UNIVERSITY OF DELHI

SCHEME OF EXAMINATION

and

COURSES OF READING

for

B.Sc. (Hons.) EXAMINATION IN BOTANY

Part I Examination 2005

Part II Examination 2006

Part III Examination 2007

Revised Syllabi applicable for students seeking admission to the B.Sc. (Hons.) Botany Course in the academic year 2004-2005.

Price: Rs. 20.00

B.Sc. (Hons.) Botany

First Year

Paper I	Introduction to the Plant World and Phycology	50 marks
Paper II	Microbiology, Mycology, Phytopathology and Lichens	50 marks
Paper III	Cell and Molecular Biology	50 marks

Second Year

Paper IV	Archegoniatae	50 marks
Paper V	Economic Botany and Crop Improvement	50 marks
Paper VI	Genetics and Biotechnology	50 marks

Third Year

Paper VII	Plant Systematics and Phytogeography	50 marks
Paper VIII	Plant Ecology and Environmental Management	50 marks
Paper IX	Developmental and Functional Plant Anatomy	50 marks
Paper X	Developmental and Experimental Embryology of Angiosperms	50 marks
Paper XI	Plant Physiological Processes, Growth and Development	50 marks
Paper XII	Plant Metabolism	50 marks

Workload:

Theory: 3 classes per week per paper

Practical: 3 classes per week per paper

First Year: 9 theory classes and 9 practical classes per week

Second Year: 9 theory classes and 9 practical classes per week

Third Year: 18 theory classes and 18 practical classes per week

Examination:

Theory: Each paper is of 3 hours duration and 50 marks

Each paper would be set by a board of examiners

Practicals:

First year	For papers I,II,III	5 Hours 100 Marks (Records, collection etc. 25 marks)
Second year	For papers IV, V and VI	5 Hours 100 Marks (Records, collection etc. 25marks)
Third year	For papers VII, VIII and IX	5 Hours 100 Marks (Records, collection etc. 25 marks)
	X, XI and XII	5 Hours 100 Marks (Records, collection etc. 25 marks)

Note: There would be three examiners for each practical examination, two from other colleges (external) and one from the same college (internal), and teaching the different papers being examined. In the third year there would be two separate examinations, with separate examiners on each day.

B.Sc. (H) Botany I Year

Paper I: Introduction to Plant World and Phycology

Section A: INTRODUCTION TO PLANT WORLD

UNIT 1 **What is Botany**? Historical background. Why study plants? Frontiers and avenues of Plant Sciences; Relevance of plants in human life and the future of plant sciences.

UNIT 2 **Diversity in Nature:** Five kingdom classification according to Whittaker and Three domain classification according to Carl Woese; Diversity: an evolutionary perspective - from prokaryotes (bacteria) to higher plants (angiosperms); Organic and molecular evolution; Geological time scale; Introductory palaeobotany - fossils.

UNIT 3 **Origin of Life** – Spontaneous and extra - terrestrial origin, Oparin–Haldane theory, microsphere and coacervates; Origin of self - replicating system, energy yielding systems, anaerobiosis, heterotrophs, chemotrophs and autotrophs; Origin of eukaryotic cell (endosymbiotic hypothesis).

UNIT 4 **Evolution:** Major theories and concepts; General trends in evolution in plants.

Section B: PHYCOLOGY

UNIT 5 **Introduction:** General characteristics; ecology and distribution; range of thallus organization; cell structure and components: cell-wall, pigments systems, reserve food, flagella; methods of reproduction; life cycle patterns, alternation of generations; classification: criteria, systems of Christensen, Fritsch, Smith; evolutionary classification of Lee; bacillariophyta and Donophyta: diagnostic features; significant contributions of some important phycologists.

UNIT 6 **Cyanophyta:** Ecology and distribution; thallus organization; cell structure; chromatic adaptation; physiology; reproduction; heterocysts (structure, development and functions); economic importance; role in biotechnology; morphology and life cycle of *Nostoc*.

UNIT 7 **Chlorophyta:** General characteristics; range of thallus organization; ecology and distribution; pigment systems; methods of reproduction, relative sexuality; evolutionary significance of *Prochloron*; morphology and life cycles of *Chlamydomonas, Volvox, Hydrodictyon, Oedogonium, Coleochaete.*

UNIT 8 **Charophyta:** General characteristics; morphology and life cycle of *Chara*; fossils; evolutionary significance.

UNIT 9 **Xanthophyta:** General characteristics; range of thallus organization; methods of reproduction; morphology and life cycle of *Vaucheria.*

UNIT 10 **Phaeophyta:** General characteristics; range of thallus structure; ecology and distribution; methods of reproduction; morphology and life cycles of *Ectocarpus, Fucus* and *Sargassum.*

UNIT 11 **Rhodophyta:** General characteristics; range of thallus organization; ecology and distribution; methods of reproduction; morphology and life cycles of *Batrachospermum* and *Polysiphonia.*

UNIT 12 **Applied Phycology:** Role in ecosystem; aquaculture, industry, biotechnology, agriculture.

Core Practicals

1. Specimen/photograph of any two plant fossils.
2. Study of the vegetative and reproductive structures in *Nostoc, Chlamydomonas, Volvox, Hydrodictyon, Oedogonium, Coleochaete, Chara, Vaucheria,* Bacillariophyta, Dinoflagellates, *Ectocarpus, Fucus, Sargassum, Batrachospermum, Polysiphonia, Prochloron* through, EM, temporary preparations and permanent slides.

Visit to Delhi Water Works/ any Aquaculture site/Algal Technology Centre in IARI/ or any other place to observe algal growth/culture etc. Students must also collect algae from different sites and submit six specimens in the annual practical examination.

Paper II: Microbiology, Mycology, Phytopathology and Lichens

SECTION A – MICROBIOLOGY

UNIT 1 **Viruses:** Discovery, physicochemical and biological characteristics; replication; lytic and lysogenic cycle; special

types; DNA virus (Coliphage T_2); RNA virus (TMV); economic importance; symptoms, Transmission, prevention and control of diseases caused by viruses.

UNIT 2 **Bacteria:** Discovery; Ecology and distribution; Cell structure; Nutrition; Reproduction; Economic importance; Symptoms, Transmission, prevention and control of diseases caused by bacteria and mycoplasma.

SECTION B – MYCOLOGY

UNIT 3 **Introduction:** Definition; major groups of fungi and fungus-like organisms; Why study fungi? General characteristics; Ecology and distribution; Thallus organization; Fungal organelles; Wall composition; Nutrition; Growth; Reproduction and spores; Heterokaryosis and parasexuality; Sexual compatibility; Life cycle patterns; Basic criteria used in fungal taxonomy; Important systems of classification; Ainsworth and Alexopoulos (to be followed in practicals).

UNIT 4 Introduction, occurrence importance; General characteristics; Phylogenetic relationships and classification; Thallus organization; Reproduction; Life cycle pattern with special reference to the forms mentioned.

Myxomycetes: *Stemonitis* and *Physarum*.

Oomycetes: *Phytophthora, Albugo* and Downy Mildews.

Chytridiomycetes: Brief introduction only.

Zygomycetes: *Pilobolus* and *Rhizopus*.

Trichomycetes: Brief introduction only.

Ascomycetes: Yeasts (*Saccharomyces*) *Eurotium (Aspergillus), Penicillium*, Powdery mildews, *Neurospora, Xylaria, Peziza*.

Basidiomycetes: Wheat rusts *(Puccinia), Loose* and *covered* Smuts (*Ustilago*), Mushroom (*Agaricus*).

Deuteromycetes: *Alternaria, Fusarium*, and *Colletotrichum*.

UNIT 5 **Applied Mycology:** Fungi and animals; fungi and man: role in biotechnology: food and food flavouring, fermentation, secondary metabolites, mycotoxins; role in agriculture: mineralization, mycorrhizae, bioremediation, biocontrol; mushroom cultivation.

SECTION C - PHYTOPATHOLOGY

UNIT 6 **Introduction:** Definition; Importance; Terms and Concepts; Classification; Causes; Symptoms; Host-Parasite relationships.

UNIT 7 **Study of some important plant diseases prevalent in India:** White rust of crucifers; Early and late blight of potato; Rusts of wheat; Smut of sugarcane, oats and wheat, Wilt of cotton, Ripe rot of chillies; with respect to geographical distribution (with emphasis on India and Delhi), etiology, symptomatology, disease cycle and environmental relation, prevention and control.

UNIT 8 **Transmission and control of plant diseases:** Prevention of diseases; Role of quarantine and of disease resistant varieties; Treatment of disease; Role of fungicides.

SECTION D: LICHENS

UNIT 9 Occurrence, General characteristics; Growth forms and range of thallus organization; Nature of association of algal and fungal partners; Reproduction, cultural studies (in *vivo* and *in vitro*); Ecological significance; Applied importance.

Core Practicals

1. EMs / models of viruses and of virus infected plants.
2. Types of bacteria from temporary/permanent slides/EM. Study of bacterial infected plants and root nodules. Gram staining.
3. Types of fungi growing in nature.
4. Ultrastructural details of fungal hyphae/cell.
5. Study of Vegetative and reproductive structures and disease symptoms (where applicable) in *Stemonitis/Physarum, Albugo, Peronospora, Rhizopus, Pilobolus, Saccharomyces, Aspergillus, Penicillium, Phyllactinia, Erysiphe, Neurospora, Claviceps, Peziza, Puccinia,* Smuts and Mushrooms through suitable methods like temporary preparations/permanent slides/photographs, specimens etc.
6. Study of asexual stages of *Alternaria, Fusarium, Graphium, Phoma, Colletotrichum.* Demonstration of inoculation technique of any deuteromycetous fungus on PDA.

7. Applied mycology: photographs of Fairy rings, bioluminescent fungi, edible and poisonous fungi, mycorrhizae, fungi used in medicine and as biological control agents, fungi causing human & animal infections.

8. White rust of Crucifers, Early blight of potato, Rusts of wheat (black, brown, yellow), Smut of barley, sugarcane and wheat, wilt of cotton.: Herbarium/museum specimens of the diseased plants.

9. Study of growth forms of lichens on different types of substratum. Study of thallus and reproductive structures through permanent slides.

Visit to any mushroom cultivation centre/ any pharmaceutical industry/ or any other lab to observe fungal cultures /growth being used for human welfare. Students should submit a report on the field visits and fieldwork undertaken at the time of annual practical examination. This field report must include general survey and a list of all the specimens collected. Students should submit six specimens from paper II.

Paper III: Cell and Molecular Biology

Section A: CELL BIOLOGY

UNIT 1 **The Cell:** a brief introduction; historical background; landmark contributions; cell theory; comparative account of prokaryotic and eukaryotic cell.

UNIT 2 **Techniques:** microscopy–principles of light and electron microscopy; types of microscopy–phase contrast and fluorescent microscopy, TEM, SEM, negative staining, shadow casting, freeze fracture and freeze etching; cell fractionation–homogenization, centrifugation; preparatory and analytic centrifuges; autoradiography and its application.

UNIT 3 **Cellular chemistry: Carbohydrates**–types; straight chain and ring formula; optical and structural isomers; disaccharides; polysaccharides: types, structure; **Amino acids and proteins**-structure, characteristics and classification of amino acids; D- and L- forms; significance of proline in protein structure; peptide bond; polypeptide: primary, secondary, tertiary and quaternary structure; types of proteins; isoelectric point; significance and functions of proteins; **Lipids**- saturated and unsaturated fatty acids; structure and significance; saponifiable and non-saponifiable lipids

UNIT 4 **Cell Wall & Cell membrane:** cell wall function, chemical composition, origin and ultrastructure; cell membrane: significance, historical models, chemical organisation; fluid mosaic model.

UNIT 5 **Cell organelles:** Mitochondria and Chloroplast–structure, and organisation of genome; endoplasmic reticulum- structure and function, signal hypothesis, membrane system in ER; Golgi complex- origin, structure and function, GERL system; Lysosomes and Vacuoles- structure and function; microbodies- characteristics and functions; Peroxisomes and Glyoxysomes; Nucleus: structure and function; Heterochromatin and euchromatin; Ribosomes: types, chemical composition, structural model.

UNIT 6 **Cytoskeleton**: microtubule- structure and function; structure of cilia and flagella; microfilaments, intermediate filaments.

Section B: MOLECULAR BIOLOGY

UNIT 7 **Nucleic acids:** Discovery and role of nucleic acids; composition and structure; identification of genetic material; DNA &RNA as genetic material; Structure of DNA, Watson and Crick double helical model; A, B and Z-DNA; Structure and role of RNA; types; DNA/RNA hybridization; Satellite DNA, Repetitive DNA, Palindromic sequence.

UNIT 8 **Organization of genetic material:** nature of genetic material in viruses; nucleoid in bacteria; genetic recombination mechanisms in bacteria.

UNIT 9 **DNA replication:** evidence for semi-conservative replication; DNA replication at molecular level; DNA replication in prokaryotes and eukaryotes; replication apparatus; rolling circle model of DNA replication.

UNIT 10 **Chromosomes:** morphology and organisation; Telomere; Karyotype and Idiogram; special types of chromosomes; Banding patterns, chromosome painting.

UNIT 11 **Chromosome number and structure:** Chromosomal aberrations and their role in evolution and cancer; position effect; fragile sites; variations in chromosome number and role in evolution with reference to cotton, wheat and *Brassica*.

UNIT 12 **Cell division:** cell cycle and role of cyclins; mitosis, stages and significance; meiosis, stages and significance; synaptonemal complex.

Core Practicals

1. Introduction of microscopy, preparation of epidermal peels, staining and mounting technique; preparation of commonly used prefixative, fixatives and stains; localization of DNA using Feulgen reaction.
2. Study of electron micrographs/photographs to understand: negative staining, shadow casting, freeze fracture technique, fluorescence microscopy and autoradiography.
3. To demonstrate differential centrifugation technique for separation of cell fractions.
4. Spectrophotometry- to prepare standard curve of a dye and of a protein.
5. Chromatography: paper chromatographic separation of amino acids.
6. Semipermeable nature of the membrane as influenced by the temperature and organic solvent; demonstration of dialysis.
7. Measure cell size by using micrometers and calculate the area of microscopic field and count number of cells per unit volume in the given yeast culture.
8. Study protoplasmic streaming in *Hydrilla* leaves/staminal hairs of *Tradescantia*.
9. Electronmicrographs of nucleus, chloroplast, mitochondria, golgi apparatus, endoplasmic reticulum and microtubules.
10. Temporary squash preparation of onion root tips to study mitosis.
11. Preparation of Idiogram from photographs of chromosomes of *Drosophila* and *Arabidopsis*; study of chromosome laggards, bridges; ring, salivary gland and lampbrush chromosome, Barr bodies and banding pattern (from slides/photograph).
12. Cairn and Taylors' experiment, organization of DNA in eukaryotic chromosomes, HIV, Rous Sarcoma life cycle, sat DNA and sat chromosome through photographs/diagrams/models.

Project: Students to submit a project in the form of scrap book or chart.

B.Sc. (H) Botany II Year

Paper IV : Archegoniatae

UNIT 1 **Introduction:** Characteristic features and life cycle patterns of bryophytes, pteridophytes and gymnosperms; classification, recent molecular classification; distribution; ecology; habit and habitat; adaptations to land habit; geological time scale; basic trends in origin and evolution; apogamy and apospory.

UNIT 2 **Structure of Bryophytes:** morphology and life cycles of *Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum* and *Funaria* (comparative account and evolution of the vegetative thallus)

UNIT 3 **Reproduction in Bryophytes:** reproduction and evolutionary trends (progressive sterilization of tissue) in *Riccia, Marchantia, Sphagnum* and *Funaria*, spore dispersal mechanisms, vegetative reproduction.

UNIT 4 **Structure in Pteridophytes:** morphology and anatomy of *Rhynia, Psilotum, Selaginella, Equisetum, Pteris, Marsilea* (a comparative account).

UNIT 5 **Reproduction in Pteridophytes:** reproductive and evolutionary trends (a comparative account of general methods of reproduction including vegetative reproduction) in *Selaginella, Equisetum, Pteris, Marsilea.*

UNIT 6 **Evolutionary concepts:** telome concept; stelar evolution; heterospory and seed habit (living and fossil).

UNIT 7 **Structure in Gymnosperms:** morphology and anatomy of *Cycas, Pinus, Ephedra, Gnetum* (a comparative account).

UNIT 8 **Reproduction in Gymnosperms:** reproduction and evolutionary trends in *Cycas, Pinus, Ephedra, Gnetum*

UNIT 9 **Importance:** importance and conservation of bryophytes, pteridophytes and gymnosperms.

UNIT 10 **Experimental studies:** experimental studies in the Archegoniatae.

Core Practicals

Study of habit, vegetative thallus organization and structure, reproductive structures of the following taxa: *Riccia, Marchantia, Pellia, Porella, Anthoceros , Sphagnum, Funaria, Psilotum, Selaginella, Equisetum, Marsilea, Pteris, Cycas, Ephedra* and *Gnetum* through specimens, temporary mounts and permanent slides.

Students have to collect and submit specimens of bryophytes, pteridophytes and gymnosperms along with a field report.

Paper V: Economic Botany and Crop Improvement

UNIT 1 **Cultivated Plants:** origin and importance with particular reference to the works of A. de Candolle and Vavilov (especially centers of diversity, primary and secondary centres, multiple origin); a brief account of Harlan and Hawkes theories; examples of major introductions; practices of floriculture.

UNIT 2 **Cereals**: Wheat, Rice and Maize with account of origin, areas of production data, botany, breeding programmes and uses; Millets- general features, nomenclature, some examples.

UNIT 3 **Legumes:** general introduction, importance to man and ecosystems, chief pulses grown in India, fodder legumes.

UNIT 4 **Fruits and Vegetables:** Mango, Citrus, Banana and Papaya - origin, production, botany, nutritional value and uses; Difficulties encountered in mango cultivation, remedial measures; Vegetables: definition, classification and names of important vegetables.

UNIT 5 **Sugars and Starches:** Sugarcane - origin, production, botany, breeding, processing and uses; Potato - origin, botany together with tuber anatomy, propagation and uses, TPS technology; Cassava - areas of production, morphology, varietal classification, uses.

UNIT 6 **Spices and Condiments:** history and a general account of origin, production, botany and uses of fennel, coriander, black pepper, saffron, clove, cardamom, turmeric and chillies; vanilla, and allspice- botanical name, family and uses.

UNIT 7 **Beverages:** Tea, Coffee and Cocoa - origin, botany, varietal (or market) classification, cultivation, processing and uses.

UNIT 8 **Oils and Fats:** general account, methods of extraction, classification, properties with particular reference to their shelf life, nomenclatural details in *Brassica*, centre of origin and production, morphological details, major component and uses of mustard and its relatives, cotton, soyabean, groundnut, linseed; botanical names and uses.

UNIT 9 **Essential Oils:** definition, differences from fatty oils; Methods of extraction; fixatives and mordants; uses of rose, jasmine, sandalwood, vetiver, cymbopogon, and eucalyptus.

UNIT 10 **Plant Fibres:** definition, classification; Cotton: origin, area of production, systematics of cultivated species, general morphology, processing and uses, origin of tetraploid cottons; Jute: origin, production, botany and uses; Coir: extraction, structures of fibres and uses.

UNIT 11 **Timber Plants:** a general account, properties of wood (density, moisture content, grain, figure, seasoning); types of wood (hard and soft; heartwood and sapwood; porous and non-porous), uses, plywood and veneers; specially timbers (introduction); Important Indian timbers– Teak, Shisham, Pine, Sal and Deodar.

UNIT 12 **Natural Rubber:** general account of latex-producing plants; *Hevea brasiliensis*- origin, production, botany, cultivation and propagation (in brief), tapping and processing, uses: Gutta Percha (*Palaquium gutta*) and its uses; Other sources of rubber.

UNIT 13 **Drug yielding plants:** introduction to the use of drug plants-therapeutic, habit-forming; centres of origin and production, botanical characterstics, active principles and uses of *Cinchona, Atropa belladonna, Digitalis, Rauvolfia, Papaver somniferum and Cannabis*; other important Indian medicinal plants (botanical names and uses only).

UNIT 14 **Masticatories and Fumitories:** general Introduction; Tobacco: origin, production area, botany, cultivation, processing and uses; health hazards.

UNIT 15 **Biocides:** Pyrethrum, with a discussion on centre of origin and regions of production, morphology, chemical constituents and uses; synthetic pyrethroid; natural insecticides versus chlorinated hydrocarbons (DDT) with emphasis on eco-friendly behaviour; other biocides: neem and *Derris* (botanical names and uses only).

Section B: CROP IMPROVEMENT

UNIT 16 **Aims and methodology:** brief account of pure line and mass clonal selection; recurrent selection; interspecific and intraspecific hybridization: advantages and disadvantages; heterosis; quarantine; Material Transfer Agreement (MTA); biosafety considerations.

UNIT 17 **Germplasm conservation:** *In situ* conservation in nature and *ex situ* conservation in Gene banks with facilities to store propagatory materials such as seeds, tissues, pollen, meristem cultures as well as DNA libraries (Native DNA and cloned DNA); tissue culture, protoplast fusion and cybridisation; research centres of wheat, rice, potato and sugarcane; ethno-botanical conservation and Intellectual Property Rights (IPR).

Core Practicals

Study of the following through habit sketches, temporary preparations, permanent slides, photographs, specimens, products, microchemical tests, etc. to bring out the economic importance: **Cereals** : Wheat, maize, rice, major millets and pseudocereals; **Legumes**: soyabean, groundnut and gram, **Fruits**: mango, citrus, papaya, banana; **Sugars and starches**: sugarcane, potato, cassava; **Spices and Condiments**: black pepper, clove, coriander, fennel; **Beverages**: tea, coffee, cocoa; **Oils and Fats**: Coconut, castor, groundnut, mustard, linseed, safflower, soyabean and sesame; **Essential - oil yielding plants**: Rosa, *Cymbopogon, Vetiveria, Jasminum, Santalum and Eucalyptus*; **Fiber-yielding plants**: *Gossypium, Corchorus, Linum, Cannabis* and *Cocos; **Woods**: Tectona, Dalbergia, Pinus, Cedrus*; **Rubber**: *Hevea brasiliensis*; **Drug yeilding plants**: *Cinchona, Atropa, Digitalis , Artemisia, Rauvolfia,* and *Taxus; Papaver, Cannabis; Tobacco: N. tabacum and N rustica*; **Biocides**: *Chrysanthemum cinerariaefolium and Azadirachta indica.*

Each student should submit at least 15 herbarium specimens of economically useful plants, preferably along with the products.

Paper VI: Genetics and Biotechnology

Section A: TRANSMISSION GENETICS

UNIT 1 **Mendel's experiments:** Laws of inheritance; Allelic and non-allelic interactions; biochemical basis of dominance and recessiveness; Modified dihybrid ratios; Multiple alleles, pleiotropy, polygenic inheritance; penetrance and expressivity; numericals on Mendelism; chromosome theory of inheritance.

UNIT 2 **Linkage:** autosomal and sex linkage, complete and incomplete linkage; crossing over, cytological evidence of crossing over; gene mapping by three point crosses; somatic cell hybridization; numericals on linkage.

UNIT 3 **Sex determination:** mechanism of sex determination; identification of sex chromosomes; chromosome balance theory, gynandromorphs; sex determination in mammals with special reference to humans- X and Y chromosomes; TDF, SRY, testicular feminisation, H-Y antigen.

UNIT 4 **Extranuclear genome:** criteria for extranuclear inheritance; non-Mendelian inheritance; Petite mutants in yeast, symbiont bacteria; Kappa particles in *Paramecium*; plasmid and episomes; cytoplasmic male sterility in plants; Maternal effect.

Section B: MOLECULAR GENETICS

UNIT 5 **Genetic fine structure:** classical versus molecular concept of gene; cistron test for functional allelism; muton, recon, cistron, one gene one enzyme hypothesis; inborn errors of metabolism.

UNIT 6 **Gene expression:** genetic code: colinearity of genes and proteins; experimental elucidation of genetic code; deciphering salient features and variation of code; transcription in prokaryotes and eukaryotes, reverse transcription; enhancers, silencers; transcription factors;. processing of RNA split genes, exons and introns, RNA splicing, ribozymes; translation in prokaryotes and eukaryotes; post translation modifications.

UNIT 7 **Regulation of gene expression:** regulation in prokaryotes, constitutive, inducible, positive and negative gene regulation, repressible systems; operons, the lac operon in *E. coli*; translational control of gene expression; regulation in eukaryotes (a brief account), levels of control.

UNIT 8 **Mutations:** types; transposable genetic elements; molecular basis of mutations; induced mutations; DNA damage and repair; SOS; photoreactivation; excision repair.

Section C: HUMAN GENETICS

UNIT 9 **Human genetics:** dominant, recessive, autosomal and sex-linked traits in man; congenital defects: hemophilia, thallesemia, sickle cell anemia, phenylketonuria, cystic fibrosis; syndromes associated with chromosomal abnormalities (Down's, Turner's, Klinefelter's); genomic imprinting, genetic counselling.

Section D: BIOTECHNOLOGY

UNIT 10 **Recombinant DNA technology:** introduction; methodology; restriction endonucleases; isolation and identification of genes; Types of vectors: prokaryotic (phage, phagemids, cosmids, BAC), eukaryotic (T1 plasmid, CAM, YAC) genomic and cDNA libraries; reverse genetics; construction of recombinant DNA, cloning in prokaryotes and eukaryotes; expression of cloned genes and selection of transgenics; tools and techniques: shot gun technique, RFLP, DNA finger printing, PCR, gene therapy; human genome project, DNA sequencing, bioinformatics: introduction and use in genetic engineering.

UNIT 11 **Cancer:** introduction; characteristics of cancerous cells; causes of cancer; role of oncogenes.

UNIT 12 **Plant biotechnology:** definition, objectives, tools and techniques; identification of plant genes; vector mediated and DNA mediated transfer of genes; transgenic plants; plant genomics (*Arabidopsis* as a tool).

UNIT13 **Applications of plant biotechnology:** application of plant biotechnology in developing nutritionally improved crops, herbicide-tolerant crops, recent improvements in floriculture.

Core Practicals

1. Meiosis in the squash preparation of onion bud.
2. Translocation in the chromosomes of *Rhoeo* meiocytes.

3. Study of Mendelian inheritance in humans with reference to colour blindness, attached ear lobes and PTC test; Pedigree analysis of hemophilia; preparation of genetic maps of human chromosomes for the cystic fibrosis, sickle cell anemia and hemophilia; study karyotypes of some syndromes.
4. To study deviations from the Mendelian ratios from the given seed samples; demonstrate incomplete dominance, multiple alleles, polygenic inheritance.
5. Estimation of DNA/RNA and/or chromatography of DNA bases.
6. To demonstrate replica plating technique to identify auxotrophs.
7. Familiarization through photographs, slides, illustration, etc. : Genetic engineering (FISH, PCR, southern blotting and northern blotting, DNA finger printing, DNA sequencing, technique of gene transfer using plasmid, electroporation and microprojectile gun), amniocentesis, sickle cell anemia, and xeroderma pigmentation.
8. Plant breeding: demonstration of techniques and some simple experiments.
9. Bio informatics: Screening of database on genomics of various organisms (*e.g. Arabidopsis*, human).

Students to submit model on any principle of genetics/project based on bio-informatics.

B.Sc. (H) Botany III Year
Paper VII: Plant Systematics and Phytogeography

UNIT 1 **Introduction** – aims; fundamental components of systematics: description, identification, nomenclature, phylogeny, classification; advancement levels.

UNIT 2 **Systematics in Practice** – field work; preparation of herbarium specimen; herbarium: role, management; botanical gardens and their role; documentation (floras, monographs, manuals, journals, abstracts, indices, dictionaries); identification keys: single access (dichotomous keys) and multi access (cards, table method, taxonomic formula) methods; role of computers and internet in identification.

UNIT 3 **Taxonomic Hierarchy** - concept of taxa, categories and hierarchy; species concepts and types of species (taxonomic, biological, evolutionary, biosystematic), generic concept, family concept.

UNIT 4 **Botanical Nomenclature** - principles and rules; ranks and names; type method; author citation; valid publication; rejection of names; principle of priority and its limitations; names of hybrids and cultivars~ concept of biocode and phylocode.

UNIT 5 **Phylogeny of Angiosperms** - terms and concepts; origin of angiosperms; primitive living angiosperms; coevolution of angiosperms and animals; evolution within angiosperms; methods of illustrating evolutionary relationship (phylogenetic tree, cladogram, phylogram, bubble diagram, phylogenetic shrub, circular diagram).

UNIT 6 **Systems of Classification** – development of classification systems; significant contributions of important authors; detailed study of classification systems of Bentham and Hooker, Engler and Prantl and Takhtajan; brief reference of Angiosperm Phylogeny Group classification.

UNIT 7 **Variation And Speciation** - species as unit of variation; types of variation in populations; ecophenes and ecotypes; Isolating mechanisms; selection and speciation.

UNIT 8 **Taxonomic Evidence** - role of anatomy (examples from wood anatomy, epidermal structures leaf anatomy and floral anatomy), palynology (primitive pollen types, pollen and age of angiosperms, specific examples), chemotaxonomy (primary metabolites, secondary metabolites, semantides, molecular systematics and serology), ultrastructure (plastids, dilated cisternae, p-proteins), micromorphology (primary, secondary and tertiary sculpturing) and cytotaxonomy (chromosome number and structure).

UNIT 9 **Biometries and Numerical Taxonomy** - characters and attributes; statistics: variance, mean and standard deviation; OTUs; character weighting and coding; character-OUT matrix; similarity and distance measures and matrix; cluster analysis (brief reference of ordination and association analysis); phenograms; concepts and practice of cladistics.

UNIT 10 **Phytogeography** - introduction; physical geography of earth; continental drift; static and dynamic plant geography; ranges; migration and barriers; endemism; factors governing distribution of vegetation, role of latitude, altitude, temperature, soil character, soil moisture, precipitation; role of monsoon with reference to the Indian sub-continent; phytogeographical divisions of India; vegetation of India; vegetation of Delhi.

Core Practicals

1. Study of vegetative and floral characters of the following families (description, floral diagram, floral formula and systematic position): Ranunculaceae, Brassicaceae, Caryophyllaceae, Malvaceae, Rutaceae, Fabaceae, Myrtaceae, Apiaceae, Rubiaceae, Asteraceae, Apocynaceae, Solanaceae, Lamiaceae, Chenopodiaceae, Euphorbiaceae, Liliaceae and Poaceae.
2. Study of the characteristic morphological features of the following families:
   Capparaceae, Cucurbitaceae, Asclepiadaceae, Acanthaceae, Moraceae and Cannaceae.
3. Study of variation at intraspecific level in populations from different habitats; calculation of Arithmetic Mean and Standard Deviation.
4. Identification of selected taxa using punched cards/taxonomic formula.
5. Familiarity with local wild flora and herbarium techniques.
6. Use of computers/internet for data collection, identification.

Students are expected to submit 15 specimens from wild flora properly mounted on standard herbarium sheets (16.5" X 11.5") and properly labelled. Field report to be submitted along with the collection.

Paper VIII: Plant Ecology and Environmental Management

Section A: GENERAL CONCEPTS

UNIT 1 **Introduction to the Biosphere:** inter-relationships between the living world and the environment, the components and dynamism, homeostasis; relevance to human civilization. Constituents: the

hydrosphere, the atmosphere and the lithosphere; concept of biome.

Section B: THE ENVIRONMENT

UNIT 2 **Soil:** Importance, origin, formation, composition; physical, chemical and biological components; soil profile; role of climate in soil development.

UNIT 3 **Water:** importance; states of water in the environment; atmospheric moisture; precipitation types; water in soil, water table, ground water recharging; water bodies: aquifers, water shed.

UNIT 4 **The Atmosphere:** composition and stratification; radiation flux; role of electromagnetic radiations, uv, visible spectrum; heat content of atmosphere and its impact (the ambient temperature); thermal stratification; variations in temperature; wind as a factor.

UNIT 5 **The Living World:** biotic component of environment; types of biotic interactions.

UNIT 6 **Fire:** as an ecological factor.

Section C: THE BIOTA

UNIT 7 **Levels of Organisation:** individual, population, community; concepts of autecology, synecology; concept of biological diversity; habitat and ecological niche.

UNIT 8 **Population Ecology:** species as biological framework of population; organization, distribution and characteristics of population; population dynamics and growth kinetics; adaptation to water, sunlight, salinity, wind and other factors.

UNIT 9 **Plant Communities:** organismic and individualistic concept of community; ecotone and edge effect; community characters (analytic and synthetic); methods of studying vegetation; dynamics of communities: plant succession, processes, types; primary and secondary succession; climax concepts; hydrosere and xerosere.

Section D: ECOSYSTEMS

UNIT 10 **Ecosystems:** structure, biotic and the abiotic components; processes within ecosystem; trophic organization, basic source

of energy, autotrophy, heterotrophy, parasitism; food chains and webs; ecological pyramids; biomass, standing crop.

UNIT 11 **Functional aspects of Ecosystem:** energy flow: principles, grazing and detritus food chains, models of energy flow; ecosystem productivity, measurement of productivity; ecological efficiencies and concept of energy subsidy; biogeochemical cycles; dynamics; hydrologic cycle; gaseous cycles, sedimentary cycles; concept of nutrient budget.

Unit 12 **Diversity of Ecosystems and Biomes:** aquatic: fresh water (lotic and lentic), marine (pelagic and benthic), estuarine; major terrestrial biomes: tundra, temperate and tropical

Section E: ENVIRONMENTAL MANAGEMENT

UNIT 13 **Impact of Human Activities:** human population, growth and density; natural resources: renewable and non-renewable; energy sources; conventional and non-conventional; pollution of air, water and soil; soil degradation; incidence of thermal and radioactive pollution; major environmental problems; environmental impact assessment: state of Delhi's environment.

UNIT 14 **Environmental Management:** aims and objectives, sustainable development; conservation of resources: prevention and control of pollution; soil conservation; afforestation; development of alternate energy sources; maintenance of biodiversity; endangered species; role of national and international organizations in environmental management; bio-indicators.

Core Practicals

1. Study of following microclimatic variables in different habitats: soil and air temperature, wind velocity, relative humidity, rainfall and light intensity.
2. Mechanical analysis of soils by sieve method.
3. Permeability (capillary rise and percolation; total capacity as well as rate of movement), saturation capacity and field capacity of different soil samples and rapid test for texture of soils.
4. Density and porosity and rate of infiltration of water in undisturbed soils.

5. pH and rapid field tests of soils for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency.
6. Soil organic matter and calcium carbonate in different soil samples.
7. Floristic survey of a specific area and study different life forms.
8. Determination of minimal area of quadrat by species area curve method.
9. Quantitative analysis of herbaceous vegetation for frequency, density and abundance; Mapping of vegetation by line transect method.
10. Determination of pH, carbon dioxide content, turbidity and dissolved oxygen of water samples from polluted and unpolluted sources.
11. Morphological adaptations of hydrophytes and xerophytes.
12. Estimation of dust accumulation (per unit area) on leaves in selected species.

Project Work (equivalent to 6-8 hours): Students to prepare an ecological project by:

a) **Collection of data (experimental and/or factual and/or reported) from different habitats so as to project or reflect ecological principle(s) and/or concern(s).**

OR

b) **Focussing on any aspect of applied ecology (topics covered in theory) such as renewable energy, waste management, pollution of air, water and soil, rain water harvesting, etc.**

Paper IX: Developmental and Functional Plant Anatomy

UNIT 1 **Introduction and scope of plant anatomy:** hierarchy- a concept of ordered relations; applications in systematics, forensics and pharmacognosy.

UNIT 2 **Techniques:** brief account of the techniques employed for the study of plant structure and organization: fixation, preservation, staining, microtomy, maceration, clearing, peel mounts, surgical and excision methods.

UNIT 3 **Tissues and Cell Walls:** classification of tissues; geometry and dimensions of cells, pits and plasmodesmata; cell wall polymers; ultrastructure; wall ingrowths and transfer cells; incrustations and adcrustations.

UNIT 4 **Primary Shoot:** general characteristics and organization of shoot apex (initial cells, apical cell theory, histogen theory, tunica corpus theory, cytohistological zonations, continuing meristem residue); shoot chimeras; terminal, lateral and adventitious buds; provascular strands; leaf traces and leaf gaps; vascular sympodia; types of vascular bundles; primary phloem and primary xylem; phloic and xylary elements; primary thickening meristem; phylogenetic trends.

UNIT 5 **Phyllotaxy and Leaf Structure:** introduction to phyllotactic patterns; plastochron; development of leaf (marginal, sub-marginal plate, intercalary, axial, adaxial meristems); histology of leaf, C_3 and C_4 leaves; basic features and diversity of stomata; foliar venation in vascular plants; scale leaf.

UNIT 6 **Root:** organization of root apex: apical cell theory, histogen theory, korper-kappe theory, quiescent centre, promeristem; root cap; primary root tissue: central cylinder, rhizodermis, cortex, endodermis, exodermis and metacutinization; lateral root apices; indeterminate v/s determinate roots; root nodules; secondary tissue in roots.

UNIT 7 **Vascular Cambium:** structure and function; concept of cambial zone; cambial derivatives; periclinal and anticlinal cell divisions in fusiform initials; control of cambial activity; seasonal activity.

UNIT 8 **Secondary Xylem:** axially and radially oriented xylary elements; cytodifferentiation of tracheary elements; cyclic aspects; dendrochronology; juvenile, adult and reaction woods; sap wood and heart wood.

UNIT 9 **Secondary Phloem:** axially and radially oriented phloic elements; phloem as a dynamic tissue; cytodifferentiation of sieve elements and sieve plate formation.

UNIT 10 **Periderm:** constituents: phellogen, phellem and phelloderm; first periderm; sequent periderm; rhytidome; tissues functioning as periderm in monocots; wound induced periderm; lenticels; dynamics of periderm and bark.

UNIT 11 **Adaptive and Protective Systems:** shoot epidermis, cuticle, epicuticular waxes; stomatal adaptations and trichomes in relation to water relations and plant defence; anatomical adaptations in stems, leaves and roots of xerophytes, hydrophytes and halophytes; unusual cambial activity and conformations.

UNIT 12 **Secretory and Excretory Systems:** secretion and excretion in plants; deposits in dead cells/tissues/organs; ergastic substances; hydathodes, salt glands, nectaries, glandular epidermis; root cap as secretory organ; ducts and cavities, lithocytes, oil cells, laticifers.

UNIT 13 **Storage Systems:** general characteristic of storage organs and tissues. Mucilage-based systems. Storage in vegetative organs, storage for perenation.

Core Practicals

Study of anatomical details through permanent slides/temporary stain mounts/macerations/museum specimens with the help of suitable examples:

1. Familiarization with techniques: double staining, maceration, peel mount, clearing.
2. Apical meristem of root and shoot, vascular cambium and intercalary meristem.
3. Distribution and types of parenchyma, collenchyma and sclerenchyma.
4. Xylem: Tracheary elements- tracheids, vessel elements; thickenings; perforation plates; xylem fibres; xylem parenchyma.
5. Wood: ring porous; diffuse porous; tyloses; heart- and sapwood.
6. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
7. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
8. Roots: monocot, dicot, origin of lateral roots; secondary growth; anomalous root structure.
9. Stem: monocot, dicot; secondary growth; periderm; lenticel; unusual conformations in dicots and monocots.

10. Leaf: isobilateral, dorsiventral, C_4 leaves (Kranz anatomy); venation patterns.
11. Adaptive Anatomy: xerophytes, hydrophytes, parasites and epiphytes.
12. Secretory tissues: ducts and cavities, lithocytes and laticifers.

Each student is expected to submit 10 permanent slides, prepared using a minimum of four different techniques, at the time of the Annual Practical Examination.

Paper X: Developmental and Experimental Embryology of Angiosperms

UNIT 1 **Introduction:** history and scope.

UNIT 2 **Anther:** structure, ontogeny; tapetum: structure and functions; micro-sporogenesis: callose deposition and it's significance.

UNIT 3 **Pollen Biology:** microgametogenesis, MGU (male germ unit); pollen wall: development and structure, npc system, pollen wall proteins; pollen viability, storage and germination; pollen tube structure.

UNIT 4 **Ovule:** structure, ontogeny, types; special structures - endothelium, operculum, obturator, aril, arillode, caruncle, hypostase, epistase; female gametophyte - megasporogenesis and megagametogenesis; organization and ultrastructure of mature embryosac (FGU).

UNIT 5 **Pollination and Fertilization** - pollination types and significance; adaptations; pollination biology; pollen-pistil Interaction; structure of stigma and style; double fertilization.

UNIT 6 **Sexual Incompatibility:** basic concepts; methods to overcome S.I.

UNIT 7 **Endosperm:** types, development and functions; endosperm haustoria.

UNIT 8 **Embryogenesis:** classification, development, organisation and differentiation of crucifer and Najas embryo; embryo - endosperm relationship; physiological and genetic control.

UNIT 9 **Polyembryony and Apomixis:** introduction; classification; causes and applications.

UNIT 10 **Embryology in relation to taxonomy:** major examples of utilization of embryological and palynological data.

UNIT 11 **Experimental Embryology:** role of tissue culture technology - introduction, achievements and applications; culture of anther, pollen (androgenesis), ovule, ovary (gynogenesis), nucellus, endosperm; genetic transformation using pollen grains/ embryological systems; somatic embryogenesis; micropropagation, protoplast culture and somatic hybridization; embryo rescue; haploid culture.

Core Practicals

1. Photographs of eminent embrylogists.
2. Anther: wall and its ontogeny; tapetum; microsporogenesis, stages; psuedomonads, massulae.
3. Pollen grains: fresh and acetolysed, ornamentation and aperture; pollen viability: tetrazolium test.
4. Pollen germination: in different media; calculation of percentage germination; male germ unit (MGU): through photographs.
5. Ovule: types; unitegmic, bitegmic; tenuinucellate and crassinucellate; special structures-endothelium, operculum, obturator, hypostase and epistase; caruncle and aril (permanent slides / specimens / photographs).
6. Female gametophyte through permanent slides/photographs: types and ultrastructure of mature embryo sac.
7. Style and stigma through suitable preparations: unpollinated and pollinated stigma and style: wet and dry stigma; hollow and solid styles; tracing the path of pollen tube.
8. Intra-ovarian pollination; test tube pollination/fertilization: through photographs.
9. Endosperm: dissections of developing seeds for free-nuclear endosperm with haustoria; types (permanent slides).
10. Embryogenesis: study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; study of suspensor through electron micrographs.

11. Experimental Embryology: study of the following through suitable photographs: androgenesis (anther and pollen culture); nucellus culture; endosperm culture; embryo culture; demonstration: preparation of the culture medium (Murashige and Skoog's semi solid medium); culture of explants; response of the explants in culture. The experimental work undertaken and the observations be submitted in the form of a minor project report.

Paper XI: Plant Biophysical Processes, Growth and Development

UNIT 1 **Organisation within a plant cell:** physical nature of cytosol; ionic status, buffering capacity, pH and its physiological significance; colloidal nature of cytosol, surface properties.

UNIT 2 **Resources and their assimilation:** principles of assimilation; relevance of laws of thermodynamics; diffusion and osmosis; chemical potential and its gradient; water potential, components of water potential; plant cell in aquatic medium; plasmolysis; turgidity.

UNIT 3 **Absorption of water by plants:** pathway of water movement, symplast and apoplast; ascent of sap, mechanism; transpiration: factors controlling, role of stomata, mechanism of stomatal movement, significance of transpiration, energy exchange during transpiration, relationship with photosynthesis, antitranspirants; guttation; exchange of gases.

UNIT 4 **Absorption of minerals:** transport of ions across cell membrane; passive absorption, electrochemical gradient, Donnan's equilibrium, facilitated diffusion, accumulation against concentration gradient; active absorption, role of ATP; carrier systems; role of cell membrane; proton pump and ion flux.

UNIT 5 **Mineral requirement of plants:** essential and non-essential elements; criteria of essentiality; macro- and micro-nutrients; role of essential elements; mineral deficiency; ion antagonism and toxicity; solution culture.

UNIT 6 **Transport of nutrients:** nature of nutrients; transport of minerals; transport of photosynthates, source-sink relationship; mechanism of transport; partitioning of nutrients; role in productivity.

UNIT 7 **Phenomena of growth and development:** definitions; phases of growth and development; morphogenesis, its mechanism; role of cell division, cell elongation and cell differentiation; totipotency.

UNIT 8 **Physiology of seed germination:** process; viability and non-viability of seeds; dormancy, causes of and removal of dormancy, mechanism; factors affecting seed germination, role of light, temperature, growth regulators.

UNIT 9 **Physiology of vegetative growth and development:** kinetics of growth; patterns of growth; juvenility and maturity; factors affecting vegetative growth.

UNIT 10 **Physiology of reproductive growth and development:** flowering: physiological definition, factors influencing role of light; photoperiodism - discovery, variation in response, long day, short day and day neutral plants, inductive and non- inductive cycles, role of dark period, role of quality and intensity of light; effect of temperature, vernalization, mechanism; bolting in long day plants, role of growth regulators, nutrients status; nature of the flowering stimulus, diffusibility of photoperiodic and vernalization stimuli; florigen concept; physiology of fruit ripening: physiological and biochemical changes, importance of respiratory climacteric; factors affecting ripening; senescence: definition; physiological and biochemical changes, mechanism; abscission of leaves; factors affecting senescence.

UNIT 11 **Plant movements:** characterisations of plant movements, tropic, nastic and tactic movements; mechanisms of movement.

UNIT 12 **Regulation of Plant growth and development:** Chemical Regulation: growth regulators and phytohormones - auxins, gibberellins, cytokinins, abscissin and ethylene: discovery, chemistry, biosynthesis, role, bioassay and mechanism of action; applications; growth regulators discovered recently; Environmental regulation: role of light and temperature, light sensitive photomorphogenetic pigment systems, phytochromes - discovery, chemical and physical nature, mode of action; role of low energy response (LER) and high irradiance radiation (HIR), red (R) and far red (FR) light on photomorphogenesis.

UNIT 13 **Response of plants to their environment:** holistic approach; basic principles, law of limiting factors, synergistic effects, adaptation; types of plant responses, direct and delayed response; homeostasis; response to stress, characterisation of stress, response to water, high and low temperature stress; response to acidic, alkaline and saline soils, mechanism of response; role of secondary metabolites.

UNIT 14 **Rhythm in behaviour of plants:** the concept of biological clock-terms and definition, mechanism of rhythmic responses.

Core Practicals

1. Preparation of solutions of various concentrations of a few selected solutes.
2. To determine osmotic potential of plant cell sap by plasmolytic method.
3. To determine water potential of given tissue by weight method and falling drop method.
4. Study of the effect of various environmental factors on transpiration by an excised twig/leaf
5. Calculation of the stomatal index, stomatal frequency and percentage of leaf area open through stomata of a mesophyte and a xerophyte.
6. Preparation of buffers (phosphate), study of buffering capacity of the prepared buffers and of plant juices.
7. Study of the mechanism of stomatal opening and closing.

Projects: Students are to do at least four long-term experiments as projects (a suggestive list of experiments will be provided).

Paper XII: Plant Metabolism

UNIT 1 **Plant metabolism:** anabolic and catabolic processes; reductive oxidative components; intermediary metabolism.

UNIT 2 **Bioenergetics:** energy relationships of biochemical reactions, free energy changes, spontaneous (downhill) and uphill reactions; special conditions governing cellular reactions, energization of

reactants, role of high energy phosphate bonds, energy rich molecules and their syntheses; phosphorylation, mechanism of phosphorylation, coupling of electron flow and phosphorylation; chemiosmotic hypothesis

UNIT 3 **Enzymes:** thermodynamic principles; enzymes as catalysts - physico-chemical and biological properties; cofactors, coenzymes, prosthetic groups, metal ions; mechanism of action; role of enzyme-substrate complex; the active centre; role of cofactors; mode of action of lysozyme; kinetics of action; measurement of rate of enzymatic reaction; effect of enzyme and substrate concentrations; derivation of Michaelis-Menten equation; effect of temperature, pH and inhibitors; competitive and non-competitive inhibition; role of allosteric effectors; specificity of enzymatic reaction; reaction related and substrate related speficity; classification and nomenclature of enzymes; isoenzymes; control of enzymatic reactions; industrial aspects of enzymology.

UNIT 4 **Carbon Assimilation:** assimilaton of energy; photosynthesis - photochemical reaction, absorption and transfer of solar energy, mechanism, role of chlorophylls and accessory pigments, antennae molecules and active centre molecules; ionization of chlorophyll and flow of electrons, carriers and terminal acceptors; energy (quantal) requirement af electron flow; photolysis of water and evolution of o_2, model of photoelectron flow; evidences for two photosystems; reduction of NADP; photophosphorylation; reduction of co_2 into glucose, Benson and Calvin cycle; Hatch, Slack Kortschak Pathway; Crassulacean Acid Metabolism (CAM); energetics of CO_2 reduction; factors affecting reduction; role of light; absorption spectrum and action spectrum; other factors; compensation points; synthesis of sucrose, starch and cellulose.

UNIT 5 **Carbon Oxidation:** retrieval of energy; oxidative metabolism; glycolysis - anaerobic conversion of pyruvate into ethanol or lactate, energy balance, reversibility and inhibition of glycolysis; Pasteur effect; oxidative decarboxylation of pyruvate into acetyl CoA; TCA cycle; reduction of NAD; oxidation of reduced NAD; oxidative phosphorylation; oxidation of RuBP (photorespiration);

factors affecting oxidative processes; respiratory quotient; regulation of TCA cycle; role of glyoxylate cycle.

UNIT 6 **Synthesis of fatty acids:** saturated and unsaturated Fatty acids; formation of glycerides; oxidation of fatty acids - beta oxidation; energy balance.

UNIT 7 **Assimilation of molecular nitrogen:** diazotroph, free living and associative; symbiotic associations; reduction of nitrogen into ammonia; nitrogenase, mechanism (symbiotic and non-symbiotic); genetic control; energetics; reduction of nitrate and nitrite into ammonia, nitrate reductase, transamination and reductive amination; role of amino acid in synthesis of other nitrogenous compounds.

UNIT 8 **Regulation of Metabolism:** nature of integrated metabolism, role of acetylCo-A, control at the level of transcription and translation; control of enzyme action.

Core Practicals

1. Detection of the presence of plant enzymes in various sources [amylase, urease, invertase, catalase, peroxidase, polyphenol oxidase, nitrate reductase (*in vivo*)], study properties (thermolability, proteinaceous nature and specificity) and the effect of various factors on the activity of selected enzymes (concentration, temperature, pH, inhibitor).
2. Preparation of standard curve for estimation of proteins spectrocolorimetrically and determine total proteins in a plant tissue.
3. Separation and identification of amino acids by thin layer chromatography.
4. Demonstration of dye reduction by isolated chloroplasts; study of the effect of different factors on O_2 evolution during photosynthesis and demonstrate the Law of limiting factors.
5. Chemical separation of chloroplast pigments and determination of absorption spectra; extract anthocyanin pigments and study the effect of pH on their absorption spectra.
6. Study of the rate of aerobic respiration and respiratory quotient in different plant parts/materials.