ASSAM UNIVERSITY: SILLCHAR
Department of Life Science & Bioinformatics
[M. Sc. Programme under CBCS]
COURSE STRUCTURE
(Effective from January 2021)

Paper	Paper Title	Type	Marks allotted			Credits
			Internal	External	Total	
Semester I						
LS 101	Genetics and molecular biology	Theory	30	70	100	6
LS 102	Cell biology and immunology	Theory	30	70	100	6
LS 103	Biochemistry	Theory	30	70	100	6
LS 104	Environment & conservation biology	Theory	30	70	100	6
LS 105	Practical – I	Practical	30	70	100	3
LS 106	Practical – II	Practical	30	70	100	3
Total					**600**	**30**
Semester II						
LS 201	Microbiology	Theory	30	70	100	6
LS 202	Techniques in biology	Theory	30	70	100	6
LS 203	Concepts in biological science*	Theory	30	70	100	6
LS 204	Biotechnology	Theory	30	70	100	6
LS 205	Practical – III	Practical	30	70	100	3
LS 206	Practical – IV	Practical	30	70	100	3
Total					**600**	**30**
Semester III (Botany)						
LS 301(B)	Plant physiology	Theory	30	70	100	6
LS 302(B)	Morphology, Differentiation and Systematic Botany	Theory	30	70	100	6
LS 303(B)	Plant diversity	Theory	30	70	100	6
LS 304(B) (Optional)	A. Microbial ecology	Theory	30	70	100	6
	B. Angiosperm Taxonomy, Biosystematics & Molecular Phylogenetics					
	C. Phytochemistry and computational drug designing					

	D. Microbial Biotechnology					
LS 305(B)	Practical - I	Practical	30	70	100	3
LS 306(B)	Practical – II (Optional) A. Microbial ecology B. Angiosperm Taxonomy, Biosystematics & Molecular Phylogenetics C. Phytochemistry and computational drug designing D. Microbial Biotechnology	Practical	30	70	100	3
Total					**600**	**30**
Semester III (Zoology)						
LS 301(Z)	Molecular endocrinology	Theory	30	70	100	6
LS 302(Z)	Applied biology	Theory	30	70	100	6
LS 303(Z)	Evolution and behaviour	Theory	30	70	100	6
LS 304(Z) (Optional)	A. Molecular genetics B. Molecular and cellular biochemistry C. Molecular cell biology	Theory	30	70	100	6
LS 305(Z)	Practical - I	Practical	30	70	100	3
LS 306(Z)	Practical – II (Optional) A. Molecular genetics B. Molecular and cellular biochemistry C. Molecular cell biology	Practical	30	70	100	3
Total					**600**	**30**
Semester IV (Botany)						
LS 401(B)	Mycology and plant pathology	Theory	30	70	100	6
LS 402(B)	Molecular genetics and plant breeding	Theory	30	70	100	6
LS 403(B)	Advanced plant biology	Theory	30	70	100	6
LS 404(B)	Projects (Dissertation)	Project	60	140	200	12
Total					**500**	**30**
Semester IV (Zoology)						
LS 401(Z)	Environmental Monitoring and assessment	Theory	30	70	100	6
LS 402(Z)	Animal physiology	Theory	30	70	100	6
LS 403(Z)	Developmental biology	Theory	30	70	100	6
LS 404(Z)	Project (Dissertation)	Project	60	140	200	6
Total					**500**	**30**
GRAND TOTAL					**2300**	**120**

SEMESTER – I

LS 101: Genetics and Molecular Biology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Chromosome inheritance)

1. Mendelian principles : Dominance, segregation, independent assortment, pleiotropy, genomic imprinting, phenocopy, linkage and crossing over, sex linkage
2. Concept of gene : Allele, multiple alleles, pseudoallele, complementation tests, Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.
3. Extra chromosomal inheritance: Mitochondrial and chloroplast genes. Chromosomes deletion, duplication, inversion, translocation, ploidy.
4. Mutation types, causes and detection, mutant types, lethal, conditional, biochemical, loss and gain of function, germinal verses somatic mutants, insertional mutagenesis.

Unit-II: (Genetic inheritance)

1. Microbial genetics: Methods of genetic transfers, transformation, conjugation, transduction, mapping genes by interrupted mating, fine structure analysis of genes.
2. Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders. Polygenic inheritance, heritability, QTL mapping.
3. The genomes of bacteria, viruses, plasmids; conjugation, transformation, transduction
4. Homologous and non-homologous recombination including transposition.

Unit – III: (Fundamental structure)

1. Structure of nucleic acids: double helical structure of DNA, right handed and left handed structure of DNA, RNA
2. DNA replication: DNA polymerase, replication in prokaryotes and eukaryotes.
3. Genetic code: deciphering the code and preparation of genetic code dictionary, exception to the universality of genetic code.
4. DNA damage and Repair: Mutations – Spontaneous and induced, mechanisms

Unit – IV: (DNA biology)

1. DNA replication, repair and recombination: replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination.
2. RNA synthesis and processing: transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport.
3. Protein synthesis and processing: Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination,

genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors

4. Post- translational modification of proteins.

Unit – V: (Gene regulation)

1. Control of gene expression at transcription and translation level: regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing.
2. Cancer**:** Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis
3. Therapeutic interventions of uncontrolled cell growth.
4. Bioethics: Dos and donts in modern biology, ethical limitation, copyright information,

LS – 101: Suggested Readings:

1. Lodish Molecular Cell Biology
2. Brown Genome (Gen),
3. Friedfelder, D. Molecular Biology, 4th Edition, Jones and Barlett Pub. Inc., USA.
4. Karp,. Cell and Molecular Biology,
5. Genes IX (2007 or later);Benjamin Lewin
6. Alberts-Molecular Biology of the Cell
7. Thrope, B. -Cell Biology, John Willey and Sons, USA.
8. Gardner, E.J. and Saastad, D.P.- Principles of Genetics, 7th Edition,
9. Wollff (ed.). Gene Therapeutics, Researchco Book Center.
10. Daniell L.Hartl & et al ;Genetics,6th edition
11. Benjamin Lewin; Essential Genes

LS 102: Cell Biology & Immunology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Fundamental cell)

1. Structure and differences between prokaryotic and eukaryotic cells.
2. Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.
3. Structural organization and function of intracellular organelles**:** Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.

Unit – II: (Cell structure and cycle)

1. Cytoskeleton: Cell junction and cell adhesion, molecular organization of microtubules, microfilaments and intermediary filaments. Vesicular trafficking: secretory and endocytotic pathway.
2. Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle in yeast and multicellular organism.
3. Microbial Physiology: Growth yield and characteristics, strategies of cell division, stress response.

Unit – III: (Cell communication)

1. Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells.
2. Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component systems, light signaling in plants, bacterial chemotaxis and quorum sensing.
3. Cellular communication: Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.
4. Concept of apoptosis

Unit – IV: (Basic immunology)

1. Basic Elements of the Immune System: Exterior defenses to infection (Skin & mucosal surface, Physiological Barriers, Phagocytic barriers, Inflammation); Innate and adaptive immune system.
2. Cellular (Lymphocytes, Phagocytes, Auxillary cells and others) and Humoral components of the immune system

3. Adaptive Immune System: Primary and secondary lymphoid organs; Lymphocyte heterogeneity - concept of T cell and B cell, Natural Killer cells; Antigens - Structure, properites, types, Epitopes, Haptens
4. Antigen Receptor Molecules: Immunoglobulins (B-cell antigen receptor)- Structure, classes and biological activities; Genetic basis of antibody heterogeneity – Isotypic, Allotypic and Idiotypic variations; T-cell antigen receptor (TCR); Major Histocompatibility Complex (MHC) – Class I and Class II molecules; HLA

Unit – V: (Advanced immunology)

1. Immune Effector Mechanisms: Lymphocyte activation, Antigen presentation, Clonal selection, Immunological memory; Antigen Recognition: Antigen-antibody binding, kinetics, specificity - Affinity and Avidity; monoclonal antibody; Cell-mediated immune reactions
2. Cytokines and Lymphokines: interleukins, interferons, TNF, CSF. Complement system: classical and alternate pathway of activation;
3. Immuno Pathology: Basic ideas about Transplantation and autoimmunity; Immunodeficiency and AIDS; Hypersensitive reactions (Type I, II, III and delayed type (DTH); Acquired immunity –Vaccines

LS – 102: Suggested Readings:

1. Bruce Alberts et al.- Molecular Biology of the Cell
2. Ivan Roit et al. – Immunology
3. Brnjamin lewin – Genes IX
4. Lodish Molecular Cell Biology
5. A.L. Lehninger – Principles of Biochemistry
6. Friedfelder, D. Molecular Biology, 4th Edition, Jones and Barlett Pub. Inc., USA.
7. Karp,. Cell and Molecular Biology,
8. Thrope, B. -Cell Biology, John Willey and Sons, USA.
9. Gardner, E.J. and Saastad, D.P.- Principles of Genetics
10. Wollff (ed.). Gene Therapeutics, Researchco Book Center.
11. Daniell L.Hartl & et al ;Genetics,6th edition
12. Benjamin Lewin; Essential Genes

LS 103: Biochemistry

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Molecular interactions)

1. Introduction to Biochemistry and biomolecules; Structure of atoms, molecules and chemical bonds.
2. Stabilizing interactions: covalent bonds, hydrogen bonds, van der Waals interactions, hydrophilic and hydrophobic interactions
3. Biophysical properties, Water as a solvent; Ionization of acids, bases, pH, buffer, reaction kinetics, thermodynamics, colligative properties
4. Concept of free energy, entropy, enthalpy and Basic Biological reactions

Unit – II: (Proteins and enzymes)

1. Proteins Structure functions: structures of proteins. Ramachandran plot
2. Enzymes: Chemical nature, Nomenclature and classification; coenzymes
3. Mechanism of Enzyme Action: Effects of substrate, temperature, pH and inhibitors on enzyme activity and stability.
4. Enzyme kinetics: Concept of Km and Vmax - Michaelis-Menten equation, Lineweaver-Burk plot and Enzyme inhibition

Unit – III: (Carbohydrates and lipids)

1. Lipids structure functions: fatty acids, and glycerides, phospholipids sterols.
2. Carbohydrate metabolism: glycolysis, TCA cycle, pentose phosphate pathway
3. Oxidation of fatty acids
4. Electron transport system -oxidative phosphorylation, mitochondrial respiratory complexes and supercomplexes

Unit – IV: (Plant biochemistry-I)

1. Photosynthesis**:** Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO2 fixation, C3 and CAM pathways; Photorespiration.
2. Nitrogen metabolism: Nitrate reduction and ammonium assimilation.
3. Plant hormones: structure and function.
4. Secondary metabolites: structure and function

Unit – V: (Plant Biochemistry-II)

1. Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins
2. Photoperiodism and biological clocks, flower development.
3. Signal communication in plants
4. Plant signaling during development and stress.

LS - 103: Suggested Readings:

1. Mazur, A. (2002). A Text Book of Biochemistry, Benjamin Harrow, Toppan Co. Ltd., Japan.
2. Campbell, (1998). Biochemistry, Purnima Book Distributors, New Delhi.
3. Stryer, L. (2005). Biochemistry.
4. Hans- Walter Heldt (2005) Plant Biochemistry , Academic Press
5. Lehninger Albert L., Cox, Michael M. and Nelson, David L. (2008) Principles of Biochemistry, W.H. Freeman & Co.
6. Alexander, R.R. and Criffithn, J.M. (1992). Basic Biochemical Methods, John Willey and Sons, Singapore.
7. Buchanan B, Gruissem, W and Jones, R. (2002) Biochemistry & Molecular Biology of Plants, Wiley.
8. Lewin, B. (1996). Genes VI, Panima Eds,., Agency, New Delhi.

LS 104: Environment and Conservation Biology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Organization & taxonomy)

1. Levels of structural organization: Unicellular, colonial and multicellular forms. Levels of organization of tissues, organs & systems. Comparative anatomy, adaptive radiation, adaptive modifications.
2. Principles & methods of taxonomy: Concepts of species and hierarchical taxa, biological nomenclature, classical & quantititative methods of taxonomy of plants, animals and microorganisms.
3. Outline classification of plants, animals & microorganisms: Important criteria used for classification in each taxon.
4. Evolutionary relationships among taxa.

Unit – II: (Environmental biology)

1. The Environment: Physical environment; biotic environment; biotic and abiotic interactions.
2. Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
3. Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
4. Population Ecology: Characteristics, growth curves and regulation of a population; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic, age structured populations.

Unit – III: (Ecology)

1. Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.
2. Natural history of Indian subcontinent: Major habitat types of the subcontinent, geographic origins and migrations of species. Common Indian mammals, birds. Seasonality and phenology of the subcontinent.
3. Concept of an ecosystem: Ecosystem and its structural components - Abiotic and Biotic components, Productivity and Energy flow, Lindemann's concept of Community dynamics, Ecological succession- Ecosystem stability, climax community
4. Levels of Organisations: Biosphere organizaton, Emergence theory, Liebig's Law of minimum; Leibig-Blackman concept of Limiting factors, Shelford's Law of Toleranc

Unit – IV: (Applied ecology)

1. Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
2. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.

3. Ecosystem Ecology: Ecosystem structure; ecosystem function; energy flow and mineral cycling (C,N,P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).
4. Applied Ecology: Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change and management approaches.

Unit – V: (Conservation Biology)

1. Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).
2. Organisms of conservation concern: Rare, endangered species. Conservation strategies. Organisms of health & agricultural importance (Common parasites and pathogens of humans, domestic animals and crops).
3. Concept of sustainability: Wetlands and Fisheries management and conservation with special emphasis on North-East India
4. Biodiversity Conventions and Acts: Application of Remote Sensing in biodiversity assessment.

LS 104: Suggested Readings:

1. Daubenmire, R. (1974). Plants and Environment, John Wiley and Sons
2. Kormondy, E.J. (1978). Concepts of Ecology, Prentice Hall of India
3. Odum, E.P. (1971). Fundamentals of Ecology, W.B. Saunders, Philadelphia
4. Whittaker, R.H. (1975). Communities and Ecosystems, McMillsn
5. Grime, J.P. (1979). Plant strategies and Ecosystem Processes, John Wiley and Sons
6. Mishra, R. (1968). Ecology Workbook, Oxford and IBH (New Delhi).
7. Smith, W.H. (1981). Air pollution and Forests, Springer Verlag (New York).
8. Weaver, J.E. and Clements, F.E. (1983). Plant Ecology, McGraw Hill (USA).
9. Freeman, B. (1989). Environmental Ecology, Academic Press (UK).

LS 105: Practical I

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Good Laboratory Practices (GLP)
2. Basic concepts on pH and buffers
3. Concept of molarity and normality, Preparation of fixative, stains and solutions of different strength
4. Estimation of DNA by Diphenyleamine reagent
5. Estimation of RNA by Orcinol reagent
6. Estimation of sugars using Anthrone reagent
7. Estimation of amino acids using Ninhydrine reagent
8. Estimation of soluble proteins by Follin-phenol reagent
9. Estimation of nitrate nitrogen by Bruicine reaction
10. Separation and identification of sugars, amino acids and phenolics by paper and thin layer chromatography
11. Effect of temperature, pH and substrate concentration on enzyme activity
12. Estimation of cholesterol contents in biological material

LS 106: Practical II

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Study of Mitosis in onion root tip.
2. Study of Meiosis in grasshopper/ sand hopper testis
3. Preparation of salivary gland polytene chromosome from Drosophila/Chironomous larva
4. Study of micronucleus in mouse/fish/bird induced by any mutagen
5. Study of lymphocytes and monocytes from blood smears of human/mouse
6. Determination of blood group
7. Demonstration of antigen-antibody reaction in agarose gel
8. Determination of Leaf Area Index of Plant community
9. Estimation of Plant population by quadrate method on land and in water
10. Determination of pH, turbidity, transparency, conductivity of water
11. Estimation of Dissolved oxygen (DO), Phosphate and Nitrate in water
12. Determination of Chlorophyll content in plants

SEMESTER – II

LS 201: Microbiology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Microbial History)

1. History of microbiology: Theory of spontaneous generation. Experiments Of Pasteur and Tyndall, Koch's Postulates, bacteria isolation form natural sample column, Control of Microbial growth methods a sterilization
2. Role of bacteria in human welfare: Biological concepts, Immunization (Pasteur experiment Antibiosis), (penicillin story), Griffith's experiment Avery and McCarty's experiment, Experiment with viruses
3. Changing concepts in microbiology taxonomy, Earlier systems, Molecular taxonomy, Jackard's similarly coefficients

Unit – II: (Cell organization)

1. The Microbial cell: General organization of cell, Prokaryotes Eukaryotes and Archaea, Cell wall organization on Prokaryotes, Eukaryotes and Archaea, Cell surface appendage spilli, locomotion by flagella chemotactic Movement, Peptidoglycan synthesis inhibitors in different steps
2. Metabolic Pathways: Metabolic versatility of microbes, Anaerobic Carbon metabolism: Anaerobic respiration, Sulphate respiration, Reference to glycolysis, Putrefaction
3. Methane oxidizing and Methanogenic bacteria, Aerobic Carbon metabolism : TCA cycle alternative metabolic pathways

Unit –III: (Viruses and Microbial genetics)

1. Nomenclature and classification of viruses; multiplication and transmission of viruses; and control measures.
2. Viral diseases with reference to encephalitis, hepatitis, AIDS, rabies and foot and mouth diseases.
3. Microbial genes and genomes. Modes of genetic exchange in microbes, Transformation, Transduction, Conjugation, Evolutionary Significance

Unit – IV: (Secondary metabolism)

1. Energy Metabolism: Chemo autotrophs, Hydrogen bacteria, Phototrophic bacteria/Cyanobacteria
2. Microbes in Extreme Environment: The basis of extremophiles and their applications, Life of a thermophile (Thermus, Pyrococcus)
3. Important Secondary metabolites from microbes (Antibiotics, Amino Acids, Biofuels etc)

Unit – V: (Agricultural microbiology)

1. Microbes and Agriculture: Symbiotic Nitrogen fixation Rhizobium, Cyanobacteria (Anabaena, Azolla etc.), Mycorrihiza
2. Clinical Microbiology: Survey of disease causing microbes, Mechanisms of Pathogenesis, Antibiotics and their targets, Immune response elicited by microorganisms
3. Environmental Microbiology: Nature of anthropogenic wastes, Municipal wastes and xenobiotics, Enrichment cultures, Xenobiotic degrading consortia, Bioremediation

LS – 201: Suggested Readings:

1. Lansing M. Prescott. Microbiology, McGraw Hill
2. Brande, A.T. (ed). Microbiology, W.B. Saunders Co.
3. Gebhartt, L.P. and Nicholas, P.S. Microbiology.
4. Rosenberg, E.R. and Cohen, I.R. Microbial Biology, Saunders College Publishing, USA.
5. Modi. Elementary Microbiology, Vol I & II, Panima Book Distributors, New Delhi.
6. Baynet, W. The Genetics of Bacteria and the Viruses.
7. Kelly, D.P. and Carz, N.C.. The Microbe, part II, The Prokaryotes, Cambridge University Press, UK.
8. Dawes and Sautherland. Microbial Physiology, Research Book Center, New Delhi.
9. Malaya, S.R. Microbial Genetics (2nd ed), Panima Publisher, New Delhi.
10. Frazier, M. Food Microbiology, Panima Publisher, New Delhi.

LS 202: Techniques in Biology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Microscopy)

1. Electron microscopy: Visulization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells
2. Instrumentation and working principle of SEM & TEM, Image formation process, optimum resolution. Different fixation and staining techniques for EM, freeze-etch and freeze- fracture methods for EM,
3. Principle and applications of fluorescence and phase contrast microscopy. image processing methods in microscopy, Confocal Laser Scanning Microscopy & Atomic Force Microscopy

Unit –II: (Biophysics and chromatography)

1. Chromatography: Thin layer, adsorption, partition, ion exchange, gel filtration and affinity.
2. Principles and applications of Mass Spectrometry, GC-MS and HPLC.
3. Principles and applications of differential and density gradient centrifugation.
4. Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR, Molecular structure determination using X-ray diffraction and NMR.

Unit – III: (Nucleic acids and proteins)

1. Isolation, purification and analysis of DNA, RNA and proteins (Southern, Northern and western Blotting; EMSA, SDS-PAGE, gradient gel, isoelectric focussing).
2. In vitro mutagenesis and detetion techniques, gene knock out in bacterial and eukaryotic organisms. DNA sequencing methods, strategies for genome sequencing.
3. Global analysis of gene expression: concepts of transcriptomics (microarray) and proteomics.
4. Primer, PCR, RT-PCR, RFLP, RAPD and AFLP techniques

Unit – IV: (Statistical methods)

1. Importance and scope of statistical method; Common statistical terms: population, sample, variables, data, statistic and parameters; sampling methods and sampling bias; methods of data collection and presentation : (frequency distribution, histogram, polygon, ogive curves and pie diagram)
2. Descriptive statistics: (i) Shape of data – Skewness and curtois, normal distribution (ii) Location of data – measures of central tendency (man, median, mode, quartiles), (iii) Dispersion of data (Measures of variability) – variance, standard deviation, coefficient of variation and standard error
3. Inferential statistics: Testing hypothesis - Chi-square test, t-test, Z-test and F-test, levels of significance
4. Inferential statistics: Analysis of variance (ANOVA); Correlation - positive and negative correlation, co-efficient of correlation; Linear regression and regression equation

Unit – V: (Immunological methods)

1. Immunological techniques: Antibody generation Immuno diffusion, immune-precipitation, direct and indirect immunoassay (ELISA)
2. Radiolabelling techniques: Properties of different types of radioisotopes, detection and measurement of radioactivity (scintillation counter, autoradiography), application of radioisotopes in biological samples
3. Radio receptor assay, Radio immune assay (RIA)
4. Detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

LS – 202: Suggested Readings:

1. Bisen, P.S. Tools and Techniques in Life Sciences, World Book Enterprise, New Delhi.
2. Sharma, V.K. Techniques in Microscopes and Cell Biology, World Book Enterprise, New Delhi.
3. Cell Biology: Essential Techniques. Rickwood and Harris Researchco Book Center, New Delhi.
4. Ralph, R. Methods in Experimental Biology, International Book Distributors, 9/3, Rajpur Road, 1st Floor, Dehradun – 1.
5. Swarup, H. Laboratory Techniques in Modern Biology, International Book Distributors, Dehradun.
6. Patel, D. Gel Electrophoresis: Essential Data, John Willey and Sons, Singapore.

LS 203: Concepts in Biological Science (Open Choice Paper)

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Basic biology)

1. Origin of life, evolution of biomolecules.
2. Concepts of species and hierarchical taxa. Levels of organization of tissues, organs and systems
3. Diversity and basic classification of plants, animals and micro-organisms
4. Biological nomenclature and code

Unit – II: (Evolutionary thoughts)

1. Lamarckian concept of evolution: Lamarkism
2. Darwin's theory of evolution: concepts of variation, adaptation, struggle, fitness and natural selection
3. Elemental forces of evolution: mutations
4. Modern synthetic theory of evolution

Unit –III: (Developmental biology)

1. Gametogenesis: Spermatogenesis and oogenesis, Fertilization: Sperm egg interaction and acrosomal reaction
2. Fusion of gametes and egg activation. Cleavage: Types of eggs; overview of types of cleavage
3. Microsporogenesis and megasporogenesis
4. Development of male and female gametophytes; double fertilization, polyembryoni and apomixis

Unit –IV: (Physiology of life process)

1. Osmotic and water potential. Aquaporins; Translocation of mineral salts
2. Photosynthesis - Mechanisms of photophosphorylation in thylakoid membranes, CO2 fixation; Photorespiration and its significance.
3. An overview of hemopoiesis and structure of hemoglobin
4. Gaseous exchange and transport in blood.

Unit –V: (Cell signaling)

1. Plant Signal transduction in relation to Sugar Signaling in Growth and Development
2. Plant stress and cell signaling; Senescence and programmed cell death (PCD) in Plants; Reactive Oxygen species (ROS) signaling in Plants
3. Hormone receptors
4. Mechanism of hormone action: Second messenger; mediated cell signaling

LS – 203: Suggested Readings:

1. The greatest show on earth by Richard dawkins
2. Organic evolution by Rastogi

3. Gilbert, S. F.. Developmental Biology (8th ed.), Sinaur Associates Inc., Sautherland.
4. Berrill, N.J. Developmental Biology, McGraw Hill Book Co., USA.
5. Taiz, L. and Zeiger E. (2010) Plant Physiology
6. Baluska F. and Mancuso, S. (2009) Signaling in Plants, Springer,
7. Leopod, A.C. and Kreidman, P.E. (1980). Plant Growth and Development.
8. Witherperson, J.D. (1984). Human Physiology, Harper and Row, USA.
9. Weddington, C.H.C. (1985). Principles of Development and Differentiation.
10. Plant Abiotic Stress (2005)- Mathew A Zenks & P.M.hasegawa, Blackwell Publishing
11. Panda, S.K. (2002)(ed): Adv. Stress Physiology of Plants

LS 204: Biotechnology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Recombinant DNA technology)

1. Restriction endonucleases (types and characteristics); Cloning vectors- plasmids, phages, phagemids, cosmids, artificial chromosome vectors; Methods of gene transfer
2. Recombinant DNA techniques, cDNA and genomic library, Gene cloning, Methods of gene transfer.
3. Application of recombinant DNA technology - Production of recombinant insulin; Gene therapy

Unit –II: (Animal cell culture technology)

1. Minimal requirement for animal cell culture; Balanced salt solutions and growth medium- physicochemical properties of different culture media.
2. Primary cell culture- cell lines and their maintenance, monolayer and suspension culture; Stem cells culture and their applications.
3. Transgenic animals and its application; Hybridoma Technology

Unit –III: (Plant tissue culture technology)

1. Plant tissue culture media; Initiation and maintenance of callus and suspension cultures; Single cell clone
2. Protoplast culture and somatic hybridization, selection of hybrids; Production of haploids and their utilization; Somaclonal and gametoclonal variations
3. Embryo culture and embryo rescue: Cryopreservation and germplasm conservation
4. Plant genetic engineering: Various methods of gene delivery into Plants, generation and applications of transgenic plants

Unit –III: (Microbial technology)

1. Growth and nutrition : Growth kinetics, Batch an continuous cultures, Nutritional classification of microorganisms, Nutritional uptake by microorganisms (C.N.P)
2. Fermentation: media; sterilization; batch, fed and continuous fermentation; control of bioprocess parameters.
3. Industrial enzymes; Enzyme and cell immobilization-its applications; organic acids production, antibiotics, amino acids and vitamins
4. Microbial food production: Cheese, bread, beer and beverages; Production of single cell protein

Unit – V: (Bioinformatics)

1. Introduction to bioinformatics: Data mining, classification, clustering.
2. Bioinformatics Softwares: Clustal W 1.7, RasMol, Treeview, Alscript, Genetic Analysis Software, Mega, Hex, Auto dock.

3. Nucleotide sequence submission methods and tools (sequin, sakura, bankit), Sequence file formats and conversion tools
4. Entrez, Sequence retrieval system (SRS), Protein identification resource (PIR), Swiss-prot, Expassy. Basics of molecular docking, drug likeliness study.

LS – 204: Suggested Readings:

1. Fogarty, et al. Microbial Enzymes and Biotechnology, Researchco Book Center, New Delhi.
2. Roberta H Smith (2012) Plant Tissue culture- Techniques and Experiments
3. John H. Dodds Ed. (2012) Plant Genetic Engineering, Cambridge University Press
4. H. Jones and John M. Walker, Plant Gene Transfer and Expression Protocols: Methods in Molecular Biology, 49, Humana Press
5. Baxevanis, B. F. F. Ouellette, Bioinformatics – A practical Guide to the analysis of Genes and Proteins, 2nd Ed, John Wiley and Sons Inc., 2001.
6. Wilseman, A. (ed). Principles of Biotechnology, Chapman and Hall, New York.
7. Rajendra, P. Molecular Biology and Biotechnology, World Book Enterprise, New Delhi.
8. M. J. Crispeels and D. E.Sadava, Plants, Genes and Crop Biotechnology, 2nd Ed, Jones and Bartlett Publishers,
9. Bhowjwani S.S. Elsevier, Plant Tissue Culture: Application and Limitations, Amsterdam,
10. Rajaraman, V. (1983). Comparative Programming in FORTAN IV, Prentice Hall of India, New Delhi.

LS 205: Practical - I

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Graphical representation of data, histograms and frequency curve.
2. Descriptive statistics of distribution mean, median, mode, variance, standard deviation, skewness, kurtosis.
3. Application of chi-square test, contingency tables with Yates correlation.
4. Application of analysis of variance.
5. Acquaintance and demonstration of the functioning of major instruments used in biology.
6. Preliminary knowledge of basic quality control measures and aseptic techniques in tissue culture.
7. Plant and Animal tissue culture media and their preparation.
8. Raising of plants by tissue culture (shoot, leaf, root, apices).
9. Biotransformation of cellulose and production of ethanol
10. Elctrophoresis and restriction analysis of Plant based vectors

LS 206: Practical - II

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Calibration of microscope and measurement of dimension of microbial cells.
2. Staining of microorganisms: single staining, double staining (Gram's reaction), staining of specific cell structure.
3. Preparation of culture media and sterilization.
4. Isolation of pure and exenic culture of microbes
5. Quantitative enumeration of microorganisma from various habitats (e.g., soil, air, water, food, sewage).
6. Growth of microorganisms in batch culture and calculation of specific growth rate and generation time.
7. Measurement of antibiotic sensitivity using absorbent disc.
8. Bacteriophage isolation and characterization by plaque method.
9. Study of food spoilage by microbes and isolation of the microbes.
10. Microbial assay for amino acids and antibiotics, study of food spoilage by microbes, study of fermentation by microbes Gametogenesis: Spermatogenesis and oogenesis, Fertilization: Sperm egg interaction and acrosomal reaction
11. Prevention of polyspermy, Fusion of gametes and egg activation
12. Cleavage: Types of eggs; overview of types of cleavage, Gastrulation in insects, amphibians, birds and mammals
13. Origin of ectoderm, mesoderm and endoderm.
14. Mechanism of cell movement during gastrulation.

BOTANY – III

LS 301 (B): Plant Physiology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit-I:

1. Water relation in plants: Properties of water, Osmotic and water potential, transpiration, stomatal physiology.Signal transdution in guard cell.
2. Aquaporins and plant hydraulic conductivity
3. Translocation of ions, solutes and macromolecules from soil, Apoplastic and symplastic transport mechanisms, passive and active transports, structure-function relationship of inward and outward ion channels, dual action of ATPases/pumps and modulation of their activity. Comparison of xylem and phloem transports, phloem loading and unloading of phtoassimilates, source & sink relationship
4. Mineral nutrition in plants.

Unit-II:

1. Photosynthesis: Basic principles of light absorption, excitation energy transfer, Light harvesting complexes,Kok curve, Kautsky curve, ETS, O2 and H2 evolution, mechanism of pigment system function, photoinhibition and photoprotective mechanism.
2. Non- cyclic and cyclic electron flow.Proton electrochemical potential, photosynthetic quantum yield and energy conversion efficiency, Mechanisms of photophosphory-lation in thylakoid membranes,.
3. CO_2 fixation.-C_3, C_4, and CAM .
4. Photorespiratory pathways and plant productivity,

Unit-III:

1. Physiology of nitrogen fixation, NOD factor, Process of nodulation in leguminous plants.Nitrogenase system. Electron transport,
2. Nitrate and Ammonia assimilation.
3. Amino acid biosynthesis.
4. Abiotic stress: Responses to the abiotic stress factors, water and salt stress,Metal(loid) stress, High and low temperature stress; Physiological and molecular mechanisms of acclimation and tolerance to abiotic stress

Unit-IV:

1. Plant growth hormones: Auxins, gibberellin, cytokinins, absisic acid, ethylene, JA,SA and Brasinosteroids.
2. Biosynthesis, storage, breakdown and transport of plant hormones.
3. Physiological effects and mechanism of action of plant growth hormones. hormones in defence against abiotic and biotic stresses

4. Mechanism of action of plant growth hormones, hormone receptors, signals transduction and gene expression.

Unit-V:

1. History and discovery of phytochromes and cryptochromes and their photochemical and biochemical properties, photophysiology of light induced repsonses, Cellular localization, molecular mechanism of action of photomorphogenetic receptors, signalling and gene expression. Phototropins.Gravitropicsignaling
2. Photoperiodism and its significance, endogenous clock and its regulation.
3. Floral induction and development. Metabolic changes during seed germination.
4. Physiology & Molecular events in Plant senescense, programmed and necrotic cell death:

Suggested Readings:

1. Salisbury, S. and Ross, C.W. (1980). Plant Physiology.
2. Goodwin, T.W. and Nereer, E.I. (1983). Introduction to Plant Biochemistry.
3. Cramer, P.J. (1982). Plant and Soil Water Relationship : a Modern Approach.
4. Buchanan et al. (2005). Biochemistry and Molecular Biology of Plants, ASPB, USA.
5. Teiz and Zeiger- Plant Physiology-5th Edition.
6. Abiotic stress Adaptation in Plants: Physiological, Molecular and Genomic Foundation (2010)- A.Pareek,S.K.Sopory, Hans Bohnert&Govindjee- Springer
7. Hans –Walter Heldt (2005) Plant Biochemistry , Academic Press
8. Leopod, A.C. and Kreidman, P.E. (1980). Plant Growth and Development.
9. Greagny, P.F. (1989). Biochemistry of Photosynthesis.
10. Atkin, (1989). Hormone Action in Plant Development, (1983) Plant Growth Substances.
11. Annual Review of Plant Biology. Academic press.
12. Encyclopedia of Plant Physiology, Springer-Verlag, F.C.
13. Plant Abiotic Stress (2005)- Mathew A Zenks&P.M.hasegawa, Blackwell Publishing
14. Panda, S.K. (2002)(ed): Adv. Stress Physiology of Plants
15. Leopold, A.C. and Kriedman, P.E. (1980). Plant Growth and Develpoment.

LS 302 (B): Morphology, Differentiation and Systematic Botany

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit-I:

1. Modified root and stem.Venations.Modification of Calyx. Inflorescence: Types and evolution.
2. Transition to flowering - vegetative to reproductive evocation, floralhomeotic mutations .Axis development in flower.
3. Placentation. Fruit and seed characteristics.
4. Gender expression in monoecious and dioecious plants.Hormonal regulation of sex expression.

Unit-II:

1. Regulation of anther and ovule development,
2. Microsporogenesis and microgametogenesis.
3. Megasporogenesis and megagametogenesis. and patterns of gametophyte organization
4. Pollen-pistil interaction: pollen tube growth and guidance, double fertilization, self-compatibility mechanisms, incongruity

Unit-III:

1. Male sterility- mechanisms and applications, pollen embryogenesis.
2. Polarity during embryogenesis, endosperm development.
3. Apomixes and polyembryony.
4. Somatic embryogenesis

Unit-IV:

1. Principles of classification of Angiosperms.
2. Comparative studies on phylogenetic system of classification with Benthum and Hookers system.
3. Molecular systematics, plant nomenclature, ICN, Concept of species and hierarchical taxa.
4. Herbarium and its significance, activities of BSI. Databases of Plant Names.

Unit-V:

1. Phylogeny and floral evolution of selected family with their economic importance (mostly Indian distribution) of following orders: Magnoliales, Ranunculales, Malvales, Euphorbiales, Fabales, Scrophulariales, Lamiales and Asterales of Dicotyledones, Orchidales, Zingiberales of Monocotyledons.
2. Phylogeny and floral evolution of Poales of monocotyledons (Takhtajan, 1980).
3. Floristic region of India, endemism. Botanical gardens of India.
4. Endangered and threatened plants of India.

Suggested Readings:

1. Maheshwari, P. (1950). An Introduction to the Embryology of Angiosperms, McGraw Hill Book Co., New York.
2. Wardllaw, C.W. (1970). Cellular Differentiation in Plants and Other Essays, Manchester University Press, New York.
3. Wareing, P.F. and Phillips, I.J.D. (1983). Growth and Differentiation in Plants, Pregamon Press, New York.
4. Creuquist, A. (1968). The Evolution and Classification of Flowering Plants.
5. Hobri, B.M. (ed.) (1982). Experimental Embryology of Vascular Plants, Narosa Publishing House, New Delhi.
6. Johason, D.A. (1949). PLANTS Microtechnique, McGraw Hill Book Co., New York.
7. Sinnot, E.W. (1960). Plant Morphogenesis, McGraw Hill Book Co., New York
8. Jain, S.K. and R.P. (1977). An Aid to International Code of Botanical Nomenclature.
9. Heywood, V.H. (1968). Modern Methods in Plant Taxonomy, Acadmic Press, London
10. Heywood, V.H. and Moore, D.M. (eds.) (1984). Current Concepts in Plant Taxonomy.
11. William, F. Grant (ed.) (1984). Plant Systematics, Academic Press, London.

LS 303 (B): Plant Diversity

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit-I:

1. Principles and systems of classification of Algae.
2. Comparative account of algal pigments, food reserves, flagellation, chloroplasts and eye spots; their taxonomic importance
3. Trends in evolution of thallus structure.
4. Cellular structure of algae (Prokaryotes and eukaryotes). Habitat diversity cell structure and reproduction
5. Pheromones.

Unit-II:

1. Classification and phylogenetic relationship of bryophytes.
2. Evolutionary lines of bryophytes.
3. Comparative morphological study of gametophytes.
4. Sporophyte evolution in bryophytes; peristome structure and its significance in classification of mosses.
5. Significance of oil bodies in taxonomy of leafy liverworts.

Unit-III:

1. Classification of pteridophytes. Evolutionary trends in ferns; Origin of land flora.
2. Comparative organography, reproduction and phylogeny.
3. Telomic concepts and its application to evolution of sporophyte.
4. Soral evolution, apogamy and apospory, heterospory and seed habit.

Unit-IV:

1. Recent trends in classification of Gymnosperms; Evolution of Gymnosperms.
2. Geological history of Gymnosperm flora.
3. Morphology and anatomy of vegetative reproductive organs; Structure and evolution of archegonium in Gymnosperms.
4. Distribution of living and fossil Gymnosperms in India.A general account of Taxales.

Unit-V:

1. Algae and human affairs : Edible algae, algal biofertilizers, phycocolloids, algal blooms and phycotoxins.
2. Bryophytes: Medicinal values; Horticulture; Industry; Pollution indicators and soil binders.Role of Bryophytes in plant succession.
3. Pteridophytes: Medicinal values; Horticulture; Pollution control.
4. Gymnosperms as a source of wood, resins, essential oils, food and drugs.

Suggested Readings:

1. Kumar, H.D. (1991). Introductory Phycology, Panima Book Distributors, New Delhi.
2. Smith, G. (1994). Manual of Phycology, Panima Book Distributors, New Delhi.
3. Johri, B.M. (1999). Gymnosperms.
4. Bryophytes By Ram Udar.
5. Pteridophytes by B. D. Sharma. (1994).
6. Fritsch, F.E. (1945). Structure and Reproduction of Algae, Vols. I & II, Cambridge University Press.
7. Pagilchar, N.S. (1955). An Introduction to Embryophyta, Vol. I Bryophyta, and Vol. II Otendophyta, Vol III, Gymnosperm.
8. Trivedi, B.S. and Singh, D.K. (1965). Structure and Reproduction of the Gymnosperms, ShashidharMalviyaPrakashan, Lucknow.
9. Chamberrlain, C.J. (1934). Gymnosperms : Structure and Evolution, ,University of Chicago Press, Chicago.
10. Morphology of pteridophytes , K.R. Sporne. Morphology of gymnosperms , K. R. Sporne.

LS 304(B): Microbial Ecology (Optional)

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit-I:

1. Microbial Evolution and Biodiversity, Population interactions and Ecosystem
2. Microbial community: structure and organization, Habitat and niche, food chain.
3. Quantitative microbial ecology, numbers and Biomass.

Unit-II:

1. Physiologicl ecology of microbes, measurement of microbial metabolism.
2. Colonization processes, succession and climax,Dispersal center, duration efficiency, active and passive dispersal.
3. Microbes in their natural habitat, Air, water and soil.

Unit-III:

1. Biodegradation of waste, xenobiotics pollutants.
2. Tolerance, competition, parasites.
3. Microbial symbiosis, competition, Interaction between microorganisms and plants.

Unit-IV:

1. Microorganisms and biogeochemical cycling with reference to CNP.
2. Bio-fertilizers, microbial control of pests.
3. Microbes in energy recovery fuel and biomass production.

Unit-V:

1. Nucleic acid extraction from environmental samples,Prokaryotic systematics. Concept of meta-genomics.
2. Molecular techniques in microbial diversity studies: PCR and variations, microbial fingerprinting and typing, Molecular detection of fungal communities in soil
3. Microbial ecology and genomics, Bioinformatics and web resources for the microbial ecologist.

Suggested readings:

1. A.I. and H. Lechevalier (1978). Microbial Ecology, C.R.C. Press, Clevevand.
2. Alexander, M. (1974). Microbial Ecology, Plenum Press.
3. Campbell, R.E. (1977). Microbial Ecology : A Conceptual Approach, Blackwell Scientific Publisher, Oxford, England.
4. Synch, J.M. and Poole, N.J. (1979). Microbial Ecology, Springer-Verlag, Berlin, West Germany.
5. Atlas, R.M. and Bartha, R. (1998). Microbial Ecology : Fundamental and Applications, Addition Wesley Publishing Co., Researchco Book center.
6. Osborn, A. Mark.; Smith, Cindy J (2005). Molecular Microbial Ecology BIOS Advanced Methods. Taylor & Francis Routledge
7. Bull, A.T. and Slatter, J.H.H. (1982). Microbial Interaction and Communities, Academic Press, England.
8. Benson,(1990). Microbial Applications : Laboratory Mannual in General Microbiology (5th ed.), Researchco Book Center, New Delhi.
9. Costa et al. (1989). Microbiology of Extreme Environments and its Potential for Biotechnology, Research Book Center, New Delhi.
10. Prescot et al. (1993). Microbiology (2nd ed.), Researchco Book Center, Bnew Delhi.

LS 304 (B): Angiosperm Taxonomy, Biosystematics & Molecular Phylogenetics (Optional)

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit I:

1. Taxonomy and Systematics: Scope and importance. Sources of taxonomic characters: Embryology, Palynology, Anatomy, Cytology, Phytochemistry; Micro-morphology; Ultrastructural systematics: SEM and TEM studies.
2. History of Classification; Artificial, Natural and Phylogenetic Systems. Outline of classification systems by Linnaeus (1753), Bentham & Hooker (1862–1883), Hutchinson (1926–1934), Cronquist (1981) and Takhtajan (1997). Merits and demerits of all systems.
3. Terminologies of different taxonomic characters. Methods of Plant Identification. Bracketed and Indented Keys.
4. Taxonomic literature: Floras, Revisions, Manuals, Monographs, Periodicals and Journals. Taxonomic databases.
5. Species Concepts - Biological species concept. Speciation of Plants – Allopatric, Sympatric, Hybrid, Apomictic, Abrupt and Phylletic Speciation. Mechanism of Reproductive Isolation. Causes of variation in population, ecotypes and ecads, evolution and differentiation of species.

Unit II:

1. International Code of Nomenclature for algae, fungi & plants (ICN): Principles, Rules and Recommendations, Articles. Scientific Names: Correct name, legitimate and illegitimate name, autonym, homonym. Nomenclatural and Taxonomic Synonyms, Basionym, Tautonym, Alternative name, Ambiguous name, Superfluous name, *nomen nudum*, Conserved name, Retention and Rejection of names. Nomenclature of hybrids, Nomenclature of cultivated plants.
2. Procedure of describing new taxon. Typification, Citation and Authority, Principles of Priority, Effective and Valid Publication.
3. Taxonomic Hierarchy.
4. Methods of plant exploration. Field and Herbarium Techniques. Major Botanic Gardens and Herbaria in India and the World. Role of Botanic Gardens and Herbaria in taxonomy.
5. Botanical Survey of India (BSI): its establishment, organizations, development, past and present activities. Floristic studies in India. Activities of other pioneer organizations: NBPGR, CSIR, DBT, Different Universities & NGOs. Convention on Biological Diversity (CBD).

Unit III:

1. Recent system of classification of Angiosperms: Angiosperm Phylogeny Group (APG IV, 2016) system. Concepts of palaeoherbs and eudicots.
2. Salient features, morphological diversity and economic importance of the following families as per Cronquist (1981) System of Classification: Magnoliaceae, Annonaceae, Nymphaeaceae, Ranunculaceae, Tetracentraceae, Trochodendraceae, Casuarinaceae,

Polygonaceae, Malvaceae, Cucurbitaceae, Ericaceae, Primulaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Verbenaceae, Lamiaceae, Scrophulariaceae, Rubiaceae, Asteraceae, Alismataceae, Arecaceae, Araceae, Cyperaceae, Poaceae, Musaceae, Zingiberaceae, Cannaceae, Liliaceae, Orchidaceae.

3. Evolution and Diversification of Angiosperms.
4. Characteristics and phylogeny of Basal Angiosperms ANITA Grade, Magnoliids, Monocots, Commelinids, Eudicots, Core Eudicots, N-Fixing Clade, Asterids.
5. History of botanical explorations in Assam and north-eastern India.

Unit IV:

1. Geography and its relationship with plant distribution. Centre of Origin of species; Patterns of geographic distribution, Disjunction and Vicariance; Ecological differentiation; Alien & Invasive Species.
2. Sustainable utilization of Biodiversity; Endemism – Concepts, factors, endemism in India. Biodiversity Hot Spots; Keystone and Flagship species. India – a mega-biodiversity country.
3. Phytogeography, Importance of phytogeography in Taxonomy; Migration and evolution of floras; Indigenous and Exotic species.
4. IUCN threat categories: methods of assessment; strategies of *in situ* and *ex situ* conservation; CITES and TRAFFIC; RET taxa, Red Data Book. Ethnobotany and Traditional Knowledge: Concept, history, procedure of study and importance; Ethnobotanical researches in India; Sacred groves.
5. GIS, GPS and Remote Sensing in vegetation studies.

Unit V:

1. Phyletic systems; Phenetics versus Cladistics.
2. Molecular Systematics: Molecular Markers; Specific applications of RAPD, RFLP & AFLP in molecular systematics; Plant genomes: nuclear, mitochondrial, chloroplast; Genome Analysis; Barcoding Concept.
3. Molecular Phylogenetics; Cladistics: Operational Taxonomic Units (OTUs), Characters and Attributes, Primitive and advanced characters, binary and multistate characters.
4. Monophyletic, paraphyletic and polyphyletic taxa; homology and analogy; parallel and convergent evolution; plesiomorphic and apomorphic characters.
5. Tree construction – algorithmic (UPGMA and Neighbour Joining); Parsimony, Maximum Liklihood and Bayesian analyses. Depiction of phylogenetic tree.

Suggested readings:

1. Lawrence, G. H. M. 1964. Taxonomy of Vascular Plants. Oxford & IBH Publishers, Calcutta.
2. Datta, S. C. 1988. Systematic Botany. Wiley Eastern Limited, New Delhi.
3. Sivarajan, V. V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
4. Davis, P. H. and Heywood, V. H. 1963. Principles of Angiosperm Taxonomy. Princeton, NJ: Van Nostrand.
5. Jain, S.K. and R.R. Rao. 1977. A Handbook of Field and Herbarium methods. Today and Tomorrow Printers and Publishers, New Delhi.

6. Sneath, P.H. and Sokal, R.R. 1973. Numerical Taxonomy: The Principles and Practice of Numerical Classification. 1st Edition, W. H. Freeman, San Francisco.
7. Weising, K., H. Nybom, K. Wolff, Kahl G. 2005. DNA Fingerprinting in Plants: Principles, Methods and Applications, 2nd ed. CRC Press. Boca Raton.
8. Nei, M. and S. Kumar 2000. Molecular Evolution and Phylogenetics. Oxford University Press, New York.
9. Turland, N. J., Wiersema, J. H., Barrie, F. R., Greuter, W., Hawksworth, D. L., Herendeen, P. S., Knapp, S., Kusber, W.-H., Li, D.-Z., Marhold, K., May, T. W., McNeill, J., Monro, A. M., Prado, J., Price, M. J. & Smith, G. F. (eds.) 2018: *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017*. Regnum Vegetabile 159. Glashütten: Koeltz Botanical Books. DOI https://doi.org/10.12705/Code.2018
10. Turland, N. 2019. The Code Decoded: A user's guide to the International Code of Nomenclature for algae, fungi, and plants. 2nd Edition. Pensoft Publishers, Sofia, Bulgaria.

LS 304(B): Phytochemistry and computational drug designing (Optional)

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit- I:

1. Ethnobotany: Ethnobotany as a source of phytochemicals .Methods of Ethnobotanical data collection .Ethnobotany in drug discovery efforts. Medicinal plant research scenario in India.
2. Neutraceuticals: Sources of Nutraceuticals, Properties, structure, functions and future prospects of various Nutraceuticals.
3. Pharmacognosy: Definition and scope, Crude drugs of plant origin and their classification. Drugs developed from traditional medicines.
4. Pharmacological methods for studying bioactivity, bioassays-calculations of doses response relationships, LD50, ED50.

Unit-II:

1. Extraction methods: Preparation of Crude extracts, Qualitative and quantitative analysis of extracts.
2. Chromatography: Principles, working procedure, functions and application of CC, TLC, PC, GC, GLC
3. Separation of pure fraction with SPE, HPLC, HPTLC.
4. Spectroscopic methods (UV, IR, NMR and A.A. Spectroscopy) in determining structure of bioactive compounds.

Unit-III:

1. Secondary metabolites- Definition, General structure and classification, major pathways of secondary metabolites
2. Secondary metabolites - Biosynthesis of terpenes, phenols and nitrogenous compounds .
3. Role of secondary metabolites in plant defence system, secondary metabolites in growth and development of plant.
4. Secondary metabolites in development of drugs,

Unit IV:

1. Bioinformatics and its relation with molecular biology. Examples of related tools (FASTA, BLAST, BLAT, RASMOL)
2. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Protein databases (Primary, Composite, and Secondary). Specialized Genome databases: (SGD, TIGR, and ACeDB). Structure databases (CATH, SCOP, and PDBsum)
3. File Format (Genbank, DDBJ, FASTA, PDB, SwissProt). Biological Databases Retrieval Systems, Biological sequence submission tools and systems.
4. Introduction to Sequence alignments; Local alignment and Global alignment, Pairwise and multiple sequence alignment. Phylogenetic Analysis.

Unit V:

1. Introduction: Principles of drug Development, Bioinformatics in drug development. Drug Designing, Computer Aided Drug Designing and types. Drug Likeness and ADME/Tox screening, Drug targets.
2. Protein Structure Prediction, Molecular Docking, Molecular Dynamics Simulation, Combinatorial Chemistry, Quantitative Structure Activity Relationship.
3. Pharmacogenomics & Pharmacoproteomics: Introduction to Pharmacogenomics. The Role of Ethnicity in Pharmacogenomics,
4. Pharmacogenomics and Pharmacoproteomics in Drug Discovery.

Suggested readings:

1. Foye W, "Principles of Medicinal Chemistry" Lea & Febiger.
2. Delgado J.N., Remers WA eds, "Wilson & Giswolds Text Book of organic Medicinal & Pharmaceutical chemistry" Lippincott, New York.
3. Alex Gringauz "Introduction to Medicinal Chemistry" Wiley-VCH, Inc. New York.
4. Abraham DJ, ed., Burger's Medicinal Chemistry & Drug Discovery, Vol-I-VI, John Wiley & sons, New Jersey.
5. Smith HJ, Williams H, eds, "Introduction to the principles of Drug Design" Wright Boston.
6. Silverman R.B. "The organic Chemistry of Drug Design and Drug Action" Academic Press New York.
7. Finney, D.J., Statistical Methods in Biological Assays, Hafner, New York.
8. Hunson, J.W., ed. Pharmaceutical Analysis, Modern Methods, part A & B, Marcel Dekker.
9. Schirmer, R.E., ed. Modern Methods of Pharmaceutical Analysis, Vols 1, 2. Boca Raton F.L., CRC Press.
10. Budzikiewicz, et al., Interpretation of Mass Spectra of Organic Compounds, Holden-Day San Francisco.
11. Malcolm Campbell, Laurie J. Heyer. Discovering Genomics, Proteomics and Bioinformatics.
12. R. Guha and A. Bender, Computational Approaches in Cheminformatics and Bioinformatics
13. David W Mount, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Press.
14. Attwood, Introduction to Bioinformatics

LS 304(B): Microbial Biotechnology (Optional)

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit I: Microbial Systematics

1. Microbial Evolution and Biodiversity, Classification of Living Things: Three Domains of Living Things.
2. Taxonomic Grouping of Micro-organisms Important in Industrial Microbiology and Biotechnology, Characteristics Important in Microbes Used in Industrial Microbiology and Biotechnolgy
3. Microbial systematics. Molecular techniques in microbial diversity studies: PCR and variations, microbial fingerprinting and typing. Metagenomics and its applications.
4. Patents and Intellectual Property Rights in Microbial and Biotechnology

Unit II: Genetic Engineering & Microbial Cell Factories

1. Tools of Genetic Engineering, Enzymes and Cloning vectors,
2. Cloning Methodologies; Insertion of Foreign DNA into Host Cells ; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; High Expression Vectors; Principles in maximizing gene expression Properties of expression vectors, Microbial Cell factories: *Pichia pastoris:* Properties Tools and Applications.
3. Mutagenesis and Protein engineering: PCR based mutagenesis, Site- Directed Mutagenesis and Protein Engineering. Application of Genetic Engineering: Expression of industrially important products in bacteria, yeast.
4. Strain Improvement: Selection from naturally occurring variants. Genomes & manipulation of industrial organisms in strain improvement.

Unit III: Microbial Interactions & Metabolites

1. Microbial symbiosis, Interaction between microorganisms and plants. Plant growth promoting microbes. Endophytic microorganisms and their products.
2. Primary and Secondary metabolites of industrial importance, Techniques involved in screening / detection of industrially important metabolites from microbes
3. Antibiotics (Penicillin, Streptomycin, Tetracycline), Anti-tumor agents, Alkaloids (ergot, lysergic acid), Biotransformations (Steroids, chirals), Vaccines (BCG, DPT, polio, hepatitis) Therapeutic Proteins (Interferons, Insulin, Streptokinase, Erythropoietin)
4. Pharma and Therapeutic enzymes, Enzymes in detergent, Enzymes in textile & leather industries

Unit IV: Microbes and Biofuels

1. Biomass and Bio– fuels: Plant biomass (Cellulose, starch, pectin, gum materials), Animal biomass (chitin, milk whey, Slaughter house wastes), Microbial biomass (algal blooms – in fresh and sea waters, Fungal – Mushrooms, yeasts and bacterial fermentation biomass wastes). Enzymes for Plant Biomass degradation (CAZY). Biofuel production
2. Concepts of single cell proteins, probiotics and their applications.
3. Microbial production of polymers (Xanthan gums, cellulose)
4. Microbial production of fuels; alcohols, hydrogen and methane.

Unit V: Bioprocess Methods

1. Fermentors and Fermentor Operation, Types, Design and operation. Solid state fermentations its uses and applications.
2. Extraction of Fermentation Products, Sterilization in bioreactors: kinetics of batch, continuous and fibrous filter sterilization.
3. Aeration and Agitation: Agitation is shake flask as tube rollers, factor affecting agitation as aeration in shake flasks, Fluid Rheology.
4. Scale – UP : Scale up of bioprocess ,Fermentation economics: cost determination in bioprocesses, capital investment and raw materials etc. Mathematical modeling: mathematical modeling in bioprocesses.

Suggested Readings:

1. Molecular Biotechnology : Principles & Applications of recombinant DNA by Bernard.
2. Microbial Biotechnology by Alexander N. Glazer, Hiroshi Nikaido.
3. Microbial Biotechnology: Microbial Biotechnology (Third Edition) 3rd Edition, by Yuan Kun Lee.
4. Microbial Biotechnology:An Interdisciplinary Approach, By Pratyoosh Shukla, CRC Prss 2017.
5. Microbial Biotechnology by D. Drilder, Narosa Publishing House New Delhi, 1989.
6. Biochemical Engienering Fundamentals by J.E. Bailley and D.F. Ollis, McGraw Hill Co., NY, 1986.
7. Methods in Industrial Microbiology by B. Sikyata, Ellis Horwood Ltd., London, 1983.
8. Industrial Biotechnology: Products and Processes & Product, Advanced Biotechnology: Industrial Biotechnology: Microorganisms 2017, Editor(s): Christoph Wittmann James C. Liao.
9. Biochemical Engineering and Biotechnology, 2nd Edition, Ghasem Najafpour, 2015.
10. Industrial Microbiology: An Introduction by Michael J. Waites, Neil L. Morgan, John S. Rockey, Gary Higton Publisher: Wiley-Blackwell

LS 305 (B): Practical - I

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Collection and identification of bryophytes study of vegetative and &reproductive structures and identification of Bryophytes.
2. Collection and study of algae from soil, ponds, lakes etc. from the Barak valley and hills of South Assam.
3. Collection, work out and identification of angiospermic plants up to genus and species level using keys available in authentic literature.
4. Culture techniques and study of morphology of certain dominant groups of microorganisms from soil, air and litter.
5. Demonstration of anatogonistic activity between pathogenic fungi and test microorganism
6. Determination of the effect of temperature and chemical treatments on the permeability properties of cell membranes.
7. Identification of causal organisms (Fungi) /bacteria from diseased plant materials.
8. Measurement of transpiration rate by cobalt chloride method
9. Paper chromatography of amino acids.
10. Separation of chloroplast pigments by TLC and portioning between solvents.
11. Study of morphology and anatomy of vegetative and reproductive structures of pteridophytes.
12. Study of structure and distribution of stomata of dicot and monocot leaves
13. Testing the goodness of fit and independent assortment using chisquare test.
14. Study of mitosis and meiosis in plants

LS 306 (B): Practical – II: Microbial Ecology (Optional)

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Basic instruments and their principles used in microbiology
2. Preparation of culture medium and application of culture techniques for dominant group of microorganisms
3. Study of morphological characteristics of microbes isolated from soil, air and litter
4. Isolation and identification of a few major plant pathogenic microbes
5. Study of pure culture techniques for some common soil bacteria
6. Effects of certain physical and chemical factors on growth of microbes
7. Study of Mycorrhizal association and its impact on seedling survival and growth
8. Study of Rhizosphere and Phylosphere microbes
9. Isolation and identification of Rhizobium bacteria from root nodules

LS 306 (B) Practical - II: Angiosperm Taxonomy, Biosystematics & Molecular Phylogenetics (Optional)

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Collection and preservation of wild angiospermic plants. Study of special collection technique of bamboos, aroids, aquatic plants, succulents, palms, gingers, orchids, etc.
2. Study of morphological characters: Leaves (phyllotaxy, shape, base, apex, margin, surface, venation pattern, etc.), Inflorescence (racemose, cymose and mixed), Flowers (symmetry, ovary position, different whorls, placentation), Fruit and Seed types.
3. Workout of plant specimens, preparation of descriptions and illustrations of vegetative and reproductive characters of locally available species and identification of taxa using relevant literature. Comparison of plant families and preparation of dichotomous keys.
4. Study of characters of anemophilous, hydrophilous, entomophilous and cheiropterophilous flowers.
5. Study of micro-morphological characteristics.
6. Pollen characters of taxonomic importance: morphology, polarity, symmetry, NPC of pollen, exine stratification, L/O pattern, etc. Semipermanent pollen preparations by acetolysis method.
7. Study of chromosome number, chromosome morphology, karyotype of closely allied species for cytotaxonomic investigation.
8. Microtome technique for study of embryological characters.
9. Local field excursions (minimum three) for familiarization with and study of flora and vegetation of the area. Herbarium sheet preparation and submission of some common plants (Maximum 20). Submission of pickled/dried specimens (Maximum 3).
10. Exercises on Nomenclatural Problems.
11. Exercises on Numerical taxonomy.
12. Phylogenetic analysis of species using different software.

LS 306 (B) Practical - II: Phytochemistry and Computational Drug Designing (Optional)

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Safety measures in handing solvents and reagents
2. Preparation of Plant crude extracts in various solvent systems
3. Qualitative tests for Plant crude extracts.
4. Quantitative estimation of secondary metabolites and enzymes
5. Thin Layer and column Chromatography for isolation of Secondary Metabolites
6. Solid Phase extraction for preparation of extract fractions.
7. Isolation of Pure fraction with Flash Chromatography and HPLC.
8. Biological database and sequence alignments.
9. Druglikeness and ADMET/Tox screening
10. Identification of drug targets.
11. Molecular Docking and QSAR

LS 306 (B) Practical - II: Microbial Biotechnology (Optional)

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Preparation of media for growth of various microorganisms.
3. Identification and culturing of bacteria, yeast and fungi.
4. Growth curve, measure of bacterial/yeast/fungal population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen.
5. Isolation and estimation of genomic DNA from Yeast/Bacterial/fungi.
6. PCR amplification of 16S/18S rDNA gene or any other locus and analysis by agarose gel electrophoresis.
7. Preparation of cloning plasmid from any bacterial or yeast host and gel analysis.
8. Restriction digestion of any cloning/expression vector (gel analysis)
9. Vector and Insert ligation, Transformation in *E.coli* DH5α confirming recombinant by PCR and RE digestion.
10. Yeast Transformation by Electroporation.
11. Screening of microbes for production of industrially important enzymes.

ZOOLOGY – III

LS 301 (Z): Molecular Endocrinology

[Full Marks = 100, 6 Contact Hours /week, Total credit = 06]

Unit – I: (Basic Concepts)

1. Hormones: Survey of endocrine glands
2. Chemical nature and classification of hormones: Endocrine, Paracrine and Autocrine.
3. Biosynthesis and transport of hormones; Regulations of hormone synthesis and feedback mechanism.
4. Concept of endocrine and Neuroendocrine system, Neuroendocrine system in insects and crustaceans; Endocrine regulation moulting in insects and crustaceans.

Unit – II: (Structure and pathophysiology)

1. Structure and functions of Hypothalamus; Hypothalamic hormones.
2. Anatomy and physiological actions of hormones secreted by Pituitary, Thyroid, Adrenal, Gonads, pancreas and pineal glands
3. Thyroid hormone synthesis and regulation: Incidence of pathophysiology. Parathyroid and thyrocalcitonin hormone structure and function
4. Hormonal control of glucose and calcium homeostasis.

Unit – III: (Mechanism of action)

1. Hormone receptors
2. Mechanism of hormone action: Second messenger, receptor mediated Transmembrane signaling, G- protein and control of adenylate cyclase, cyclic nucleotide cascade.
3. Role of Calcium in hormone action.
4. Steroid hormone regulation of gene transcription and other signal transduction systems.

Unit – IV: (Reproductive health)

1. Contraception and family planning issues: socioeconomical, behavioural and political factors.
2. Infertility: causes, male and female factors;
3. Artificial reproductive techniques; In vitro fertilization.Handlling of sperms and oocytes;
4. Micromanipulation; Embryo culture and embryo transfer; cryopreservation of gametes and oocytes.

Unit V: (Applied endocrinology)

1. Genetic analysis and clinical management of hormonal disorders
2. Endocrine disrupting chemicals and hormonal disorders
3. Phytoestrogens
4. Production of hormones by DNA technologies.

Suggested Readings:

1. Turner, C.D. and Bagnara, J.T.(1975). General Endocrinology,W.B. Saunders Co, UK.
2. Bentley, P.L. (1998). Comparative Vertebrate Endocrinology (3rd ed.), Cambridge university Press, UK.
3. Norman and Litwack (1987). Hormones, Academic Press.
4. Gorbman et al. (1983). Comparative Endocrinology, John wiley and Sons, New York

LS 302 (Z): Applied Biology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit I: (Application of immunological principles)

1. Engineered antibodies: monoclonal, bispecific, chimeric phage display
2. Vaccination: live & attenuated vaccines, recombinant & naked DNA vaccines
3. Immunodiagnostics

Unit II: (Risk assessment and mitigation)

1. Risk assessment: hazard identification, toxicity assessment, exposure assessment and risk characterization
2. Bioremediation and phytoremediation
3. Biosensors

Unit III: (Bioresource and uses of biodiversity)

1. Wildlife and its values: Ecological and economic values
2. Wildlife protection scenario in India: Wildlife protection, biodiversity and forest right acts.
3. Endemic and restricted zone animals: Conservation needs, techniques of wildlife census
4. Conservation breeding: Genetic management in captivity; inbreeding depression;

Unit IV: (Introduction to parasitism)

1. Parasites: Habitat and environment
2. Host-parasite interactions with special reference to immunity and resistance
3. Mosquito and housefly as vectors of human diseases
4. Outline knowledge of prophylaxis

Unit V: (Organisms of health & agricultural importance)

1. Common parasites and pathogens of humans and domestic animals
2. Life cycle, pathogenicity and control of Entamoeba histolytica, Plasmodium sp. of man, Leishmania donovani.
3. Life cycle, pathogenesis and control of Fasciola hepatica, Echinococcus granulesus. Ancylostoma duodenale, Wuchereria bancrofti.

LS 303 (Z): Evolution and Behaviour

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit I: (Emergence of evolutionary thoughts)

1. Lamarckian concept of evolution
2. Darwin's theory of evolution: concepts of variation, adaptation, struggle, fitness and natural selection
3. Elemental forces of evolution: mutations
4. Modern synthetic theory of evolution

Unit – II: (Molecular Evolution)

1. Concepts of neutral evolution, molecular divergence and molecular clocks;
2. Molecular tools in phylogeny, classification and identification;
3. Origin of new genes and proteins;
4. Gene duplication and divergence.

Unit – III: (Evolutionary genetics)

5. Population genetics; Populations, Gene pool, Gene frequency and genotype frequency
6. Genetic equilibrium and Hardy-Weinberg Law
7. Migration and random genetic drift
8. Isolating mechanisms and speciation: Allopatricity and Sympatricity evolution

Unit – IV: (Brain and Behaviour)

1. Neural basis of learning, memory, cognition
2. Sleep and arousal;
3. Timing in behaviour: Circadian and circannual rhythm Biological clocks;
4. Approaches and methods in study of behavior; Proximate and ultimate causation;

Unit – V: (Reproductive Behaviour)

1. Altruism and evolution-Group selection, Kin selection, Reciprocal altruism
2. Social communication, Social dominance and territoriality
3. Sexual selection and reproductive strategies
4. Parental investment and reproductive success: Parental care

Suggested readings:

1. Futuyama, D.J. (1986). Evolutionary Biology, Sinavar Association Inc.
2. Colbert, E.H. (1984). Evolution of Vertebrates, Wiley Eastern Ltd. (New Delhi).
3. Dobzhansky et al. (1976). Evolution; Surjeet
4. Li, W.H. and Graur, D. (1991). Fundamentals of Molecular Evolution. Sinavar Associates Inc.
5. Stebbins(1966). Process of Organic Evolution. Prentice Hall of India (New Delhi).

LS 304(Z): Molecular Genetics (Optional)

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Structure, organisation & regulation)

1. Molecular Evolution: , DNA, RNA and RNP ; types of DNA and satellite DNA; Types of RNA; miRNA and siRNA, ncRNA
2. Organisation of active chromatin, heterochromatin and euchromatin. Y chromosome and sex determination
3. Regulation of gene expression in prokaryotes: RNA polymerase-promoter interaction, post-transcriptional control, antitermination and attenuation; antisense RNA.
4. Regulation of gene expression in eukaryotes. Role of chromatin in gene expression and gene silencing.

Unit – II: (Microbial genetics)

1. Genetic recombination: conjugation, transformation and transduction.
2. Bacteriophages: Lysogenic and lytic cascade.
3. Lac-operon and Tryptophan-operon,
4. Transposable elements.

Unit – III: (Recombinant DNA technology)

1. Enzymes used in gene cloning.
2. Cloning vectors and Identification of recombinant clones.
3. Techniques in molecular biology – c-DNA library, gene expression analysis (PCR, RT-PCR & DNA microarray)
4. Gene cloning in eukaryotic organisms: transgenic animals. Modern methods for detecting defective genes

Unit – IV: (Xenobiotic metabolism)

1. Concept of Pharmacogenetics and Toxicogenomics
2. Xenobiotic metabolizing enzymes and their role in pharmacology
3. Concept of Metabolomics
4. Cytochrome P450s and Flavin Monooxygenase.

Unit – V: (Cancer biology)

1. Cell Cycle and its regulation. virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.
2. DNA and RNA Tumor viruses.
3. Oncogenes, mechanism of activation of proto-oncogenes;
4. Tumor suppressor genes and immortalisation.

Suggested Readings:

1. Gardner, E. J. and Snustad, D.P. Principles of Genetics ,Wiley, New York.
2. Kornberg, A. ,DNA Replication (2nd ed.), Freeman, San Francisco.
3. Swanson, C.P. et al. Cytogenetics, Prentice Hall of India, New Delhi.
4. Medical Molecular Genetics Blackwell
5. Lewin, B. ,Genes VII, Oxford University Press.
6. Drilica, K., Understanding DNA and Gene Cloning (Latest ed.), Wiley, New York.
7. Freifelder, D., Recombinant DNA (Latest ed.), Freeman, San Francisco.
8. Freifelder, D., Microbial Genetics (Latest ed.), Jones and Barlett Publications Inc.,Boston.
9. Watson, J.D. et al. (2004 or latest). Molecular Biology of the Gene, Benzamin/Cummings Publ. Co. inc., California.
10. Lewin, B.M., The Molecular Basis of Gene Expression (Latest ed.), Vol 2, Wiley, New York.

LS 304(Z): Molecular and Cellular Biochemistry (Optional)

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Cellular components)

1. An overview of Biochemistry.
2. Molecular interactions and its importance in understanding cellular processes.
3. Macromolecules: proteins, polysaccharides, lipids, glycoproteins, glycolipids, Lipoproteins, lipopolysaccharides, Protein modifications and functional implications.

Unit – II: (Enzyme Kinetics)

1. Basic concepts of protein folding, folding pathways role of accessory proteins in protein folding. Dynamics of protein structure: primary, secondary and tertiary structure.
2. Classification of enzymes, factors affecting enzymes activities, feedback and allosteric inhibition. Enzyme catalysis, specificity of enzyme action coenzymes, Michaelis Menten equation.
3. Competitive and uncompetitive inhibition, bi-substrate reaction.

Unit – III: (Metabolic regulation)

1. Metabolism: Basic concepts, Central role of ATP in metabolism, Concept of energy rich compounds and intermediates.
2. Glycolysis regulation, energetics and ATP productions, metabolic flux and its regulation by various metabolic intermediates.
3. TCA cycle regulation and its role in generating biosynthetic intermediates, glyoxylate cycle and energy generation.

Unit – IV: (ATP synthesis)

1. Redox reaction, mitochondrial structure and its role in energy metabolism, electron transport system.
2. ATP synthesis and chemo-osmotic hypothesis of ATP generation.
3. Pentose phosphate pathway and its significance.

Unit – V: (Regulation and application)

1. Glycogen synthesis, breakdown and its regulation.
2. Fatty acid biosynthesis and degradation.
3. Amino acid metabolism, Urea cycle, amines and their role in cell function.
4. Metabolic engineering

Suggested Readings

1. Biochemistry (5 th Edition) by Jeremy Berg, John Tymoczko and Lubert Stryer,
2. Biochemistry (3 rd Edition) by Donald J. Voet and Judith G. Voet.
3. Lehninger Principles of Biochemistry (4 th Edition) by David L. Nelson and Michael M. Cox.
4. Trehan, K. (1994). Biochemistry, Benjamin Harrow, Toppan Co. Ltd., Japan.
5. Alexander, R.R. and Criffithn, J.M. (1992). Basic Biochemical Methods, John Willey and Sons, Singapore.
6. Lewin, B. (1996). Genes VI, Panima Eds,., Agency, New Delhi.

LS 304(Z): Molecular Cell Biology (Optional)

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit-I: Cell Architecture

1. General structure of cell, cell variability, origin of cell, cell theory.
2. Structural organization of prokaryotic and eukaryotic cells.
3. The ultra structure of cell organelles and their functions.
4. The cytoskeleton- microfilaments, microtubules and intermediate filaments

Unit-II: Cell membrane and communications

1. Cell membrane structure, lipid bilayer, membrane proteins, membrane carbohydrates.
2. Transport across membranes, diffusion, active transport, exocytosis, endocytosis.
3. Cell adhesions, cell junctions and the extracellular matrix.
4. Electrical properties of cell, action potential and synaptic transmission.

Unit-III: Cellular transport and signaling

1. Overview of cell signaling, paracrine, autocrine and endocrine.
2. Vesicular trafficking, secretory and endocytic pathway.
3. Cell surface receptors, g-protein coupled receptors, receptor tyrosine kinases.
4. Mechanism of signal transduction

Unit-IV: Cell cycle regulation

1. Overview of cell cycle, cyclin and cyclin dependent kinases, maturation promoting factors.
2. Checkpoints in cell cycle regulation.
3. Programmed cell death, apoptosis, caspases.
4. Molecular basis of cancer, oncogene and tumor suppressor gene.

Unit-V: Cell death and disease

1. Cell death and disease- neurodegenarative disorders, diabetes.
2. Autophagy and macromolecular crowding in disease pathogenesis.
3. Role of free radicals, oxidative stress, antioxidant defense system, antioxidants.
4. Epigenetic mechanisms, epigenome as a therapeutic target.

Suggested Readings:

1. Lodish, H. F. Molecular Cell Biology. New York: W.H. Freeman and Co, 2016.
2. Cooper, G. M. The cell: A Molecular Approach.Washington, D.C: ASM Press, 2015.
3. Alberts, B. Molecular Biology of the Cell. New York: Garland Science, 2002.
4. Nelson D. L. Lehninger Principles of Biochemistry. New York:W.H. Freeman, 2017.

LS 305 (Z): Practical - I

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Study of natural habitats through Species diversity index.
2. Study of natural habitats through Equitability index (Similarity-dissimilarity index).
3. Estimation of total alkalinity and total hardness in water samples.
4. Estimation of phosphate and nitrate in water samples.
5. Estimation of chemical oxygen demand in water samples.
6. To learn the use of steriotaxic instrument for neuroscience research.
7. Acquisition of data for neurolophysiological parameters like EEG, EMG, Evoked potential.
8. Study of histological slides of different endocrine glands.
9. Study of Estrous cycle in female rat/mice.
10. Comparison of RBC and WBC number in different vertebrates.
11. Estimation of haemoglobin concentration in vertebrate blood and preparation of haemin crystals.
12. Estimation of ascorbic acid in tomato, lemon, and milk.
13. Recording of muscle contraction.
14. Determination of casein content in milk.

LS 306 (Z): Practical – II: Molecular Genetics (Optional)

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Mitotic chromosome preparation from mouse/rat bone marrow cells.
2. Meiotic chromosome preparation from rat/grasshopper testis.
3. Banding technique of mouse/rat chromosome: G- banding and C-banding
4. Study of chromosome aberration induced by mutagens and /or radiation rat/ mouse chromosome
5. Leukocyte culture technique from peripheral blood of human.
6. Electrophoretic studies of isozymes.
7. Study of sister chromatid exchange.
8. Human normal and aberrant mitotic chromosome karyotyping.
9. Barrbody (sex chromosome) test from hair root tip and buccal mucosal cell of human.
10. Study of contaminant induced micronucleus in erythrocytes of mouse/amphibians.

LS 306 (Z) Practical – II: Molecular and cellular Biochemistry (Optional)

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Estimation of Carbohydrate by anthrone's reagent.
2. To find out the monosaccharide , polysacharide if any in a given compound.
3. Estimation of protein by lowry's method.
4. Chromatographic determination of amino acids
5. Estimation of DNA by spectrophotometric analysis.
6. Estimation of RNA by spectrophotometric analysis.
7. Mitochondrial complex I assay.
8. Mitochondrial complex II assay.
9. To study the specificity of enzymes by the amylase test on saliva.
10. Quantitative determination of ascorbic acid in various food stuffs.

LS 306 (Z) Practical – II: Molecular Cell Biology (Optional)

[Full Marks = 100; 6 Contact hours/week; Total credit = 03]

1. Understanding the basics and practical handing of microscope.
2. Preparations of physiological buffers and pH adjustment.
3. Staining, visualization and identification of prokaryotic and eukaryotic cells.
4. Staining and visualization of blood cells (RBC, WBC, platelets).
5. Counting of cells by using haemocytometer.
6. Histological analysis of liver tissue- identification of necrotic tissue.
7. Crystal violet staining of neuronal cells- visualization and identification.
8. Eosin and haemotoxylin staining for identification of macromolecular crowing in cells.
9. Histochemical analysis of cholinergic neurons.
10. Understanding the basics of ANOVA and its implications

BOTANY – IV

LS 401 (B): Mycology and Plant Pathology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit-I:

1. General features of Fungi, Nutrition and growth.
2. Classification of fungi: recent trends with reference to vegetative structure, phylogeny and affinities of the main groups
3. Sexuality and parasexual cycles.
4. Tools and techniques uses for identification of fungi.

Unit -II:

1. Ecology of fungi; soil fungi, rhizosphere fungi, phylosphere andair fungi.Mycorrhizal association and its application in forestry and agriculture. Lichens: Thallus structure, reproduction and economic importance
2. Economic importance of fungi: fungal enzymes- Cellulases, Lipases, proteases;Bio-degradation of cellulose and hemi-cellulose.
3. Fungal primary and secondary metabolites for agriculture and Industry (Acids, Antibiotics, pharmacologically active compounds, anti-fungals)
4. Fungi as Plant Growth Promoter and Disease Suppressor, Biofungicides**.**

Unit –III:

1. Symptomatology and identification of fungal diseases.
2. Symptomatology and identification of bacterial diseases
3. Symptomatology and identification of viral diseases
4. Principles of plant disease control: physical, chemical, biological

Unit –IV:

1. Disease development- role of enzymes, toxins, growth regulators
2. Defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors
3. Interrelationship of parasitism and pathogenicity.
4. Molecular basis of pathogen host recognition and regulation. Host genetics in relation to types of pathogenicity.

Unit-V:

1. Resistant variety and development of disease resistant plant.
2. Genetic engineering for disease resistance.
3. Quarantine – domestic and international. Quarantine restrictions in the movement ofagricultural produce, seeds and planting material;
4. Crop rotation.

Essential Readings:

1. Tarr, S. (1979). Principles of Plant Pathology.
2. Control of Plant Pathogens, A.P.S. books, 3340, Pilot Knob Road, St. Paul, MN 55121, USPI.
3. Aggrios (1998). Plant Pathology (2nd ed.) Panima Book Distributors, New Delhi.
4. Nene, Y.L. and Thapilyal, P.N. (1984). Fungicides in Plant Disease, Central Oxford and IBH Publications Co., New Delhi.
5. Subramanian, C.V. (1983). Hyphomycetes : Taxonomy and Biology, Academic Press, London.

LS 402 (B): Molecular Genetics and Plant Breeding.

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I:

1. Fine structure of gene.
2. Structure of chromatin: Euchromatin and heterochromatin
3. Exons and Introns,Overlapping & split genes, Pseudogenes, Gene expression,
4. Post transcriptional and translational modification

Unit – II:

1. Multiple alleles, pseudoallele, complementation tests.
2. Gene mapping methods: Linkage maps, mapping with molecular markers, development of mapping population in plants.
3. Microsatelite markers and Marker assisted breeding
4. Epigenetics , DNA methylation and demethylation

Unit-III:

1. Plant gene structure and expression.
2. Regulation of plant gene expression.
3. Cytoplasmic inheritance involving chloroplast
4. RNA interference and regulatory RNA

Unit – IV:

1. Polygnenic traits, multiple factors hypothesis and heritability. Polygenic heritability and its measurements.
2. Gene effect and components of phenotypic variance.
3. Genetic variance and its components, variance due to environment, gene frequency in a population
4. Genetic equilibrium and Hardy-Weinberg law.

Unit – V:

1. Objectives of plant breeding, characteristics improved by plant breeding. Centres of Origin
2. Heterosis and inbreeding depression
3. Hybrid seed production, Mutation breeding, Selection and hybridization for crop improvement.
4. Self-incompatibility and male sterility in crop plants and their commercial exploitation.

LS – 402(B) Suggested Readings:

1. Acquaah,G (2012) Principles of Plant genetics & breeding, WileyFreifelder, D. (1990). Molecular Biology, Narosa Publications, new delhi.
2. Watson, J.D. (1990). Molecular Biology of the Gene, 2nd ed., Narosa Publ., ND.
3. Bose (1997). Selection Methods in Plant Breding, Panima Book Distributors, ND.
4. Jorgensen (2013) Plant Genetics & Genomics: Crops and models-Series
5. Falconer (1998). Introduction to Quantitative Genetics, Panima Book distributors, ND.
6. Swanson, C.P. et al. (1981). Cytogenetics : The Chromosomes on Division, Inheritance and Evaluation, Prentice Hall India Ltd., New Delhi.
7. Obe, G. (1987). Cytogenetics, Springer-Verlag, New York.
8. Simonds, N.W. (1979). Principles of Crop Inprovement, Longmer, J.K.
9. Hughes,MA (1996) Plant Molecular Genetics, Longman

LS 403 (B): Advanced Plant Biology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I:

1. Molecular tools for Identification of Microbes (rDNASequencing , PCR and variations-RT-PCR, Nested PCR, Multiplex, RFLP: Ribotyping, PFGE; RAPD, PCR-RFLP.
2. Methods of Strain Improvement and its applications.
3. General Introduction to IPR,
4. Patenting of biological processes, patenting regulations in India**.**

Unit – II:

1. Plant genome sequencing and functional Genomics
2. High-throughtput genomic and proteomic platforms for novel plant gene and protein s discovery
3. Plant metabolomics
4. Plant systems biology

Unit – III:

1. Sequencing Technologies: First Generation, Next Generation and third generation
2. Gene identification and annotation.
3. Comparative and functional genomics.,miRNomics
4. Genome Analysis: Completed genomes, Eukaryotic genomes

Unit - IV:

1. Molecular Phylogeny, Application of DNA markers in Angiosperm Taxonomy.
2. Database development for Herbarium.
3. Phylogenetic trees for graphic representation of the evolutionary divergences of organisms.
4. Modern Trends in Taxonomy – Taxometrics, Cytotaxonomy, serotaxonomyCladistics.

Unit – V:

1. Phytochemicals from medicinal and aromatic plants: Role in drug discovery
2. Prediction of 3D structure of Proteins: Comparative modeling; Concept of active sites and its identification
3. ADME/Tox and Lipinski Ro5
4. Structure based drug designing:QSAR and molecular Docking

LS – 403(B) Suggested Readings:

1. JonathanPevsnerBIOINFORMATICS ANDFUNCTIONAL GENOMICS, 2nd Edition.
2. Jorgensen (2013) Plant Genetics & Genomics: Crops and models-Series
3. Jay C. Dunlap. FungalGenomics:AdvancesinGenetics, Volume 57
4.Weising, K., H. Nybom, K. Wolff & G. Kahl 2005.DNA Fingerprinting in Plants - Principles, Methods and Applications.CRC Press.
5. Minelli, A. 1993. Biological Systematics. Chapman & Hall, London, UK.
6.Ziwei Huang (2007).Drug Discovery Research.Willey Interscience.

LS 404 (B): Project (Special Paper)

[Full Marks = 200; 12 Contact hours/week; Total credit = 12]

ZOOLOGY - IV

LS 401(Z): Environmental Monitoring and Assessment

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit I: The Web of Life

1. Concept of environment: components and characteristics
2. The biosphere: terrestrial and aquatic (freshwater and marine) biological zones
3. Population: distribution and abundance, geographic range and distribution
4. Population: estimating species abundance and distribution through direct, indirect and remote observations

Unit II: Environmental Challenges

1. Biodiversity: current scenario, mega-diversity centres and countries, homogenized biota
2. Threats to biodiversity: Species and habitat loss, land degradation, invasive species and overexploitation of biological resources
3. Approaches to biodiversity conservation: genetic analysis, demographic models, *in-situ* and *ex-situ* conservation strategies; and legal and policy measures
4. Impact of climate change, environmental pollution and diseases on populations

Unit III: Environmental Monitoring

1. Environmental monitoring: Introduction; Chemical monitoring and biomonitoring
2. Biological indicators: microbial systems, lower plants, higher plants, animal systems, aeroallergens, human systems, physiological systems
3. Use of remote sensing and geographic information system in environmental monitoring
4. Concept and scope of environmental management system (EMS)

Unit IV: Environmental Impact Assessment (EIA)

1. EIA: Introduction, objectives, evolution, and benefits
2. EIA action plan: Developed and developing countries including Indian scenario
3. EIA: Institutional framework, principles, purpose, process methods; mitigation and impact
4. Strategic environmental analysis (SEA): Scope, processes, benefits and constraints; methodological difference between EIA and SEA; Preliminary concepts on environmental auditing

Unit V: Environmental Risk Assessment (ERA)

1. ERA: definition, scope and process outline
2. Hazard Identification: Structure-Activity relationships, In vitro and short-term tests, Animal Bioassays
3. Toxicity assessment: Characterization of the dose-response relationship and Extrapolation to human exposure conditions
4. Exposure assessment: Intensity, Frequency and Duration of exposure
5. Risk characterization: Intrinsic toxic properties of the pollutants, quantities of the pollutant released into the environment and the size of population at risk

Suggested readings:

1. Michel L. Cain, William D. Brown and Sally D. Hacker: Ecology, Sinauer associates, Inc. Publishers, Sunderland, Massachusetts, USA, 3rd edition, 2014.
2. P.D. Sharma: Ecology and Environment, rastogi Publications, 13th Edition, 2018- 19
3. Rao J.C. and D. C. Wooten: Environmental impact analysis handbook, McGraw- Hill Book Co.
4. Canter L.W., Environmental impact assessment, Mc. Graw Hill publication.
5. Morris P.and R. Therivel,Methods of environmental impact assessment, UCL press.
6. Srivastav A.K. Environmental impact assessment, APH publishing Corporation.
7. Introduction to environmental impact assessment, Glasson research press.
8. Barrow, C. J. Environmental and social impact assessment and introduction.
9. Morris P. and Therivel, R. (2001). Methods of environmental impact assessment, 2nd edition, Spon press, NY.
10. Glasson, J., Therival, R. , Chadwick, A. (1994). Introduction to environmental impact assessment- principles and procedures, process, practice and prospects. Research press New Delhi,
11. Larry W. Canter," Environment Impact Assessment", McGraw-Hill Book Company, New York
12. Rau G.L. and C.D. Weeten, "Environmental Impact Analysis Hand book, McGraw Hill, 1980.
13. Kulkarni V. and T V Ramchandra. “Environmental management” Capital Publishing Co
14. Mhaskar A.K.“Environmental Audit" Enviro Media Publications. 5. S.K. Dhameja, "Environmental Engineering and Management" S.K. Kalaria and Sons Publishers.

LS 402 (Z): Animal Physiology

[Full Marks = 100, Contact Hours = 50, Total credit = 05]

Unit – I:

1. An overview of hemopoiesis
2. Structure and function of hemoglobin.
3. Gaseous transport and exchange in blood.
4. Coagulation of blood.

Unit – II:

1. General organization of respiratory system
2. Pulmonary volume and capacities, Alveolar ventilation, rate of alveolar ventilation
3. Gaseous exchange: Diffusion through respiratory membrane and tissue.
4. Neural and chemical regulation of respiration.

Unit – III:

1. General organization of the kidney and structure of nephron
2. Glomerular filtration
3. Tubular reabsorption and secretion
4. Water excretion

Unit – IV:

1. Structure and function of neurons and glial cells.
2. Resting membrane potential and action potential
3. Neurotransmitters.
4. Ultra structure of skeletal muscle fiber, Mechnism of muscle contraction, muscle fatigue.

Unit – V:

1. Basic concept of toxicology; types of toxic agents
2. Basic mechanism of action of toxic agents and dose-response relationship
3. Free radicals - reactive oxygen and reactive nitrogen species; Role of free radicals in cellular metabolism
4. Cellular response to toxic agents - antioxidant defence system -enzymatic and non-enzymatic.

Suggested Readings:

1. Hoar, W.S. (1983). General and Comparative Physiology, Prentice Hall of India, ND.
2. Prosser, C.L. and Brown, F. A. (1965). Comparative Animal Physiology, Prentice Hall of India, New Delhi.
3. Arthur, C., Guyton and Hall (1996). Textbook of Medical Physiology (9^{th} ed.), W.B. saunders and Company.
4. Ganong (1991). Review of Medical Physiology (15^{th} ed.), Lange Medical Publications.

LS 403 (Z): Developmental Biology

[Full Marks = 100; 6 Contact hours/week; 1.2 credits/unit; Total credit = 06]

Unit – I: (Principles of Developmental Biology)

1. Potency, commitment, specification, induction, competence,
2. Determination and differentiation; morphogenetic gradients; cell fate and cell lineages
3. Stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development

Unit – II: (Early Development)

1. Production of gametes, Gametogenesis: Spermatogenesis and ogenesis, cell surface molecules in sperm-egg recognition in animals
2. Fertilization: Sperm egg interaction and acrosomal reaction ,Species specific recognition of gamates, Prevention of polyspermy, Fusion of gametes and egg activation and zygote formation
3. Cleavage: Types of eggs; overview of types of cleavage ,blastula formation, embryonic fields

Unit – III: (Gastrulation)

1. Gastrulation: A comparison of process of gastrulation in insects, amphibians, birds and mammals
2. Gastrulation and formation of germ layers in animals ectoderm, mesoderm and endoderm.
3. Mechanism of cell movement during gastrulation.

Unit – IV: (Gene and development)

1. Pattern formation in Dictyostellium
2. Early events in Drosophila development
3. Drosophila axis formation and embryonic patterning
4. Drosophila segmentation and segment identity (Hox genes)

Unit – V: Programmed cell death, aging and senescence

1. Apoptosis and its role in development, Mechanism of apoptosis
2. Ageing and Senescence, Mitochondrial control of ageing
3. Insulin pathway control of ageing and possible relation to oxygen radicals .
4. “Ageless” animals and environmental control of ageing; Senesence and cell death

Suggested Readings:

1. Gilbert, S. F. Developmental Biology (8th ed.), Sinaur Associates Inc., Sautherland.
2. Berrill, N.J. Developmental Biology, McGraw Hill Book Co., USA.
3. Slack (1991). From Egg to Embryo, Cambridge University Press, UK.
4. Weddington, C.H.C. (1985). Principles of Development and Differentiation.
5. Bronson (1989). Mammalian Reproductive Biology, University of Chicago Press.

LS 404 (Z): Projects

[Full Marks = 200; 12 Contact hours/week; Total credit = 200]