COURSES OF STUDIES

FOR POST GRADUATE PROGRAM

IN BOTANY

(UNDER SEMESTER SYSTEM)

(Academic session 2020-2022)

GANGADHAR MEHER UNIVERSITY,

AMRUTA VIHAR, SAMBALPUR, ODISHA

Post Graduate
Programme Structure
SCHOOL OF BOTANY
G.M. University, Sambalpur

Post graduate programme comprising two years, will be divided into 4 (four) semesters each of six months duration.

Year	Semesters	
First Year	Semester I	Semester II
Second Year	Semester III	Semester IV

The detail of title of papers, credit hours, division of marks etc of all the papers of all semesters is given below.

1. There will be two elective groups namely:

- Discipline Specific Elective in Sem II.
- Interdisciplinary Elective in Sem III.

A student has to select one of the DSE paper in Sem II and one of the paper in Sem III as offered by the respective department at the beginning of the semester II and semester III respectively.

2. Each paper will be of 100 marks out of which 80 marks shall be allocated for semester examination and 20 marks for internal assessment (Mid Term Examination).

3. There will be four lecture hours of teaching per week for each paper.

4. Duration of examination of each paper shall be three hours.

5. Pass Percentage:

- The minimum marks required to pass any paper shall be 40 percent in each paper and 40 percent in aggregate of a semester.
- No students will be allowed to avail more than three (3) chances to pass in any paper inclusive of first attempt.

1st Year: Semester-I

Paper				Total Marks	Duration (Hrs)	Credit Hours
Paper No	Title	Mid Term	End Term			
101	CRYPTOGAMS	20	80	100	3	4
102	TRADITIONAL AND MODERN TAXONOMY	20	80	100	3	4
103	ARCHEGONIATE	20	80	100	3	4
104	CYTOLOGY	20	80	100	3	4
105	PRACTICALS RELATED TO -101 to -104		100	100	3	4
Total		80	420	500	15	20

1st Year: Semester-II

Paper				Total Marks	Duration (Hrs)	Credit Hours
Paper No	Title	Mid Term	End Term			
201	BIOCHEMISTRY-1	20	80	100	3	4
202	BIOCHEMISTRY-2	20	80	100	3	4
203	GENETICS	20	80	100	3	4
204	DEVELOPMENTAL BIOLOGY	20	80	100	3	4
205	PRACTICALS PERTAINING TO PAPERS -201 TO -204		100	100	3	4
DSE Papers*						
206A	ADVANCED MICROBIOLOGY	20	80	100	3	4
206B	ADVANCED GENETICS	20	80	100	3	4
206C	PLANT BIOTECHNOLOGY AND PRODUCTION OF TRANSGENICS	20	80	100	3	4
Total		100	500	600	18	24

*Discipline Specific Elective Paper. Any one paper can be opted by students of this Department.

2nd Year: Semester-III

Paper				Total Marks	Duration (Hrs)	Credit Hours
Paper No	Title	Mid Term	End Term			
301	PLANT PHYSIOLOGY-1	20	80	100	3	4
302	PLANT PHYSIOLOGY-2	20	80	100	3	4
303	ECOLOGY AND ECOSYSTEM	20	80	100	3	4
304	MICROBIOLOGY, PLANT PATHOLOGY AND IMMUNOLOGY	20	80	100	3	4
305	PRACTICALS PERTAINING TO 301 TO 304		100	100	3	4
IDSE Papers*						
306A	ORIGIN OF LIFE	20	80	100	3	4
306B	MOLECULES AND THEIR INTERACTION RELAVENT TO BIOLOGY	20	80	100	3	4
306C	CELL BIOLOGY	20	80	100	3	4
Total		100	500	600	18	24

*Inter Discipline Specific Elective Paper. Any one paper can be opted by students of other Departments.

2nd Year: Semester-IV

Paper				Total Marks	Duration (Hrs)	Credit Hours
Paper No	Title	Mid Term	End Term			
401	PLANTS IN HUMAN WELFARE AND BIODIVERSITY ASSESSMENT	20	80	100	3	4
402	EVOLUTION AND PLANT BREEDING	20	80	100	3	4
403	MOLECULAR BIOLOGY AND BIOTECHNOLOGY	20	80	100	3	4
404	BIOSTATISTICS, INSTRUMENTATION	20	80	100	3	4
405	Project Work Report and VIVA VOCE(Non Practical Papers)		100	100	3	4
Total		80	420	500	15	20

SEMESTER-I

101: CRYPTOGAMS

Unit 1: Algae

Classification; criteria, system of Fritsch, and evolutionary classification of Lee; significant contributions of important phycologists (F.E. Fritsch, G.M. Smith and Chapmann), modern system. Range of Thallus organization and reproduction in Cyanophyta, Chlorophyta, Xanthophyta, Phaeophyta, Rhodophya.

Unit 2: Applied Phycology

Role of algae in the environment: Algae as food, Algae as fodder, Algae in reclamation, Algae in Sewage disposal Algae in agriculture: Algae as fertilizer, Algae in Pisci culture. Algae in biotechnology and industry : Antibiotics, Algae as research material and other..

Unit 3: Fungi

Thallus organization cellwall composition, nutrition and reproduction in Zygomycetes, Oomycetes Ascomycetes , Basidiomycetes,

Unit 4: Applied Mycology

Role of fungi in biotechnology, Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.

-102: TRADITIONAL AND MODERN TAXONOMY

Unit 1: Plant identification, Classification, Nomenclature; Biosystematics.

Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys:Single access and Multi-access, Systematics- an interdisciplinary science, Evidence from palynology, cytology, phytochemistry and molecular data. Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary). Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.

Unit 2: Systems of classification

Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (upto series) and Engler and Prantl (upto series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.

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Unit 3: Biometrics, Numerical taxonomy, cladistics and Phylogeny of Angiosperms

Characters; Variations; OTUs, character weighting and coding; cluster analysis; Phenograms, cladograms (definitions and differences).Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades).origin& evolution of angiosperms; co-evolution of angiosperms and animals; methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

Unit 4: Range of floral structures and comparative study of important orders.
Dicots: Ranales, Urticales, Umbelliferae, Rosales, Asterales.
Monocots: Glumiflorae, Scitamineae, Microspermae. Brief account of flora of Odisha.

-103 ARCHEGONIATE

Unit 1: Bryophytes
Porella, Anthoceros, Sphagnum and Funaria; Reproduction and evolutionary trends in Riccia, Marchantia , Anthoceros and Funaria.

Unit 2: Pteridophytes
Life history of *Psilotum, Selaginella, Equisetum* and *Marsilea*. Progressive sterilization of sporogenous tissues in bryophytes, Apogamy, and apospory, heterospory and seed habit, telome theory, stelar evolution.

Unit 3: Paleobotany
Process of Fossilisation, Geological time scale, General character of fossil groups, Bennettitales, Pentoxylales, Chorditales.

Unit 4: Gymnosperms
Classification, morphology, anatomy and reproduction of *Cycas*, *Pinus*,*Ginkgo* and *Gnetum*.

-104 CYTOLOGY

Unit 1: Introduction to the Cell and Cell division
The evolution of the cell: From molecules to first cell, From Prokaryotes to eukaryotes, From single cells to multicellular organisms, The Plasma membrane, Membrane structure: The Lipid bilayer, Membrane proteins, Membrane carbohydrates, Membrane transport of Micro & Macromolecules exocytosis and endocytosis, Cell division: Overview of the Cell cycle and its control, The mechanisms for regulating mitotic and meiotic events.

Unit 2: The Cell nucleus,
Morphology and functional elements of eukaryotic chromosomes, Chromosomal DNA and its packaging and organization: The complex global structure of chromosomes and functions, implications, lampbrush Chromosomes, Polytene chromosomes, Heterochromatin, Centromeres, Telomeres.

Unit 3: Organelles of the eukaryotic cell
Lysosomes, Peroxisomes, Golgi apparatus, Endoplasmic reticulum, Mitochondria and chloroplast, Structure and Semi autonomic nature of the mitochondria and chloroplast,

Unit 4: Protein sorting and cell signaling
Protein secretion, synthesis and targeting of mitochondria, chloroplast and peroxisomal proteins, translational modification in the ER. Intracellular traffic, protein sorting in the Golgi, traffic in the endocytic pathway, exocytosis, Cell to cell signaling, Overview of the extracellular signaling, Identification of cell surface receptors, G Protein coupled receptors and their effectors, Second messengers.

-105 PRACTICALS RELATED TO -101 to -104.

1. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electron micrographs), Volvox, *Oedogonium,Coleochaete, Chara, Vaucheria, Ectocarpus, Fucus and Polysiphonia,Prochloron* through electron micrographs, temporary preparations and permanent slides.
2. Study of micro and macro algae in the field and in the laboratory (preparation of temporary and permanent materials and identification).
3. Study of morphology and reproductive structures of algae belonging to different classes through permanent microscopic preparations and preserved specimens.
4. Study of temporary & permanent preparation for microscope observation of external and internal features of vegetative and reproductive structure of important genera of Bryophytes.
5. Study of temporary and permanent preparation of vegetative and reproductive structure of Pteridophytes.
6. Study of temporary and permanent preparation of vegetative and reproductive structure of Gymnosperms.
7. Squashing techniques for study of mitosis and meiosis in onion root tip and flower bud. Use of camera lucida to study chromosomes & calculating the magnification.
8. To find out mitotic index of dividing cells of Allium cepa root tips.
9. Comparative karyotypic analysis of two species of a genus.
10. And any other experiment related to the papers 101 to 104.

SEMESTER- 2

-201: BIOCHEMISTRY-1

Unit 1: Principles of Biochemistry

Cellular environment and applicability of basic laws of chemistry and thermodynamics. Concept of micro and macromolecules, Molecular interactions and its importance in understanding cellular processes

Unit 2: Macromolecules-1

Monosaccharides and derivatives of sugars, (glucose, fructose, sugar alcohol– mannitol and sorbitol);Disaccharides (sucrose, maltose, lactose), Oligosaccharides and polysaccharides (structural-cellulose, hemicelluloses, pectin, chitin, mucilage; storage – starch, inulin); Isomers of glucose, derivatives of glucose.

Unit 3: Macromolecules-2

Structure of amino acids and peptide bonds, Primary structures of protein, Ramachandran Plot, alpha helical and beta pleated structures, Dynamics of protein structure , Protein modifications

and their functional implications , Basic concepts of protein folding, folding pathways, role of accessory proteins in protein folding, protein stability, globular proteins and maintenance of specific conformation.

Unit-4: Macromolecules-3

Lipids: Definition and major classes of storage and structural lipids. Fatty acids structure and functions. Essential fatty acids. Triglycerides; structure and function, Saponification, Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids: structure of sphingosine, ceramide. Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers, bilayers.

202: BIOCHEMISTRY-II

Unit-:1 ATP Metabolism

Concept of energy rich compounds, Central role of ATP in metabolism, Common types of reactions involved in ATP metabolism, ATP Synthesis.

Unit-:2 Carbohydrate Metabolism

Metabolic importance of glycolysis, TCA cycle, Amphibolic nature of TCA cycle, Energetics of Glucose oxidation, gluconeogenesis from TCA cycle intermediates and amino acids. Regulation of gluconeogenesis, Glycogenolysis, HMP shunt, Synthesis of Starch by C3 and C4 pathways of photosynthesis.

Unit-:3 Lipid and Amino Acid Metabolism

Degradation of odd and even carbon-fatty acids, minor pathways of fatty acid oxidation, Energetics of Beta Oxidation, The Glyoxylate cycle, Biosynthesis of saturated fatty acids. Oxidative degradation of aminoacids leading to Acetyl Co-A, Alpha- Keto Glutarate pathway, Succinate Pathway, Fumarate Pathway, Oxaloacetate pathway of amino acid oxidation, decarboxylation and deamination.

Unit-: 4 Metabolism of Vitamins and Nucleotides.

Nomenclature and roles of vitamins, Sources and deficiency symptoms in plants, metabolism of water soluble vitamins, Biosynthesis of thiamines, riboflavins, Vitamin B6, Pantothenic acid, Co-enzyme A, Nucleotide biosynthesis and degradation, salvage pathways, its regulation and diseases. Mechanisms of hormone action, metabolism of lipids during seed germination.

203: GENETICS

Unit 1-: Introduction and scope of Genetics

Chromosomal basis of inheritance during cell division, DNA as genetic material, Basic mechanism of DNA replication, Basic structure of DNA and RNA, DNA replication: Messelson and Stahl Experiment, Carins Experiment, Okazaki Experiment,

Unit 2-: Mendelian and non Mendelian inheritance

Basic Principles of Mendelian Inheritance: Segregation and Independent Assortment, Alleles and Multiple Alleles, Human pedigrees and inheritance, Gene Interaction: Sex determination and Sex linked inheritance, Drosophila and other animals, Sex-determination in plants, Pedigree analysis

Unit 3-: Molecular and Cellular genetics-1

Linkage analysis and gene mapping in eukaryotes, Coupling and repulsion phases, Crossover and recombination. Chloroplast and Mitochondrial inheritance: Yeast, *Chlamydomonas/ Neurospora* and higher plants, Basic Principles of Genetic Engineering, Fine Structure of gene and gene concept: Fine structure of rII gene – Benzer's experiments, complementation analysis and fine structure of gene, Recombination, concept of gene

Unit 4-: Molecular and Cellular genetics-2

Mutations, Spontaneous and induced mutations, Chromosomal mutation and aberrations, Change in chromosome number: trisomy and polyploidy. Evolutionary history of bread wheat, Aneuploids –nullisomics, monosomics, and uisomics, Somatic aneuploids, Changes in chromosome structure, Properties of chromosomes for detection of structural changes, Main type of changes– deletions duplications, inversions. Mechanism of chromosome mutations genetic and cytological features of deletions, Duplications, inversions and translocations, Somatic vs germinal mutation, Population genetics: application of Mendel's laws to whole population, Calculation of allele frequencies, Hardy-Weinberg principle for calculating recessive gene frequency, Calculating frequency of sex –linked alleles.

204 DEVELOPMENTAL BIOLOGY

Unit 1-: Morphogenesis and organogenesis in plants:

Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum, Programmed cell death, aging and senescence

Unit 2-: Reproduction and embryogenesis

Male and female gametophyte development, genetic and hormonal regulation of reproduction, pollination and fertilization , Basic layout of dicot and monocot embryos, stages of embryo development, embryonic axis, cell division and pattern formation in embryo, genetic and hormonal regulation of embryo development, cell polarity in embryo

Unit 3-: Shoot development

Structure and function of shoot apical meristem (SAM), initiation and maintenance of SAM, regulation of meristem size, antagonism between SAM and lateral organs, genetic regulations, axial bud formation, shoot branching , Emergence of leaf primordium from SAM, abaxial and adaxial identity of leaf cells, leaf margin, trichome, epidermis and stomata development, vascular differentiation .

Unit 4-: Root and Flower Development

Root apical meristem structure and function, lateral root development, lateral and adventitious root development, root hair development, hormonal regulations in root development, Transition from vegetative to reproductive stage, inflorescence meristem, floral whorls specification, ABC model and beyond, whorl boundary specification, asymmetric flower development, structure and development of monocot flowers, Use of in vitro system for studying development.

- 205:- PRACTICALS PERTAINING TO PAPERS -201 TO -204

1. pH buffers etc
2. Absorption measurements
3. Protein estimations
4. Enzyme kinetics
5. Carbohydrates and lipid analysis
6. Protein purification
7. Chromatography (a) TLC, (b) paper, (c) GLC
8. Sectioning of tissues (Plant and animal)
9. And any other practical related to the papers 201 to 204.

206 A ADVANCED MICROBIOLOGY

Unit1-: Microbial Classification And Bacteria

Molecular taxonomy of microorganisms, Advanced Bacterial Metabolism: Recent Advances in bacterial metabolism with emphasis on unusual bacterial pathways

Unit 2-: Bacteriology

Stressors, Stress reactions and Survival of bacteria: Prokaryotic responses to Environmental stress: Heat shock and molecular chaperones. Oxidative stress. Hydrostatic stress. Osmotic shock. Cross responses to stress factors Quorum sensing in Bacteria: Gram negative bacteria: LUXI LUXRType: Gram Positive bacteria: Peptide mediated quorum sensing

Unit 3-: Mechanisms In Bacteria

Mechanisms in bacteria with special emphasis on Caulobacter development and cell cycle control, Interactions between Humans and microorganisms: Nonspecific and specific defense mechanisms. Mechanisms of pathogenesis. host factors influencing resistance to infection, Physiology of growth: Growth kinetics. Regulation. Effect of environmental factors on growth e.g., pH. Temperature. Oxygen. Nutrient limitations etc

Unit 4-: Applied Microbiology

Physiology and vaccine development: Use of proteomics and genomics and physiology for the development of vaccine of specific microorganisms, Environmental Microbiology: Microbial degradation of xenobiotics. Catabolic genes and their regulation. Biomaterials. Isolation. Production. Characterization and its use, Industrial Microbiology: The application of fundamental principles of Microbiology to industrial Fermentations and processing. Antibiotics production etc

206 B ADVANCED GENETICS

Unit 1-: Neo- Mendelian Principles

Dominance, segregation, independent assortment, Extensions of Mendelian principles : Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters

Unit 2-: Concept of Gene
Allele, multiple alleles, pseudoallele, complementation tests , Gene mapping methods : Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.

Unit 3-: Extra Chromosomal inheritance :
Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Microbial genetics : Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. IOD score for linkage testing, karyotypes, genetic disorders. Quantitative genetics : Polygenic inheritance, heritability and its measurements, QTL mapping.

Unit 4-: Mutation
Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. Structural and numerical alterations of chromosomes : Deletion, duplication, inversion, translocation, ploidy and their genetic implications. Recombination : Homologous and non-homologous recombination including transposition

206 C PLANT BIOTECHNOLOGY AND PRODUCTION OF TRANSGENICS

Unit 1-: Hybrid Production And Germplasm Conservation
Selection of heterokaryotic fusion products, analysis of hybrids, somatic hybrids and cybrids for crop improvement, artificial seeds, cryopreservation, slow growth and DNA banking for germplasm conservation, Vector-mediated Gene Transfer to plants: Molecular basis of crown gall and hairy root diseases, features of Ti and Ri plasmids, mechanism of T -DNA transfer, role of virulence genes, hairy root cultures as source of pharmaceuticals, vectors based on PTi & PRi, binary and co-integrate vectors, optimized protocols for Agrobacterium-mediated genetic transformation, transgenic dicots and monocots. Plant viruses as vectors. Vectorless direct gene transfer to plants and in plant transformation: Rationale for monocot transformation, physical methods (particle bombardment/ microprojectile / biolistics, electroporation, microinjection, liposome mediated, silicon carbide fibers), chemical methods (PEG - mediated, calcium phosphate co-precipitation), transgenic monocots and dicots via direct gene transfer, in planta transformation. Integration and fate of transgene, precision of transgene integration by site-specific recombination.

Unit 2-: Processing of The Recombinant Proteins:
Purification and refolding; characterization, stabilization. Analysis of proteins: SDS-PAGE, 2-D Gel electrophoresis, mass spectrometry (MALDI TOF, QTOF, QUADRAPOLE), NMR, X-ray crystallography, Mutagenesis: tools for protein engineering; site saturated and site-directed mutagenesis. Chloroplast Engineering: Chloroplast genome, chloroplast transformation: rationale, methods used for generation of homoplasmic transplastomic plants, vectors for chloroplast transformation, strategies for optimizing foreign gene expression in chloroplast, transplastomics without antibiotic resistant gene, applications of chloroplast transformation. Metabolic engineering: Molecular farming of carbohydrates (case study-starch), lipids (case studybiodegradable plastics) and proteins (Hirudin production in Brassica napus)

Unit 3 Antisense RNA Technology:
Regulatory RNA (micro RNA), Antisense RNA, construction of antisense vectors, analysis of antisense clones, applications of antisense technology. Gene silencing: causes (DNA methylation, homology-dependent suppression by antisense gene), strategies for avoiding gene silencing, methods of inducing gene silencing and its application. Diagnostics in agricultures and molecular breeding: ELISA.

Unit 4-: Detection of Transgene and Products,
Opine assay, enzyme activity assay (GUS, NPT), transient and stable expression, transgene stability and silencing, production of marker free transgenic plants: co-transformation, site specific recombination, intra-chromosomal recombination. Biosafety regulation and commercialization , Gene tagging: Transposable genetic elements in bacteria, IS elements, composite transposon, Class I & II transposable elements in eukaryotes, isolation of genes by transposon gene tagging and T-DNA tagging. DNA Sequencing: Sanger's technique, Maxam & Gilbert technique and automated sequencing. Advantages of transgenics.

MASTERS-1
301: PLANT PHYSIOLOGY-1

Unit 1-: Water relations
Properties of water, Properties of solutions, water potential, Soil-plant-atmosphere continuum, Transport processes in plant, Active and passive transport systems, ion channels, driving forces and flow, electrochemical gradient, facilitated diffusion, transport of nutrients across the primary root, transport through sieve element, transport of metabolites from the source to the sink, genetic regulation of transport systems in response to nutrients availability and growth status ,

Unit 2-: Mineral nutrition and assimilations of inorganic nutrients.
Plant mycrorrhiza association, nitrogen metabolism, assimilation of cations, chloride dynamics, Essential and beneficial elements, macro and micronutrients, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents, Soil as a nutrient reservoir, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.
Unit 3-: Pathway of water movement
Symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap– cohesion-adhesion theory. Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement. Physiology of stomata and Mechanism of stomatal movement, Siginificance of transpiration

Unit 4-: Plant Growth Regulators.
Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene.Brassinosteroids and Jasmonic acid, Physiology of flowering: Photoperiodism, flowering stimulus, florigen concept, vernalization. Seed dormancy. Rhythms in plants.

302: PLANT PHYSIOLOGY-2
Unit 1-: Photosynthesis,

Light absorption, emission, energy transfer, Z-scheme of photosynthesis, electron transfer, photo-phosphorylation, CO_2 fixation, C2, C4, CAM plants, Photo-morphogenesis: Phytochromes, Cryptochromes,

Unit 2-: Respiration

Glycolysis, fate of pyruvate, oxidative decarboxylation of pyruvate, regulation of pentose phosphate pathway, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the TCA cycle. mitochondrial electron transport, Complex-I, complex-II, complex-III, complex-IV, Oxidative phosphorylation, Cyanide-resistant respiration.

Unit 3-: ATP Synthesis

Mechanism of ATP synthesis, substrate level phosphorylation and oxidative phosphorylation), chemiosmotic mechanism, ATP synthatase, Boyers conformational change model, role of uncouplers.

Unit 3-: Stress Physiology

Defining plant stress, Acclimation and adaptation. Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction, stress related proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates, Stress sensing mechanisms in plants, Role of nitric oxide. Calcium modulation, Phospholipid signaling, Adaptation in plants; Changes in root: shoot ratio; Aerenchyma development; Osmotic adjustment; Compatible solute production. Calcium, phospholipids, cGMP.

303: ECOLOGY AND ECOSYSTEM

Unit 1: Ecological principles

Physical environment; biotic environment; biotic and abiotic interactions. Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation - demes and dispersal, interdemic extinctions, age structured populations.

Unit 2-: Species interactions and succession

Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis. Nature of communities, community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.

Unit 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, estuarine). Biogeography, Major terrestrial biomes, theory of island biogeography; biogeographical zones of India.

Unit 4: Applied ecology:

Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Principles of conservation, major approaches to management, Indian case studies on

conservation/management strategy (Project Tiger, Biosphere reserves).

304: MICROBIOLOGY, PLANT PATHOLOGY AND IMMUNOLOGY

Unit 1-: Bacteriology.

Theory of spontaneous generation Experiments of Pasteur and Tyndall, Koch's Postulates, Isolation of bacteria from natural sample column, Control of Microbial growth methods of sterilization , The Microbial cell: Cell wall organization on Prokaryotes, Eukaryotes and Archaea, Cell surface appendages pilli, locomotion by flagella chemotactic Movement, Peptidoglycan synthesis, inhibitors in different steps. Growth and nutrition, Growth kinetics, Batch and continuous cultures, Nutritional classification of microorganisms, Nutritional uptake by microorganisms (C.N.P). Metabolic versatility of microbes, Microbial respiration, Fermentation, Microbial Genetics: Modes of genetic exchange in microbes, Transformation, Transduction, Conjugation.

Unit 2-: Virology

Viruses as a living system, Classification of viruses, Organization of viruses, Protein structure and assembly, nucleic acid packaging, geometrical aspects, icosahedral and helical symmetry, Virus attachment and entry in to host cells, Cellular and molecular biology of Host virus interaction Genome replication and mRNA production by RNA viruses, Reverse transcription and integration in to the host genome (retroviruses), DNA virus replication strategies, Unique features of viral gene expression, Translational control of viral gene expression, Viral pathogenesis and cell transformation by viruses, Viral Genetics, Viral vaccines, Antiviral chemotherapy, Persistence of viruses , Hepadna viruses, HIV, Polyomaviruses (SV40), Baculovirus, Topsoviruses, Potyviruses , Virus evolution, Viral vectors and gene therapy

Unit 3-: Plant pathology

Physiological, Biochemical, Genetic aspects of symbionts Host- Pathogen relationships; Disease cycle and environmental relation; General symptoms; Geographical distribution of diseases; etiology; symptomology; prevention and control of plant diseases and role of quarantine. Bacterial diseases – Citrus canker and angular leaf spot disease of Cotton.Viral diseases – Tobacco Mosaic viruses, vein clearing. Fungal diseases – Early blight of potato, Black stem rust of wheat, white rust of crucifers.

Unit 4-: Immunology

Introduction to Immune System, organs, cells and molecules involved in innate and adaptive immunity. Mechanisms of barrier to entry of microbes/pathogens Antigens, antigenicity, and immunogenicity. B and T cell epitopes Antibody structure and function, Antigen-antibody interactions Hybridoma, monoclonal antibodies, and antibody engineering, Immunological Techniques (antibody generation, detection of molecules using ELISA, RIA, Western blot, immunoprecipitation, flowcytometry, immunofluorescence microscopy etc) .

- 305 PRACTICALS PERTAINING TO 301 TO 304

1. General idea on instruments used in microbiology laboratory.
2. Preparation and sterilization of media (Nutrient Agar, Nutrient Broth, Czapeck-Dox), Plating, Tubing, Slanting of media.
3. Gram staining and acid-fast staining of bacteria.
4. Isolation of bacteria in pure culture.
5. Study of commonly occurring cyanobacteria.
6. Measurement of length/breadth/diameter of microbial cell/spore using ocular and stage micrometer.
7. Study of principles of spectrophotometer and verification of Beer-Lambert's law.
8. Effect of substrate concentration on activity of any enzyme and determination of Km value. (Acid Phosphatase, peroxidase, catalase)
9. Extraction of pigment from leaves and preparation of absorption spectra for chlorophylls and carotenoids.
10. Preparation of standard curves for quantification of protein, carbohydrate and reducing sugar.
11. Quantification of soluble and total protein and total carbohydrate contents of plant samples.
12. Isolation of Chloroplast and study of protein profile of RUBISCO by SDS-PAGE.
13. And any other practical related to the papers 301 to 304.

306 A- ORIGIN OF LIFE

Unit 1-: Evolutionary Origin of Life

Introduction to the Cell: The evolution of the cell, From molecules to first cell, From Prokaryotes to eukaryotes, from single cells to multicellular organisms, Formation of Angiosperm,

Unit 2-: Reproduction In Plants

Gametes, self pollination vs out crossing, mechanisms of pollen dispersal, adaptive traits, fertilization (double fertilization, triple fusion), seed and fruit formation, Embryogenesis, seed dormancy, dispersal of Seed, seed germination

Unit 3-: Development Of Plants And Plant Kingdom

Basics of plant development, shoot, leaf, root and floral meristems, transition from vegetative to reproductive stages, growth regulation of plants, Plant kingdom-classification.

Unit 4-:Maintaining Life

food chain, producers and consumers, pyramid of energy, food webs, decomposers, food chains and human, the fuel of life, Mode of nutrition in plants, chloroplasts, site of photosynthesis, the reaction in photosynthesis.

- 306 B- MOLECULES AND THEIR INTERACTION RELAVENT TO BIOLOGY

Unit 1-: Structure of Biomolecules
Structure of atoms, molecules and chemical bonds, Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins).

Unit 2-: Biochemical Interactions
Weak interactions such as Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc. Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties).

Unit 3-: Bioenergetics
Glycolysis, TCA cycle oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers. Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes

Unit 4-: Biomolecules
Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Stability of proteins and nucleic acids.

306 C- CELL BIOLOGY

Unit 1-: Cell Structure
Cell 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).

Unit 2-: Cell Organells
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 3-: Nuclear Organisation
Organization of genes and chromosomes (Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons).

Unit 4 -: Cellular Processess
Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle). Microbial Physiology (Growth yield and characteristics, strategies of cell division, stress response)

- 401 PLANTS IN HUMAN WELFARE AND BIODIVERSITY ASSESSMENT
Unit-1 -: Role of plants in relation to human welfare
Importance of forestry their utilization and commercial aspects, Avenue trees, Ornamental plants of India. Alcoholic beverages through ages. Fruits and nuts: Important fruit crops

their commercial importance, Wood and its uses, plant products in World, Plant products from India, Status of India in export and import of various plant products, NTFP, role of NTFP in livelihood support of tribals, Medicinal Plants, Some important medicinal plants and their phytochemistry, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity:Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes.

UNIT 2-: Phytodiversity

Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Concept of centers of origin, their importance with reference to Vavilov's work, Threats to biodiversity; Management strategies; Bio- prospecting; IPR; CBD; National Biodiversity Action Plan, Principle of Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phyto geographical division of India; Local Vegetation. Forests, Forest Cover and its significance (with special reference to India); Depletion; Management.

UNIT 3-: Biodiversity Assessment

EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management. National and international efforts in Biodiversity information management and communication. Field inventory methods and practices, Floristics and quantitative methods of plant populations, Quadrate and transact method of plant diversity estimation, Belt transact, Biodiversity indices and different statistical measurements of Biodiversity.

UNIT 4: Conservarion of Biodiversity:

Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agro biodiversity, Projected scenario for biodiversity loss. Forest management and conservation, Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development.

- 402 EVOLUTION AND PLANT BREEDING

Unit 1-: Emergence of evolutionary thoughts

Lamarck; Darwin-concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; The evolutionary synthesis, Origin of cells and unicellular evolution, Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiement of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes; Anaerobic metabolism, photosynthesis and aerobic metabolism.

Unit 2-: Paleobotany and Evolutionary history

The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals; Molecular Evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of new genes and proteins; Gene duplication and divergence.

Unit 3-: Evolution at population level

Population genetics - Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution.

Unit 4-: Plant breeding

Introduction and objectives, Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding. Selection methods: For self pollinated, cross pollinated and vegetative propagated plants; Hybridization: For self, cross and vegetative propagated plants – Procedure, advantages and limitations. Quantitative inheritance, Concept, mechanism, examples of inheritance of Kernel colour in wheat, Monogenic vs polygenic Inheritance. Inbreeding depression and heterosis, History of genetic basis of inbreeding depression and heterosis; Applications. Crop improvement and breeding, Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

- 403 MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Unit 1-: Molecular genetics

Gene, Gene Concept, Structure and Organization, Transcriptional control regions of eukaryotic and prokaryotic genes, Restriction and Modifying enzymes, Cloning Vectors, cDNA synthesis and construction of cDNA libraries, Genomic libraries and their construction,

Unit 2-: Molecular mechanisms

Identification and analysis of recombinant DNA clones, DNA sequencing methods, Genome Sequencing and Analysis, Methods to study gene expression, Protein-protein interaction, PCR and its application, Generation of mutation and mutants: Random mutations, Targeted mutations and raising mutants, RNA interference and gene silencing, gene knockouts, Transgenic systems, genome editing.

Unit 3-: Plant biotechnology

Historical perspective; Plant Tissue Culture, Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation) Gene Cloning (Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR-mediated gene cloning); Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligo- nucleotide, heterologous.

Unit 4-: Fundamental Processes in molecular biology

DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extra-chromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination). 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 poly-adenylation, structure and function of different types of RNA, RNA transport). Protein synthesis and processing (Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, amino-acylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post- translational modification of proteins). 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).

- 404 BIOSTATISTICS, INSTRUMENTATION AND BIOINFORMATICS

Unit 1-: Biostatistics

Applications of statistics in biology, Introduction to probability theory, Basic concepts, sampling; Defining sample space, Random variables, Discrete variable, probability distributions: binomial distribution, Poisson distribution with examples, Continuous random variables, Normal random variable, other continuous distributions, Arithmetic and other means, median, mode; Variance and Standard Deviation, Standard Error; Skewness, Kurtosis; Quantiles, Outliers , standard error of differences between means, T-test, Regression, Variances and co-variances Hypothesis test with regression; Assumptions, Analyses of variance, ANOVA, Hypothesis tests with ANOVA; Constructing F-Ratios; ANOVA tables, Analyses of categorical data, Two-way contingency tables; Chisquare Test.

Unit 2-: Instrumentation-1

Radiolabeling techniques: Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines. Tracing cellular molecular with radioactive isotopes and antibodies. Microscopic techniques: resolving powers of different microscopes, scanning and transmission electron microscopes, different fixation and staining techniques for EM, freeze-etch and freezefracture methods for EM, image processing methods in microscopy, fluorescence microscopy; Phase contrast microscopy; flow cytometry, Fractionation of cell contents, Centrifugation and HPLC technique, GISH, FISH.

Unit 3-:

Flow cytometry, Fractionation of cell contents, Centrifugation and HPLC technique, GISH, FISH. PCR; Methods of gene transfer- *Agrobacterium*-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics–selectable marker and reporter genes (Luciferase, GUS, GFP). Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean);

Unit 4: Applications of Biotechnology

Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

405: Project Work Report and VIVA VOCE(Non Practical Papers)