Detailed Curriculum

of

B.Sc. (General)

B.SC. (GENERAL) DIVERSITY OF MICROBES AND CRYPTOGAMS

Viruses and Bacteria: General account of viruses and mycoplasma; bacteria - structure, nutrition, reproduction and economic importance; general account of cyanobacteria.

Algae: General characters, classification and economic importance; important features and life history of Chlorophyceaė - *Volvox, Oedogonium, Coleochaete;* Xanthophyceae – *Vaucheria;* Phaeophyceae - *Ectocarpus, Sargassum*; Rhodophyceae - *Polysiphonia.*

Fungi: General characters, classification and economic importance; important features and life history of Mastigomycotina - *Pythium, Phytophthora*; Zygomycotina – *Mucor*; Ascomycotina - *Saccharomyces, Eurotium, Chaetomium, Peziza;*. Basidiomycotina – *Puccinia, Agaricus*; Deuteromycotina - *Cercospora*, *Colletotrichum*; general account of Lichens.

Bryophyta: Amphibians of plant kingdom displaying alternation of generations; structure, reproduction and classification of Hepaticopsida (e.g. *Marchantia*); Anthocerotopsida (e.g. *Anthoceros*), Bryopsida (e.g. *Funaria*).

Pteridophyta: The first vascular plants; important characteristics of Psilopsida, Lycopsida, Sphenopsida and Pteropsida; structure, reproduction in *Rhynia*, *Lycopodium, Selaginella, Equisetum, Pteris* and *Marsilea.*

Suggested Readings

Smith, G.M. 1971. Cryptogamic Botany. Vol. I. Algae & Fungi. Tata McGraw Hill Publishing Co., New Delhi.

Smith, G.M. 1971. Cryptogamic Botany. Vol. II. Bryophytes & Pteridophytes. Tata McGraw Hill Publishing Co., New Delhi.

Sharma, O.P. 1992. Text Book of Thallophytes. McGraw Hill Publishing Co.

Sharma, O.P. 1990. Text Book of Pteridophyta. McMillan India Ltd.

Sharma, P.D. 1991. The Fungi. Rastogi & Co., Meerut.

Dube, H.C. 1990. An Introduction to Fungi. Vikas Publishing House Pvt. Ltd., Delhi.

Puri, P. 1980. Bryophyta. Atma Ram & Sons, Delhi.

Clifton, A. 1958. Introduction to the Bacteria. McGraw Hill & Co., New York.

Suggested Laboratory Exercises

1. Study of the genera included under algae and fungi.
2. Study of morphology, reproductive structures and anatomy of the examples cited in theory under Bryophyta and Pteridophyta.
3. Observation of disease symptoms in hosts infected by fungi, viruses and mycoplasma. Section cutting of diseased material and identification of the pathogens as per the theory syllabus.
4. Gram staining of bacteria.
5. Study of crustose, foliose and other types of lichen thalli.

COURSE II. CELL BIOLOGY AND GENETICS

Structure and function of nucleus: Ultrastructure; nuclear membrane; nucleolus.

Chromosome organization: Morphology; centromere and telomere; chromosome alterations; deletions, duplications, translocations, inversions; variations in chromosome number, aneuploidy, polyploidy; sex chromosomes.

DNA the genetic material: DNA structure; replication; DNA-protein interaction; the nucleosome model; genetic code; satellite and repetitive DNA.

Cell division: Mitosis; meiosis.

Genetic inheritance: Mendelism; laws of segregation and independent assortment; linkage analysis; allelic and non-allelic interactions.

Gene expression: Structure of gene; transfer of genetic information; transcription, translation, protein synthesis; tRNA; ribosomes; regulation of gene expression in prokaryotes and eukaryotes; proteins, 1D, 2D and 3D structure.

Genetic variations: Mutations, spontaneous and induced; transposable genetic elements; DNA damage and repair.

Extranuclear genome: Presence and function of mitochondrial and plastid DNA; plasmids.

Structure and function of other organelles: Golgi, ER, peroxisomes, vacuoles.

The cell envelopes: Plasma membrane; bilayer lipid structure; functions; the cell wall.

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* Teachers should cover historical aspects and the basic experiments that led to major discoveries.

Suggested Readings

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, I.D. 1999. Molecular Biology of Cell. Garland Publishing Co., Inc., New York, USA.

Atherly, A.G., Girton, J.R. and McDonald, J.F. 1999. The Science of Genetics. Saunders College Publishing, Fort Worth, USA.

Gupta, P.K. 1999. A Text-book of Cell and Molecular Biology. Rastogi Publications, Meerut, India.

Kleinsmith, L.J. and Kish, V.M. 1995. Principles of Cell and Molecular Biology (2nd edition). Harper Collins College Publishers, New York, USA.

Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimoe, D. and Darnell, J. 2000. Molecular Cell Biology. W.H. Freeman & Co., New York, USA.

Russel, P.J. 1998. Genetics. The Benjamin/Cummings Publishing Co. Inc., USA.

Snustad, D.P. and Simmons, M.J. 2000. Principles of Genetics. John Wiley & Sons, Inc., USA

Stent, G.S. 1986. Molecular Genetics. CBS Publications.

Wolfe, S.L. 1993. Molecular and Cell Biology. Wadsworth Publishing Co., California, USA.

Suggested Laboratory Exercises

1. To study cell structure from onion leaf peels; demonstration of staining and mounting methods.
2. Comparative study of cell structure in onion cells, *Hydrilla* and *Spirogyra*. Study of cyclosis in *Tradescantia* staminal cells.
3. Study of plastids to examine pigment distribution in plants (e.g. *Cassia, Lycopersicon* and *Capsicum*).
4. Examination of electron micrographs of eukaryotic cells with spcial reference to organelles.
5. Study of electron micrographs of viruses, bacteria, cyanobacteria and eukaryotic cells for comparative cellular organization.
6. Examination of various stages of mitosis and meiosis using appropriate plant material (e.g. onion root tips, onion flower buds).
7. Preparation of karyotypes from dividing root tip cells and pollen grains.
8. Cytological examination of special types of chromosomes : bar body, lampbrush and polytene chromosomes.
9. Working out the laws of inheritance using seed mixtures.
10. Working out the mode of inheritance of linked genes from test cross and/or F2 data.

Suggested Readings (for laboratory exercises)

Fukui, K. and Nakayama, S. 1996. Plant Chromosomes: Laboratory Methods. CRC Press, Boca Raton, Florida.

Gunning, B.E.S. and Steer, M.W. 1996. Plant Cell Biology: Structure and Function. Jones and Bartlett Publishers, Boston, Massachusetts.

Harris, N. and Oparka, K.J. 1994. Plant Cell Biology: A Practical Approach. IRL Press, at Oxford University Press, Oxford, UK.

Sharma, A.K. and Sharma, A. 1999. Plant Chromosomes: Analysis, Manipulation and Engineering. Harwood Academic Publishers, Australia.

COURSE III. DIVERSITY OF SEED PLANTS AND THEIR SYSTEMATICS

1. Characteristics of seed plants; evolution of the seed habit; seed plants with (angiosperms) and without (gymnosperms) fruits; fossil and living seed plants.
2. General features of gymnosperms and their classification; evolution and diversity of gymnosperms; geological time scale, fossilization and fossil gymnosperms.
3. Morphology of vegetative and reproductive parts; anatomy of root, stem and leaf; reproduction and life cycle of *Pinus*, *Cycas* and *Ephedra*.
4. Angiosperms: origin and evolution. Some examples of primitive angiosperms.
5. Angiosperm taxonomy; brief history, aims and fundamental components (-taxonomy, -taxonomy, holotaxonomy); identification, keys, taxonomic literature.
6. Botanical nomenclature: Principles and rules; taxonomic ranks; type concept; principle of priority.
7. Classification of angiosperms; salient features of the systems proposed by Bentham and Hooker and Engler and Prantl.
8. Major contributions of cytology, phytochemistry and taximetrics to taxonomy.
9. Diversity of flowering plants as illustrated by members of the families Ranunculaceae, Brassicaceae, Malvaceae, Rutaceae, Fabaceae, Apiaceae, Acanthaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Lamiaceae, Chenopodiaceae, Euphorbiaceae, Liliaceae and Poaceae.

Note to teachers

The students should be made familiar with the families listed at Serial No. 9 only in the practical classes with representative species or any other that may be available locally. See the list for practical classes. However, questions pertaining to these may be asked in the theory examination.

The teachers should prevent students from collecting plants from the wild and submitting them for the practical examination. Instead, the students should be asked to prepare field reports.

Suggested Readings

Bhatnagar, S.P. and Moitra, A. 1996. Gymnosperms. New Age International Limited, New Delhi.

Davis, P.H. and Heywood, V.H. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd, London.

Gifford, E.M. and Foster, A.S. 1988. Morphology and Evolution of Vascular Plants. W.H. Freeman & Company, New York.

Heywood, V.H. and Moore, D.M. (eds) 1984. Current Concepts in Plant Taxonomy. Academic Press, London.

Jeffrey, C. 1982. An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge, London.

Jones, S.B., Jr. and Luchsinger, A.E. 1986. Plant Systematics (2nd edition). McGraw-Hill Book Co., New York.

Maheshwari, J.K. 1963. Flora of Delhi. CSIR, New Delhi.

Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper and Row, New York.

Singh, G. 1999. Plant Systematics: Theory and Practice. Oxford and IBH Pvt. Ltd., New Delhi.

Sporne, K.R. 1965. The Morphology of Gymnosperms. Hutchinson & Co. (Publishers) Ltd., London.

Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd edition). Edward Arnold, London.

Stewart, W.M. 1983. Paleobotany and the Evolution of Plants. Cambridge University Press, Cambridge.

Suggested Laboratory Exercises

Angiosperms

The following species are suitable for study. This list is only indicative. Teachers may select plants available in their locality.

1. Ranunculaceae: *Ranunculus, Delphinium*
2. Brassicaceae: *Brassica, Alyssum, Iberis, Coronopus*
3. Malvaceae: *Hibiscus, Abutilon*
4. Rutaceae: *Murraya, Citrus*
5. Fabaceae: Faboideae: *Lathyrus, Cajanus, Melilotus, Trigonella*; Caesalpinioideae: *Cassia, Caesalpinia*; Mimosoideae: *Prosopis, Mimosa, Acacia.*
6. Apiaceae: *Coriandrum, Foeniculum, Anethum*
7. Acanthaceae: *Adhatoda, Peristrophe*
8. Apocynaceae: *Vinca, Thevetia, Nerium*
9. Asclepiadaceae: *Calotropis*
10. Solanaceae: *Solanum, Withania, Datura*
11. Euphorbiaceae: *Euphorbia, Phyllanthus*
12. Lamiaceae: *Ocimum, Salvia*
13. Chenopodiaceae: *Chenopodium, Beta*
14. Liliaceae: *Asphodelus, Asparagus*
15. Poaceae: *Avena, Triticum, Hordeum, Poa, Sorghum*

Gymnosperms

Cycas

i. Habit, armour of leaf bases on the stem (if specimen is not available show photograph), very young leaf (circinate vernation) and old foliage leaves, scale leaf, bulbils, male cone (specimen); microsporophyll, megasporophyll, mature seed.

ii. Study through permanent slides – normal root (T.S.), stem (T.S.) (if sections are not available show photographs), ovule (L.S.).

iii. Study through hand sections or dissections – coralloid root (T.S.), rachis (T.S.), leaflet (V.S.), microsporophyll (V.S.), pollen grains (W.M.).

Pinus

i. Habit, long and dwarf shoot showing cataphylls and scale leaves, T.S. wood showing growth rings, male cone, 1st year, 2nd year and 3rd year female cones, winged seeds.

ii. Study through permanent slides – root (T.S.), female cone (L.S.), ovule (L.S.), embryo (W.M.) showing polycotyledonous condition.

iii. Study through hand sections or dissections – young stem (T.S.), old stem (wood) (T.L.S. and R.L.S.), needle (T.S.), male cone (L.S.), male cone (T.S.), pollen grains (W.M.).

Ephedra

i. Habit and structure of whole male and female cones.

ii. Permanent slides – female cone (L.S.).

iii. Hand sections/dissections – node (L.S.), internode (T.S.), macerated stem to see vessel structure;, epidermal peel mount of vegetative parts to study stomata, male cone (T.S. and L.S.), pollen grains.

COURSE IV. STRUCTURE, DEVELOPMENT AND REPRODUCTION IN FLOWERING PLANTS

1. The basic body plan of a flowering plant – modular type of growth.
2. Diversity in plant form in annuals, biennials and perennials; convergence of evolution of tree habit in gymnosperms, monocotyledons and dicotyledons; trees - largest and longest-lived organisms.
3. **The shoot system:** the shoot apical meristem and its histological organization; vascularization of primary shoot in monocotyledons and dicotyledons; formation of internodes, branching pattern; monopodial and sympodial growth; canopy architecture; cambium and its functions; formation of secondary xylem; a general account of wood structure in relation to conduction of water and minerals; characteristics of growth rings, sapwood and heart wood; role of woody skeleton; secondary phloem – structure-function relationships; periderm.
4. **Leaf:** origin, development, arrangement and diversity in size and shape; internal structure in relation to photosynthesis and water loss; adaptations to water stress; senescence and abscission.
5. **The root system:** the root apical meristem; differentiation of primary and secondary tissues and their roles; structural modification for storage, respiration, reproduction and for interaction with microbes.
6. **Flower:** a modified shoot; structure, development and varieties of flower; functions; structure of anther and pistil; the male and female gametophytes; types of pollination; attractions and rewards for pollinators; pollen-pistil interaction, self incompatibility; double fertilization; formation of seed -- endosperm and embryo; fruit development and maturation.
7. **Significance of seed** – suspended animation; ecological adaptation; unit of genetic recombination and replenishment; dispersal strategies.
8. **Vegetative reproduction:** vegetative propagation, grafting, economic aspects.

Note to teachers:

Wherever required, role of environment and hormones in plant development and reproduction should be emphasized.

Suggested Readings

Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms, 4th revised and enlarged edition. Vikas Publishing House, Delhi.

Cutter, E.G. 1969. Part I. Cells and Tissues. Edward Arnold, London.

Cutter, E.G. 1971. Plant Anatomy: Experiment and Interpretation. Part II. Organs. Edward Arnold, London.

Esau, K. 1977. Anatomy of Seed Plants, 2nd edition. John Wiley & Sons, New York.

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

Fahn, A. 1974. Plant Anatomy, 2nd Edition. Pergamon Press, Oxford.

Hartmann, H.T. and Kestler, D.E. 1976. Plant Propagation : Principles and Practices. 3rd edition. Prentice-Hall of India Pvt. Ltd., New Delhi.

King, J. 1997. Reaching for the Sun: How Plants Work. Cambridge University Press, Cambridge, U.K.

Mauseth, J.D. 1988. Plant Anatomy. The Benjamin/Cummings Publishing Company Inc., Menlo Park, California, USA.

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

Raven, P.H., Evert, R.F. and Eichhorn, S.E. 1999. Biology of Plants. 5th edition. W.H. Freeman and Co., Worth Publishers, New York.

Thomas, P. 2000. Trees: Their Natural History. Cambridge University Press, Cambridge.

Suggested Laboratory Exercises

1. Study of any commonly occurring dicotyledonous plant (for example *Solanum nigrum* or *Kalanchoe*) to understand the body plan and modular type of growth.
2. Life forms exhibited by flowering plants (by a visit to a forest or a garden). Study of tree-like habit in cycads, bamboos, banana, traveller's tree (*Ravenala madagascariensis*) or yucca and comparison with true trees as exemplified by conifers and dicotyledons.
3. L.S. shoot tip to study the cytohistological zonation and origin of leaf primordia.
4. Monopodial and sympodial types of branching in stems (especially rhizomes).
5. Anatomy of primary and secondary growth in monocots and dicots using hand sections (or prepared slides). Structure of secondary phloem and xylem. Growth rings in wood. Microscopic study of wood in T.S., T.L.S. and R.L.S.
6. Field study of diversity in leaf shape, size, thickness, surface properties. Internal structure of leaf. Structure and development of stomata (using epidermal peels of leaf).
7. Anatomy of the root. Primary and secondary structure.
8. Examination of a wide range of flowers available in the locality and methods of their pollination.
9. Structure of anther, microsporogenesis (using slides) and pollen grains (using whole mounts). Pollen viability using *in vitro* pollen germination.
10. Structure of ovule and embryo sac development (using serial sections).
11. Test of self-incompatibility (using *Petunia axillaris, Brassica campestris, B. oleracea* or a suitable available material) using field pollinations.

12. Nuclear and cellular endosperm. Embryo development in monocots and dicots (using slides/dissections).
13. Simple experiments to show vegetative propagation (leaf cuttings in *Bryophyllum, Sansevieria, Begonia*; stem cuttings in rose, salix, money plant, sugarcane and *Bougainvillea*).
14. Germination of non-dormant and dormant seeds.

Suggested Readings (for laboratory exercises)

Steeves, T.A. and Sussex, I.M. 1989. Patterns in Plant Development (2nd Edition). Cambridge University Press, Cambridge.

Raven, P.H., Evert, R.F. and Eichhorn, S.E. 1992. Biology of Plants (5th Edition). Worth Publishers, New York.

Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edtion). Vikas Publishing House, New Delhi.

Mauseth, J.D. 1988. Plant Anatomy. The Benjamin/Cummings Publishing Co. Inc., Mehlo Park, California, USA.

COURSE V. PLANT PHYSIOLOGY, BIOCHEMISTRY AND BIOTECHNOLOGY

Basics of enzymology: Discovery and nomenclature; characteristics of enzymes; concept of holoenzyme, apoenzyme, coenzyme and cofactors; regulation of enzyme activity; mechanism of action.

Plant-water relations: Importance of water to plant life; physical properties of water; diffusion and osmosis; absorption, transport of water and transpiration; physiology of stomata.

Mineral nutrition: Essential macro- and micro-elements and their role; mineral uptake; deficiency and toxicity symptoms.

Transport of organic substances: Mechanism of phloem transport; source-sink relationship; factors affecting translocation.

Photosynthesis: Significance; historical aspects; photosynthetic pigments; action spectra and enhancement effects; concept of two photosystems; Z-scheme; photophosphorylation; Calvin cycle; C4 pathway; CAM plants; photorespiration.

Respiration: ATP – the biological energy currency; aerobic and anaerobic respiration; Kreb's cycle; electron transport mechanism (chemi-osmotic theory); redox potential; oxidative phosphorylation; pentose phosphate pathway.

Nitrogen and lipid metabolism: Biology of nitrogen fixation; importance of nitrate reductase and its regulation; ammonium assimilation; structure and function of lipids; fatty acid biosynthesis; β-oxidation; saturated and unsaturated fatty acids; storage and mobilization of fatty acids.

Growth and development: Definitions; phases of growth and development; kinetics of growth; seed dormancy, seed germination and factors of their regulation; plant movements; the concept of photoperiodism; physiology of flowering; florigen concept; biological clocks; physiology of senescence, fruit ripening; plant hormones – auxins, gibberellins, cytokinins, abscisic acid and ethylene, history of their discovery, biosynthesis and mechanism of action; photomorphogenesis; phytochromes and cryptochromes, their discovery, physiological role and mechanism of action.

Genetic engineering: Tools and techniques of recombinant DNA technology; cloning vectors; genomic and cDNA library; transposable elements; techniques of gene mapping and chromosome walking.

Biotechnology: Functional definition; basic aspects of plant tissue culture; cellular totipotency, differentiation and morphogenesis; biology of *Agrobacterium*; vectors for gene delivery and marker genes; salient achievements in crop biotechnology.

Suggested Readings

Bhojwani, S.S. 1990. Plant Tissue Culture : Applications and Limitations. Elsevier Science Publishers, New York., USA.

Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell (eds). 1997. Plant Metabolism (2nd Edition). Longman, Essex, England.

Galston, A.W. 1989. Life Processes in Plants. Scientific American Library, Springer-Verlag, New York, USA.

Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.

Lea, P.J. and Leegood, R.C. 1999 Plant Biochemistry and Molecular Biology. John Wiley & Sons, Chichester, England.

Mohr, H. and Schopfer, P. 1995. Plant Physiology. Springer-Verlag, Berlin, Germany.

Old, R.W. and Primrose, S.B. 1989. Principles of Gene Manipulation. Blackwell Scientific Publications, Oxford, UK.

Raghavan, V. 1986. Embryogenesis in Angiosperms: A Developmental and Experimental Study. Cambridge University Press, New York, USA.

Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4th Edition). Wadsworth Publishing Co., California, USA.

Taiz, L. and Zeiger, E. 1998. Plant Physiology (2nd Edition). Sinauer Associates, Inc., Publishers, Massachusetts, USA.

Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.

Suggested Laboratory Exercises

1. To study the permeability of plasma membrane using different concentrations of organic solvents.
2. To study the effect of temperature on permeability of plasma membrane.
3. To prepare the standard curve of protein and determine the protein content in unknown samples.
4. To study the enzyme activity of catalase and peroxidase as influenced by pH and temperature.
5. Comparison of the rate of respiration of various plant parts.
6. Separation of chloroplast pigments by solvent method.
7. Determining the osmotic potential of vacuolar sap by plasmolytic method.
8. Determining the water potential of any tuber.
9. Separation of amino acids in a mixture by paper chromatography and their identification by comparison with standards.
10. Bioassay of auxin, cytokinin, GA, ABA and ethylene using appropriate plant material.

11. Demonstration of the technique of micropropagation by using different explants, e.g. axillary buds, shoot meristems.
12. Demonstration of the technique of anther culture.
13. Isolation of protoplasts from different tissues using commercially available enzymes.
14. Demonstration of root and shoot formation from the apical and basal portion of stem segments in liquid medium containing different hormones.

Suggested Readings (for laboratory exercises)

Devi, P. 2000. Prnciples and Methods of Plant Molecular Biology, Biochemistry and Genetics. Agrobios, Jodhpur, India.

Dixon, R.A. (Ed.) 1987. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boxa Raton, Florida.

Hall, R.D. (Ed.), 1999. Plant Cell Culture Protocols. Humana Press, Inc., New Jersey, USA.

Moore, T.C. 1974. Research Experiences in Plant Physiology: A Laboratory Manual. Springer-Verlag, Berlin.

Ninfa, A.J. and Ballou, D.P. 1998. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc., Maryland, USA.

Roberts, J. and Tucker, G.A. (Eds.) 2000. Plant Hormone Protocols. Humana Press, New Jersey, USA.

Scott, R.P.W. 1995. Techniques and Practice of Chromatography. Marcel Dekker, Inc., New York.

Smith, R.H. 2000. Plant Tissue Culture: Techniques and Experiments. Academic Press, New York.

Wilson, K. and Goulding, K.H. (Eds.) 1986. A Biologists Guide to principles and Techniques of Practical Biochemistry. Edward Arnold, London, UK.

COURSE VI. ECOLOGY AND UTILIZATION OF PLANTS

ECOLOGY

Plants and environment: Atmosphere (gaseous composition), water (properties of water cycle), light (global radiation, photosynthetically active radiation), temperature, soil (development, soil profiles, physico-chemical properties), and biota.

Morphological, anatomical and physiological responses of plants to water (hydrophytes and xerophytes), temperature (thermoperiodicity and vernalization), light (photoperiodism, heliophytes and sciophytes) and salinity.

Population ecology: Growth curves; ecotypes; ecads.

Community ecology: Community characteristics, frequency, density, cover, life forms, biological spectrum; ecological succession.

Ecosystems: Structure; abiotic and biotic components; food chain, food web, ecological pyramids, energy flow; biogeochemical cycles of carbon, nitrogen and phosphorus.

Biogeographical regions of India.

Vegetation types of India: Forests and grasslands.

UTILIZATION OF PLANTS

Food plants: Rice, wheat, maize, potato, sugarcane.

Fibres: Cotton and jute.

Vegetable oils: Groundnut, mustard and coconut.

General account of sources of firewood, timber and bamboos.

Spices: General account.

Medicinal plants: General account.

Beverages: Tea and coffee.

Rubber.

Suggested Readings (for Ecology)

Odum, E.P. 1983. Basic Ecology. Saunders, Philadelphia.

Kormondy, E.J. 1996. Concepts of Ecology. Prentice-Hall of India Pvt. Ltd., New Delhi.

Mackenzie, A et al. 1999. Instant Notes in Ecology. Viva Books Pvt. Ltd., New Delhi.

Suggested Readings (for Utilization of Plants)

Kocchar, S.L. 1998. Economic Botany in Tropics, 2nd edition. Macmillan India Ltd., New Delhi.

Sambamurthy, A.V.S.S. and Subramanyam, N.S. 1989. A Textbook of Economic Botany, Wiley Eastern Ltd., New Delhi.

Sharma, O.P. 1996. Hill's Economic Botany (Late Dr A.F. Hill, adapted by O.P. Sharma). Tata McGraw Hill Co. Ltd., New Delhi.

Simpson, B.B. and Conner-Ogorzaly, M. 1986. Economic Botany– Plants in Our World. McGraw Hill, New York.

Suggested Laboratory Exercises (Ecology)

1. To determine minimum number of quadrats required for reliable estimate of biomass in grasslands.
2. To study the frequency of herbaceous species in grassland and to compare the frequency distribution with Raunkair's Standard Frequency Diagram.
3. To estimate Importance Value Index for grassland species on the basis of relative frequency, relative density and relative biomass in protected and grazed grassland.
4. To measure the vegetation cover of grassland through point frame method.
5. To measure the aboveground plant biomass in a grassland.
6. To determine Kemp's constant for dicot and monocot leaves and to estimate the leaf area index of a grassland community.
7. To determine diversity indices (richness, Simpson, Shannon-Wiener) in grazed and protected grassland.
8. To estimate bulk density and porosity of grassland and woodland soils.
9. To determine moisture content and water holding capacity of grassland and woodland soil.
10. To study the vegetation structure through profile diagram.
11. To estimate transparency, pH and temperature of different water bodies.
12. To measure dissolved oxygen content in polluted and unpolluted water samples.
13. To estimate salinity of different water samples.
14. To determine the percent leaf area injury of different leaf samples collected around polluted sites.
15. To estimate dust holding capacity of the leaves of different plant species.

Suggested Readings (for laboratory exercises in Ecology)

Krebs, C.J. 1989. Ecological Methodology. Harper and Row, New York, USA.

Ludwig, J.A. and Reynolds, J.F. 1988. Statistical Ecology. Wiley, New York.

Moore, P.W. and Chapman, S.B. 1986. Methods in Plant Ecology. Blackwell Scientific Publications.

Misra, R. 1968. Ecology Work Book. Oxford & IBH, New Delhi.

APHA – Standard Methods for the Examination of Water and Waste Water. American Public Health Association, Washington, D.C.

Suggested Laboratory Exercises (for Utilization of Plants)

1. **Food Plants** : Study of the morphology, structure and simple microchemical tests of the food storing tissues in rice, wheat, maize, potato and sugarcane. Microscopic examination of starch in these plants (excepting sugarcane).
2. **Fibres** : Study of cotton flowers, sectioning of the cotton ovules/developing seeds to trace the origin and development of cotton fibers. Microscopic study of cotton and test for cellulose. Sectioning and staining of jute stem to show the location and development of fibres. Microscopic structure. Tests for lignocellulose.
3. **Vegetable oils**: study of hand sections of groundnut, mustard and coconut and staining of oil droplets by Sudan III and Sudan Black.
4. **Field visits** : To study sources of firewood (10 plants), timber-yielding trees (10 trees) and bamboos. A list to be prepared mentioning special features.
5. **Spices** : Examine black pepper, cloves, cinnamon (hand sections) and opened fruits of cardamom and describe them briefly.
6. **Preparation of an illustrated inventory of 10 medicinal plants used in indigenous systems of medicine or allopathy** : Write their botanical and common names, parts used and diseases/disorders for which they are prescribed.
7. **Beverages** : Section boiled coffee beans and tea leaves to study the characteristic structural features.
8. **Rubber** : Collect illustrative materials of *Hevea brasiliensis*; morphology of the plant and tapping practices, history of rubber. List the many uses of rubber.

Suggested Readings (for laboratory exercises for Utilization of Plants)

Kocchar, S.L. 2000. Economic Botany of the Tropics. Macmillan India Pvt. Ltd., New Delhi.

Council of Scientific & Industrial Research 1986. The Useful Plants of India. Publications and Information Directorate, CSIR, New Delhi.

Pimentel, D. and Hall, C.W. (Eds) 1989. Food and Natural Resources. Academic Press, London-New York.

Sharma, O.P. 1996. Hill's Economic Botany. Tata McGraw Hill Co. Ltd, New Delhi.

Swaminathan, M.S. and Kocchar, S.L. (Eds) 1989. Plants and Society. Macmillan Publications Ltd., London.

Detailed Curriculum

of

B.Sc. (Honours)

COURSE I. DIVERSITY AND CLASSIFICATION OF THE PLANT KINGDOM

1. **Plant kingdom:** Classification of kingdoms and the criteria (according to Mayr, the seven kingdoms of living organisms); diversity in habitat, form, life span, nutrition and ecological status; origin, evolution and phylogeny of land plants; extinctions and possible causes; fossils and living fossils (a brief account).
2. **Algae:** General characters, classification and economic importance; important features and life history of Chlorophyceae - *Volvox, Oedogonium, Coleochaete;* Xanthophyceae – *Vaucheria;* Phaeophyceae - *Ectocarpus, Sargassum*; Rhodophyceae - *Polysiphonia.*
3. **Fungi:** General characters, classification and economic importance; important features and life history of Mastigomycotina - *Pythium, Phytophthora*; Zygomycotina – *Mucor*; Ascomycotina - *Saccharomyces, Eurotium, Chaetomium, Peziza;*. Basidiomycotina – *Puccinia, Agaricus*; Deuteromycotina - *Cercospora*, *Colletotrichum*; general account of Lichens.
4. **Bryophytes:** Classification and comparative study of morphology, anatomy, reproduction; broad interrelationships of Hepaticopsida, Anthocerotopsida, Bryopsida; ecological and economic importance of bryophytes.
5. **Pteridophytes:** Salient features of primary vascular plants; classification, comparative study of morphology, anatomy, reproduction; stelar evolution; a general account of evolutionary significance of Psilopsida, Lycopsida, Sphenopsida and Pteropsida; heterospory and seed habit.
6. **Gymnosperms:** Classification and salient features; evolutionary significance of gymnosperms; comparative general study of morphology, anatomy and reproduction of Cycadales, Coniferales and Gnetales.
7. **Angiosperms:** Unique features of angiosperms and diversity; identification, nomenclature and classification; comparison of systems of classification (Bentham & Hooker and Engler & Prantl); primitive and advanced features; salient features of the International code of Botanical Nomenclature; general account of morphology, anatomy, flower structure, reproduction and seed development.

Suggested Readings

Bold, H.C., Alexopoulos, C.J. and Delevoryas, T. 1980. Morphology of Plant and Fungi (4th Edition). Harper and Foul Co., New York.

Clifton, A. 1985. Introduction to the Bacteria. McGraw Hill Co., New York.

Dube, H.C. 1990. An Introduction to Fungi. Vikas Publishing House Ltd., Delhi.

Gifford, E.M. and Foster, A.S. 1989. Morphology and Evolution of Vascular Plants. W.H. Freeman & Co., New York.

Gilbert, M.S. 1985. Cryptogamic Botany, Vol. I & II (2nd Edition). Tata McGraw Hill Publishing Co. Ltd., New Delhi.

Kumar, H.D. 1988. Introductory Phycology. Affiliated East-West Press Ltd., New York.

Mandahar, C.L. 1978. Introduction to Plant Viruses. Chand & Co. Ltd., New Delhi.

Puri, P. 1985. Bryophytes. Atmaram & Sons, Delhi, Lucknow.

Raven, P.H., Evert, R.F. and Eichhorn, S.E. 1999. Biology of Plants (5th edition). W.H. Freeman & Co., Worth Publ., New York, USA.

Sporne, K.R. 1991. The Morphology of Gymnosperms. B.I. Publications Pvt., Bombay, Calcutta, Delhi.

Wilson, N.S. and Rothwell, G.W. 1993. Palaeobotany and the Evolution of Plants (2nd Edition). Cambridge University Press, UK.

Suggested Laboratory Exercises

1. Study of prokaryotic organisms: bacteria (*Bacillus, Coccus, Streptococcus, Spirillum*). Bacterial staining (Gram's staining), Blue green algae – *Anabaena.*
2. Study of eukaryotic organisms
3. Algae : *Volvox, Cladophora, Oedogonium, Sargassum, Polysiphonia.*
4. Fungi : *Rhizopus, Yeast, Asperigillus, Penicillium, Chaetomium, Peziza, Agaricus.*
5. Study of morphology, anatomy and reproductive structures in *Riccia, Marchantia, Anthoceros, Funaria.*
6. Study of morphology, anatomy and reproductive structures in *Rhynia, Lycopodium, Selaginella, Equisetum, Marsilea, Pteris, Lepidodendron, Lepidocarpon.*
7. Study of morphology, anatomy and reproductive structures in *Cycas, Pinus, Gnetum* or *Ephedra.*
8. A study of the representative members of the following angiosperm families: Ranunculaceae or Magnoliaceae, Euphorbiaceae, Fabaceae (Papilionoideae, Caeselpinioideae, Mimosoideae), Apiaceae, Acanthaceae/Labiatae, Asteraceae, Liliaceae, Poaceae.

COURSE II. CELL BIOLOGY AND BASIC BIOCHEMISTRY

Cellular chemistry: Covalent and noncovalent interactions; hydrogen bond; electrostatic interactions; hydrophobic interactions; van der Walls forces and their significance; structure, properties of water and its biological significance; pH and its significance; pH scale; Henderson-Haselbach equation; isoelectric point; buffers (inorganic and organic) and their importance; ATP – the energy currency; phosphorylation/dephosphorylation of proteins.

Energy flow and enzymology: Laws of thermodynamics; concept of free energy; energy transfer and redox potential; classification and nomenclature of enzymes; enzymes as biocatalysts; physico-chemical properties of enzymes; cofactors and coenzymes; isozymes; kinetics of enzyme action; significance of Km; regulation of enzyme activity; factors affecting enzyme activity, e.g. temperature, pH; allosteric modification and feedback regulation.

The cell: Historical background; cell theory; kingdom-wise cell size and cell structure; viroids and prions; comparative account of prokaryotic and eukaryotic cell; characteristics of archaebacteria and mycoplasma.

Cell division and its regulation: Mitosis and meiosis – historical perspective and significance; various stages of cell division progression; cytokinesis; role of centromere, kinetochore and spindle apparatus; animal and plant cell cycle; mechanisms of cell cycle control; apoptosis.

Nucleus and ribosomes: Ultrastructure; nuclear envelope and nuclear pore complex; nuclear matrix and nucleoplasm; DNA and histones; nucleosome and higher level of organization; centromere and telomeres; ribosome structure; prokaryotic, eukaryotic and organelle ribosomes and their functional significance.

Mitochondrion and chloroplast: Origin of organelles; organelle structure and biogenesis; organelle membranes and organization of macromolecular complexes; variation in size, shape and number; types of plastids; organelle-nuclear interactions; organelle genome organization.

Structure/function of other sub-cellular structures: Golgi complex; endoplasmic reticulum; lysosomes; microbodies – peroxisomes and glyoxysomes; cytoskeleton.

Cell wall and cell membrane: Origin, ultrastructure, chemical constituents and functions of cell wall; models of cell membrane organization; role of various membrane proteins, lipids and carbohydrates; role of ion channels and pumps in cellular transport and signalling.

Techniques in cell biology: Principles of light and electron microscopy; phase contrast and fluorescence microscopy; TEM and SEM; cell fractionation procedures; principles of various chromatography techniques – paper chromatography, TLC, GLC and HPLC; autoradiography and its applications.

Suggested Readings

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1999. Molecular Biology of Cell. Garland Publishing Co., Inc., New York, USA.

Avers, C.J. 1986. Molecular Cell Biology. Addison-Wesley Publishing Co., Massachusetts, USA.

Campbell, M.K. 1999. Biochemistry (3rd Edition). Saunders College Publishing, Philadelphia, USA.

Gupta, P.K. 1999. A Text-book of Cell and Molecular Biology. Rastogi Publcations, Meerut, India.

Kleinsmith, L.J. and Kish, V.M. 1995. Principles of Cell and Molecular Biology (2nd Edition). Harper Collins College Publishers, New York, USA.

Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. 2000. Molecular Cell Biology (4th Edition). W.H. Freeman and Co., New York, USA.

Nelson, D.L. and Cox, M.M. 2000. Lehninger Principles of Biochemistry (3rd Edition). Worth Publishers, New York, USA.

Rawn, D.J. 1989. Biochemistry. Neil Patterson Publishers, North Carolina, USA.

Stryer, L. 1995. Biochemistry. W.H. Freeman and Co., New York, USA.

Wolfe, S.L. 1993. Molecular and Cellular Biology. Wadsworth Publishing Co., California, USA.

Zubay, G. 1993. Biochemistry (3rd Edition). WCB Publishers, Iowa, USA.

Suggested Laboratory Exercises

1. Study of cell structure from onion leaf peels; demonstration of staining and mounting methods.
2. Comparative study of cell structure in onion cells, *Hydrilla* and *Spirogyra*. Study of cyclosis in *Tradescantia* staminal hairs.
3. Study of plastids to examine pigment distribution in plants (e.g. *Cassia*, *Lycopersicon*, *Capsicum*).
4. Examinations of electron micrographs of eukaryotic cells with special reference to organelles.
5. Preparation of phosphate buffer. Measurement of pH of different plant juices.
6. Use of dialysis to separate small molecules from larger molecules.
7. Enzymology: activity of catalase, invertase, amylase and urease, and effect of pH and temperature on enzyme activity.
8. Study of various stages of mitosis and meiosis using appropriate plant material (e.g. root tips and flower buds of onion).

Suggested Readings (for laboratory exercises)

Dryer, R.L. and Lata, G.F. 1989. Experimental Biochemistry. Oxford University Press, New York.

Gunning, B.E.S. and Steer, M.W. 1996. Plant Cell Biology : Structure and Function. Jones and Bartlett Publishers, Boston, Massachusetts.

Harris, N. and Oparka, K.J. 1994. Plant Cell Biology : A Practical Approach. IRL Press, at Oxford University Press, Oxford, UK.

Ninfa, A.J. and Ballou, D.P. 1998. Fundamental Laboratory Approaches for Biochemistry and Biotechnology Fitzgerald Science Press, Inc., Maryland, USA.

Wilson, K. and Goulding, K.H. (Eds.) 1986. A Biologists Guide to Principles and Techniques of Practical Biochemistry. Edward Arnold, London, UK.

COURSE III. PLANT PHYSIOLOGY AND ECOLOGY

PLANT PHYSIOLOGY

Plant-water relations: Water transport processes; diffusion and osmosis; water potential and chemical potential; absorption of water, water transport through tracheids and xylem; transpiration and its significance; factors affecting transpiration; mechanism of stomatal movement.

Mineral nutrition: Criteria of essentiality of elements; macro- and micronutrients; role of essential elements; mineral deficiency symptoms and plant disorders; nutrient uptake and transport mechanisms; role of cell membrane, ion pumps and carriers.

Photosynthesis: Historical background and significance; structure of photosynthetic apparatus; photosynthetic pigments; accessory pigments and the photoprotective carotenoids; reaction center complexes; photochemical reactions; electron transport pathways in chloroplast membranes; photophosphorylation; the Calvin cycle; the C_4 carbon cycle; crassulacean acid metabolism; synthesis of starch and sucrose; photorespiration.

Transport of organic substances: Transport of photosynthates; source-sink relationship; the mechanism of translocation in the phloem; assimilate partitioning.

Respiration: Glycolysis; the TCA cycle and its regulation; electron transport in mitochondria; oxidative phosphorylation; pentose phosphate pathway; cyanide-resistant respiration.

Nitrogen metabolism: Biological nitrogen fixation; reduction of N_2 into ammonia; *nif* genes; regulation of nitrate reductase and nitrogenase; nitrate and ammonium assimilation.

Growth and development: General aspects - definitions, phases of growth; kinetics of growth; physiology of seed dormancy and seed germination; concept of photoperiodism; physiology of flowering; the florigen concept and role of hormones; vernalization; senescence and fruit ripening; importance of respiratory climacteric; discovery, physiological role and mechanism of action of the phytohormones - auxins, cytokinins, gibberellins, abscisic acid and ethylene; photomorphogenesis; discovery of phytochromes and cryptochromes, their role and mechanism of actions; signal transduction – basic concept; plant movements – tropic and nastic; biological clocks.

ECOLOGY

Introduction: Holocoenotic nature of environment; limiting factors; ecological amplitude; triggering factors (soil, water, atmosphere).

Ecological adaptations: Concept, ecads, ecotypes and ecoclines; adaptations in relation to soil oligotrophy; adaptive significance of photosynthetic pathways.

Population: Concepts; density and pattern; idealized plant life history; population growth; carrying capacity; population regulation; r and k selection; population interactions.

Community: Community characteristics and their measurement; species diversity (alpha, beta and gamma); niche.

Ecosystem: Concept, components and organization; energy flow; ecological efficiencies; cycling of C, N, and P; characterization and structure of ecosystem; the biotic and abiotic components, their inter-relationships; the processes within ecosystem; the trophic organization; autotrophy, heterotrophy, parasitism, detritus, decomposition.

Ecological succession: Mechanism and types; nature of climax; food chains and food webs; ecological pyramids.

Flow of energy and materials: Flow of energy and materials within ecosystem; models of energy flow; ecosystem productivity; biogeochemical cycles; major types of ecosystems.

Plant indicators and their role in environmental monitoring.

Phytogeography: General principles; vegetation of India.

Suggested Readings

Plant Physiology

Galston, A.W. 1989. Life Processes in Plants. Scientific American Library, Springer-Verlag, New York, USA.

Hooykaas, P.J.J., Hall, M.A. and Libbenga, K.R. (eds) 1999. Biochemistry and Molecular Biology of Plant Hormones. Elsevier, Amsterdam, The Netherlands.

Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.

Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones (2nd edition). Springer-Verlag, New York, USA.

Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4th edition). Wadsworth Publishing Co., California, USA.

Taiz, L. and Zeiger, E. 1998. Plant Physiology (2nd edition). Sinauer Associates, Inc., Publishers, Massachusetts, USA.

Ecology

Odum, E.P. 1983. Basic Ecology. Saunders, Philadelphia.

Barbour, M.G., Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology. Benjamin/Cummings Publication Co., California.

Kormondy, E.J. 1996. Concepts of Ecology, Prentice-Hall of India Pvt. Ltd., New Delhi.

Hill, M.K. 1997. Understanding Environmental Pollution. Cambridge University Press.

Mackenzie, A. et al. 1999. Instant Notes in Ecology. Viva Books Pvt. Ltd., New Delhi.

Suggested Laboratory Exercises

PLANT PHYSIOLOGY

1. To study the permeability of plasma membrane using different concentrations of organic solvents.
2. To study the effect of temperature on permeability of plasma membrane.
3. To extract enzymes and study their activity, e.g. amylase, lipase, acid phosphatase, catalase, peroxidase.
4. Effect of the following factors on enzyme activity: pH, temperature, enzyme and substrate concentration, heavy metals.
5. Comparative study of rate of respiration of various plant parts.
6. To extract and separate chloroplast pigments by solvent method and demonstrate fluorescence in chloroplast extracts.
7. To determine the osmotic potential of vacuolar sap by plasmolytic method.
8. To determine the water potential of given tissue (any tuber).
9. Bioassay of plant hormones – auxins, ethylene, GA, ABA and cytokinin.
10. To determine stomatal index, stomatal frequency and percentage of leaf area open through stomata. Also, to study the effect of ABA on stomatal closure.
11. Role of light in germination of photoblastic seeds, e.g. *Lactuca sativa, Arabidopsis.*

Suggested Readings (for laboratory exercises)

Copeland, R.A. 1996. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis. VCH Publishers, New York.

Dryer, R.L. and Lata, G.F. 1989. Experimental Biochemistry. Oxford, Univeristy Press, New York.

Moore, T.C. 1974. Research Experiences in Plant Physiology: A Laboratory Manual. Springer-Verlag, Berlin.

Wilson, K. and Goulding, K.H. (Eds.) 1986. A Biologist's Guide to Principles and Techniques of Practical Biochemistry. Edward Arnold, London, UK.

ECOLOGY

1. To determine the working and use of instruments for the measurement of temperature (soil, air, water), moisture (rainfall, relative humidity, soil moisture), wind (velocity and direction) and light intensity.
2. To study selected soil properties by spot test: texture, pH, carbonate, nitrate, base deficiency and reductivity.

3. To study ecological adaptations (morphological and anatomical) in plants (hydrophytes, xerophytes, epiphytes).
4. To determine minimum area of sampling unit (quadrat) for the study of grassland community.
5. To estimate Importance Value Index for grassland species.
6. To study leaf form spectrum of a woodland.
7. To prepare maps of India with respect to (i) major climatic zones (ii) forest types, and (iii) biogeographical regions and to comment on it.

Suggested Readings (for laboratory exercises)

Smith, R.L. 1996. Ecology and Field Biology. Harper Collins, New York.

Moore, P.W. and Chapman, S.B. 1986. Methods in Plant Ecology. Blackwell Scientific Publications.

Misra, R. 1968. Ecology Work Book. Oxford & IBH, New Delhi.

COURSE IV. DEVELOPMENT OF PLANTS AND THEIR UTILIZATION

Organization of the higher plant body: The shoot and root systems; variation in habit and longevity; environmental influences.

Meristems and development: Shoot apical meristem, root apical meristem, lateral meristems and their functions.

Range of form and structure of stem, leaf and root; their tissues and functions.

Secondary body of the plant: Vascular cambium; secondary xylem (basic structure of wood); secondary phloem and periderm.

Role of wild plants in ecosystem functioning: A general account.

Domestication of plants: Primary and secondary centers of diversity; plant introductions.

A general account of wheat, rice, maize, sorghum, bajra, potato and sugarcane.

Legumes: Chickpea (Bengal gram), red gram (arhar) and fodder legumes - a general account.

Vegetable oil sources: Mustard, groundnut, soybean and coconut – a brief account.

Plant fibres: Cotton, jute and coir.

Timber and firewood species: A general account of use of properties of *any ten* plants of your region.

Medicinal plants: A brief account of *ten* important plant drugs and their chief constituents used in indigenous and allopathic systems of medicine.

Natural rubber (*Hevea brasiliensis*), essential oils, insecticides and dyes - a concise account.

Ornamental plan Familiarity with seasonals and perennials grown in your locality.

Suggested R adings

Carlquist, S. 1988. Comparative Wood Anatomy: Systematic, Ecological and Evolutionary Aspects of Dicotyledonous Wood. Springer-Verlag, Berlin.

Cutter, E.G. 1969. Part I. Cells and Tissues. Edward Arnold, London.

Cutter, E.G. 1971. Plant Anatomy: Experiment and Interpretation. Part II. Organs. Edward Arnold, London.

Esau, K. 1977. Anatomy of Seed Plants, 2nd edition. John Wiley and Sons, New York.

Fahn, A. 1974. Plant Anatomy, 2nd edition. Pergamon Press, Oxford.

Fuller, K.W. and Gallon, J.R. 1985. Plant Products and New Technology. Clarendon Press, Oxford, New York.

Kocchar, S.L. 1998. Economic Botany in Tropics, 2nd edition. Macmillan India Ltd., New Delhi.

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

Mauseth, J.D. 1988. Plant Anatomy. The Benjamin/Cummings Publishing Company Inc., Menlo Park, California, USA.

Nair, M.N.B. 1998. Wood Anatomy and Major Uses of Wood. Faculty of Forestry, Universiti Putra Malaysia, 43400 Serdang, Selangor D. E., Malaysia.

Raghvan, V. 2000. Developmental Biology of Flowering Plants. Springer-Verlag, New York.

Raven, P.H., Evert, R.F. and Eichhorn, S.E. 1999. Biology of Plants. 5th edition. W.H. Freeman and Co., Worth Publishers, New York.

Sambamurthy, A.V.S.S. and Subramanyam, N.S. 1989. A Textbook of Economic Botany. Wiley Eastern Ltd., New Delhi.

Sharma, O.P. 1996. Hill's Economic Botany. Tata McGraw Hill Publishing Company Ltd., New Delhi.

Simpson, B.B. and Conner-Ogorzaly, M. 1986. Economic Botany– Plants in Our World. McGraw Hill, New York.

Steeves, T.A. and Sussex, I.M. 1989. Patterns in Plant Development, 2nd edition. Cambridge University Press, Cambridge.

Thomas, P. 2000. Trees: Their Natural History. Cambridge University Press, Cambridge.

Tippo, O. and Stern, W.L. 1977. Humanistic Botany. W.W. Norton, New York.

Vishnu Swarup 1997. Ornamental Horticulture. Macmillan India Ltd., New Delhi.

Suggested Laboratory Exercises

1. Study of organization in a flowering plant. Role of shoot apical and root apical meristem (using whole mounts of shot tips of *Hydrilla,* vertical sections of *Coleus* or *Bryophyllum*, and whole mounts of root tips of *Pistia*, or vertical sections of root tips of onion, maize, aerial roots of *Ficus benghalensis* or *Tinospora cordifolia*).
2. Study in the field of a large variety of herbaceous and perennials, both monocotyledonous and dicotyledonous; aquatic, mesophytic, xeromorphic plants, succulents, climbers, twiners, parasites, and trees with varied canopy architecture. Field diary to be prepared.
3. Morphology and anatomy of stems, roots, and leaves using stained hand sections or permanent slides (tapioca, carrot, radish, onion, garlic, turnip, potato, etc.).
4. Study of vascular cambium in stem and root. Secondary growth. Examples of cambial variants and resultant secondary structures.
5. Preparation of world maps to show Vavilov's centres of origin of cultivated plants and Zhukovsky's concept of mega centres.
6. Preparation of maps showing the centers of primary diversity of important economic plants that originated in India and the regions of cultivation of plants introduced from the New World, Africa, Europe, Central Asia, Australasia, Malaysia, China.
7. Study of vegetative and reproductive morphology and anatomy of wheat, rice, maize, sorghum, bajra, potato and sugarcane. Also study of starch grains in these plants (except in sugarcane). Epidermal structure of sugarcane stem and leaves. Tests for surose.

8. Study of vegetative and floral morphology, and pod development in chickpea and red gram. Familiarization with four fodder legumes (such as berseem, lucerne, methi, *Clitoria*, guar, cowpea etc.).
9. Study of structure of oil storing tissues in sectioned seeds of mustard, groundnut and soybean, and coconut endosperm, using mirochemical tests.
10. Study of vegetative, floral and fruit morphology of cotton. Ontogeny of cotton fibre in young ovules and tracing the development of cotton fibre. Mature microscopic structure of cotton fibre. Preparation of absorbent cotton by alkali treatment. Staining of cotton with and without mordanting. Study of stem of jute showing origin and development of jute fibre. T.S. coir to show that coir is a fibrovascular bundle.
11. Study of wood anatomy of ring-porous, diffuse porous woods using hand sections or prepared slides. Understanding of wood anatomy using T.S., T.L.S and R.L.S in *five* timber yielding species (teak, *Dalbergia*, *Albizzia, Gmelina, Eucalyptus, Cedrus* or *Pinus, Acacia, Shorea, Terminalia, Mangifera, Azadirachta*, or any other depending on the location of the institution). Preparation of a list of 10 fire wood species in your region and their properties).
12. Study of 10 whole plants (live or from herbarium specimens) used as resources of drugs: (Poppy, *Rauvolfia, Adhatoda, Emblica officinalis, Terminalia bellirica, T. chebula, Glycyrrhiza, Phyllanthus amarus (P. fraternus),* garlic, *Andrographis paniculata, Catharanthus rosesus, Atropa belladonna, Digitalis purpurea, Aloe barbadense*, or any other important plants of your area).
13. Study of laticiferous system in the stem of *Hevea brasiliensis*, familiarization with whole plants (fresh or herbarium specimens of *Cymbopogon* sp., *Eucalyptus, Jasminum, Geranium, Pandanus* sp., *Rosa*, *Vetiveria zizaniodes, Santalum album* (or any other local sources of essential oils).
14. Study of the neem plant, *Artemisia annua, Chrysanthemum cinerarifolium* (pyrethrum) from live specimens.
15. Souces of dyes: *Curcuma longa* (turmeric), *Bixa orellana* (annato), *Crocus sativus*, *Butea monosperma* (palash), *Indigofera* (indigo), *Lawsonia inermis* (mehndi). Extraction of pigments.
16. Preparation of a list of trees and shrubs used as ornamentals alongwith their popular and scientific names. Seasons of flowering and brief description. Calendar of seasonals grown as bed plants, potted plants, house plants, flowers used for worship or ornamentation. This may be illustrated and presented as a term paper at the time of examination.

COURSE V. BIOLOGY OF CRYPTOGAMS

17. **Algae:** Occurrence and distribution; thallus organization and evolutionary tendencies; ultrastructure of algal cell; criteria for classification and typical life histories of algae belonging to various classes; role of algae in human welfare.
18. **Fungi and plant diseases:** Occurrence and distribution; ultrastructure of fungal cell, cell wall composition; modern concepts in the classification of fungi; nutrition, reproduction, life histories of main groups of fungi; types of fungal spores and mode of their liberation; role of fungi in human welfare; major diseases of plants and their control (blast and brown spot of rice, rust and smuts of wheat, downy mildew and green ear disease of bajra, white rust of crucifers, late blight of potato, wilt of pigeon pea, damping off, Tikka disease of groundnut, citrus die back, powdery mildews of cucurbits and grapes, red rot of sugarcane).
19. **Bryophytes:** Comparative account of morphology, anatomy and reproduction in *Riccia, Marchantia, Anthoceros, Funaria*; evolution of sporophyte and gametophyte; classification, ecological aspects and economic importance.
20. **Pteridophytes:** The primary vascular plants; classification; comparative account of morphology, anatomy and reproduction in *Rhynia, Lycopodium, Selaginella, Equisetum, Marsilea, Pteris*; telome theory; stelar evolution; heterospory and seed habit.

Suggested Readings

Bold, H.C., Alexopoulos, C.J. and Delevoryas, T. 1980. Morphology of Plant and Fungi (4th Edition). Harper and Foul Co., New York.

Clifton, A. 1958. Introduction to the Bacteria. McGraw Hill Co., New York.

Dube, H.C. 1990. An Introduction to Fungi. Vikas Publishing House Pvt. Ltd., Delhi.

Gifford, E.M. and Foster, A.S. 1989. Morphology and Evolution of Vascular Plants. W.H. Freeman & Co., New York.

Gilbert, M.S. 1985. Cryptogamic Botany, Vol. I & II (2nd Edition). Tata McGraw Hill Publishing Co. Ltd., New Delhi.

Kumar, H.D. 1988. Introductory Phycology. Affiliated East-West Press Ltd., New York.

Mandahar, C.L. 1998. Introduction to Plant Viruses. Chand & Co. Ltd., Delhi.

Puri, P. 1985. Bryophytes. Atmaram & Sons, Delhi.

Rangaswamy, G. and Mahadevan, A. 1999. Diseases of Crop Plants in India. Prentice Hall India Pvt. Ltd., New Delhi

Sporne, K.R. 1991. The Morphology of Gymnosperms. B.I. Publications Pvt., Bombay, Calcutta, Delhi.

Wilson, N.S. and Rothwell, G.W. 1993. Palaeobotany and the Evolution of Plants (2nd Edition). Cambridge University Press, UK.

Suggested Laboratory Exercises

1. Comparative study of algal genera with reference to the classes mentioned in theory.
2. Comparative study of fungal genera with reference to the classes mentioned in theory.
3. Fungal diseases: White rust of crucifers, downy mildew of pearl millet, green ear disease of bajra, powdery mildew, rust of wheat and sorghum, Tikka leaf spot disease of ground nut, red rot of sugar cane.
4. Section cutting of fungal diseased specimens and preparation of lactophenol mounts.
5. Comparative study of morphology, anatomy and reproductive structures in *Marchantia*, *Anthoceros* and *Funaria*.
6. Comparative study of morphology, anatomy and reproductive structures of representative pteridophytes available and mentioned in theory.

COURSE VI. BIOLOGY OF SEED PLANTS

Phanerogams, the seed bearing plants: General characteristics and types.

Gymnosperms: General characters, ontogeny and structure of seed; the ovule and megasporogenesis, female gametophyte; pollination, formation of pollen tubes and fertilization; embryogeny and maturation of seed.

The living cycads: Distribution; vegetative organography and anatomy; reproductive cycle – sporophytes and sporangia, gametophytes, fertilization, embryogeny and seed development.

The coniferales: General organography and anatomy; foliage leaves; strobilli and sporangia; reproductive cycle - sporogenesis, gametophytes, fertilization, embryogeny and seed development.

The Gnetales: Habit and distribution; vegetative organography and anatomy; reproductive cycle – the strobilli, sporogenesis, male and female gametophytes, pollination, fertilization and embryogeny.

Angiosperms: Organography and anatomy; leaf morphology, histology and venation; nodal and wood anatomy; general concepts of floral anatomy.

Alternatives for reproduction: Vegetative and sexual reproduction; transition from vegetative to reproductive development.

Flower: Evolution; concept of flower as a modified determinate shoot; genetic control of floral organs; functions of flower.

Structure of anther: Microsporogenesis; formation of pollen grains (male gametophyte); pollen germination; pollen tube growth.

Structure of pistil: Ovules; megasporogenesis; development of embryo sac (female gametophyte).

Mechanisms and agencies of pollination: Pollen-stigma interaction; self-incompatibility; double fertilization; apomixis.

Seed and fruit: Development of endosperm and embryo in monocotyledons and dicotyledons; storage of reserve materials and desiccation in seeds; dormancy and seed germination; fruit maturation; ripening and dispersal.

Suggested Readings

Cronquist, A. 1968. The evolution and classification of flowering plants. Thomas Nelson (Printers) Ltd., London & Edinburgh.

Delevoryas, Th. 1965. Plant Diversification. Modern Biology Series, Halt, Rinehart & Winston, New York.

Foster, A.S. and Gifford, A.E.M., Jr. 1967. Comparative Morphology of Vascular Plants. Vakils, Peffer & Simons Pvt Ltd.

Sporne, K.R. 1977. The Morphology of Angiosperms. B.I. Publication, Bombay.

Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms, 4th revised and enlarged edition. Vikas Publishing House, Delhi.

Johri, B.M. 1984. Embryology of Angiosperms. Springer-Verlag, Berlin.

Raghvan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, N.Y.

Suggested Laboratory Exercises

1. Comparative anatomical structure of stem/wood of Cycadales, Coniferales, Ginkgoales, Ephedrales, Gnetales and angiosperms, from sections and macerations.
2. Comparative structure of leaf, leaf appendages, venation and stomata of gymnosperms and angiosperms.
3. Comparative structure of the male and female cones of Cycads, Conifers, Ginkgoales (wherever available) and Ephedrales and flowers of Ranales and Magnoliales.
4. Diversity in pollen grain structure among Cycads, Conifers, Ephedrales and angiosperms with respect to size, exine sculpturing, germpore number, number of constituent cells and any other features.
5. Microsporogenesis and male gametophyte development in angiosperms through microtome sectioning and acetocarmine squash technique.
6. Pollen grain germination by hanging-drop and sitting-drop techniques in *Impatiens, Catharanthus roseus* (=*Vinca rosea*) or any other suitable material.
7. Diversity in the structure of stigma, style, stigmatic papillae and transmitting tissue of style.
8. Comparison of mating types in species exhibiting heteromorphic self incompatibility *Hamelia patens, Pentas* or any other suitable material.
9. Studies on gametophytic and sporophytic self-incompatibility in *Petunia.*
10. Microdissection of embryo with suspensor at different stages of development to unravel relationship between the two.
11. Microdissection of endosperm with different types of haustoria.

COURSE VII. MICROBIOLOGY AND PLANT PATHOLOGY

MICROBIOLOGY

1. **Discovery of microorganisms;** systematic position of microorganisms in biological world; classification of microorganisms and characteristic features of different groups.
2. **Methods in microbiology:** basic principles of microscopy, micrometry, staining, sterilization methods; culture media, pure culture methods; methods for population estimation, growth determination.
3. **Ultrastructure of microorganisms**: prokaryotic microorganisms; fine structure of prokaryotic cell; eukaryotic microorganisms; viruses – properties and classification; characteristic features of host-virus interaction; bacteriophage T4; tobacco mosaic virus; general account of mycoplasma and actinomycetes.
4. **Genetic recombination in prokaryotes:** Conjugation, transformation and transduction.
5. **Role of microorganisms in biogeochemical cycling of nitrogen and carbon; biological N_2 fixation.**
6. **Industrial application of microorganisms:** Organic acids, alcohol, food processing, milk products, antibiotics, biopesticides.

PLANT PATHOLOGY

7. **General account of plant pathogens:** Historical developments; general account of diseases caused by plant pathogens.
8. **Pathogen attack and defense mechanisms:** Physical, physiological, biochemical and molecular aspects.
9. **Plant disease epidemology:** Transmission and spread of plant pathogens; disease cycles, epidemics; modeling and disease forecasting.
10. **Plant disease management:** Chemical, biological; IPM systems; development of transgenics; biopesticides; plant disease clinics.
11. **Genetics of resistance and susceptibility:** Genes for virulence and avirulence, their application in resistance and susceptibility; induced resistance (immunization).
12. **Molecular plant pathology:** Molecular diagnosis; identification of genes and specific molecules in disease development; molecular manipulation of resistance.

13. **Application of information technology in plant pathology:** Simulation of epidemics; programmes for diagnosis; remote sensing and image analysis for ecosystem level effects; prediction of disease control decisions.

Suggested Readings

Books

Agrios, G.N. 1997. Plant Pathology. Academic Press, London.

Albajes, R., Gullino, M.L., van Lenteren, J.C. and Elad, Y. 2000. Integrated Pest and Disease Management in Greenhouse Crops. Kluwer Academic Publishers.

Bridge, P. et al. 1998. Molecular Variability of Fungal Pathogens. CAB International, UK.

Bridge, P. et al. 1999. Application of PCR in Mycology. CAB International, UK.

Bridge, P., Moore, D.R. and Scott, P.R. 1998. Informational Technology, Plant Pathology and Biodiversity. CAB International, UK.

Persley, G.J. 1996. Biotechnologies and Integrated Pest Management. CAB International, UK.

Skerritt, J.H. and Apples, R. 1995. New Diagnostics in Crop Sciences. CAB International, UK.

Suggested Laboratory Exercises (Microbiology)

1. Calibration of microscope: determination of dimensions of microorganisms (suggested model organisms: yeast, lactobacilli, cyanobacteria).
2. Cultivation media for autotrophic and heterotrophic microorganisms (cleaning of glasswares, mineral media, complex media, solid media, sterilization) (based on topic 3).
3. Isolation of microorganisms: streaking on agar plates/pour plate method, isolation of clones, preservation (based on topic 2 and 3).
4. Determination of growth of a microorganism (model organism: *Escherichia coli*, effects of nutrients, e.g. glucose, fructose, sucrose; principle of colorimetry/spectrocolorimeter) (based on topic 3).
5. Determination of microbial population size (suggested model organism: yeast; use of haemocytometer, serial dilution technique, relationship between dilution and cell count, determination of standard error, reliability in cell counts) (based on topic 3).
6. Preparation of Winogradsky column using pond bottom mud, observations on temporal sequence of appearance of microbes. (visual appearance, microscopic observations) (based on topic 7).
7. Observation on virus infected plants (symptoms) (based on topic 5).
8. Fermentation by yeast (inverted tube method, use of different substrates, e.g. glucose, fructose, cane sugar, starch) (based on topic 8).

Suggested Readings (for laboratory exercises)

Eklund, C. and Lankford, C.WE. 1967. Laboratory Manual for General Microbiology. Prentice-Hall, Inc., Engle-wood Cliffs, N.J.

Gunasekaran, P. 1995. Laboratory Manual in Microbiology. New Age International Pvt Ltd.

Pawsey, R.K. 1974. Techniques with Bacteria – A Guidebook for Teachers. Hutchinson Educational.

Pelezor, M.J. and Chan, E.C.S. 1972. Laboratory Exercises in Microbiology. McGraw Hill Book Co.

Meynell, E. and Meynell, G.G. 1970. Theory and Practice in Experimental Bacteriology. University Press, Cambridge.

Wistreich, G.A. and Lechtman, M.D. 1973. Laboratory Exercises in Microbiology. Glencoe Press, New York, Beverly Hills, Collier Macmillan Publishers, London.

Suggested Laboratory Exercises (Plant Pathology)

1. Study of important plant pathogens (symptoms and host parasite relationship).
2. Isolation and culture of plant pathogens (e.g. *Colletotrichum, Fusarium, Alternaria*) and establishment of Koch's postulates and their pathogenicity.
3. Effect of pathogens on physiology of a host.
4. Isolation of cellulase from diseased plants.
5. Isolation of pectolytic enzymes from diseased plants.
6. Study on antagonism between isolated antagonists and plant pathogens and test of biological control. Demonstration of antibiosis using a bacterial culture and known antibiotics.
7. Demonstration of the assay of prohibitins (phytoalexins).
8. Demonstration of biopesticides (essential oils, neem, turmeric and garlic) against some pathogens.

Suggested Readings (for laboratory exercises)

Books

Aneja, K.R. 1993. Experiments in Microbiology, Plant Pathology and Tissue Culture. Wishwa Publication, New Delhi.

Mahadevan, A. and Sridhar, R. 1986. Methods in Physiological Plant Pathology. Sivakami Publication, Madras.

Schaad, N.W. 1988. Plant Pathogenic Bacteria: Laboratory Guide for Identification of Plant Pathogenic Bacteria. Academic Press.

Journals/Series

Methods in Microbiology

Methods in Enzymology

Methods in Biochemistry

COURSE VIII. GENETICS AND PLANT BREEDING

GENETICS

Mendel's experiments and principles of inheritance; backcross and test cross; gene interactions and modified dihybrid ratios – complementary, supplementary, duplicate and epistatic factors.

Multiple allelism: Multiple alleles in *Drosophila* (eye colour), man (blood groups) and plants (self incompatibility).

Quantitative genetics: Quantitative traits and quantitative genetics; the multiple factor hypothesis; descriptive statistics.

Linkage and recombination: Coupling and repulsion phases; two and three point test crosses with their significance in chromosome mapping; interference and co-efficient of coincidence.

Sex chromosomes in *Drosophila*, Man and *Melandrium*: Balance concept of sex determination in *Drosophila*; mechanisms of sex determination; sex linked inheritance in *Drosophila* and man; sex limited characters.

Maternal influence on heritance: Shell coiling in snails and Kappa particles in *Paramecium*; cytoplasmic inheritance in yeast (mitochondria) and *Mirabilis jalapa* (plastids).

Alterations in the genetic make up – changes at genetic level: Spontaneous and induced mutations; mutagens – types and mode of action; transitions, transversions and frame-shift mutations; detection of mutations.

Alterations in genetic make up – changes in chromosome structure: Origin, types and effects of duplications, deletions, inversions and translocations; meiosis in structural heterozygotes.

Alterations in genetic make up – changes in chromosome number: Origin, types and effects of auto and allopolyploidy; origin and meiosis in nullisomics, monosomics and trisomics.

Plant Breeding

Types of plant reproduction: Vegetative, sexual and apomixis; their effect on generating and fixing genotypic variation.

Methods of plant improvement: Pure line and mass selection; hybridization in self and cross pollinated crops; introduction and acclimatization; hybrid vigour.

Mutations and polyploidy as methods of plant improvement.

Suggested Readings

Atherly, A.G., Girton, J.R. and McDonald. 1999. The Science of Genetics. Saunders College Publishing Co., Fort Worth, USA.

Gardener, J., Simmons, H.J. and Snustad, D.P. 1991. Principles of Genetics (8th Edition). John Wiley & Sons, New York.

Gupta, P.K. 1994. Genetics. Rastogi Publications. Shivaji Road, Meerut.

Gupta, P.K. 1995. Cytogenetics. Rastogi Publications, Meerut.

Hartl, D.L. and Jones, E.W. 1998. Genetics: Principles and Analysis (4th Edition). Jones & Bartlett Publishers, Massachusetts, USA.

Poehlmann, J.M. and sleeper, D.R. 1995. Breeding Field Crops. Panima Publishing House, New Delhi.

Russel, P.J. 1998. Genetics (5th Edition). The Benjamin/Cummings Publishing Co., Inc., USA.

Simmonds, N.W. 1979. Principles of Crop Improvement. Longman, London and New York.

Snustad, D.P. and Simmons, M.J. 2000. Principles of Genetics (2nd Edition). John Wiley & Sons, Inc., USA.

Sharma, J.R. 1994. Principles and Practice of Plant Breeding. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Suggested Laboratory Exercises

1. Determination of chromosome count from dividing pollen mother cells, root tips and pollen grains.
2. Preparation of karyotypes from dividing root tip cells and pollen grains.
3. Determination of intraspecific variation in chromosome number from locally available taxa.
4. Study of sex chromosomes and their behaviour during meiosis from grasshopper and any appropriate dioecious plant (e.g. *Coccinia*).
5. Detection of anomalies in chromosome pairing and disjunction caused by mutant genes and structural alterations of chromosomes.
6. Preparation of chromosome maps from 3-point test cross data.
7. Identification of mutant phenotypes in *Drosophila* and *Arabidopsis* stocks maintained by the Department.
8. Correlation of floral structure with pollination system (e.g. *Salvia, Sesamum,* pea, *Lathyrus*, wheat, rice, maize, *Ricinus*).
9. Field exploration for detection of male sterile plants and estimation of their pollen fertility in locally grown crop plants e.g. *Sorghum*, tomato and *Linum*.
10. Estimation of pollen ovule ratio and its bearing on pollination system.
11. Emasculation and bagging of flowers of Brassicaceae, Poaceae, Paplionaceae, Malvaceae and Linaceae, pollinating them manually and estimating fruit and seed set.

Suggested Readings (for laboratory exercises)

Fukui, K and Nakayama, S. 1996. Plant Chromosomes: Laboratory Methods. CRC Press, Boca Raton, Florida.

Sharma, A.K. and Sharma, A. 1999. Plant Chromosomes: Analysis, Manipulation and Engineering. Harwood Academic Publishers, Australia.

COURSE IX. BIOCHEMISTRY, MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Nucleic acids: Composition of nucleic acids and synthesis of nucleotides; DNA structure; A, B and Z forms of DNA; denaturation and renaturation of DNA; chromatin structure; DNA replication and recombination; DNA polymerases; different forms of RNA and their role.

Amino acid and protein metabolism: Structure, characteristics and classification of amino acids; protein and non-protein amino acids; amino acid biosynthesis; GS/GOGAT cycle; transamination; peptide bond and polypeptide chain; primary, secondary, tertiary and quaternary structure of proteins; protein biosynthesis and its regulation; post-translational modification of proteins; protein targeting; protein degradation.

Carbohydrate metabolism: Classification; structure of some representative examples of monosaccharides, disaccharides, polysaccharides; stereoisomers, enantiomers and epimers; biosynthesis and degradation of sucrose and starch.

Lipid metabolism: Saturated and unsaturated fatty acids; fatty acid biosynthesis; oxidation of fatty acids; storage and mobilization of fatty acids and lipids.

Gene structure, expression and regulation: Gene organization in prokaryotes and eukaryotes; operon concept; gene regulation in prokaryotes and eukaryotes; inducible, repressible, positive and negative gene regulation; interrupted genes in eukaryotes; RNA splicing; mRNA stability.

Recombinant DNA technology: Restriction endonucleases; prokaryotic and eukaryotic cloning vectors; genomic and cDNA libraries; Southern and northern analysis; various techniques of gene mapping and DNA fingerprinting (RFLP, RAPD, AFLP); chromosome walking; polymerase chain reaction; DNA sequencing.

Plant biotechnology: Cellular differentiation and totipotency; organogenesis and embryogenesis; protoplast isolation and culture; somatic hybridization; clonal propagation; genetic engineering of plants; vectors for gene delivery; selectable markers and reporter genes; methods of gene delivery; *Agrobacterium* – the natural genetic engineer; salient achievements in crop biotechnology (with suitable examples) and prospects.

Suggested Readings

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1999. Molecular Biology of Cell. Garland Publishing Co., Inc., New York, USA.

Bhojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.

Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.

Collins, H.A. and Edwards, S. 1998. Plant Cell Culture. Bios Scientific Publishers, Oxford, UK.

Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, D.B. (eds) 1997. Plant Metabolism (2nd Edition). Longman, Essex, England.

Lea, P.J. and Leegood, R.C. 1999. Plant Biochemistry and Molecular Biology (2nd Edition). John Wiley and Sons, Chichester, England.

Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. 2000. Molecular Cell Biology (4th Edition). W.H. Freeman and Co., New York, USA.

Old, R.W. and Primrose, S.B. 1989. Principles of Gene Manipulation. Blackwell Scientific Publications, Oxford, UK.

Raghavan, V. 1986. Embryogenesis in Angiosperms: A Developmental and Experimental Study. Cambridge University Press, New York, USA.

Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.

Suggested Laboratory Exercises

1. Chemical tests to demonstrate the presence of starch, sugar, fat and protein in plant material.
2. To identify the amino acids in a mixture by resolving through paper chromatography or TLC.
3. To prepare the standard curve for protein and determine the protein content in unknown samples by Biuret method.
4. Colorimetric estimation of RNA using orcinol.
5. Colorimetric estimation of DNA using diphenyl amine.
6. Isolation of plant genomic DNA and its spooling.
7. Isolation of total RNA from plant tissue and its colorimetric estimation.
8. Preparation of tissue culture media, sterilization and inoculation of plant material.
9. Demonstration of techniques of *in vitro* culture of various explants.
10. Isolation of plant protoplasts (e.g. tobacco, petunia) using enzymes available commercially and estimation of their yield.

Note: In the practical classes, emphasis should be given on basic principles of spectro-photometry, chromatography, electrophoresis and rDNA technology and related fundamentals.

Suggested Readings (for laboratory exercises)

Devi, P. 2000. Priciples and Methods of Plant Molecular Biology, Biochemistry and Genetics. Agrobios, Jodhpur, India.

Dixon, R.A. (Ed.) 1987. Plant Cell Culture : A practical Approach. IRL Press, Oxford.

Dryer, R.L. and Lata, G.F. 1989. Experimental Biochemistry. Oxford Univeristy Press, New York.

Glick, B.R. and Tompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.

Hackett, P.B., Fuchs, J.A. and Messing, J.W. 1988. An Introduction to Ecombinant DNA Techniques : Basic Experiments in Gene Manipulation. The Bengamin/Cummings Publishing Co., Inc., Menlo Park, California.

Hall, R.D. (Ed.) 1999. Plant Cell Culture Protocols. Humana Press Inc., New Jersey, USA.

Ninfa, A.J. and Ballou, D.P. 1998. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc., Maryland, USA.

Scott, R.P.W. 1995. Techniques and Practice of Chromatography. Marcel Dekker, Inc., New York.

Wilson, K. and Goulding, K.H. (Eds.) 1986. A Biolgoist's Guide to Principles and Techniques of Practical Biochemistry. Edward Arnold, London, UK.

COURSE X. SYSTEMATICS OF ANGIOSPERMS AND ENVIRONMENTAL BIOLOGY

ANGIOSPERM SYSTEMATICS

Introduction: Aims and components of systematics; introduction to identification, nomenclature, phylogeny and classification.

Systematics in practice: Importance of herbarium specimens and their preparation; role of herbaria and botanical gardens; documentation (floras, monographs, manuals, journals, abstracts, indices and dictionaries); keys for identification of plants – single access and multi access; value of computers and databases for identification.

Taxonomic hierarchy: Taxonomic category; taxonomic groups; concepts of species, genus and family.

Botanical nomenclature: Principles and rules; ranks and names; type method; principle of priority and its limitations; names of hybrids and cultivars; concept of biocode.

Phylogeny of angiosperms: A general account of the origin and evolution of angiosperms (special reference to Bennettitalean, Gnetalean, Caytonialean and herbaceous origin theories); primitive living angiosperms; co-evolution of angiosperms and animals.

Systems of classification: Bentham and Hooker's system, Engler and Prantl's system, and Takhtajan's system.

Modern taxonomy: Supporting evidences/inputs for taxonomy; taxonomy in relation to anatomy, embryology, palynology, ecology, cytology (cytotaxonomy), secondary metabolites in plants (chemotaxonomy).

Numerical taxonomy: Concepts, characters and attributes; OTU's; coding; cluster analysis; cladistics.

ENVIRONMENTAL BIOLOGY

Introduction: Inter-relationships between the living world and the environment; the components and dynamism; homeostasis; relevance to man.

Earth as a system: The biosphere, the hydrosphere, the atmosphere and the lithosphere; components within biosphere (biomes); parameters delimiting individual biomes.

The environment: Soil - general account and adaptations; water - general account and adaptations; the atmosphere - general account and adaptations; the living world – biotic component of environment; types of biotic interactions; fire as an ecological factor.

Organismal ecology/biotic components: Individuals, species, populations, communities and their characteristics.

Ecosystems: Concepts of ecosystem; homeostasis; structure of ecosystem; functions of ecosystem; transfer of energy and minerals via grazing and detritus chains and role of micro-organisms; cycles (hydrologic, gaseous); role of humans in maintaining biogeochemical cycles.

Diversity of ecosystem: Aquatic (fresh water); terrestrial (forest/grassland); man-made ecosystems.

Phytogeography: Introduction; endemism, static and dynamic plant geography; a short account of vegetation of India.

Human ecology and ecological management: The human population; renewable and non-renewable natural resources and their management; conservation of biodiversity; endangered species; conventional and non-conventional energy sources.

Impact of human activities: Pollution of air, water and soil; a brief account of environmental toxicology; incidence of noise; thermal and radioactive pollution; prevention and control of pollution; global warming, desertification and ozone depletion.

Role of national and international organizations in environmental management; formulation of optimal models.

Bio-indicators.

Environmental impact assessment: A brief account.

Suggested Readings

Angiosperm Systematics

Davis, P.H. and Heywood, V.H. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd, London.

Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London.

Jones, S.B., Jr. and Luchsinger, A.E. 1986. Plant Systematics (2nd edition). McGraw-Hill Book Co., New York.

Lawrence, G.H.M. 1951. Taxonomy of Vascular Plants. MacMillan, New York.

Naik, V.N. 1984. Taxonomy of Angiosperms. Tata McGraw Hill, New Delhi.

Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper and Row, New York.

Singh, G. 1999. Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi.

Jeffrey, C. 1982. An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge, London.

Stace, C.A. 1989. Plant Taxonomy and Biosystematics, 2nd ed. Edward Arnold, London.

Woodland, D.W. 1991. Contemporary Plant Systematics. Prentice Hall, New Jersey.

Nordenstam, B., El-Gazaly, G. and Kassas, M. 2000. Plant Systematics for 21st Century. Portland Press Ltd., London.

Environmental Biology

Ambasht, R.S. 1988. A Text Book of Plant Ecology. Students Friends Co., Varanasi.

Botkin, D.B. and Keller, E.A. 2000. Environmental Planet (2nd edition). John Wiley & Sons Inc., New York.

Chapman, J.L. and Reiss, M.J. 1995. Ecology: Principles and Applications. Cambridge University Press.

Cunningham, W.P. and Saigo, S.W. 1997. Environmental Science: A Global Concern. WCB, McGraw Hill.

Dash, M.C. 1993. Fundamentals of Ecology. Tata McGraw Hill Publishing Co. Ltd., New Delhi.

Daubenmire, R.F. 1974. Plants and Environment – A Text Book of Plant Ecology (3rd edition). John Wiley & Sons, New York.

Kendeigh, S.C. 1980. Ecology with Special Reference to Animals and Man. Prentice Hall of India Pvt. Ltd., New Delhi.

Kumar, H.D. 1996. Modern Concepts of Ecology (4th edition). Vikas Publishing House Pvt. Ltd., Delhi.

Kumar, H.D. 1997. General Ecology. Vikas Publishing House Pvt. Ltd., Delhi.

Kormondy, E.J. 1996. Concepts of Ecology. Prentice Hall of India Pvt. Ltd., New Delhi.

Miller, W.R. and Donahue, R.L. 1992. Soils – An Introduction to Soil and Plant Growth (6th edition). Prentice Hall of India Pvt. Ltd., New Delhi.

Odum, E.P. 1996. Fundamentals of Ecology. Natraj Publishers, Dehradun.

Pickering, K.T. and Owen, L.A. 1997. An Introduction to Global Environmental Issues (2nd edition). Butter and Tanner Ltd., Great Britain.

Smith, L.R. 1996. Ecology and Field Biology (5th edition). Harper Collins College Publishers, USA.

Smith, L.R. and Smith, T.M. 1998. Elements of Ecology (4th edition). An Imprint of Addison Wesley, Longman Ink., California.

Tyler, M.G., Jr. 1997. Environmental Science: Working with Earth (6th edition). Wadsworth Publishing Co.

Weaver, J.E. and Clements, S.E. 1966. Plant Ecology. Tata McGraw Publishing Co. Ltd., Bombay.

Suggested Laboratory Exercises

Systematics of Angiosperms

1. Description of the locally available species of the following families & genera:
2. Ranunculaceae : *Ranunculus, Delphinium*
3. Brassicaceae : *Brassica, Alyssum, Iberis, Coronopus*
4. Capparidaceae : *Capparis, Cleome*
5. Caryophyllaceae : *Dianthus, Stellaria, Spergula*
6. Rutaceae : *Citrus, Murraya*
7. Tiliaceae : *Corchorus, Grewia*
8. Fabaceae : Faboideae : *Lathyrus, Clitoria, Melilotus, Cajanus;* Caesalpinioideae : *Cassia, Caesalpinia;* Mimosoideae *: Prosopis, Mimosa, Acacia*
9. Myrtaceae : *Callistemon, Eucalyptus*
10. Cucurbitaceae : *Luffa, Coccinia*
11. Apiaceae : *Coriandrum, Anethum*
12. Rubiaceae : *Hamelia, Mussaenda*
13. Asteraceae : *Tridax, Helianthus, Calendula, Ageratum, Vernonia, Sonchus, Launaea*
14. Apocyanaceae : *Vinca, Thevetia, Nerium, Tabernaemontana*
15. Asclepiadaceae : *Calotropis, Asclepias*
16. Solanaceae : *Solanum, Withania*
17. Acanthaceae : *Adhatoda, Peristrophe*
18. Lamiaceae : *Ocimum, Salvia*
19. Chenopodiaceae : *Chenopodium, Beta*
20. Euphorbiaceae : *Euphorbia, Phyllanthus, Jatropha*
21. Moraceae : *Morus, Ficus*

22. Cannaceae : *Canna*
23. Liliaceae : *Asphodelus, Asparagus*
24. Commelinaceae : *Tradescantia, Commelina*
25. Poaceae : *Avena, Triticum, Hordeum, Poa*

Environmental Biology

1. Mechanical analysis of soils by sieve method
2. Determination of soil porosity and density (sand and pit method)
3. Determination of water holding capacity and field capacity of soil.
4. Determination of permeability (capillarity and percolation) of different types of soils.
5. Titrimetric estimation of total carbonates of soil samples.
6. Quantitative determination of soil organic matter by Walklay and Black's rapid titration method.
7. Determination of species area curve by minimal quadrat size.
8. Analysis of the herbaceous vegetation for frequency, density and abundance.
9. Study the height specrum of herbaceous vegetation by line transect method.
10. Effect of tree canopy on the distribution of herbaceous vegetation.
11. Estimation of biomass of aerial parts of herbaceous plants (fresh weight and dry weight).
12. Analysis of different water samples for pH, oxygen, carbon-dioxide (titrimetric estimation), turbidity and temperature.
13. Demonstration of desert and aquatic ecosystems with the help of models.
14. Field visit: students should be taken for field visits to places of ecological/environmental interest. They should submit detailed report of the visit in the form of project report in the final practical examination for evaluation. The report shall carry marks.

Suggested Readings (for Environmental Biology laboratory exercises)

Ambasht, R.S. 1990. Environment and Pollution. Students Friends and Co. Varanasi, Idnia.

Kapur, P. and Govil, S.R. 2000. Experimental Plant Ecology. S.K. Jain for CBS Publishers and Distributors, New Delhi.

Misra, R. 1968. Ecology Work Book. Oxford and IBH. New Delhi.

Moore, P.W. and Chapman, S.B. 1986. Methods in Plant Ecology. Blackwell Scientific Publication.

Piper, C.S. 1950. Soil and Plant Analysis. University of Adelaide, Australia.

Smith, R.L. 1966. Ecology and Field Biology. Harper Collins, New York.

Smith, R.L. 1990. (4th edition). Ecology and Field Biology. Harper Collins, New York.

Note to teachers:

The students are to be familiarized with the families listed above in the practical classes with representative species or any other that may be available locally. However, questions pertaining to these may be asked in the theory examinations.

The teachers should prevent the students from collecting plants and submitting them for the practical examinations. Instead, the students should be asked to prepare field reports.