bio-Process Engineering; Biotech Industries; Basic concepts of GLP, GMP and FDA; Scope and Importance of Biotechnology and allied fields. Role of Biotechnology in economic development of society.

Unit II: Entrepreneur and Entrepreneurship
Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

Unit III: Introduction to Bio-entrepreneurship
Definition of Bioentrepreneurship, traits of an entrepreneur; Copyright, Patents, trademark, plant breeders and farmers' rights, biodiversity related issues; Biopiracy, International and Indian business policies with the focus on Bio and Pharmaceutical products. - BIRAC

Unit IV: Planning a Small-Scale Enterprises
Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site. Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership.

Unit V: Case study of any three of the following enterprises (start-up, various stages in establishment, etc.,):
1) Biotechnology Company
2) Pharma company
3) Apiculture company
4) Aquaculture company
5) Mushroom farming company
6) Horticulture company

Reading:

1. G.G. Meredith, R.E.Nelson and P.A. Neek, The Practice of Entrepreneurship, ILO, 1982.
2. Dr. Vasant Desai, Management of Small Scale Enterprises, Himalaya Publishing House, 2004.
3. Patzelt, Holger, Brenner, Thomas (Eds.). Handbook of Bioentrepreneurship. Springer, 2008.
4. A Handbook for New Entrepreneurs, Entrepreneurship Development Institute of India, Ahmedabad, 1988.
5. Bruce R Barringer and R Duane Ireland, Entrepreneurship: Successfully Launching New Ventures, 3rd ed., Pearson Edu., 2013.
6. Lee, James W., 2013. Advanced Biofuels and Bioproducts. Springer New York.
7. C. T. Hou, Jei-Fu Shaw, 2008. Biocatalysis and Bioenergy Wiley.

Course code: BOTPGGEC04
Course name: Phytochemistry

Course Objective	Course Outcome
1. Classification of phytochemicals 2. Extraction and isolation techniques of phytochemicals from various plant sources. 3. Quantification methods for determination of phytochemicals from plant sources 4. Cataloguing of plants based on their phytochemical components 5. To identify potential applications of various phytochemicals.	The students would be able to 1. distinguish between phytochemicals and primary metabolites 2. identify and categorize phytochemicals based on their structures. 3. Perform various qualitative and quantitative analytical techniques of phytochemical analysis 4. apply the knowledge of phytochemical properties in a wide range of domains including agriculture, medical and biomedical fields.

Unit I: Concept of secondary metabolism and phytochemicals. Classification of secondary metabolites based on the molecular structures.

Unit II: Introduction of alkaloids, classification, physical, chemical and general methods for isolation of alkaloids.

Unit III: Introduction to polyphenols, classification, physical, chemical and general methods for isolation of polyphenols.

Unit IV: Psychoactive plants: stimulants (cocaine, caffeine), Hallucinogens (Marijauana, LSD), depressants (opium), tobacco, ergot, Khat, nutmeg, *Daturastramonium*.

Unit V: Anticancer plants- *Peganumharmala* (harmine, harmaline), *Catharanthus roseus*, *Colchicum autumnale, Taxus brevifolia.*

Unit VI: Anti-diabetic plants: *Curcuma longa, Phylanthusamarus, Withaniasomnifera,* bitter gourd.

Unit VII: Definition of functional food and nutraceuticals. Classification of nutraceuticals. Source, name of marker compounds and their chemical nature, medicinal uses and health benefits of following used as Nutraceuticals/Functional foods- i) Spirulina ii) Soya bean iii) Ginseng iv) Garlic v) Broccoli vi) Ginkgo vii) Flax seeds viii) Black cohosh ix) Turmeric x) Tea.

Suggested Readings

1. Phytochemistry of medicinal plants. John T. Arnason, Rachel Mata, John T. Romeo. Springer, Boston, MA. ISBN: 978-0-306-45181-2.
2. Phytochemical Techniques. N. Raaman. New India Publishing Agency. ISBN: 978-8189422301
3. Textbook of Phytochemistry. Iqbal Syed Aftab, Noor Ahmed Khan. Discovery Publishing Pvt.Ltd. ISBN: 9788183568470.