CHRIST UNIVERSITY
BENGALURU, INDIA
Declared as Deemed to be University under Section 3 of UGC Act 1956

Department of Life Sciences

Syllabus

Master of Science (BOTANY)

2017-18

Christ University, Bengaluru

Karnataka, India

www.christuniversity.in

PROGRAMME STRUCTURE

SEM	Course Code	TITLE	No. of Hrs/wk	Marks	Credit
I	MLIF 131	Microbiology	4	100	4
	MLIF132	Biochemistry	4	100	4
	MBOT133	Phycology, Mycology and Crop Pathology	4	100	4
	MLIF 134	Genetics	4	100	4
	MLIF151	Practical I- Microbiology and Biochemistry	8	100	4
	MBOT152	Practical II- Phycology, Mycology, Crop Pathology and Genetics	8	100	4
	MLIF135	Mathematics for Biologists	2	50	2
II	MBOT 231	Cell and Molecular Biology	4	100	4
	MLIF 232	Genetic Engineering	4	100	4
	MLIF 233	Bioanalytical Tools and Bioinformatics	4	100	4
	MLIF 234	Research Methodology and Biostatistics	4	100	4
	MLIF 251	Practical III- Molecular Biology and Genetic Engineering	8	100	4
	MLIF 252	Practical IV – Bioanalytical Tools, Bioinformatics, Research Methodology and Biostatistics	8	100	4
	MLIF235	Ethics in Science and Medicinal Botany	2	50	2
	MLIF 253	Summer Internship		50	2
III	MBOT 331	Archegoniatae	4	100	4
	MBOT 332	Environmental Science	4	100	4

	MBOT 333	Principles of Angiosperm Systematics and Taxonomy	4	100	4
	MBOT 334	Plant Anatomy, Developmental Biology and Plant Breeding	4	100	4
	MBOT 351	Practical V- Archegoniatae, Plant Anatomy and Environmental Science	8	100	4
	MBOT 352	Practical VI – Principles of Angiosperm Systematics, Taxonomy, Developmental Biology and Plant Breeding	8	100	4
IV	MBOT 431	Plant Physiology	4	100	4
	MBOT 432	Plant Biotechnology	4	100	4
	MBOT 433 Elective	MBOT 433 A- Floristics and New Trends in Taxonomy MBOT433 B- Food, Agricultural and Environmental Microbiology MBOT433 C – Pharmaceutical Botany	4	100	4
	MBOT 451 Elective	MBOT451A- Practical VII- Plant Physiology, Plant Biotechnology, Floristics and New Trends in Taxonomy MBOT451B- Practical VII- Plant Physiology, Plant Biotechnology, Food, Agricultural and Environmental Microbiology MBOT451C- Practical VII- Plant Physiology, Plant Biotechnology, Pharmaceutical Botany	8	100	4
	MBOT 452	Dissertation		150	4

Semester I

MLIF**131: MICROBIOLOGY**

Core Course

Credits: 4 **Total Hours: 60**

Course objective

Microbes play a very significant role in the lives of higher organisms. The paper surveys the features of microbes like bacteria, viruses, fungi, algae and protozoa in order to make the students understand their biology so as to manipulate them. This course fulfils the basic knowledge in microbiology for those students who wish to pursue career in allied health fields and other technical programs.

Learning outcome

This course will make the students adept in the structure and functions of these microbes which in turn will give them confidence to work using these organisms. The students will become competent for jobs in dairy, pharmaceutical, industrial and clinical research.

Unit I Introductory Microbiology **10 hours**

History of Microbiology, Microscopy – Light, Phase contrast, Fluorescence & Electron microscopy – TEM and SEM, Physical and Chemical control of microorganisms, Classification and nomenclature of microorganisms, Bergey's manual, Staining techniques - Gram's, acid fast, capsular, flagellar and endospore staining. Microbial Taxonomy: Pure culture techniques (Streaking, spread plate, pour plate, serial dilution), Identification of microorganisms – Morphological, Biochemical, serological and molecular techniques.

Unit II Prokaryotic cell structure **5 hours**

Bacterial cell structure, classification based on shape and arrangement of cells, Cellwall, flagella, pili and capsule – structure & functions, endospore formation, Features of mycoplasma, Rickettsia, Prions and diseases caused. Biofilms and its significance.

Unit III Physiology of Microorganisms **9 hours**

Growth curve, factors affecting growth, Quorum sensing and its significance, Nutritional classification, Microbial associations (Parasitism, Saprophytism, Mutualism and Symbiosis, Commensalism, endozoic microbes). Antibiotic – types and mechanism of action, Stress physiology: effect of oxygen toxicity, pH, osmotic pressure, heat shock on bacteria, HSPs, Adaptations, uses and examples of thermophiles, halophiles, alkaliphiles,acidophiles, psychrophiles and cryophiles, their uses – adaptations & significance in biotechnology. Nitrogen fixation mechanisms and genes involved.

Unit IV Virology 8 hours

Viruses – Structure and classification based on shape and nucleic acid, Plant viruses – symptoms, transmission and control strategies of TMV, CaMV, Animal viruses - DNA viruses: Hepatitis B virus. RNA viruses:HIV, bacteriophages-. Lifecycle of Lambda phage. Evolution and mutation of viruses.Cultivation and assay of viruses: Cultivation of viruses in embryonated eggs, experimental animals and cell cultures

Unit V Mycology and Phycology 7 hours

Fungi:- Structural features, Ainsworth's system of classification, salient features of division–Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina, parasitism, predation, mutualism and symbiosis with plants and animals,reproduction of fungi, fungi as food, as plant pathogens, control measures of fungi, Mycorrhizae- ecto and endomycorrhizae, significance, Algae:- Salient features, classification (Fritsch's) and reproduction,measurement of algal growth, strain selection and large scale cultivation, Symbiotic algae, use as biofuel.

Unit VI Pathogenic Microorganisms 10 hours

Major Bacterial diseases – Typhoid, Tetanus, Tuberculosis, Pneumonia and Cholera, Viral diseases - Dengue, Chikungunya, Rabies. Emerging viruses – H1N1, Ebola, Zika. Major parasitic diseases –Malaria, Amoebiasis, Giardiasis- pathogen, lifecycle and treatment measures. Etiology, symptoms and control measures of some plant diseases - Bacterial blight of rice, Late blight of potato, Coconut Root wilt, Ginger Soft Rot, Downy Mildew of Grapes, Rust of Wheat, Red Rot of Sugarcane.

Unit VII Medical Microbiology 6 hours

Concepts of pathogenesis, virulence and epidemiology, Disease classification - Epidemic, endemic and pandemics, CDC and its role, normal human microflora, gut microbiota and its relevance. Diagnosis and control of infections, biomedical waste management,

nosocomial infections, Drug resistance in bacteria – causes and consequences, super bugs.

Unit VIII Applied Microbiology 6 hours

Microbes in food manufacture (Yeast, Lactobacillus etc), food spoilage (Brucella, Bacillus, Clostridium, Escherichia etc, mycotoxins - aflatoxins, ochratoxins, ergot alkaloids), agriculture (Rhizobium, Trichoderma etc), environmental management, Biodegradation of Xenobiotics - hydrocarbons, pesticides and plastics, Bioleaching of Copper, Iron , Uranium, Gold.

MLIF132: BIOCHEMISTRY

Core Course

Credits: 4 Total Hours: 60

Unit-1 Foundation of Biochemistry and Bioenergetics 8 Hours

Forces and interactions of biomolecules; chemical bonds – Covalent and Ionic bond (bond energy), Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction.), high energy molecules in living system (ATP, ADP, NAD, NADH, NADPH, FAD, $FADH_2$), Laws of thermodynamics, Concept of free energy, enthalpy, entropy, Coupled reactions, group transfer, biological energy transducers, redox potential.Buffers and Solutions: Concept of pH, pKa, titration curve, acids, bases and buffers, Henderson-Hasselbalch Equation, biological buffer solutions.Principles of thermodynamics; Kinetics, dissociation and association constants; energy rich bonds and weak interactions; Bioenergetics.

Unit-2 Carbohydrates 10 Hours

Classification, structure and Properties of mono, oligo and polysaccharides. Chirality and optical activity, stereoisomerism, cyclic structure of monosaccharide, (pyranoses and furanoses) , structures of glucose. Absolute and relative configuration (D & L and R & S nomenclature). Disaccharides-structures of Maltose, Lactose, Sucrose, Trehalose, Raffinose. Polysaccharides. Structure and properties of homo and hetero polysaccharides. Storage polysaccharides. (Starch, Glycogen, cellulose, hemicellulose, and chitin) Derived sugars- Sugar acids (Aldonic, Aldaric and Saccharic acids), amino sugars. Derivatives of carbohydrates (Glycosaminoglycans, glycolipids, Proteoglycan and glycoproteins).

Carbohydrate metabolism: Glycogenolysis, Glycogenesis, Glycolysis- Energetics and Regulation, Fermentation reactions (Lactic acid and alcoholic fermentation), Gluconeogenesis, Reciprocal regulation of Glycolysis and Gluconeogenesis, Citric acid cycle- Energetics and regulation, Glyoxylate cycle. Pentose phosphate pathway.

Unit-3 Amino acids and Proteins 10 Hours

Amino acids: Structure, properties, classification and functions, reactions of amino acids, modifications of amino acids in proteins, non-protein amino acids,.

Proteins- peptide bond, psi and phi angle, Ramachandran's plot,Structural organizations of proteins (primary, secondary, tertiary and quarternary, Domains, Motifs & Folds), conformational analysis. Structure and functional classification of proteins. Structure- function relationship. Thermodynamics of protein folding, chaperones and chaperonins, Stability of Protein Structures, examples of specific proteins; Keratin, Silk fibroin, collagen triple helix and hemoglobin; Denaturation and renaturation of proteins; neurotransmitters, Peptide hormones .

Amino acid and Protein metabolism: Transamination, Deamination, Decarboxylation, basic glutamine and glutamic acid pathways, urea cycle and its regulation, formation of uric acid.

Unit-4Enzyme kinetics 11 Hours

Enzyme nomenclature and classification, Isolation of enzymes. Extraction of soluble and membrane bound enzymes: Purification of enzymes-Criteria for purification; Assay of enzymes. Factors affecting enzyme activity, Isozymes, Coenzymes and cofactor, Metalloenzymes, membrane bound enzymes, Multienzyme complexes, Synthetic enzymes, Ribozymes. Mechanism of enzyme action, Active site and Specificity of enzyme. Theories on enzyme substrate complex. Free energy of enzyme reactions. Steady state kinetics. Michaelis-Menton, Lineweaver–Burk, Edde-Hofstee and Hanes-Woolf equations. Pre-steady state kinetics. Fast kinetics to elucidate the intermediates and rate limiting steps.

Enzyme inhibition: types of inhibitors; Mechanism of enzyme inhibition –competitive, non – competitive, uncompetitive, mixed and irreversible inhibition. Allosteric regulation in metabolic pathways. Applications of enzymes, enzyme engineering (Protein engineering). Immobilization of enzymes and their application.

Unit-5 Lipids 7 Hours

Classification- Structure, properties, reactions and biological functions of lipids. Phospholipids, Sphingo and glyco lipids, Steroids-cholesterol-bile salts, steroid hormones,Cerebrosides, lipoamino acids, lipoproteins, lipopolysaccharides, eicosanoids (Prostaglandins, leucotrienes and thromboxane).Role of lipids in biomembranes

Metabolism of Lipids: Biosynthesis of saturated and unsaturated fatty acids and cholesterol. Beta oxidation of Fatty acids: activation, transport to mitochondria, metabolic pathway. Oxidation of saturated and unsaturated fatty acids. Alpha and omega oxidation, metabolic disorders (Triglyceridemia, NaymanSacchs Disease).

Unit-6Nucleic acids 3 Hours

Structure and properties- Bases, Nucleosides, Nucleotides, Polynucleotides.

Nucleic acid metabolism: Biosynthesis and regulation of purines and pyrimidines, Denovo and Salvage pathways, biodegradation of purines and pyrimidines.

Unit-7 Vitamins and Hormones 8 Hours

Vitamins: Classification, Chemistry and Biological Functions, Fat and water soluble vitamins. Role in metabolism, Vitamins as co-enzymes. Metabolic Disorders –A, B, C, D, K.

Hormones: Autocrine, paracrine and endocrine action**.** Endocrine glands, Classification of hormones, basic mechanism of hormone action, importance of TSH,T3,T4, Estrogen, Testosterone, HCG, FSH, LH, Prolactin, Progesteron, adrenaline, insulin and glucagon. Hormone imbalance and disorders: hypothyroidism, hyperthyroidism, Polycystic Ovarian Disorder PCOD), Insulin Dependent Diabetes.

Plant Growth regulators: Biosynthesis, Physiological role and mechanism of action of plant growth hormones (Auxins, Gibberellins, Cytokinins, Ethylene, abscisic acid, Brassinosteroids), receptors and signal transduction (salicylic acid and jasmonic acid pathways).

Unit-8Oxidative phosphorylation 3 Hours

Electron transport chain, Electron transfer reactions in mitochondria, Electron carriers, Ubiquinone, Cytochromes, Iron sulfur centers, Methods to determine sequence of electron carriers, Fractionation of Multi enzyme complexes I, II, III, IV of Mitochondria and their inhibitors, Oxidative phosphorylation, ATP synthesis, Chemiosmotic model, Proton gradient, Structure of ATP synthetase, Mechanism of ATP synthesis, Brown fat, Regulation of Oxidative phosphorylation.

References:

1. Nelson, D. C. and Cox, M.M., Lehninger Principles of Biochemistry, 5th Edition, W. H. Freeman, 2010.
2. Elliott, W.H., Elliott, D.C. Biochemistry and Molecular Biology 3rd Indian edition, Pub. Oxford.
3. Mathews, Van Holde and Ahern, Biochemistry by 3rd edition, Pub Pearson education
4. Berg J.M., Tymoczko J.L. and Stryer L., Biochemistry. 7th edition, W.H. Freeman and Co. New York, 2011.
5. Kuchel, P.W., Ralston Schaums, G.B. Outlines of Biochemistry 2nd edition Pub: Tata.
6. Voet D., Voet J.G, Biochemistry 4th Edition., John Wiley and Sons, 2011.
7. Devlin, T.M. (1997). Biochemistry with clinical correlations, Wiley-Liss Inc. NY
8. Zubey, G.L. Parson, W.W., Vance, D.E. (1994). Principles of Biochemistry WmC Brown publishers. Oxford.
9. Edwards and Hassall. Biochemistry and Physiology of the cell 2ndEdn. McGraw Hill Co. UK. Ltd.

Semester I

MBOT 133: PHYCOLOGY, MYCOLOGY AND CROP PATHOLOGY

Credits: 4, Lectures: 60

Core Course

THEORY

Phycology (20 hrs)

Unit I: Introduction (2 hours)

(a) History of algal classification. Detailed study of the classification by F. E. Fritsch and G. M. Smith. Modern trends and criteria for algal classification.

(b) Centers of algal research in India. Contributions of Indian phycologists – M O P Iyengar, V Krishnamurthy, T V Desikachary.

Unit II: General features of Algae (12 hours)

(a) Details of habit, habitat and distribution of Algae.

(b) Algal components: Cell wall, flagella, eye-spot, pigments, pyrenoid, photosynthetic products.

(c) Range of thallus structure and their evolution.

(d) Reproduction in algae: Different methods of reproduction, evolution of sex organs.

(e) Major patterns of life cycle and post fertilization stages in Chlorophyta, Xanthophyta, Phaeophyta and Rhodophyta.

(f) Fossil algae.

Unit III: Algal ecology and Economic Importance (2 hours)

Ecological importance of Algae. Productivity of fresh water and marine environment. Algae in

symbiotic association, Algae in polluted habitat, Algal indicators, Algal blooms.

Economic importance of Algae

(a) Algae as food, fodder, biofertilizer, medicine, industrial uses, and other useful products. Harmful effects of algae.

(b) Use of Algae in experimental studies.

Unit IV: Algal biotechnology (4 hrs)

(a) Methods and techniques of collection, preservation and staining of Algae.

(b) Algal culture: Importance, methods; Algal culture media.

Mycology (25 hrs)

Unit V: General introduction (2 hrs)

General characters of Fungi and their significance. Principles of classification of fungi, Classifications by G C Ainsworth (1973) and C. J. Alexopoulos.

Unit VI: Thallus structure and reproduction in Fungi (18 hrs)

Mycelial structure and reproduction of;

(a) Myxomycota –Acrasiomycetes, Hydromyxomycetes, Myxomycetes, Plasmodiophoromycetes.

(b) Mastigomycotina - Chytridiomycetes, Hyphochytridiomycetes, Oomycetes.

(c) Zygomycotina - Zygomycetes, Trichomycetes.

(d) Ascomycotina - Hemiascomycetes, Pyrenomycetes, Plectomycetes, Discomycetes, Laboulbeniomycetes, Loculoascomycetes.

(e) Basidiomycotina - Teliomycetes, Hyphomycetes, Gastromycetes.

(f) Deuteromycotina - Blastomycetes, Hyphomycetes, Coelomycetes.

(g) Types of fruiting bodies in fungi.

Unit VII: Fungal associations and their significance (5 hrs)

(a) Symbionts - Lichens, Mycorrhiza, Fungus-insect mutualism.

(b) Parasites - Common fungal parasites of plants, humans, insects and nematodes.

(c) Saprophytes - Fungal decomposition of organic matter, coprophilous fungi, cellulolytic fungi, lignolytic fungi.

(d) Agricultural significance of Fungi - Mycoparasite, mycoherbicide.

Unit VIII: Crop Pathology (15 hrs)

i: Introduction to crop pathology: Classification of plant diseases based on; (a) Major causal agents - biotic and abiotic, (b) General symptoms.

ii: Process of infection and pathogenesis:

(a) Penetration and entry of pathogen into host tissue – mechanical, physiological and enzymatic.

(b) Host-parasite interaction, enzymes and toxins in pathogenesis.

iii: Defense mechanism in plants: Pre-existing structural and biochemical defense mechanisms, lack of essential nutrients. Induced structural and biochemical defense mechanisms, inactivation of pathogen enzymes and toxins, altered biosynthetic pathways.
iv: Transmission of plant disease: Spread and transmission of plant diseases by wind, water, seeds and vectors.
v: Plant disease management: Exclusion, eradication and protection. Chemical means of disease control – common fungicides, antibiotics and nematicides. Biological means of disease control. Biotechnological approaches to disease resistance: Fungi in agricultural biotechnology, control of fungal plant pathogens by mycofungicides. Transgenic approaches to disease resistance.
vi: Major diseases in plants:
(a) Cereals: Rice - blast disease, bacterial blight; Wheat - black rust disease.
(b) Vegetables: Chilly - leaf spot; Ladies finger - vein clearing disease.
(c) Fruits: Banana - bacterial leaf blight, leaf spot; Mango - Anthracnose; Citrus - bacterial canker; Papaya – mosaic.
(d) Spices: Ginger - rhizome rot; Pepper - quick wilt; Cardamom - marble mosaic disease.
(e) Oil seeds: Coconut - grey leaf spot, bud rot disease.
(f) Rubber yielding: *Hevea braziliensis* - abnormal leaf fall, powdery mildew.
(g) Sugar yielding: Sugarcane - red rot; root knot nematode.
(h) Cash crops: Arecanut - nut fall disease.
(i) Beverages: Tea - blister blight; Coffee - rust.

MLIF134: GENETICS

Core Course

Credits: 4 **Total Hours: 60**

Unit 1: History of Genetics **2 hrs**

Transmission genetics, Molecular genetics and Population genetics (brief introduction). Mendelism – basic principles (brief study). Extensions of Mendelism, penetrance and expressivity of genes. Nonmendelian inheritance – cytoplasmic inheritance.

Unit 2: **Sex Chromosomes and sex determinationin animals and plants 3 hrs**

Sex Chromosomes and sex determination in animals and plants; Dosage Compensation of X-Linked Genes: Hyperactivation of X-linked genes in male*Drosophila,* Inactivation of X-linked genes in female mammals

Unit 3: Linkage and genetic mapping **10 hrs**

Linkage and Crossing over - Stern's hypothesis, Creighton and McClintock's experiments, single cross over, multiple cross over, two-point cross, three-point cross, map distances, gene order, interference and co-efficient of coincidence. Haploid mapping (*Neurospora*), Mapping in bacteria and bacteriophages.

Unit 4: **Inheritance of traits in humans**: **4hrs**

pedigree analysis, determination of human genetic diseases by pedigree analysis, genetic mapping in human pedigrees.

Unit 5: Quantitative genetics **6 hrs**

Polygenic inheritance, Statistics of Quantitative Genetics: Frequency distributions, the mean and the modal class, the variance and the standard deviation, Analysis of quantitative traits: -The multiple factor hypothesis, Partitioning the phenotypic variance**;** QTL, effect of environmental factors and artificial selection on polygenicinheritance.

Unit 6: Population genetics **10 hrs**

(a) Gene pool, allele and genotype frequency. Hardy-Weinberg law and its applications, estimation of allele and genotype frequency of dominant genes, codominant genes, sex-linked genes and multiple alleles. Genetic equilibrium, genetic polymorphism.

(b) Factors that alter allelic frequencies; (i) mutation (ii) genetic drift - bottle neck effect and founder effect (iii) migration (iv) selection (v) nonrandom mating, inbreeding coefficient.

Unit 7: Speciation and Evolutionary Genetics **16hrs**

Emergence of evolutionary theory; Genetic Variation in Natural Populations: variation in phenotypes, variation in chromosome structure; Molecular Evolution: Molecules As "Documents of EvolutionaryHistory", Molecular Phylogenies, Rates of Molecular Evolution, the Molecular Clock, Variation in the Evolution of Protein Sequences, Variation in the Evolution of DNA Sequences, The Neutral Theory of Molecular Evolution, Mutation And GeneticDrift, Molecular Evolution and Phenotypic Evolution. Species concept; subspecies, sibling species, semi species, demes. Types of speciation - Phyletic speciation and True speciation. Mechanism of speciation - Genetic divergences and isolating mechanisms. Patterns of speciation - allopatric, sympatric, quantum and parapatric speciation, Convergent evolution; sexual selection; co-evolution; Human Evolution: Humans and the Great Apes, Human Evolution in the Fossil Record, DNA Sequence Variation and Human Origins

Unit 8: Microbial Genetics 9hrs

Fundamentals of Bacterial and Viral Genetics, Bacterial and Bacteriophage Evolution, Genetic Transformation, Conjugation and the *Escherichia coli* Paradigm, Plasmids and Conjugation Systems Other than F, Plasmid Molecular Biology, Genetics of Temperate Bacteriophages, T4 Bacteriophage as a Model Genetic System, Genetics of Other Intemperate Bacteriophages

References

1. Benjamin Lewin (2000). *Genes VII*. Oxford university press.
2. Gardner E J, Simmons M J, Snustad D P (1991). *Principles of Genetics* (III Edn). John Wiley and Sons Inc.
3. Snustad D P, Simmons M J (2000). *Principles of Genetics* (III Edn). John Wiley and Sons.
4. Strickberger (2005). *Genetics* (III Edn). Prentice Hall of India Pvt. Ltd.
5. William S Klug, Michael R Cummings (1994). *Concepts of Genetics*. Prentice Hall.
6. Robert J Brooker (2009). *Genetics: Analysis and principles* (III Edn). McGraw Hill.
7. Daniel L Hartl, Elizabeth W Jones (2009). *Genetics: Analysis of genes and genomes* (VII Edn). Jones and Bartlett publishers.
8. D Peter Snustad, Michael J Simmons (2010). *Principles of genetics* (V Edn). John Wiley and Sons.
9. George Ledyard Stebbins (1971). *Process of Organic evolution*.
10. Roderic D M Page, Edward C Holmes (1998). *Molecular Evolution: A phylogenetic approach*.
11. Blackwell Science Ltd.
12. MaxtoshiNei, Sudhir Kumar (2000). *Molecular Evolution and phylogenetics*. Oxford University Press.
13. Katy Human (2006). *Biological evolution: An anthology of current thought.* The Rosen publishing group, Inc.
14. Monroe W Strickberger (1990). *Evolution*. Jones and Bartlett publishers.
15. E d w a r d A . B i r g e, Bacterial and Bacteriophage Genetics, 5th Ed. Springer

MLIF151: PRACTICAL I: MICROBIOLOGY AND BIOCHEMISTRY

Credits: 4, Lectures: 120 Hrs

Core Course

PracticalMicrobiology 60 hours 15 units

1. Safety rules, instrumentation and media preparation-- Nutrient agar, Potato dextrose Agar, differential media etc.
2. Staining techniques: Simple, Differential:acid-fast, endospore, capsule, cell wall, cytoplasmic inclusion, vital stains: flagella, spore and nuclear staining.
3. Collection and processing of clinical samples for microbiological examination
4. Antimicrobial susceptibility tests- a. Kirby-Bauer disc diffusion test and Dilution sensitivity test-MIC and MBC against Yeast and other fungi.
5. Mutagenesis- By physical and Chemical agents
6. Production and separation of aflatoxin using paper chromatography.
7. Determination of Growth of bacteria, yeast and algae – Growth curve and generation time.
8. Isolation and culture of Rhizobium and production of biofertilizer
9. Biochemical tests Catalase, oxidase, IMViC, motility, gelatine test, urease, coagulase, nitrate reduction, acid and gas from glucose, chitin, starch.
10. Isolation of fungi from soil: Dilution plate method, Warcup method, stamping method.
11. Plaque assay.
12. Screening for antibiotic producing microbes (antibacterial, antifungal)
13. Visit to microbiology R & D lab.

Biochemistry Practical

1. Laboratory safety guidelines
2. Preparation of buffers applying HH equation
3. Validation of Beer-Lambert's Law (colorimetery and spectrophotometer)
4. Qualitative and Quantitative analysis of carbohydrates
5. Analysis of Amino Acids and Sugars (TLC and Colorimetric)
6. Isolation and quantification of protein (Folin Lowry/BCA, Bradford).
7. Purification of protein by affinity chromatography
8. Determination of isoelectric pH of proteins / amino acids
9. Determination of specific activity, Km & Vmax, Optimum pH, Temperature of Amylase/Alkaline phosphatase /protease/cellulase
10. Isolation, qualitative and quantitative analysis of fatty acids and lipids.
11. Acid values Iodine number & Saponification values of fats
12. Estimation of Ascorbic acid in citrus using 2, 6 dichlorophenol Indophenol.
13. Simple assays for vitamins and hormones

14. Bilirubin, Cholesterol, inorganic phosphate, creatinine, urea and uric acid estimation

15. **Practical in Phycology, Mycology, Crop Pathology and Genetics (120 hrs)**

16. **Unit I: Phycology (52 hrs)**

17. 1. Critical study of diagnostic features and identification of the following genera based on morphological, anatomical and reproductive parts;

18. (a) Cyanophyceae - *Gleocapsa, Gleotrichia, Spirulina, Microcystis, Oscillatoria, Lyngbya, Anabaena, Nostoc, Rivularia, Scytonema*.

19. (b) Chlorophyceae - *Chlamydomonas, Gonium, Eudorina, Pandorina, Volvox, Ecballocystis, Tetraspora, Ulothrix, Microspora, Ulva, Shizomeris, Cladophora, Pithophora. Coleochaete, Chaetophora, Drapernaldia, Drapernaldiopsis, Trentepohlia, Fritschiella, Cephaleuros, Oedogonium, Bulbochaete, Zygnema, Mougeotia, Sirogonium. Desmedium, Bryopsis, Acetabularia, Codium, Caulerpa, Halimeda, Neomeris, Chara, Nitella*.

20. (c) Xanthophyceae – *Vaucheria*.

21. (d) Bacillariophyceae - *Biddulphia, Pinnularia*.

22. (e) Phaeophyceae - *Ectocarpus, Colpomenia, Hydroclathrus, Dictyota, Padina, Sargassum, Turbinaria*.

23. (f) Rhodophyceac - *Brtrachospermum, Gelidium, Amphiroa, Gracilaria, Polysiphonia*.

24. 2. Students are to collect and identify algae from different habitat or visit an Algal research station.

25. 3. Prepare and submit a report of the field work/research station visit.

26. **Unit II: Mycology (36 hrs)**

27. 1. Critical study of the following types by preparing suitable micropreparations; *Stemonitis, Physarum,*

28. *Saprolegnia, Phytophthora, Albugo, Mucor, Aspergillus, Penicillium, Pilobolous, Saccharomyces,*

29. *Xylaria, Peziza, Phyllochora, Puccinia, Termitomyces, Pleurotus, Auricularia, Polyporus, Lycoperdon,*

30. *Dictyophora, Geastrum, Cyathus, Fusarium, Alternaria, Cladosporium, Pestalotia, Graphis, Parmelia,*

31. *Cladonia, Usnea.*

32. 2. Isolation of fungi from soil and water by culture plate technique.

33. 3. Estimation of mycorrhizal colonization in root.

34. 4. Collection and identification of common field mushrooms (5 types).

35. **Unit III: Crop Pathology (16 hrs)**

36. 1. Make suitable micropreparations and identify the diseases mentioned with due emphasis on symptoms and causative organisms.

37. 2. Isolation of pathogens from diseased tissues (leaf, stem and fruit) by serial dilution method.
38. 3. Collection and preservation of specimens from infected plants. Submit 5 herbarium sheets/live
39. specimens along with a report.
40. 4. Tests for seed pathology – seed purity test.
41. 5. Calculation of Spore load on seeds using Haemocytometer.
42. **Genetics (16 hrs)**
43. 1. Workout problems related to linkage, crossing over and gene mapping, human pedigree analysis.
44. 2. Workout problems in population genetics - gene and genotype frequency, Hardy Wienberg equilibrium

Semester II

Semester II

CELL AND MOLECULAR BIOLOGY

(Theory 60 hrs; Credits: 4)

Unit 1: Intracellular compartments in eukaryotic cells (4 hrs)

Major intracellular compartments in eukaryotic cells (brief study only), Detailed structure of mitochondria, chloroplast, peroxisomes and glyoxysomes with reference to their functional interrelationship. Genetic systems in mitochondria and chloroplast, endosymbiont hypothesis on the evolution of mitochondria and chloroplast. Structural organization of cell membranes: Chemical composition; structure and function of membrane carbohydrates, membrane proteins and membrane lipids . Membrane functions .

Unit 2: Cell communication and Cell signaling (5 hrs)

(a) Cell communication: general principles. Signaling molecules and their receptors external and internal signals that modify metabolism, growth, and development of plants .

(b) Receptors: Cell surface receptors – ion-channel linked receptors, G-protein coupled receptors, and Tyrosine-kinase linked receptors (RTK), Steroid hormone receptors.

(c) Signal transduction pathways, Second messengers, Regulation of signaling pathways. Bacterial and plant two-component signaling systems.

Unit 3: Life cycle of the cell (5 hrs)

(a) Cell growth and division. Phases of cell cycle, cell cycle control system; extracellular and intracellular signals. Cell cycle checkpoints – DNA damage checkpoint, centrosome duplication checkpoint, spindle assembly checkpoint. Cyclins and Cyclin-dependent kinases. Regulation of plant cell cycle.

(b) Cell division – mitosis and meiosis (brief study only). Significance of meiosis in generating genetic variation.

(c) Programmed cell death – molecular mechanism and control.

Unit 4: Cytoskeleton (3 hrs)

Functions of cytoskeleton; Structure, assembly, disassembly and regulation of filaments involved – actin filaments (microfilaments), microtubules, and intermediate filaments. Molecular motors – kinesins, dyneins, myosins.

Unit 5: Genetic material and its molecular structure (5 hrs)

(a) Identification of DNA as genetic material: Transformation experiment, Hershey Chase experiment. RNA as the genetic material in some viruses.

(b) Important features of Watson and Crick model of DNA structure, Chargaff's rules, preferred
tautomeric forms of bases.

(c) Alternative conformations of DNA – type(s) of right handed and left handed helices, DNA triplex and quadruplex. circular and linear DNA, single-stranded DNA.

(d) Structure and function of different types of RNA - mRNA, tRNA, rRNA, SnRNA, and Micro RNA. RNA tertiary structures. Ribozymes – Hammerhead ribozyme.

Unit 6: Genome and chromosome organization in eucaryotes (5 hrs)

(a) c-value paradox, DNA renaturation kinetics, Tm, Cot curve. Unique and Repetitive DNA –mini- and microsatellites.

(b) Structure of chromatin and chromosomes - histones and nonhistone proteins, nucleosomal organization of chromatin, higher levels of chromatin structure. Heterochromatin and Euchromatin, formation of heterochromatin. Chromosomal packing and structure of metaphase chromosome. Molecular structure of the Centromere and Telomere.

Unit 7: DNA replication, repair and recombination (8 hrs)

(a) DNA replication: Unit of replication, enzymes and proteins involved in replication (in both
procaryotes and eucaryotes). Structure of the replication origin (in both procaryotes and eucaryotes), priming (in both procaryotes and eucaryotes), replication fork, fidelity of replication. Process of replication – initiation, elongation and termination. Replication in the telomere - telomerase.

(b) DNA repair mechanisms: Direct repair, excision repair – base excision repair and nucleotide
excision repair (NER), eucaryotic excision repair – GG-NER, TC-NER. Mismatch repair, Recombination repair – homologous recombination repair, nonhomologous end joining, SOS response – Transletion DNA polymerase.

(c) Recombination: Homologous and nonhomologous recombination, molecular mechanism of
homologous recombination. Site-specific recombination, transposition–types of transposons.

Unit 8: Gene expression (15 hrs)

(a) Gene: Concept of gene; structural and genetic definitions – complementation test.

(b) Transcription in procaryotes: Initiation – promoter structure, structure of RNA polymerase, structure and role of sigma factors. Elongation – elongation complex, process of RNA synthesis. Termination – rho-dependent and rho-independent termination.
(c) Transcription in eucaryotes: Types, structure and roles of RNA polymerases. Promoters – important features of class I, II, & III promoters. Enhancers and silencers. General transcription factors and formation of pre-initiation complex. Elongation factors, structure and function of transcription factors.
(d) Post-transcriptional events: Split genes, splicing signals, splicing mechanisms of group I, II, III, and tRNA introns. Alternative splicing, exon shuffling, *cis* and *trans* splicing, Structure, formation and functions of 5' cap and 3' tail of mRNA, RNA editing, mRNA export.
(e) Translation: Important features of mRNA – ORF, RBS (10, 16). Fine structure, composition and assembly of procaryotic and eukaryotic ribosomes. tRNA charging, initiator tRNA.
(f) Stages in translation: Initiation – formation of initiation complex in procaryotes and eucaryotes, initiation factors in procaryotes and eucaryotes, Kozak sequence.
Elongation – process of polypeptide synthesis, active centers in ribosome - 3-site model, peptidyl transferase, elongation factors. Termination – process of termination, release factors, ribosome recycling.
(g) Genetic code: Cracking the genetic code – simulation synthetic polynucleotides and mixed copolymers, synthetic triplets. Important features of the genetic code, proof for the triplet code (10, 27), Exceptions to the standard code.
(h) Protein sorting and translocation: Cotranslational and posttranslational – signal sequences, SRP, translocon. Membrane insertion of proteins. Post-translational modification of proteins. Protein folding – self assembly, role of chaperones in protein assembly.

Unit 9: Control of gene expression (10 hrs)

(a) Viral system: Genetic control of lytic and lysogenic growth in λ phage, lytic cascade
(b) Procaryotic system: Transcription switches, transcription regulators. Regulation of transcription initiation; Regulatory proteins - activators and repressors. Structure of *Lac* operator, CAP and repressor control of *lac* genes. Regulation after transcription initiation – regulation of amino acid biosynthetic operons- attenuation of trp operon, riboswitches.
(c) Eucaryotic system: Changes in chromatin and DNA structure – chromatin compaction, transcriptional activators and repressors involved in chromatin remodellin, gene amplification, gene rearrangement, alternate splicing, gene silencing by heterochromatization, and DNA methylation. Effect of regulatory transcription factors on transcription. Post-transcriptional control – mRNA stability, RNA interference, micro RNA. Role of small RNA in heterochromatization and gene silencing.

Practical

References

1. Wayne M Becker, Lewis J Kleinsmith, Jeff Hardin (2007). *The world of the cell* (VI Edn). Pearson.
2. Geoffrey M Cooper, Robert E Hausman (2009). *The Cell: A molecular approach* (V Edn). Sinaeur.
3. Gerald Karp (2008). *Cell and Molecular biology: Concepts and experiments* (V Edn). John Wiley &
Sons.
4. Harvey Lodish, Arnold Berk, Lawrence Zipursky, Paul Matsudaira, David Baltimore, James Darnell (2000). *Molecular cell biology* (IV Edn). W H Freeman & Company.
5. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2002). *Molecular biology of the cell* (IV Edn). Garland Science, Taylor and Francis group.
6. Robert J Brooker (2009). *Genetics: analysis and principles* (III Edn). McGraw Hill.
7. Jocelyn E Krebs, Elliott S Goldstein, Stephen T Kilpatrick (2011). *Lewin's Genes X*. Jones and
Bartlett Publishers.
8. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and Molecular biology of plants*. I K International Pvt. Ltd.
9. Daniel L Hartl, Elizabeth W Jones (2012). *Genetics: Analysis of genes and genomes* (VII Edn). Jones and Bartlett publishers.
10. James D Watson, Tania A Baker, Stephen P Bell, Alexander Gann, Michael Levine, Richard Losick (2009). *Molecular biology of the gene* (V Edn). Pearson.
11. William S Klug, Michael R Cummings (2004). *Concepts of Genetics* (VII Edn). Pearson.
12. Daniel J Fairbanks, W Ralph Anderson (1999). *Genetics: The continuity of life*. Brooks/Cole publishing company.
13. Robert F Weaver (2002). *Molecular biology* (II Edn). McGraw Hill.
14. Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2010). *Essential Cell Biology*. Garland Science.
15. Leland H Hartwell, Leroy Hood, Michael L Goldberg, Ann E Reynolds, Lee M Silver, Ruth C Veres (2004). *Genetics from genes to genomes* (II Edn). McGraw Hill.
16. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira (2007). *Molecular cell biology* (VI Edn). W H Freeman & Company.
17. James D. Watson, Amy A. Caudy, Richard M. Myers, Jan A. Witkowski (2007). *Recombinant DNA* (III Edn). W H Freeman.
18. William H Elliott, Daphne C Elliott (2001). *Biochemistry and molecular biology* (II Edn). Oxford.
19. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman & company.
20. David P Clark (2010). *Molecular biology*. Elsevier.

21. David R Hyde (2010). *Genetics and molecular biology*. Tata McGraw Hill.
22. D Peter Snustad, Michael J Simmons (2010). *Principles of genetics* (V Edn). John Wiley and Sons.
23. David A Micklos, Greg A Freyer with David A Crotty (2003). *DNA Science: A first course* (II Edn). L K Inter.
24. Benjamin A Pierce (2008). *Genetics: A conceptual approach* (IV Edn). W H Freeman and Company.
25. Anthony J F Griffiths, Susan R Wesler, Sean B Carroll, John Doebley (2012). *Introduction to genetic analysis*. W H Freeman & Company.
26. T A Brown (2002). *Genomes* (II Edn). Bios.
27. Robert H Tamarin (2002). *Principles of genetics*. McGraw Hill.
28. David E Sadava (2009). *Cell biology: Organelle structure and function*. CBS.
29. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2010). *Essential Cell Biology* (III Edn.). Garland Science.
30. Pranav Kumar, Usha Mina (2011). *Biotechnology: A problem approach*. Pathfinder Academy.
31. Burton E Tropp (2012). *Molecular biology: Genes to Proteins* (IV Edn). Jones and Bartlett
Learning.
32. Lynne Cassimeris, Viswanath R Lingappa, George Plopper (Eds) (2011). *Lewin's Cells* (II Edn). Jones and Bartlett Publishers.

MLIF232: GENETIC ENGINEERING

Core Course

Credits: 4 **Total Hours: 60**

Course objective

The objective of the course is to impart in depth knowledge about the concepts in genetic engineering - enzymes, biology of cloning vehicles, vector and host considerations, gene libraries, analysis and expression of the cloned gene in host cell and understand ethical issues and biosafety regulations. It gives emphasis to practical applications of genetic engineering tools in academic and industrial research. At the end of the course the student will have detailed knowledge of recombinant DNA technology essential for taking up projects in the field of Biotechnology.

Learning outcome

By the end of this course, the students will have in-depth knowledge about different techniques used in rDNA technology, different methods of generating recombinant DNA, different types of vectors, host, methods and means of making of rDNA molecules and analysing them, fingerprinting and more over the students will have the idea about the application of genetic engineering and the biosafety and ethics related to such experiments.

Unit I Tools to Make rDNA 20Hrs

Introduction to rDNA technology, DNA modifying enzymes and its functions (DNA Polymerases, Klenow fragment, Ligase, S1 Nuclease, Mung Bean nuclease, Alkaline Phosphatase, Terminal Transferase, Polynucleotide kinases, Polynucleotide phosphorylase, Calf intestinal alkaline Phosphatases, Shrimp Alkaline Phosphatases, RNase A, RNase H, DNase 1, DNase II, Exonuclease III, Reverse Transcriptase) Restriction modification system, Restriction enzymes – function, classification (Based on recognition and restriction sequence:-type I, II and III; based on buffer salt concentration: - low, medium and high; based on pattern of restriction:-sticky (5' and 3') and blunt end cutters, Plasmids (Types, copy number, properties, origin of replication and incompatibility group, plasmid amplification), bacteriophages eg. λ (Life cycle, genome organization, feasibility as a cloning vehicle), Types of Cloning Vectors (structure and general features of General Purpose cloning vectors, Expression vectors, Promotor probe Vectors, shuttle vectors), Examples of cloning vectors (pBR322, pUC series of vectors, λ insertional and replacement vectors), derivatives of phages and plasmids (cosmids, phagemids, phasmids) cloning vectors for large DNA fragments and genomic DNA library YACs, PACs and BACs. Host and vector consideration, Host Organisms and its genotypes- JM 109 & DH5α, Selectable and scorable markers, reporter genes, prokaryotic and eukaryotic markers (lacZ, CAT, Gus, GFP,cre-loxP system, sac B system, npt II gene, luciferase gene, dhfr gene, herbicide resistance gene)

Unit II Making of rDNA Molecule 8 Hrs

General strategies for isolation of genomic and plasmid DNA, RNA, strategies for isolation of gene of interest (restriction digestion, PCR), Creation of r-DNA (Restriction Digestion, modification of vector and insert, linker, adaptors, homopolymer tailing, ligation), PCR Cloning, Construction of genomic and cDNA libraries (Selection of vectors and Complexity of library), Methods of gene transfer- Calcium chloride mediated, Electroporation, Biolistic gun, lipofection and microinjection. In vitro packaging.

Unit III Screening and analysis of rDNA molecules 10Hrs

Blotting techniques- Southern, Northern and Western, Differential display. Gene sequencing- Chemical, enzymatic, pyrosequencing, next generation sequencing, Immunological screening and colony and plaque hybridization, dot blot hybridization, chromosome walking, FISH, RACE, Chromosome walking.

Unit IV Expression & control of Genes 10Hrs

Protein production by foreign DNA in the host bacteria E. coli, Factors influencing expression, properties of expression vector, examples of expression vectors, tags for purification of expressed proteins, FLAG expression vector system, cloning in pET vectors, eukaryotic vectors- Baculovirus based vectors, mammalian viral vectors., expression Host, Modification and folding of protein in-vitro, genome editing, CRISPR/Cas9 and Targeted Genome Editing,

Unit V Applications of r-DNA Technology 12Hrs

RNA interference and gene silencing, Transgenic organisms, Advantages and disadvantages of Genetically Modified Organisms, Transgenic animal- Gene therapy. The Use of Transgenic animals in areas other than recombinant protein production. Transgenic plants- applications, special emphasis to pharmaceutical products. Engineered Nutritional Changes- golden rice, Engineered herbicide resistance, Engineered pesticide resistance. Production of recombinant proteins (Insulin), recombinant vaccines (Hepatitis B), Hormones (Human growth hormone). Genome projects and its Applications. International treaties/agreements in biosafety, public perception on rDNA technology, IPR related to rDNA technology.

Essential reading

1 M. L. Srivastava, Bioanalytical Techniques, New Delhi: Narosa Publications, 2011.
2 E. L. Winnacker, From Genes to Clones Introduction to Gene Technology,New Delhi, India: Panima Publishing Corporation, 2003.
3 T. A. Brown, Gene Cloning and DNA Analysis-An Introduction. 5th ed. UK: Wiley Blackwell Publishers. 2006.

Recommended Reading

4 Alkami Quick Guide for PCR A laboratory reference for the Polymerase Chain Reaction, USA. Alkami Biosystems Inc., 1999.
5 B. R. Glick. J. J. Pasternak and C. L. Patten. Molecular Biotechnology: Principles and application of recombinant DNA. 4th ed. Washington D. C: American Society for Microbiology Press, 2010.

6 S. B. Primrose, R. M. Twyman and R. W. Old, Principles of Gene Manipulation, 6th ed. USA: Wiley-Blackwell, 2001
7 K. Wilson and J. Walker, Principles and Techniques of Biochemistry and Molecular Biology, 7th ed. New York: Cambridge University Press, 2010.
8 J. W. Dale, M. von Schantz and N. Plant, From Genes to Genomes: Concepts and Applications of DNA Technology, USA: John Wiley & Sons Inc., 2012.

MLIF233: BIOANALYTICAL TOOLS AND BIOINFORMATICS

Core Course

Credits: 4 **Total Hours: 60**

Course objective

Analytical tools are becoming very important tools in different fields of Biology. The paper deals with the principle, instrumentation and uses of such tools. This course fulfils the basic knowledge in analytical techniques for those students who wish to pursue career in allied health fields and other technical programs.

Learning outcome

This course will make the students adept in the working of analytical instruments. They also become confident to use bioinformatics softwares and work with different databases for applications in upcoming fields of biology, which in turn make them competent for jobs in clinical and medical data analysis labs.

Unit I Introduction to Analytical Biochemistry 7 hours

Concept of pH, Henderson Hesselbach equation. Importance of buffers in living systems – bicarbonate buffer, phosphate buffer. Breaking of cells by chemical and physical methods, ultrasonication, pressure cell disintegrators, detection of cell-free and cell-bound proteins.Extractions: Preparation of extracts for biochemical investigations, methods of extraction of phytochemicals (Maceration, Soxhlet, Microwave assisted, Ultrasonic, Pressurized liquid extraction)type and choice of solvents.

Unit 2- Separation techniques 15 hours

Centrifugation: Principle of centrifugation, the Swedberg equation, types of centrifuges and rotors. Density gradient centrifugation, Cesium chloride and sucrose density gradients; examples of separations, analytical ultracentrifuges. Ultra-filtration -Principle, instrumentation and application. Dialysis-principle and uses. Precipitation- methods and applications. Flow Cytometry; Principle and uses.

Chromatography- principle, types (Column, Ion exchange, Gel permeation, Affinity), Gas chromatography, HPLC, HPTLC

Electrophoresis - buffers, agarose gel electrophoresis, native and SDS -PAGE, Isoelectric focusing, Zymogram, 2 D gel electrophoresis, DGGE, PFGE, Protein staining, trouble shooting,

Protein purification methods, salt fractionation, salting in and salting out, methods of crystallizing proteins

Unit 3- Spectroscopy 8 hours

Spectroscopy: Absorption and emission spectra. Electromagnetic radiation. Fluorescence and phosphorescence, Beer- Lambert's law, principle, operation and applications of Colorimeter, Spectrophotometer, Concept of Stoke's shift-hypochromicity, hyperchromicity, fluorimeter, flame photometer, Atomic absorption spectrophotometer. IR, Mass spectroscopy and NMR, ICP-MS, GC-MS, LC-MS, X ray crystallography.

Unit 4 Detection methods 9 hours

Radioactive isotope, Radioactivity and units of radioactivity (Curie, Rutherford and Becquerel).GM and Scintillation counters. radioactive decay, Radiocarbon dating, autoradiography, use of radioisotope tracer techniques in disease diagnosis, PET scan for tumor detection, Radioimmunoassay, ELISA, Western Blot, Nanoparticles – synthesis and uses, application of nanotechnology in disease diagnosis and treatment, Microarrays.

Unit 5: Databases 9 Hours

Introduction and application of bioinformatics. Definition and types, Nucleotide sequence database - brief note on EMBL, NCBI and DDBJ. Protein structure database [PDB]. Sequence alignment: pair wise and multiple alignments [Definition, applications, BLAST and FASTA, Clustal W, PAM and BLOSUM matrices]. ORF. Structure prediction, and molecular visualization – use of Rasmol, PDB, ExPASY and KEGG. Online tools – SDSC Biology workbench.

Unit 6: Genomics and Proteomics 7 Hours

Genomics: Definition. Types [Structural, functional and comparative genomics]. Pharmacogenomics: Definition and its benefits in the health care sector. Genome projects- Human, Rice, Arabidopsis, Tomato, *Hemophilusinfluenzae,* Proteomics,

Transcriptomics and Metabolomics – current status and potential applications in agriculture and medicine. Systems Biology- concept and applications.

Unit 7 Molecular Phylogeny and drug design 7 hours

Molecular phylogeny and phylogenetic trees, tools for phylogeny analysis, Computer aided drug design. Docking Studies - Target Selection, Active site analysis, Ligand preparation and conformational analysis, Rigid and flexible docking, Structure based design of lead compounds and Library docking.

Essential Reading

1.T. Attwood and P. Smith. Introduction to Bioinformatics, USA: Pearson Education, 2007.

2.Brown TA. Genome III. Garland Science Publ.2007

3. Azuaje F &Dopazo J. Data Analysis and Visualization in Genomics and Proteomics. John Wiley & Sons.2005

4. K. Wilson and J. Walker,Principles and Techniques of Biochemistry and Molecular Biology, 7th ed.New York: Cambridge University Press, 2010.

5. S. B. Primrose and R. Twyman R. Principles of Gene Manipulation and Genomics. USA: John Wiley and Sons, 2013.

Recommended reading

1. Gibson G & Muse SV. 2004. A Primer of Genome Science. Sinauer

Associates.

2. W. Taylor and D. Higgins. Bioinformatics: Sequence, Structure and Databanks: A Practical Approach, Oxford, 2000.

3. Jollès P &Jörnvall H. 2000. Proteomics in Functional Genomics: Protein

Structure Analysis.

4. Campbell AM &Heyer L. 2004. Discovery Genomics, Proteomics and Bioinformatics. Pearson Education.

MLIF234: RESEARCH METHODOLOGY AND BIOSTATISTICS

Core Course

Credits: 4 **Total Hours: 60**

Research Methodology (25hrs)

Unit I. Concepts of Research and Research Formulation 7 hrs.

Need for research, stages of research; Basic concepts of research -Meaning, Objectives, Motivation and Approaches. Types of Research (Descriptive/Analytical, Applied/ Fundamental, Quantitative/Qualitative, Conceptual/ Empirical); Research formulation - Observation and Facts, Prediction and explanation, Induction, Deduction; Defining and formulating the research problem, Selecting the problem and necessity of defining the problem; Literature review -Importance of literature reviewing in defining a problem, Critical literature review, Identifying gap areas from literature review; Hypothesis -Null and alternate hypothesis and testing of hypothesis -Theory, Principle, Law and Canon.

Unit II. Research Designs (5hrs).

Research Design -Basic principles, Meaning, Need and features of good design, Important concepts; Types of research designs; Development of a research plan - Exploration, Description, Diagnosis, Experimentation, determining experimental and sample designs; Data collection techniques, Case-Control Studies, Cohort Studies.

Unit III. Scientific Documentation and Communication (4hrs).

Workbook maintenance, Project proposal writing, Research report writing (Thesis and dissertations, Research articles, Oral communications); Presentation techniques - Assignment, Seminar, Debate, Workshop, Colloquium, Conference.

Unit IV. Information Science, Extension and Ethics (9hrs).

Sources of Information -Primary and secondary sources; Library - books, Journals: Indexing journals, abstracting journals, research journals, review journals, e-journals. Impact factor of journals, NCBI-Pub Med.; periodicals, reference sources, abstracting and indexing sources, Reviews, Treatise, Monographs, Patents. Internet -Search engines and software, Online libraries, e-Books, e-Encyclopedia, TED Talk, Institutional Websites; Intellectual Property Rights - Copy right, Designs, Patents, Trademarks, plagiarism, Geographical indications; Safety and precaution - ISO standards for safety, Lab protocols, Lab animal use, care and welfare, animal houses, radiation hazards; Extension: Lab to Field, Extension communication, Extension tools; Bioethics: Laws in India, Working with man and animals, Consent, Animal Ethical Committees and Constitution.

Biostatistics: (35 hours)

Unit V. Introduction: 5 Hrs

The scope of biostatistics; Classification of study design, Observationalstudies and Experimental studies (uncontrolled studies, trials with external controls, crossoverstudies, trials with self-controls, trials with independent concurrent controls); Exploration and presentation of data: Scales of measurement, Tables, Graphs,Histograms, Box and Whisker plots, Frequency polygon, Scatter Plots, Principle component analysis.

Unit VI. Probability: 11Hrs

Definition, mutually exclusive events and addition rule, independent events andmultiplication rule. Sampling: Reasons for sampling, methods of sampling, SRS, Systematic, Stratified, Cluster, NPS. Probability distribution: Binomial, Poisson, Gaussian,Standard normal distribution. Drawing inferences from data: **Tests of significance:** Statistical inference – estimation - testing of hypothesis - t-test, Chi square test (goodness of fit,independence or association, detection of linkages), Z-test, Confidence intervals,Confidence limits, Hypothesis tests, Types of errors, P-values.

Unit VII. Estimating and comparing means: 12Hrs

Decision about single mean (normal population andnon-normal population), decision about single group, decision about paired groups, decisionabout two independent groups, equality of population variances, computer-aided illustrationfor comparison of means; Comparing three or more means: ANOVA – one way, two way, A-priori comparison,Posterior or Post Hoc comparison. Statistical methods for multiple variables: Multiple regression, predicting with more than 1 variable, Statistical test for regression coefficient, Role of R and R2 in multiple regression, Confounding variable (ANACOVA), Predicting categorical outcomes – logistic regression, discriminant analysis.

Unit VIII. Correlation and Regression: 7Hrs

Pearson's correlation coefficient, Spearman's rho, Linearregression, Least Square method, predicting with regression equation, comparing tworegression lines, dealing with nonlinear observation, Common errors in regression,Comparing correlation and regression.

MILF251 Practical III: Molecular Biology & Genetic Engineering

1. Isolation and purification of DNA from plant, animal, Bacterial and fungal samples
2. Isolation of plasmid DNA from the bacteria
3. Isolation of megaplasmid from the environmental isolates

4. Isolation of RNA from plant, animal and bacterial samples and separation on denaturing gel
5. Primer design and PCR amplification of DNA
6. Gel-band purification for DNA
7. RFLP and RAPD, ISSR/SSR analysis of DNA
8. Cloning and expression of gene in *E. coli*.
9. Southern blotting and hybridization.
10. Site directed mutagenesis

MLIF252: PRACTICAL IV: Bioanalytical Tools, Bioinformatics, Research Methodology and Biostatistics

Credits: 4, Lectures: 120 Hrs

Core Course

Bioanalytical Tools and Bioinformatics

1. Extraction of phytochemicals using Soxhlet apparatus
2. Column Chromatography
3. Ion exchange and affinity chromatography.
4. HPLC- Principle and sample preparation, visit to Research Institute for analysis.
5. Protein and DNA homology search and sequence alignment.
6. Docking studies of ligands.
7. Construction of dendrogram

Biostatistics:

1. Contingency table, frequency table
2. Simple bar chart, stem and leaf plot
3. Histogram, Box and whisker plot
4. Scatter plot
5. One sample t-test, independent t-test, paired t-test
6. Wilcoxon rank-sum test, Mann-Whitney U
7. One way ANOVA, 2-way ANOVA, Kruskal-Wallis test
8. Correlation, linear regression, ANACOVA.
9. SPSS/SAS/minitab/excel

Research Methodology

1. Visit a scientific library or documentation center and submit a report.

2. Prepare a project proposal.

3. Prepare an outline of dissertation and research paper.

4. Prepare a list of references.

Semester III
ARCHEGONIATAE
(Lectures 60 hrs, Credit 4)

Bryology (18 hrs)

Unit 1: General introduction (2 hrs)

Introduction to Bryophytes, their fossil history and evolution. Concept of algal and pteridophytic origin of Bryophytes. General characters of Bryophytes. History of classification of Bryophytes.

Unit 2: Ecology and Economic importance of bryophytes (4 hrs)

(a) Bryophyte habitats. Water relations - absorption and conduction, xerophytic adaptations, drought tolerance, dessication and rehydration, ectohydric, endohydric and myxohydric Bryophytes.

(b) Ecological significance of Bryophytes - role as pollution indicators.

(c) Economic importance of Bryophytes.

Unit 3: Thallus structure (12 hrs)

Comparative structural organization of gametophytes and sporophytes in an evolutionary perspective. Asexual and sexual reproductive structures, spore dispersal mechanisms and germination of the following groups with reference to the types mentioned in the practical (development of sex organs not necessary).

(a) Hepaticopsida (Sphaerocarpales, Marchantiales, Jungermanniales and Calobryales).

(b) Anthocerotopsida (Anthocerotales).

(c) Bryopsida (Sphagnales, Polytrichales and Bryales).

Pteridophytes (22 hrs)

Unit 4: General introduction and classification (3 hrs)

Introduction, origin, general characteristics and an outline of the classification of Pteridophytes.

Unit 5: Structure of the plant body (18 hrs)

a) Distribution, habitat, range, external and internal morphology of sporophytes, spores, mechanism of spore dispersal, gametophytic generation, sexuality, embryogeny of the following classes of Pteridophytes with reference to the genera mentioned (development of sex organs is not necessary):

(I) Psilopsida (a) Rhyniales; *Rhynia*

(II) Psilotopsida (a) Psilotales; *Psilotum*

(III) Lycopsida (a) Protolepidodendrales; *Protolepidodendron* (b) Lycopodiales; *Lycopodium*, (c) Isoetales; *Isoetes* (d) Selaginellales; *Selaginella*.

(IV) Sphenopsida (a) Hyeniales (b) Sphenophyllales; *Sphenophyllum* (c) Calamitales; *Calamites*

(d) Equisetales; *Equisetum*.

(V) Pteropsida (i) Primofilices (a) Cladoxylales; *Cladoxylon* (b) Coenopteridales.

(ii) Eusporangiatae (a) Marattiales; *Angiopteris* (b) Ophioglossales; *Ophioglossum*.

(iii) Osmundales; *Osmunda*.

(iv) Leptosporangiatae (a) Marsileales; *Marsilea* (b) Salviniales; *Salvinia*, *Azolla* (c) Filicales; *Pteris, Lygodium, Acrostichum, Gleichenia, Adiantum*.

b) Comparative study of Pteridophytes

Stelar organization, soral and sporangial characters, gametophytes and sporophytes of Pteridophytes in an evolutionary perspective.

Unit 6: Ecology and Economic importance (1 hrs)

Ecological and economic significance of Pteridophytes.

GYMNOSPERMS: (20 hrs)

Unit 7: Introduction (2 hrs)

Origin, general characteristics, distribution and classification of Gymnosperms (K R Sporne and

C J Chamberlain). Distribution of living gymnosperms in India.

Unit 8: Vegetative and reproductive structures of Gymnosperms (18 hrs)

i) Detailed study of the vegetative morphology, internal structure, reproductive structures, and evolution of the orders and families (with reference to the genera mentioned).

(a) Class Progymnospermopsida: *Aneurophyton*

(b) Class Cycadopsida: *Heterangium, Lyginopteris, Lagenostoma, Glossopteris, Medullosa, Caytonia. Bennettites, Williamsoniella, Nilsonia, Cycas, Zamia, Pentoxylon*.

(c) Class Coniferopsida: General account of families under Coniferales, range of form and structure of stem, leaves; range of form, structure and evolution of female cones in coniferales such as *Pinus, Taxodium, Cupressus, Podocarpus, Agathis, Araucaria, Taxus and Ginkgo*.

(d) Class Gnetopsida: *Gnetum*.

ii) Gametophyte development and economic importance of Gymnosperms

General account on the male and female gametophyte development in Gymnosperms (Cycas). Economic significance of Gymnosperms.

References

1. Vashishta B R, A K Sinha, A Kumar (2003). Bryophyta. S Chand & Co. Ltd.
2. Pandey B P (1994). Bryophyta. S Chand and Co. Ltd.
3. Goffinet B, A J Shaw (2009). Bryophytic Biology (II Edn). Cambridge University Press.
4. Srivastava S N (1992). Bryophyta. Pradeep Publications.
5. Agashe S N (1995). *Palaeobotany*. Oxford and IBH publishing House.
6. Arnold C R (1977*). Introduction to Palaeobotany*. McGraw Hill Book Com.
7. Chandra S, Srivastava M (Eds) (2003). *Pteridology in the New Millennium*. Khuwar Acad. Publishers.
8. Beddome C R H (1970). *Ferns of south India*. Today & Tommorrows Publ.
9. Dyer A F (1979). *The experimental biology of ferns*. Academic Press.
10. Gifford E M, A S Foster (1989). *Morphology and evolution of Vascular plants* (III Edn). W H Freeman & Co.
11. Khullar S P (2000). *An illustrated fern flora of West Himalayas* (Vol I, II). International Book Distributers.

Semester III

PRINCIPLES OF ANGIOSPERM SYSTEMATICS AND TAXONOMY

(Theory 60 hrs; Credits 4)

Unit 1: Phylogeny of Angiosperms (3 hrs)

Important phylogenetic terms and concepts: Plesiomorphic and Apomorphic characters; Homology and Analogy; Parallelism and Convergence; Monophyly, Paraphyly and Polyphyly. Phylogenetic tree - Cladogram and Phenogram.

Unit 2: Concept and principles of assessing relationships (3 hrs)

Phenetic - Numerical Taxonomy - principles and methods; Cladistic - Principles and methods. Chemotaxonomy, basic concepts of genome analysis – bar coding.

Unit 3: Botanical nomenclature (5 hrs)

History of ICBN, aims and principles, rules and recommendations: rule of priority, typification, author citation, retention, rejection and changing of names, effective and valid publication.

Unit 4: Morphology of Angiosperms (2 hrs)

Habitat and habit; Morphology of root, stem, leaf, bract and bracteoles, inflorescence, flowers, fruits and seeds.

Unit 5: Classification (3 hrs)

Major systems of angiosperm classification with special emphasis on the conceptual basis of the classifications of; (i) Linnaeus (ii) Bentham & Hooker (iii) Engler & Prantl (iv) Bessey (v) Takhtajan (vi) APG.

Unit 6: Tools of Taxonomy (4 hrs)

Functions of field study, herbarium, botanical gardens, BSI, Floras/Taxonomic literature and GIS (Geographic Information System). Construction of taxonomic keys – indented and bracketed – their utilization.

Unit 7: Angiosperm diversity with special reference to Tropical flora (40 hrs)

Study of the following families (Bentham & Hooker) in detail with special reference to their salient features, interrelationships, evolutionary trends and economic significance.

1. Rununculaceae 2. Magnoliaceae 3. Annonaceae 4. Cruciferae (Brassicaceae) 5. Polygalaceae 6. Caryophyllaceae 7. Guttiferae (Clusiaceae) 8. Malvaceae 9. Tiliaceae 10. Geraniaceae 11. Rutaceae 12. Vitaceae 13. Sapindaceae 14. Fabaceae 15. Caesalpiniaceae 6. Mimosaceae 17. Rosaceae 18. Lythraceae 19. Melastomaceae 20. Myrtaceae 21. Cucurbitaceae 22. Apiaceae 23. Aizoaceae 24. Rubiaceae 25. Compositae (Asteraceae) 26. Campanulaceae 27. Myrsinaceae 28. Sapotaceae 29. Oleaceae 30. Apocynaceae 31. Asclepiadaceae 32. Boraginaceae 33. Convolvulaceae 34. Solanaceae 35. Scrophulariaceae 36. Bignoniaceae 37. Acanthaceae 38. Verbenaceae 39. Lamiaceae 40. Polygonaceae 41. Aristolochiaceae 42. Lauraceae 43. Loranthaceae 44. Euphorbiaceae 45. Orchidaceae 46. Dioscoriaceae 47. Zingiberaceae 48. Araceae 49. Cyperaceae 50. Poaceae.

References

1. Jain S K (1991). *Dictionary of Indian Folkmedicine and Ethnobotany*.

2. Paye G D (2000). *Cultural Uses of Plants: A Guide to Learning about Ethnobotany*. The New York Botanical Garden Press.

3. Hooker J D. *The flora of British India* (Vol. I – VII).

4. Gamble J S. *Flora of the Presidency of Madras*. (Vol. I – III).

5. Cronquist A (1981). *An integrated system of classification of flowering plants*. Columbia University Press.

6. Woodland D W (1991). *Contemporary Plant Systematics*. Prentice Hall.

7. Sivarajan V V (1991*). Introduction to Principles of Plant Taxonomy*. Oxford IBH.

8. Takhtajan A L (1997). *Diversity and Classification of Flowering Plants*. Columbia Univ. Press

Semester III

Plant Anatomy, Developmental Biology and Plant Breeding

(lectures: 60 hrs, Credit: 4)

Introduction: (1hr)

Unique features of plant development; differences between animal and plant development.

Seed germination and seedling growth: (4 hrs)

Metabolism of nucleic acids, proteins and mobilization of food reserves; tropisms; hormonal control of seedling growth; gene expression; use of mutants in understanding seedling development.

Shoot development: (4 hrs)

Organization of the shoot apical meristem (SAM); cytological and molecular analysis of SAM; control of cell division and cell to cell communication; control of tissue differentiation, especially xylem and phloem; secretory ducts and laticifers; wood development in relation to environmental factors.

Leaf growth and differentiation: (3 hrs)

Determination; phyllotaxy; control of leaf form; differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll.

Root development: (3hrs)

Organization of root apical meristem (RAM); cell fates and lineages; vascular tissue differentiation; lateral roots; root hairs; root-microbe interactions.

Reproduction: (5 hrs)

Vegetative options and sexual reproduction; flower development; genetics of floral organ differentiation; homeotic mutants in *Arabidopsis* and *Antirrhinum;* sex determination.

Male gametophyte: (4hrs)

Structure of anthers; microsporogenesis, role of tapetum; pollen development and gene expression; male sterility; sperm dimorphism and hybrid seed production; pollen germination, pollen tube growth and guidance; pollen storage; pollen allergy; pollen embryos.

Female gametophyte: (4 hrs)

Ovule development; megasporogenesis; organization of the embryo sac, structure of the embryo sac cells.

Pollination, pollen-pistil interaction and fertilization: (8 hrs)

Floral characteristics, pollination mechanisms and vectors; breeding systems; commercial considerations; structure of the pistil; pollen-stigma interactions, sporophytic and gametophytic self-incompatibility (cytological, biochemical and molecular aspects); double fertilization; in vitro fertilization.

Seed development and fruit growth: (7 hrs)

Endosperm development during early, maturation and desiccation stages; embryogenesis, ultrastructure and nuclear cytology; cell lineages during late embryo development; storage proteins of endosperm and embryo; polyembryony; apomixis; embryo culture; dynamics of fruit growth; biochemistry and molecular biology of fruit maturation.

Latent life - dormancy: (2 hrs)

Importance and types of dormancy; seed dormancy; overcoming seed dormancy; bud dormancy.

Senescence and programmed cell death (PCD): (5 hrs)

Basic concepts, types of cell death, POD in the life cycle of plants, metabolic changes associated with senescence and its regulation; influence of hormones and environmental factors on senescence.

Plant Breeding: (10 hrs)

Objectives of plant breeding, important achievements and future prospects. Genetic variability and its role in plant breeding. Domestication and centers of origin of cultivated plants. Hybridization - role and methods, Inter-varietal, inter specific and inter generic crosses. Back-cross breeding. Heterosis, Inbreeding depression. Breeding for resistance - Breeding for biotic (disease) and abiotic (drought) stresses; loss due to diseases, disease development, disease escape, disease resistance, vertical and horizontal resistances of biotic stress; methods of breeding for disease resistance. Mutation breeding- Mutagens and crop improvement. Spontaneous and induced mutations, effects of mutation. Physical and chemical mutagens; principles and working of Gamma gardens, methods of mutation breeding, mutations in oligogenic traits, mutations in polygenic traits, limitations of mutation breeding, achievements of mutation breeding. Role of mutations in Plant Breeding.

Suggested Readings

Atwell, B.J., Kriedermann, P.E. and Jurnbull, C.G.N. (eds) 1999. Plants in Action: Adaptation in Nature, Performance in Cultivation. MacMillan Education, Sydney, Australia.

Bewley, J.D. and Black, M. 1994. Seeds: Physiology of Development and Germination. Plenum Press, New York.

Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4^{h} revised and enlarged edition). Vikas Publishing House, New Delhi.

Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.

Fageri, K. and Van der Pijl, L. 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford.

Fahn, A. 1982. Plant Anatomy. (3^{rd} edition). Pergamon Press, Oxford.

Fosket, D.E. 1994. Plant Growth and Development. A Molecular Approach. Academic Press, San Diego.

Howell, S.H. 1998. Molecular Genetics of Plant Development. Cambridge University Press, Cambridge.

Leins, P., Tucker, S.C. and Endress, P.K. 1988. Aspects of Floral Development. J. Cramer, Germany.

Lyndon, R.F. 1990. Plant Development. The Cellular Basis. Unnin Hyman, London.

Murphy, T.M. and Thompson, W.F. 1988. Molecular Plant Development. Prentice Hall, New Jersey.

Proctor, M. and Yeo, P. 1973. The Pollination of Flowers. William Collins Sons, London.

Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.

Raghavan, V. 1999. Developmental Biology of Flowering Plants. Springer-Verlag, New York.

Raven, P.H., Evert, R.F. and Eichhorn, S.E. 1992. Biology of Plants O^{h} edition). Worth, New York.

Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4^{h} edition). Wadsworth Publishing, Belmont, California.

Steeves, T.A. and Sussex, I.M. 1989. Patterns in Plant Development (2^{6} edition). Cambridge University Press, Cambridge.

Sedgely, M. and Griffin, A.R. 1989. Sexual Reproduction of Tree Crops. Academic Press, London.

Waisel, Y., Eshel, A. and Kafkaki, U. (eds) 1996. Plant Roots: The Hidden Hall (2^{d} edition). Marcel Dekker, New York.

Shivanna, K.R. and Sawhney, V.K. (eds) 1997. Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge.

Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology: A Laboratory Manual. Springer-Verlag, Berlin. Shivanna, K.R. and John, B.M. 1985. The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd., New York.

The Plant Cell. Special Issue on Reproductive Biology of Plants, Vol. 5(10) 1993. The American Society of Plant Physiologists, Rockville, Maryland, USA.

Semester III

ENVIRONMENTAL SCIENCE

(Lectures: 60 hrs, Credit: 4)

Unit 1: Ecology and Environment (2 hrs)

Definition, history and scope of ecology, sub divisions of ecology, ecology vs environmental science. Interdisciplinary nature of environmental science.

Unit 2: Autecological concepts - Population Ecology (7 hrs)

(a) Characteristics of populations - size and density, dispersion, age structure, natality and mortality.

(b) Population growth – characteristics of a population, factors affecting population growth, environmental resistance, biotic potential, carrying capacity, positive and negative interaction, migration, subsistence density, security and optional density. Ecological consequence of overpopulations.

(c) Genecology - ecological amplitude, ecads, ecotypes, ecospecies, coenospecies, *k*-selection and *r*- selection populations. Concept of metapopulation- demes and dispersal, interdemic exstinctions.

Unit 3: Synecological concepts - Community ecology (6 hrs)

(a) Ecological processes of community formation, ecotone, edge effect. Classification of communities - criteria of classification, dynamic system of classification by Clement.

(b) Special plant communities - quantitative, qualitative and synthetic characteristics of plant communities, Sorenson's Index of similarity, coefficient of communities.

(c) Dynamic community characteristics - cyclic replacement changes and cyclic no-replacement changes.

Unit 4: Dynamic Ecology - Ecological succession (6 hrs)

(a) The concept, definition and reasons of succession. Classification of succession: Changes – autogenic and allogenic, primary and secondary, autotrophic and heterotrophic, Models of Succession.

(b) Retrogressive changes or the concept of degradation, concept of climax or stable communities, resilience of communities, ecological balance and survival thresholds.

Unit 5: Biosphere and Ecosystem (5 hrs)

(a) Significance of habitat and niche, niche width and overlap, fundamental and realized niche, resource partitioning, character displacement, biodiversity, trophic level, primary and secondary productivity, food chains, food webs, ecological pyramids, energy flow and nutrient cycles.

(b) Comparative study of the major world ecosystems: Different aquatic and terrestrial ecosystems with regard to their productivity, biodiversity, energy flow, food chains and trophic levels.

Unit 6: Phytogeography (6 hrs)

(a) Definition, principles governing plant distribution, factors affecting plant distribution, theories of distribution, different types of distribution of vegetations on the earth, continuous and discontinuous distribution.

(b) Major terrestrial biomes, theory of Island Biogeography, Climate, vegetation and botanical zones of India.

(c) Remote sensing: Definition and data acquisition techniques. Application of remote sensing in vegetation classification, understanding the key environmental issues and ecosystem management.

Unit 7: Environmental pollution (10 hrs)

(a) Definition and classification.

(b) Water pollution: Water quality parameters and standards, different types of pollutants and their consequences. Types of water pollution, prevention and control - water shed management, waste water treatment. Waste water treatment with aquatic macrophytes.

(c) Air pollution: Air quality standards and index, ambient air monitoring using high volume air sampler, types and sources of air pollutants, air pollution and human health hazards, control of air pollution.

(d) Noise pollution.

(e) Radioactive and thermal pollution: Causes and hazardous effects, effective management.

Unit 8: Environmental biotechnology and solid waste management (6 hrs)

Concept of waste, types and sources of solid wastes including e-waste. Bioremediation, Phytoremediation, bioaugmentation, biofilms, biofilters, bioscrubbers and trickling filters. Use of bioreactors in waste management.

Unit 9: Global environmental problems and climate change (4 hrs)

(a) Global warming, green house gases, acid rain, ozone depletion. Holistic relationship between air water and land pollution.

(b) Factors responsible for climate change, *El-Nino* and *La Nina* phenomenon and its consequences.

(c) Effect of climate change on reproductive biology and biogeography.

(d) Environmental laws, environmental monitoring and bio indicators, environmental safety provisions in Indian constitution, major environmental laws in free India, ISO-14000.

Unit 10: Biodiversity and its conservation (8 hours)

(a) Basic principles of resource management, definition and classification of resources, problems of resource depletion, preservation, conservation and restoration, patterns of resource depletion, resource economics and resource overuse. Indian case studies on conservation/management strategy (Project tiger, Biosphere reserve)

(b) Current biodiversity loss - concept of endemism, rare, endangered and threatened species (RET), key stone species, IUCN account of biodiversity, red data book and hot spots, reasons to stop extinction, methods to save species.

(c) Principles of conservation - *ex-situ* and *in-situ* conservation techniques. Biodiversity conservation: Species diversity, community diversity, ecosystem diversity and landscape preservation. Role of biotechnology in conservation of species.

(d) Ecotourism - positive and negative impacts.

References

1. Ahmedullah M, Nayar M P (1987). *Endemic plants of India*.

2. Apha, Awwa, Wep. *Standard methods for the examination of water and waste water*.

3. Barbour M D, et. al., (1980). *Terrestrial plant ecology.* The Benjamin-Cammings Pub. Com.

4. Benton A H, Werner W E (1976). *Field biology and Ecology*. Tata McGraw Hill.

5. Clarke G L (1954). *Elements of Ecology.* John Wiley Pub.

6. Dash M C (1993). *Fundamentals of Ecology*. Tata McGraw Hill.

7. Eldon D, Enger, Bradley, Smith F (1995). *Environmental Science*. W C Brown publications.

8. *Ecological Guidelines for tropical costal developments*. UNESCO.

9. Furley P A et. al., (1983). *Geography of the biosphere: An introduction to the nature, distribution and*

evolution of the world life zones. Butterworths.

10. IUCN (2000). *The IUCN red list category*. IUCN England.

11. IUCN (2007). *The 2000 IUCN red list of threatened species*. IUCN. England.

12. Jain S K, Sastry A R K (1984). *The Indian plant red data book*. BSI, Calcutta.

13. Jones H G, Vaugham R A. *Remote sensing of vegetation*. Oxford university press.

14. Kormondy E J (Ed) (1965). *Reading in ecology*. Prentice Hall.

15. Kormondy E J (Ed) (1999). *Concept of ecology*. Prentice Hall.

16. Kumar H D (1977). *Modern Concept of Ecology*. Vikas Publication.

17. Michael P (1984). *Ecological methods of field and laboratory investigations*. Tata McGraw Hill.

18. Misra K C. *Manual of plant ecology*. Oxford and IBH Pub. Com. P. Ltd.

19. Odum E P (III Edn) (1991). *Fundamentals of ecology*. Saunders and Com.

PRACTICAL V

ARCHEGONIATAE, PLANT ANATOMY AND ENVIRONMENTAL SCIENCE

(120 hrs, 4 credits)

Bryophytes (20 hrs)

1. Detailed study of the structure of gametophytes and sporophytes of the following genera of bryophytes by suitable micropreparation: *Riccia, Targionia, Cyathodium, Marchantia, Lunularia, Dumortiera, Reboulia, Pallavicinia, Aneura, Fossombronia, Porella, Anthoceros, Notothylas, Sphagnum, Pogonatum.*

2. Students are expected to submit a report of field trip to bryophyte's natural habitats to familiarize with the diversity of Bryophytes.

Pteridophytes (36 hrs)

1. Study of morphology and anatomy of vegetative and reproductive organs using clear whole mounts/sections of the following genera: *Psilotum, Lycopodium, Isoetes, Selaginella, Equisetum, Angiopteris, Ophioglossum, Osmunda, Marsilea, Salvinia, Azolla, Lygodium, Acrostichum, Gleichenia, Pteris, Adiantum, Polypodium and Asplenium.*

2. Study of fossil Pteridophytes with the help of specimens and permanent slides.

3. Field trips to familiarize with the diversity of Pteridophytes in natural habitats.

Gymnosperms (20 hrs)

1. Study of the morphology and anatomy of vegetative and reproductive parts of Cycas, Zamia, Pinus, Cupressus, Agathis, Araucaria and Gnetum.

2. Study of fossil gymnosperms through specimens and permanent slides.

3. Conduct field trips to familiarize various gymnosperms in nature and field identification of Indian gymnosperms and submit a report.

Plant Anatomy (20 hrs)

1. Study of living shoot apices by dissections using aquatic plants such as *Ceratophyllum* and *Hydrilla.*
2. Study of cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant such as *Coleus, Kalanchoe.* Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
3. Study of alternate and distichous, alternate and superposed, opposite and superposed; opposite and decussate leaf arrangement. Examination of rosette plants *(Raphanus, Hyoscyamus* etc) and induction of bolting under natural conditions as well as by GA treatment.
4. Microscopic examination of vertical sections of leaves such as *Nerium,* maize and wheat to understand the internal structure of leaf tissues and trichomes, glands etc. Also study the C3 and 04 leaf anatomy of plants.
5. Study of epidermal peels of leaves such as *Coccinia, Tradescantia* etc. to study the development and final structure of stomata and prepare stomatal index. Demonstration of the effect of ABA on stomatal closure.
6. Study of whole roots in monocots and dicots. Examination of L.S. of root from a permanent preparation to understand the organization of root apical meristem and its derivatives. (use maize, aerial roots of banyan, *Pistia, Jussieua* etc.) Origin of lateral roots. Study of leguminous roots with different types of nodules.

Environmental Science (24 hrs)

1. Analysis of water quality for; (a) Dissolved CO2 (b) Dissolved oxygen (c) COD (d) Total dissolved minerals (e) Quantitative estimation of dissolved chloride ions and dissolved sulphate (f) Total alkalinity.

2. Quantitative estimation of dissolved chloride ions, dissolved sulphate, nitrate and total alkalinity.

2. Physico-chemical analysis of soil: (a) Total water soluble mineral ions (b) estimation of soil organic carbon (Walkey and Black method).

3. Quantitative and qualitative community analysis. Carry out a project on species structure and the frequency, abundance, density of different species and similarity index of different communities in a natural system. Students must be able to explain the structure of vegetation from the given data on the above mentioned characteristics.

4. Phytoplankton counting using Sedgwick Rafter counter.

5. Field visit to natural ecosystem and identification of trophic levels, food webs and food chains, plant diversity (species and community).

6. Students should be aware of the common environmental problems, their consequences and possible solutions.

PRACTICAL - VI

PRINCIPLES OF ANGIOSPERM SYSTEMATICS, TAXONOMY, DEVELOPMENTAL BIOLOGY AND PLANT BREEDING

PRINCIPLES OF ANGIOSPERM SYSTEMATICS AND TAXONOMY (84 hrs)

1. Work out a minimum of two members from each family mentioned in the syllabus with suitable sketches and description in technical terms.

2. Study of local flora, construction of keys and use of floras in the identification up to species.

3. Preparation of dichotomous keys based on 4 sample plant materials from the same family.

4. Workout nomenclatural problems regarding priority and author citations.

5. Students should familiarize with all the economically/ethnobotanically important plants of the families mentioned in the syllabus.

Field study: A field study for not less than 5 days under the guidance and supervision of teachers and preparation of a minimum of 25 herbarium specimens of different categories with supporting field book.

DEVELOPMENTAL BIOLOGY AND PLANT BREEDING (36 hrs)

1) Study of microsporogenesis and gametogenesis in sections of anthers.

2) Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, *Crotolaria, Tradescantia, Brassica, Petunia, Solanum melongena,* etc.).

3) Tests for pollen viability using stains and *in vitro* germination. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture.

4) Estimating percentage and average pollen tube length *in vitro.*

5) Role of transcription and translation inhibitors on pollen germination and pollen tube growth.

6) Pollen storage, pollen-pistil interaction, self-incompatibility, *in vitro* pollination.

7) Study of ovules in cleared preparations; study of monosporic, bisporic and tetrasporic types of embryo sac development thorough examination of permanent, stained serial sections.

8) Field study of several types of flower with different pollination mechanisms (wind pollination, thrips pollination, bee/butterfly pollination, bird pollination).

9) Emasculation, Bagging and Hand Pollination to study pollen germination, seed set and fruit development using self compatible and obligate outcrossing systems.

10) Study of nuclear and cellular endosperm through dissections and staining

11) Isolation of zygotic globular, heart-shaped, torpedo stage and mature embryo from suitable seeds and polyembryony in citrus, Jamun (Syzygium cumini) etc. by dissections

12) Study of seed dormancy and methods of break dormancy

Semester IV

PLANT PHYSIOLOGY

(60 Hrs, Credit 4)

Unit 1: Plant water relations (4 hrs)

Structure and properties of water, Water transport – diffusion, bulk flow, Osmosis – waterpotential, Water absorption by root, pathways of water uptake and transport, xylem and phloem transport, passive and active transport, Aquaporins. Water pathway in the leaf – driving force of transpiration, leaf anatomy for regulating transpiration. Control of stomatal mechanism. Soil-plant-atmosphere continuum.

Unit 2: Absorption of minerals (2 hrs)

Soil characters influencing nutrient availability – size and charge of soil particles, soil pH. Entry of minerals into roots; bulk flow, diffusion. Role of Mycorrhizae in nutrient uptake.

Unit 3: Transport of ions, solutes and macromolecules (5 hrs)

Electrical properties of membranes, Membrane potential. Transport across cell membranes: Passive – diffusion, facilitated diffusion, membrane channels; gap junctions, porins, ion channels – gated channels, structure and working of K+ ion channels. Active transport: Carrier proteins; Na+K+ pump, ABC transporters.

Unit 4: Photosynthesis (12 hrs)

(a) Light harvesting complexes: PS I, PSII; Structure and composition of reaction centers. Basic principles of light absorption, excitation energy transfer, mechanism of electron transport, photooxidation of water, proton electrochemical potential – photophosphorylation. (b) Structure and function of RuBisco, CO2 fixation – Calvin cycle. Photorespiration, role of photorespiration in plants. CO2 concentrating mechanisms – algal and cyanobacterial pumps, C4 cycle, CAM pathway. Photoprotective mechanisms . Synthesis of starch and sucrose, photosynthetic quantum yield and energy conversion efficiency. Transport of photoassimilates – phloem loading and unloading, mechanism of phloem translocation – pressure flow. Thylakoid ET inhibitors, Photoinhibition and its tolerance mechanism.

Unit 5: Respiration (10 hrs)

(a) Three stages of respiratory metabolism (brief study only). Plant mitochondrial electron transport and ATP synthesis – structure of electron transfer complexes (complex I – IV). ATPase – detailed structure of F1 and Fo subunits, binding change mechanism of ATP synthesis. Comparison of mitochondrial and chloroplast ATP synthesis. Cyanide resistant

pathway – alternative oxidase, its regulation and significance. (b) Lipid metabolism in oilseeds – glyoxylate cycle, gluconeogenesis.

Unit 6: Nitrogen metabolism: (5 hrs)

N cycle. N fixation processes. Biological N fixation – structure of nitrogenase complex, reduction of N. Symbiotic N fixation – nodule formation, leghaemoglobin. Nitrate and ammonium assimilation. Transport of amides and ureides.

Unit 7: Stress physiology (5 hrs)

Response of plants to biotic (pathogen and insects) and abiotic (water, temperature – low and high, salt, oxygen deficiency, heavy metal and air pollution) stresses. Mechanisms of resistance to biotic stress and tolerance to abiotic stress.

Unit 8: Sensory photobiology (4 hrs)

Sensory photobiology: History of discovery of phytochromes and cryptochromes, and their photochemical and biochemical properties, photophysiology of light-induced responses, cellular localization, molecular mechanism of action of photomorphogenic receptors, signaling and gene expression. The flowering process: Photoperiodism and its significance, endogenous clock and its regulation, floral induction and development - genetic and molecular analysis, role of vernalization.

Unit 9: Plant growth regulators and elicitors: (13 hrs)

Physiological effects and mechanism of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid, brassinosteroids, polyamines, jasmonic acid and salicylic acid, hormone receptors, signal transduction and gene expression.

References

1. Lincoln Taiz, Eduardo Zeiger (2002). *Plant physiology* (II Edn). Sinaeur Associates, Inc. Publishers.

2. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and molecular biology of plants*. L K International Pvt. Ltd.

3. Reginald H Garrett, Charles M Grisham (2005). *Biochemistry*. Thomson Brooks/Cole

4. H Robert Horton, Laurence A Moran, Raymond S Ochr, J David Rawn, K Gray Scrimgeour (2002). *Principles of Biochemistry* (III Edn). Prentice Hall.

5. Frank B Salisbury, Cleon W Ross (1992). *Plant Physiology* (IV Edn). Wadsworth Publishing Company.

6. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2002). *Molecular biology of the cell* (IV Edn). Garland Science, Taylor and Francis group.

7. Gerald Karp (2008). *Cell and Molecular biology: Concepts and experiments* (V Edn). John Wiley & Sons.

8. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira (2007). *Molecular cell biology* (VI Edn). W H Freeman & Company.

9. William H Elliott, Daphne C Elliott (2001). *Biochemistry and molecular biology* (II Edn). Oxford

10. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman and company.

11. David E Sadava (2009). *Cell biology: Organelle structure and function*. CBS

12. S Sadasivam, A Manickam (1996). *Biochemical methods* (II Edn). New age international Publishers.

Semester IV

Floristics and New Trends in Taxonomy

Floristics: Need and significance of floristic studies, methodology, analysis and data presentation.

Taxonomic literature: General taxonomic indexes, world floras and manuals, monographs and revisions, bibliographies, catalogues, review serials, periodicals, glossaries, dictionaries, cultivated and economic plants, maps and cartography, biographical references, dates of publication, location of type specimens, dictionaries and addresses, color charts, outstanding botanical libraries.

Herbarium and botanical gardens: Herbarium as a store house of plants and plant information, its role in research and teaching; Botanical and experimental gardens and their role in teaching, training and conservation of plants. Important Herbaria and Botanical Gardens of the world and India.

Botanical keys: Diagnostic, synoptic and artificial keys-Single access (sequential)-bracketed and indented keys and multi-access keys- edgepunched and body-punched(polyclave) keys, tabular and lateral keys; computerized keys, their merits and demerits.

History of botanical exploration in india: Beginning of botany in India, contributions made in earlier phase by Garcia d'Orta, C. acosta, Van Rheede, John Burman, John Koenig, Robert kid, Buchnan, Roxbugh, N. Wallich, William Griffith, Robert Wight, Thomas Thomson, J. D. Hooker and recent phase by Collet, Brandis, T. Cooke, Duthie, Fyson, Gamble, Haines, Parkinson, Prain, Santapau, and present works with special emphasis on Maharashtra. Botanical Survey of India (BSI).

Embryology in relation to taxonomy: Embryological characters of taxonomic importance, utilisation of embryological data in solving taxonomic problems at different levels.

Anatomy in relation to taxonomy:Vegetative, wood and floral anatomy, anatomical characters of taxonomic importance, use of anatomical data in understanding interrelationship and evolution of angiosperms and solving taxonomic problems.

Palynotaxonomy: Pollen morphology- Polarity, symmetry, NPC of pollen, exine stratification, excrescences, L/O pattern, palynogram; pollen characters of taxonomic importance.

Phytogeography, Ecology, Genetics And Taxonomy: Phytogeography and speciation; adaptations, ecological variations, genetic variations and plant systematics.

Numerical Taxonomy: Phenetic methods in taxonomy [Taxometrics]: principles, construction of taxonomic groups, OUTs, unit characters, character coding, measurement of resemblances, cluster analysis, phenons and ranks, discrimination, nomenclature and numerical taxonomy, applications, merits and demerits. Cladastics and cladogram, parsimony analysis, cladastics and classification.

Cytotaxonomy: Chromosome number, Basic chromosome number, polyploidy, aneuploidy, chromosome morphology, karyotype, chromosome banding, meiotic analysis and plant systematics, scope and limitations.

Chemotaxonomy: Origin of chemotaxonomy, classes of compounds and their biological significance, Stages in chemotaxonomic investigations, techniques,Use of chemical criteria in plant taxonomy; Proteins and taxonomy: seed proteins, techniques of protein electrophoresis, chemical protein analysis procedures, analysis of aminoacid sequence and its significance in systematics; serology and taxonomy: history, precipitation reaction, techniques, antigen, antisera antibody, application of serological data in systematics.

Ultrastructural Systematics: SEM and TEM studies and plant systematics; SEM and plant surface stucture, TEM and dilated cisterneae of endoplasmic reticulum and sieve element plastids, applications of data in the classification of higher taxa.

Molecular Systematics: Molecular diagnostic tools, restriction fragment length polymorphism (RFLP's), Random amplified polymorphic DNA (RAPD), Polymerage chain reaction (PCR) analysis, specific applications of RAPD in molecular systematics. Molecular data and systematic position of Hydatellaceae.

Morphological variations, Systematic Position, Interelationships, Phylogeny and Economic Importance Of Following Families:

Gentianaceae, Cuscutaceae, Boraginaceae, Plantaginaceae, Lentibulariaceae, Lobeliaceae, Asteraceae, Costaceae, Pontederiaceae, Dioscoriaceae, Burmanniaceae, Orchidaceae.

MBOT451A- PRACTICAL VII- PLANT PHYSIOLOGY, PLANT BIOTECHNOLOGY, FLORISTICS AND NEW TRENDS IN TAXONOMY

Plant Physiology

1. Measurement of Photosynthesis - Hill Reaction.

2. Estimation of proline in plant tissues under various abiotic stresses

3. Estimation of phenol in plant tissues affected by biotic stress

4. Determination of peroxidase activity in plant tissues affected by biotic/abiotic stresses

5. Estimation of free amino acids in senescing leaves to understand the source to sink transformation phenomenon

6. Determination of osmotic potential by tissue weight method.

7. Separation of photosynthetic pigments by TLC/paper chromatography and calculating the Rf value

8. Demonstration of amylase activity and GA effect in germinating cereal seeds.

9. Estimation of total chlorophyll and study of absorption pattern of chlorophyll solution

10. Separation and collection of leaf pigments by silica gel column chromatography.

11. Determination of nitrate reductase activity.

12. Extraction and estimation of leghaemoglobin from root nodules.

13. Separation of isozymes of esterases, peroxidases by native polyacrylamide gel electrophoresis.

14. Preparation of the standard curve of protein (BSA) and estimation of the protein content in extracts of plant material by Lowry's or Bradford's method.

FLORISTICS AND NEW TRENDS IN TAXONOMY

Unit-I

• Microtome technique for study of embryological characters

• Study of wood character, vessels, storied and nonstoried wood

• Semipermanent pollen preparations by acetolysis method and study of

different pollen morphotypes.

• Study of chomosomes, chromosome banding and Karyotype analysis

• Interpretation of flavonoid data for taxonomy using PC/TLC / protein profile analysis

Unit-II

• Practical based on numerical taxonomy

• Study of plant surface attributes with the help of SEM photographs and sieve tube plastid and dilated cisternae of endoplasmic reticulum with the help of TEM photographs

• Descriptions, Sketching, classification and identification of families: Gentianaceae, Cuscutaceae, Boraginaceae, Plantaginaceae, Lentibulariaceae, Lobeliaceae, Asteraceae, Costaceae, Pontederiaceae, Dioscoriaceae, Burmanniaceae, Orchidaceae and identification of wild and cultivated plants represented in local flora..

References

- Bhojwani, S. S. and Bhatnagar, S. P. 1984. Embryology of Angiosperms. Vikas Publ. House, New Dehli.
- Cronquist, A. 1988. The Evolution and Classification of Flowering Plants (2nd ed.)
- Allen Press, U.S.A. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
- Davis, P. H. and V. H. Heywood 1991. Principles of Angiosperm Taxonomy. Today and Tommorow Publications, New Delhi.

- Judd Walter S., Cmpbell C. S., Kollogg, E. A., Stevens P.F. and M. J. Donoghue 2008. Plant Systematics. Sinauer Associates, INC,Publishers.Sunderland, Massachusetts, USA.