M.Sc.

in

Botany

COURSE STRUCTURE

महात्मा गाँधी केन्द्रीय विश्वविद्यालय
Mahatma Gandhi Central University
A Central University established by an Act of Parliament

Department of Botany

School of Life Sciences

SUMMARY SHEET

Teaching Department	:	Botany
School	:	School of Life Sciences
Name of Course	:	M.Sc. in Botany
Duration	:	Two Years
Total number of Credits	:	84

MAHATMA GANDHI CENTRAL UNIVERSITY

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Chanakya Parisar, Zila School Campus, Motihari, District: East Champaran, Bihar – 845401

Department of Botany

M.Sc. in Botany

Semester I

S. No.	SUBJECT CODE	Title of Paper	HOURS				CREDITS
			L	**T**	**P**	**TOTAL**	
1	BOTY4101	Cell and Molecular Biology	4	0	0	4	4
2	BOTY4102	Cytology and Genetics	4	0	0	4	4
3	BOTY4103	Microbiology and Mycology	4	0	0	4	4
4	BOTY4104	Lower Plants and Gymnosperms	4	0	0	4	4
5	BOTY4105	Lab I	0	0	4	4	2
6	BOTY4106	Lab II	0	0	4	4	2
TOTAL			**16**	**0**	**8**	**24**	**20**

Semester II

S. No.	SUBJECT CODE	Title of Paper	HOURS				CREDITS
			L	**T**	**P**	**TOTAL**	
1	BOTY4201	Developmental and Reproductive Biology	4	0	0	4	4
2	BOTY4202	Systematics and Evolution	4	0	0	4	4
3	BOTY4203	Plant Physiology and Biochemistry	4	0	0	4	4
4	BOTY4204	Techniques in Plants Sciences, Biostatistics and bioinformatics	4	0	0	4	4
5	BOTY4205	Lab III	0	0	4	4	2
6	BOTY4206	Lab IV	0	0	4	4	2
7	BOTY4207	Seminar I	0	0	2	2	1
TOTAL			**16**	**0**	**10**	**26**	**21**

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Department of Botany

Semester III

S. No.	SUBJECT CODE	Title of Paper	HOURS				CREDITS
			L	T	P	TOTAL	
1	BOTY4301	Genetic engineering	4	0	0	4	4
2	BOTY4302	Environment and Ecology	4	0	0	4	4
3	BOTY4303	Economic Botany	4	0	0	4	4
4	BOTY400-	Discipline Specific Elective Courses-I	4	0	0	4	4
5	BOTY4305	Lab V	0	0	4	4	2
	BOTY4306	Lab VI	0	0	4	4	2
	BOTY4307	Seminar II	0	0	2	2	1
TOTAL			**16**	**0**	**10**	**26**	**21**

Semester IV

S. No.	SUBJECT CODE	Title of Paper	HOURS				CREDITS
			L	T	P	TOTAL	
1	BOTY4401	Plant biotechnology	4	0	0	4	4
2	BOTY4001-	Discipline Specific Elective Courses -II	4	0	0	4	4
4	BOTY4405	Lab VII	0	0	6	6	2
5	BOTY4406	Dissertation	0	0	24	24	12
TOTAL			**8**	**0**	**30**	**38**	**22**

Total credits: 84

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Discipline Specific Elective

S. No.	SUBJECT CODE	Title of Paper	HOURS				CREDITS
			L	T	P	TOTAL	
1	BOTY4001	Industrial Microbiology	4	0	0	4	4
2	BOTY4002	Plant Virology	4	0	0	4	4
3	BOTY4003	Advances in Plant Breeding	4	0	0	4	4
4	BOTY4004	Stress Biology of plants	4	0	0	4	4
5	BOTY4005	Nanomaterials in Plant Sciences	4	0	0	4	4
6	BOTY4006	Applied phycology	4	0	0	4	4
7	BOTY4007	Medicinal and Aromatic Plants	4	0	0	4	4
8	BOTY4008	Herbal Drug Technology and Development	4	0	0	4	4

Lab Courses

S. No.	SUBJECT CODE	Title of Paper	HOURS				CREDITS
	Lab						
			Lab based on paper	**L**	**P**	**TOTAL**	
1	BOTY4105	Lab I	BOTY 4101 and 4102	0	4	4	2
2	BOTY4106	Lab II	BOTY 4103 and 4104	0	4	4	2
3	BOTY4205	Lab III	BOTY4201 and 4202	0	4	4	2
4	BOTY4206	Lab IV	BOTY4203 and 4204	0	4	4	2
5	BOTY4305	Lab V	BOTY 4301 and 4302	0	4	4	2
6	BOTY4306	Lab VI	BOTY4303 and 4304	0	4	4	2
7	BOTY 4405	Lab VII	BOTY 4401 and DSE	0	4	4	2

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Department of Botany

EVALUATION SCHEME

THEORY

Components	Continuous Assessment (40)				End Semester Examination
	Attendance	Test 1	Test 2	Mid semester	
Marks	5	7.5	7.5	20	60

PRACTICALS

Components	Continuous Assessment (40)				End Semester Examination
	Attendance	Test 1	Test 2	Mid semester	
Marks	5	7.5	7.5	20	60

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Department of Botany

Semester I

Course Title: Cell and Molecular Biology

Course Code: BOTY 4101
Course Type: Core
Credit: 4
L-T-P: 4-0-0

Contact Hours : 40

Unit 1

Cell components and their functions

The cell: Structure of prokaryotic and eukaryotic cells.

Cell wall and plasma membrane: Structure, composition and function of plant cell wall. Origin, evolution and composition of biological membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis

Unit II

Cytoskeleton: Role and structure of microtubules and microfilaments. Endomembrane system and peroxisomes; Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing and export; Smooth ER and its role, ER stress. Golgi Apparatus organization, protein glycosylation, protein sorting and export from Golgi Apparatus; the vesicular transport: secretory and endocytic mechanism, Lysosomes structure and function; Peroxisome: The role of peroxisome in plant metabolism, its genesis, and its types.

Ribosome - Ribosomes, structure, functional domain and subunit assembly,

Chloroplast and mitochondria: Structure, function and genome organization; Function; Semiautonomous nature of mitochondria and chloroplast, targeting and sorting of protein.

Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus, trafficking between nucleus and cytoplasm.

Unit III

Cell division

Eukaryotic cell cycle, mitosis: karyokinesis and cytokinesis, meiosis: various stages of meiosis, significance of crossing over, significance of irregular meiosis; Regulation of cell cycle- check points, role of protein kinases.

Gene and genome: Fine structure of gene, genome organization in prokaryotes and eukaryotes, transfer of genes between nucleus and organelles. DNA and RNA as genetic material, Mechanism and regulation of DNA Replication in prokaryote and eukaryote, Recombination mechanism and types, and Transposition: prokaryotic and eukaryotic transposon, retrotransposon.

Unit IV

Transcription: Transcription unit, cistrons, promoter architecture, regulatory sequences, enhancers and repressor: their mechanism of action, transcription mechanism- RNA polymerases, transcription factors, Post Transcription gene regulation: Introns, RNA splicing, alternative splicing, RNA stability - cap structure and function, polyadenylation, PTGS, Transcription mechanism of rRNA and tRNA, RNA degradation. Gene regulation in bacteria:

operon system, Positive regulation, negative regulation: lac operon, tryptophan operon, Histidine operon, Ara operon

Unit V

Translation: mechanism of translation in eukaryotes and prokaryotes,

Genetic code: Deciphering of the codons, reading frame of a sequence, degeneracy of the genetic code, Wobble hypothesis, variations to the standard genetic code. translational and post translational regulation: posttranslational modifications (Proteolytic cleavage, covalent modifications, glycosylation of proteins, disulfide bond formation). Inhibitors of protein biosynthesis, Co- and post-translational protein traslocation; chaperones and protein folding, Protein degradation

Suggested Readings

1. Alberts B, Johnson A, Lewis J, Raff Martin, Roberts K and Walter P. (2007) Molecular Biology of the Cell. Garland Publ., New York.
2. Bonifacino JS, Dasso M, Harford JB, Liipincott-Schwartz J and Yamada KM. (2004) Short Protocols in Cell Biology. John Wiley & Sons, New Jersey.
3. Bregman AA (1987) Laboratory Investigations in Cell Biology. John Wiley & Sons, New York.
4. Hawes C and Satiat-Jeunemaitre B (2001) Plant Cell Biology: Practical Approach. Oxford University Press, Oxford.
5. Hirt RP and Horner DS (2004) Organelles, Genomes and Eukaryote Phylogeny: An evolutionary synthesis in the age of genomics. CRC Press.
6. Lodisch H, Berk A, Kaiser CA, Krieger M, Scott MP, Bretscher A, Ploegh H and Matsudaire P (2008) Molecular Cell Biology. WH Freeman & Co., New York.
7. Ruzin SE (1999) Plant Microtechnique and Microscopy. Oxford Univ. Press, Oxford.
8. Wischnitzer S. (1989) Introduction to Electron Microscopy. Pergamon Press, New York.
9. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
10. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
11. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
12. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.
13. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
14. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
15. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
16. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco
17. Weaver, R, F , (2008) Molecular biology 5th edition McGraw-Hill publication.

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Department of Botany

Semester I

Course Title: Cytology, Genetics and Genomics

Course Code: BOTY 4102
Course Type: Core
Credit: Theory-4
L-T-P: 4-0-0

Contact Hours : 40

Unit I

Mendelian and Non-Mendelian Inheritance: Mendelian laws of inheritance/law of segregation and law of inheritance; Gene interactions (Complementary, supplementary, inhibitory, epistatic, additive, duplicate, polygenic interaction and pleiotropic), linkage, cytoplasmic inheritance; Concepts in Population genetics.

Unit II

Prokaryotic and Eukaryotic Genetics: Recombination in viruses and bacteria (transformation, conjugation and transduction); fungal genetics – mating types and genetic exchange, heterokaryosis, parasexual cycle.

Gene Mapping: Basic concepts, gene maps, correlation of genetic and physical maps, molecular markers and construction of linkage maps; Molecular mechanism of recombination; QTL mapping, Gene mapping in prokaryotes.

Mutation: Basic concept, spontaneous and induced mutations, allele theory, physical and chemical mutagens.

Unit III

Chromatin Organization, assembly and replication: Nucleosome and higher order organization of chromatin, conformational changes in chromatin and genetic activity, assembly/deassembly of nucleosomes during chromatin replication, centromere and telomere; Chromosome banding patterns: Linear differentiation of chromosome segments, types of chromosome banding, uses of chromosome banding in cytogenetics, Chromosome engineering: transfer of gene through individual chromosome, alien addition and substitution lines; characterization and utility

Sex determination in plants-mechanisms, sex chromosomes;

Chromosomal aberrations: Duplications, deficiencies/deletions, inversions,

Interchanges/translocations; Role of chromosomal aberrations in crop evolution

Ploidy changes: Haploids, polyploids and aneuploids; Genome analysis in crop plants;

Unit IV

Epigenetics: Basic concepts and scope, chromatin remodeling histone modifications, methylation, epialleles; their inheritance and role in regulation. Techniques for studying epigenetic mechanisms (immunoprecipitation- ChiP, Chip-Seq)

Unit V

Genomics: Concepts Genome and Genomics, genomes sequencing, genomic databases; Physical Mapping of DNA, Restriction site mapping, hybridization mapping. Genome size and C-value paradox, repetitive DNA, split genes, overlapping genes, reverse genetics, genome editing tools (ZFNs, TALENs, CRISPR/Cas9)

Suggested Readings:

1. A. K. Sharma and A. Sharma. 1990. Chromosome techniques. Butterworths.1990 Ed
2. Ram J Singh (2016), Plant Cytogenetics, third edition, C R C press.
3. Ram J Singh (2017), Practical manuals of plant cytogenetics, C R C Press.
4. Brown, T.A. (1999). Genomes. BIOS Scientific Publishers limited, UK.
5. Gardener, E.J., Simsons, M.J., and Sinustad, D.P. (1991). Principles of Genetics. John Wiley Sons Inc., New York.
6. Griffiths, A.J.F., Miller, J.H., Suzuki, D.T., Lewontin, R.C., and Gelbart, W.M. (1993). An Introduction to Genetic Analysis. Freeman and Comapany, USA.
7. Hawley R.S. and Walker, M. Y. (2003) Advanced Genetics analysis-Finding meaning inGenome. Blackwell Publishing, USA.
8. Klug W. S. and Cummings, M. R. (1997). Concepts of Genetics. Printice Hall International,Inc.
9. J E Krebs, E S Goldstein, S T Kilpatrick Lewin's gene (2017). Gene XII. Oxford University Press, New York.
10. Schulz-Schaeffer, J. (1980). Cytogenetics of Plants, Animals and Human. SpingerVerlag,New York.
11. Strickberger, M.W. (2001). Genetics. Prentice-Hall, Inc., Englewood Cliffs, N. Jersey.
12. Smith, J. M. (1998). Evolutionary Genetics. Oxford University Press, New York.
13. Snustab, D. P., Simmons, M. J. and Jenkins, J. B. (1997). Principles of Genetics, John Wileyand Sons, Inc., New York.
14. Hartl, D. L. and Ruvolo, M. (2012). Genetics, Analysis of Genes and Genomes. 8th Edition.Jones and Bartlet, Ontario.

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Semester I

Course Title: Microbiology and Mycology

Course Code: BOTY 4103
Course Type: Core
Credit: 4
L-T-P: 4-0-0

Contact Hours : 40

Unit I
Viruses: Origin and evolution of microorganisms; Viruses: morphology, architecture, classification, transmission and genetics of viruses, Economic importance of viruses; General account of Prion and Viroid

Unit II
Prokaryotes: Ultrastructure, reproduction and economic importance of Mycoplasma, Phytoplasma, Cynobacteria, Archaeaobacteria, Eubacteria and Actinomycetes.

Unit III
Fungi: Classification and Phylogeny of fungi. Economic importance of Fungi. Life cycle of representative of each division of Fungi: *phytopthora*, *Rhizopus, Penicillium, Puccinia*, and *Fusarium.*

Unit IV
Mycorrhiza: Ectomycorrhiza, Endomycorrhiza and their significance
Plant growth promoting bacteria: Phosphate solubilizing bacteria (PSB); Plant growth-promoting rhizobacteria (PGPR); Consortium of Agriculturally important microbes; Bioremediation; Bacteria as bio-control agent

Unit V
Plant Disease: Pathogenesis, Role of enzymes and toxins in plant disease; Plant defence against pathogens; List of major plant diseases caused by virus, phytoplasma, bacteria and fungi; Diagnosis of plant diseases, Management of plant diseases

Suggested Readings

1. Bergey's Manual of Systematic Bacteriology. Second Edition. Springer.
2. Boyd, R. F. 1984. General Microbiology. Times Mirror Publishers, New Delhi.
3. Pelczar, M. J., Chau, E. C. G. and Krieg, N. R. 1993.Microbiology concepts and application.McGraw Hill, New Delhi.
4. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International
5. Alexopoulus, C.J., Mims. C.W. and Blackwel, M. 1996. Introductory Mycology, John Wiley & Sons Ind.

6. Dube, H. S. 2013. An introduction of Fungi. Scientific Publishers. India.
7. Mehrotra, R.S. and Aneja, R.S. 1998. An Introduction to Mycology, New Age Intermediate Press.

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Semester I

Course Title: Lower Plants and Gymnosperms

Course Code: BOTY 4104
Course Type: Core
Credit: 4
L-T-P: 4-0-0

Contact Hours : 40

Unit I
Phycology: Algae in diversified habitats; thallus organization; reproduction; and classification of algae. Salient features of Protochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta

Unit II
Algal blooms, algal biofertilizers; algae as food, source of phycocolloids, feed and uses in industry; Lichen – Thallus structure, reproduction and economic importance.

Unit III
Bryophytes: Features of Bryophytes, Classification and Alternation of generation in Bryophytes; A general account and phylogeny of Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Funariales and Polytrichales; Economical importance of Bryophytes.

Unit IV
Pteridophytes: Salient features of Psilopsida, Lycopsida, Sphenopsida and Pteropsida; Structure and Evolution of Stelar System in Pteridophytes; Evolution of Sporophytes, Alternation of generation, Natural and Induced implications of Apogamy and Apospory, Heterospory and Seed Habit; Economic importance of Pteridophytes.

Unit V
Gymnosperms: salient features, Classification; A general account of structure, reproduction and evolutionary relationships of Progymnosperms, Cycadofilicales, Cycadeoidales, Glossopteridales, Pentoxylales, Cycadales, Cordaitales, Coniferales, Ginkgoales, Taxales, Ephedrales, Welwitchiales, Gnetales. Economic Importance of Gymnosperms

Suggested Readings

1. Kumar, H. D. 1988. Introductory Phycology. East-West Press Ltd., New Delhi.
2. Round, F. E. 1986. The Biology of Algae. Cambridge University Press, Cambridge.
3. Morris, I. 1986. An Introduction to the Algae. Cambridge University Press, U.K.
4. Morris, I.1986. An Introduction to the Algae. Cambridge University Press, U.K.
5. Parihar, N.S. 1991. Bryophyta. Central Book Depot, Allahabad.
6. Chopra, R.N. and P. K. Kumra. Biology of Bryophytes. Wiley Eastern Ltd., New Delhi, 1988.
7. Dyer, A. F. and J. G. Duckett.(Eds.). The Experimental Biology of Bryophytes.

Academic press, London, 1984.
8. Goffinet, B. and A.J. Shaw. Bryophyte Biology. 2 nd Ed. Cambridge Univ. Press, Cambridge, 2009.
9. Parihar, N.S. 1996. Biology and Morphology of Pteridophytes, Central Book Depot, Allahabad.
10. Puri, P. 1980, Bryophytes. Atma Ram & Sons, Delhi.
11. Round, F.E. 1986. The Biology of Algae. Cambridge University Press, Cambridge.
12. Bhatnagar, S.P. and Moitra, A. 1996. Gymnosperm New Age International pvt. Ltd., NewDelhi.
13. Sunderrajan, S.2007. Introduction to pteridophyta, New Age International Publishers, New Delhi.

Semester I

Course Title: Practical I

Course Code: BOTY 4104
Course Type: Core
Credit: 2
L-T-P: 0-0-2

List of Experiments

Cytology, Genetics and Genomics

1. Preparation of mitotic and meiotic spreads and analysis of various stages of cell division (Phlox, Allium and Rhoeo).
2. Extraction of genomic DNA from plants by CTAB method.
3. Molecular markers: SSR, CAPS, RAPD.
4. Analysis of molecular polymorphism in parental lines and derived mapping population using different types of molecular markers.
5. Construction of a linkage map using available data.
6. Mutagenesis experiments in E. coli.
7. QTL mapping (Theoretical using available data)
8. Meiosis and mitotic studies of given plant materials.
9. Chromosomal analysis of given plant materials.
10. To test the goodness of fit of Data by chi square test.
11. Karyotypic analysis and ideogram
12. Experiments in Neurospora genetics. Basis of specific ascospores arrangement inside ascus of Neurospora.

Cell and Molecular Biology

1. To exemplify the use of phase contrast and fluorescence microscopy in plant biology by studying phase objects and autofluorescent specimens or those stained with fluorochromes, such as, carbo fluorescein diacetate, aniline blue, calcofluor white, Evans blue and neutral red.
2. Isolation of DNA and RNA.
3. Visualization of DNA and RNA by electrophoresis.
4. Isolation and separation of proteins.
5. PCR amplification of selected genes
6. Quantification of DNA, RNA and protein by spectrophotometer.
7. Isolation and purification of nuclei and their staining with Feulgen stain or DAPI.

8. Isolation of mitochondria and their visualization with Janus green B and mitotracker.
9. Isolation of chloroplasts and determination of number of chlorophyll molecules per chloroplast.
10. In silico analysis (sequence comparison) of mitochondrial and chloroplast genes for identification of the loci for interspecific discrimination.
11. Multiple sequence alignment and ontology based database searches on selected plant cytoskeletal genes to deciphering the molecular phylogeny of cytoskeleton genes.
12. Measurement of cell size by the technique of micrometry.
13. Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollen grains).

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Semester I

Course Title: Practical II

Course Code: BOTY 4106
Course Type: Core
Credit: Practical II
L-T-P: 0-0-2

Microbiology and Mycology

1. Morphological and reproductive study of different groups of fungi through preparation of whole mounts and sections
2. Demonstration of phosphate solubilization by bacterial isolates using PVK medium
3. Study of types of root nodules/morphology/anatomical preparation showing infection zone
4. Isolation of fungal and bacterial pathogens from leaves.
5. Isolation of fungal and bacterial pathogen from stems fruits and other aerial plant parts.
6. Microscopic preparation and study of pathogenic microbes.
7. Detection of plant viruses from infected leaf tissue using ELISA and Western Blot.
8. Screening for antagonism.

Lower plants and Gymnosperms

1. Morphological and reproductive study of different groups of algae through preparation of whole mounts and sections
2. Morphological and reproductive study of different groups of bryophytes through preparation of whole mounts and sections
3. Morphological and reproductive study of different groups of pteridophytes through preparation of whole mounts and sections
4. Morphological and reproductive study of different groups of gymnosperms through preparation of whole mounts and sections

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Semester II

Course Title: Developmental and Reproductive Biology

Course Code: BOTY 4201
Course Type: Core
Credit: 4
L-T-P: 4-0-0

Contact Hours : 40

Unit I
Plant development: Shoot apical meristem (SAM) and development of shoot; Cell to cell communication; Regulation of tissue differentiation with special reference to xylem and phloem, secretory ducts and laticifers; Wood development in relation to environmental factors

Unit II
Differentiation and development of plant organs; Pattern formation in plants; Differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll; Programmed cell death, aging and senescence; Root apical meristem (RAM) and development of root(s), lateral roots and root hairs; Hormonal control of root development

Unit III
Reproduction: Vegetative and sexual reproduction; flower development; genetics of floral organ differentiation; homeotic mutants in Arabidopsis, Antirrhinum and Petunia
Male gametophyte: microsporogenesis, pollen development and gene expression; pollen germination, pollen tube growth and guidance; pollen storage; pollen allergy; pollen embryos

Unit IV
Female gametophyte: Ovule development; megasporogenesis; organization and structure of the embryo sac. Pollination, pollen-pistil interaction, self incompatibility in plants, Double fertilization and in vitro fertilization in plants, Polarity during embryogenesis, Somatic embryogenesis

Unit V
Endosperm development: Early, maturation and desiccation stages; Embryogenesis; Storage proteins of endosperm and embryo; polyembryony; apomixes; Seed development, Fruit development and maturation: biochemistry and molecular biology aspects; Seed dormancy: Importance and types

Suggested Readings

1. Bewley, J. D. and Black, M. 1994. Seeds: Physiology of Development and Germination, Plenum Press, New York.
2. Bhojwani, S. S. and Bhatnagar, S. P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition), Vikas Publishing House, New Delhi.
3. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
4. Fahn, A. 1982. Plant Anatomy (3rd edition), Pergamon Press, Oxford.

5. Fosket, D. E. 1994. Plant Growth and Development. A Molecular Approach. Academic Press, San Diego.
6. Howell, S. H. 1998. Molecular Genetics of Plant Development. Cambridge University Press, Cambridge.
7. P. Maheshwari, An introduction to embryology of angiosperms

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Semester II

Course Title: Systematics and Evolution

Course Code: BOTY 4202
Course Type: Core
Credit: 4
L-T-P: 4-0-0

Contact Hours : 40

Unit I

History of developments in taxonomy: Linnaean to post-Linnaean era; Outline of classification of Angiosperms; Hutchinson, Takhtajan, Cronquist, merits and demerits; Systematics-concepts and components; International code of Botanical Nomenclature; Principles: rules and recommendations; priority; typification; Rules of effective and valid publications; retention and choice of names.

Unit II

Taxonomic features, systematic phylogeny and economic importance of families: Rananculaceae, Magnoliaceae, Capparidaceae, Combretaceae, Rosaceae, Asteraceae, Apocynaceae, Asclepiadaceae, Convolvulaceae, Scrophulariaceae, Acanthaceae, cucurbitaceae, Bignoniaceae, Lamiaceae, Verbenaceae, Polygonaceae, Euphorbiaceae, Orchidacae, Zingiberaceae, Araceae, Cyperaceae and Poaceae.

Unit III

Numerical taxonomy: Aims and objectives, characters and attributes, OTUs, coding, cluster analysis, merits and demerits; Chemotaxonomy: Role of phytochemicals in taxonomy; Embryology in relation to taxonomy; Molecular approaches to plant taxonomy: Application of DNA markers in angiosperm taxonomy; molecular phylogeny.

Unit IV

Evolutionary ecology-concepts and principles; Microevolution - theory and concepts; Species and speciation; Phylogenetic systematics; Macroevolution - inferring phylogenies; Diversity and classification of flowering plants.

Unit V

Biological diversity-concepts and applications; Diversity: patterns, indices and applications, hot spots; herbarium.

Suggested Readings

1. Grant, W. F. 1984. Plant Biosystematics. Academic Press, London.
2. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F. and Donoghue, M. J. 2007.
3. Plant Systematics: A Phylogenetic Approach, 3rd ed. Sinauer. Nordenstam, B., El Gazaly, G. and Kassas, M. 2000. Plant Systematics for 21st Century. Portlant Press Ltd., London.
4. Radford, A. E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
5. Simpson, M. G. 2006. Plant Systematics. Elseiver & Academic Press.

6. Singh, G. 2005. Plant Systematics. Oxford & IBH, New Delhi.
7. Takhtajan, A. L. 1997. Diversity and Classification of Flowering Plants.Columbia University Press, New York.Woodland, D. W. 1991. Contemporary Plant Systematics. Prentice Hall, New Jersey.

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Department of Botany

Semester II

Course Title: Physiology and Biochemistry

Course Code: BOTY 4203
Course Type: Core
Credit: 4
L-T-P: 4-0-0

Contact hours: 40

Unit I

Dissociation of Water and biological Buffers; Principles of thermodynamics in biology, concepts of Bioenergetics.

Transport of Water and Solute

Soil water- plant atmosphere continuum; Water absorption by roots, water transport through the xylem, Transpiration and guttation.

Mineral nutrition; essential nutrients deficiency and plant disorder, soils roots and microbes; Solute transport molecular motors and pumps.

Unit II

Biomolecules: Structure and function of amino acid, Protein, lipid, carbohydrate, nucleotide and nucleic acid and vitamins

Enzymes: origin and evolution of biocatalytic reactions; mechanism of action of enzyme, enzyme kinetics, enzyme inhibition, regulation of enzymatic activity significance of ribozymes; abzymes; artificial enzymes; enzyme technology

Unit III

Photosynthesis: light reaction, carbon assimilation (C_2, C_3, C_4 and CAM metabolism), phloem translocation, evolution of electron transport chain; ATP synthesis.

Respiration: Aerobic and anaerobic, carbohydrate metabolism and lipid metabolism,

Unit IV

Signal Transduction

Second messengers, receptors and G-proteins, phospholipid signaling, role of cyclic nucleotides, calcium-calmodulin cascade, diversity in protein kinases and phosphatases, specific signaling mechanisms and their regulation.

Sensory Photobiology:

Phytochromes: Structure, function and mechanisms of action.

cryptochromes and phototropins: stomatal movement; scotomorphogenesis and photomorphogenesis

Unit V

Growth and Development

Plant growth regulators (PGR): Concept of PGR as chemical messengers, techniques for detection and quantitation of PGR, classical approaches and use of mutants in understanding PGR actions, hormones in defense against abiotic and biotic stresses, synthetic regulatory compounds and their uses.

Developmental Biology of Plants: vegetative and flower development. Plant growth, development and senescence. Physiological aspect of biotic interaction and abiotic stress Tropic Movement in Plants: growth in response to directional stimuli;

Suggested Readings

1. Ainsworth C (2006) Flowering and its Manipulation, Annual Plant Reviews, Vol. 20. Blackwell Publishing, Oxford, U.K.
2. Buchanan B, Gruissem G and Jones R. (2000) Biochemistry and Molecular Biology ofPlants, American Society of Plant Physiologists, USA.
3. Davies P J. (2004) Plant Hormones: Biosynthesis, Signal Transduction, Action. 3rd Edition,Kluwer Academic Publisher, Dordrecht, The Netherlands.
4. Jordan BR. (2006) The Molecular Biology and Biotechnology of Flowering, 2nd Edition,CAB International, Oxfordshire, U.K.
5. Lodish H, Berk A, Kaiser CA and Krieger M. (2008) Molecular Cell Biology, 6th Edition,W.H. Freeman and Company, New York, USA.
6. Nelson DL and Cox MM. (2004) Lehninger Principles of Biochemistry, 4th Edition, W.H.Freeman and Company, New York, USA.
7. Taiz L and Zeiger E. (2017) Plant Physiology, 4th Edition, Sinauer Associates Inc.Publishers, Massachusetts, USA.
8. Slisburry and Ross, Plant Physiology, 3rd edition, CBS publisher and distributers.
9. Hopkins, W.G, Introduction to plant physiology, 4th edition,

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Department of Botany

Semester II

Course Title: Techniques in Plant Science, Biostatistics and Bioinformatics

Course Code: BOTY 4204
Course Type: Core
Credit: Theory-4
L-T-P: 4-0-0

Contact hours: 40

Unit I
Microscopic techniques: light microscopy, resolving powers of different microscopes, microscopy for living cells, scanning and transmission electron microscopes, confocal microscopy.

Unit II
Fractionation Methods: Centrifugation, Electrophoresis: Paper and Gel Electrophoresis
Chromatography: Paper chromatography; Column chromatography, Spectrophotometry: UV/visibles, Atomic Absorption Spectroscopy, fluorescence spectroscopy.

Unit III
Radiolabeling techniques: Detection and measurement of different types of radioisotopes used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.
Histochemical and Immunotechniques: Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, fluocytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

Unit IV
Statisitcal Methods: Central tendency, dispersion, standard error, coefficient of variation; Probability distributions (normal, binomial of Poission) and Confidence limits. Test of statistical significance (t-test, Chi-square): Analysis of variance- Random Block Design and its application in plant breeding and genetics; Correlation and Regression.

Unit V
Introduction to Bioinformatics: Databases: NCBI, EMBL, Genbank. Sequence alignment, phylogenetic prediction, Gene prediction, Protein classification and structure prediction, Genome analysis. Bioinformatics tools and softwares: BLAST, ORF finder, Primer 3.

Suggested Readings

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

2. Gustafson, J. P. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA
3. Brown, T. A. 1999. Genomes. John Wiley & Sons (Asia) Pvt. Ltd., Singapore.
4. Primrose, S. B. 1995. Principles of Genome Analysis. Blackwell Science Ltd., Oxford, UK
5. Singer, M. and Berg, P. 1991. Genes and Genomes: A Changing Perspective. University Science Books, CA, USA
6. Attwood, T.K. and Parry-Smith, D.J. 2004. Introduction to Bioinformatics. Pearson Education (Singapore) Pvt. Ltd
7. David, E. (Ed.) 2007. Plant Bioinformatics: Methods and Protocol. Humana Press, New Jersey, USA
8. Wilson, K., Walker, J. (2005) Principles and Techniques of Biochemistry and Molecular Biology, 6th Edition, Cambridge University Press
9. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. USA
10. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons
11. Mishra, B.N. and Mishra M.K. 1989.Introductory Practical Biostatistics. Naya Prokash Publication, Calcutta
12. Rao, Sundar P.S.S. and Richard, J. 2011.Introduction to Biostatistics and Research Methods.(4th Ed), PHI Learning Pvt. Ltd., New Delhi
13. Edmondson, A., Druce, D. (1996) Advanced Biology Statistics, Oxford University Press
14. Williams, Brain. 1993. Biostatistics- Concepts and Applications for Biologist. Chapman & Hall, London

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Semester II
Course Title: Botany Practical III

Course Code: BOTY 4205
Course Type: Core
Credit: 2
L-T-P: 0-0-2

List of Experiments

Developmental and Reproductive Biology

1. Study of living shoot apices by dissections using aquatic plants such as Ceratophyllum and Hydrilla. .
2. Study of different types of leaf arrangement.
3. Microscopic examination of vertical sections of leaves such as Cannabis, tobacco, Nerium, maize and wheat to understand the internal structure of leaf tissues and trichomes, glands, etc. Also study the C3 and C4 leaf anatomy of plants.
4. Study of epidermal peels of leaves such as Coccinia, Gaillardia, Tradescantia, Notonea, etc. to study the development and final structure of stomata and prepare stomatal index.
5. Study of L.S. and T.S. of monocots and dicots roots
6. Study of leguminous roots with different types of nodules.
7. Study of microsporogenesis and gametogenesis in sections of anthers.
8. Tests for pollen viability using stains and in vitro germination. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture.
9. Estimating percentage and average pollen tube length in vitro.
10. Study of nuclear and cellular endosperm through dissections and staining.
11. Isolation of zygotic globular, heart-shaped, torpedo stage and mature embryos from suitable seeds and polyembryony in citrus, jamun (Syzygium cumini), etc. by dissections.
12. Study of seed dormancy and methods to break dormancy

Systematics and Evolution

1. Live plants/ Herbarium specimens of the following families will be provided in the class for description and identification (classification based on APG II, 2003): Basal Angiosperm and Magnoliids: Monocots: Commelinids: Basal Eudicots and Caryophyllids:Ranunculaceae, Rosids: Asterids.
2. Phylogenetic analyses using Software.
3. Local flora study

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Semester II
Course Title: Botany Practical IV

Course Code: BOTY 4206
Course Type: Core
Credit: 2
L-T-P: 0-0-2

List of Experiment

Plant Physiology and Biochemistry

1. Assay for different enzymes in leaf tissues.
2. Comparative assessment of methods for protein quantitation.
3. Study of enzyme kinetics for determination of Km value, nature of inhibition competitive/non competitive.
4. Study of enzyme kinetics for effect of time/ enzyme concentration/ pH.
5. Extraction of proteins from plant tissue and their quantitative (Bradford's) and qualitative (SDS, PAGE gel) analysis.
6. Qualitative and quantitative analysis of photosynthetic pigments and anthocyanins by spectrophotometric and chromatographic techniques.
7. PAGE analysis of pigment-protein complexes from chloroplasts.
8. Impact of stress on stomatal opening and closing using potassium chloride.
9. Measurement of stomatal size using epoxy raisin

Techniques in Plant Science, Biostatistics and Bioinformatics

1. Verification of Beer's and Lambert's law for spectrophotometry
2. To separate sugars and lipids by thin layer chromatography
3. Isolation of chloroplasts by differential centrifugation
4. Estimation of leaf pigments by spectrophotometry.
5. Colorimetric estimation of biochemical and plant extracts.
6. Assay of enzymes using spectrophotometry.
7. To separate chloroplast pigments by column chromatography
8. To estimate protein concentration through Lowry's methods
9. To separate proteins using PAGE
10. To separation DNA (marker) using AGE
11. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
12. Demonstration of ELISA.
13. Labeling and scoring of molecular markers and phylogenetic tree preparation through NTSYS software, and analysis of genetic diversity relationship
14. Database searching and sequence retrieval of nucleic acids and proteins
15. BLAST (n and p-blast)
16. Multiple sequence alignment using ClustalW

17. Computation of Central tendency
18. Computational techniques for ANOVA
19. Computational techniques for Correlation and Regression

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Semester III

Course Title: Genetic Engineering

Course Code: BOTY4301
Course Status: Core
Credits: 4
L-T-P: 4-0-0

Contact Hours: 40

Unit I
Restriction Enzymes Type I, II, III and IV; Restriction sites, DNA Modifying enzymes- terminal deoxynucleotidyl transferase, polynucleotide kinase, Phosphatases and DNA ligases; DNA ligase; Other important enzymes of genetic engineering; Cohesive and blunt end ligation; Linkers, Adaptors; Homo-polymer tailing

Unit II
Characteristics of cloning vectors: Plasmid based vectors (pBR322, PUC19 and Bluescript vectors); Bacteriophage based vectors (M13MP1, λ GT10); Phagemids; Cosmids; Artificial chromosomes (YACs; BACs); Characteristics of host cells for cloning ; Cloning methodology, Insertion of foreign DNA into vectors, Transformation, Selection of transformants

Unit III
Nucleic acid extraction; PCR, Types of PCR – multiplex, nested, reverse transcriptase, real time PCR; Labelling of DNA: Nick translation, Random priming; Construction of libraries, cDNA and genomic libraries; Screening of gene libraries by colony hybridization and southern blotting; NA Sequencing, conventional and NGS

Unit IV
Expression vectors; His-tag, GFP and GST-tag based vectors; Plant virus based vectors, Ti plasmid based Co-integrated and binary vectors; Yeast vectors; Gene construct preparation, Expression; Methods of gene delivery, Screening and analysis of gene expression

Unit V
Mutagenesis ; Creation of Transgenic plants; Molecular pharming

Suggested Readings
1. Brown T.A, "Gene Cloning and DNA Analysis:An Introduction", John Wiley & Sons, 2010
2. Molecular Biotechnology. Principles and Applications.3rd Edition. Glick BR and Pasternak JJ. ASM Press @2003. ISBN 1-55581-224-4.

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Semester: III

Course Title: Plant Ecology & Environment

Course Code: BOTY4302
Course Type: Core
Credits: 4
L-T-P: 4-0-0

Contact Hours: 40

Unit I
Concept of ecology and environment. Physical environment, biotic and abiotic interactions. Biogeographical distributions – ecological equivalents, Phytogeography and vegetational zones, The biosphere, biomes and ecological zones, Bioindicators and biomarkers, Population concepts: Characteristics (density, natality, mortality, dispersion, population size dynamics and control, Vegetation organization and characteristics: population size, population regulation, life histories (r and k selection) Concepts of community and continuum; community, coefficients, interspecific associations, species interactions. ordination; habitat and ecological niche; niche width and overlap, fundamental and realized niche. Gauze competitive exclusion principles. species diversity (α, β, γ),

Unit II
Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies); mineral cycling (c and n) food web and food chain decomposition (mechanism, controlling factors); ecosystem nutrient Cycles.

Unit III
Ecosystem stability: Concept (resistance and resilience); ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems; ecology of plant invasion, ecological succession and types

Unit IV
Biological diversity: Concept and levels; distribution and global patterns; terrestrial biodiversity hot spots; role of biodiversity in ecosystem functions; Botanical garden, IUCN categories of threat; inventory; conservation, protected area network

Unit V
Environmental pollution and mitigation strategies. Environmental pollution: Kinds, sources, effects on plants and ecosystems, Global change: Greenhouse gases, consequences of climate change; ozone layer depletion, causes and consequences. Sustainable development, Natural resource management in changing environment, Environmental Impacts and their assessment.

Suggested Readings

1. Odum, E.P. 1978. Fundamentals of ecology.

2. Odum, E.P. 1978. Basic principles of ecology.
3. Kormandy. . E. J. 1984. Concept of Ecology. Prentice New Delhi.
4. P.D Sharma . 1996 Ecology and environment
5. Moore, P.D. and Chapman, S.B. (1986). Methods in plant ecology. Blackwell Scientific Publications.
6. J.S. Singh, S.P. Singh and S.R. Gupta. 2008. Ecology, Environment & Resource Conservation. Anamaya Publications.
7. V.H. Heywood and Watson R.T. (Ed). 1995. Global Biodiversity Assessment: UNEP. Cambridge University Press
8. A. K. De. (3rd Ed). 2008 Environmental Chemistry. New Age Publications India Ltd
9. Jonathan turk and amosturk environmental science book

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Semester III

Course Title: Economic Botany

Course Code: BOTY 4303
Course Type: Core
Credit: Theory-4
L-T-P: 4-0-0

Contact hours: 40

Unit I
Brief account of bioresources; Concept and importance of plant genetic resources and its erosion; Biodiversity related conventions; Centers of origin and diversity of crop plants; Domestication

Unit II
Cereal crops: Origin, botanical description, cultivation and uses.
General account of pulses along with their economic uses: detailed study of any two representative legumes.
General account of fruits for human consumption: detailed study of any two tropical/temperate fruits.
General account of vegetables for human consumption: detailed study of any two vegetables.

Unit III
Brief overview of the following category of crops along with study of two representative examples from each category:
Spice yielding plants.
Oil yielding crops.
Dye yielding plants.
Resin yielding plants.

Unit IV
Brief overview of the following category of crops along with study of two representative examples from each category:
Timber yielding plants.
Beverage yielding plants.
Fumigatories and masticatories.

Unit V
Importance of medicinal and aromatic plants; Different plant parts used as medicine (roots, stem, leaves and seeds); Two representative examples of each category.

Suggested Readings
1. S. L. Kocchar 1998. Economic Botany of the Tropics, 2nd Ed. Macmillan India Ltd., Delhi.
2. Sammbamurthy 2008. A Textbook of Modern Economic Botany, 1st edition, CAS publishers

& Distributors Pvt, Ltd.
3. Ashwin Dutt, 2008. Economic Botany, 1st edition, Aahyayan Publishers & Distributors.
4. Biber-lemm and T. Cottier 2006. Rights to plant genetic resources and traditional knowledge: Basic issues and Prespectives, Cabi Publication, UK.
5. B.B. Simpson and M. Conner-Ogorzaly 1986. Economic Botany-Plants and our World. McGraw Hill, New York.
6. GE Wickens 2004. Economic Botany: Principles and Practices, Springer, ISBN.
7. P. Ganguli 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.

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Semester: III

Course Title: Lab V

Course Type: Practical
Course Code: BOTY4305
Credit: 2
L-T-P: 0-0-4

List of Experiments

Genetic engineering

1. Buffer preparation
2. E. coli culture and growth curve
3. DNA extraction , purification
4. DNA estimation
5. PCR
6. Agarose gel electrophoresis.
7. Transformation of E. coli (chemical method)
10. Plasmid DNA isolation, quantification and agarose gel electrophoresis.

Environment and Ecology

1. Determination of the minimum size of quadrat by species area curve (for grazing land, forest) field study.
2. Determination of the quantitative characters of a plant community by random quadrat method (abundance, density, dominance, species diversity, frequency) in grazing land, forests.
3. Estimation of above ground and below ground biomass in a grazing land employing minimum size of quadrat.
4. Estimation of Dissolved Oxygen in different water samples by Winkler method.
5. Estimation of Carbonate, Bicarbonates, Chlorides in given samples.
6. Determination of leaf area Index (LAI)
7. Determination of chlorophyll a and b and total chlorophyll hydrophytes and xerophytes in
8. Determination of morphology of hydrophytes and xerophytes in different plants.

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Semester: III

Course Title: Lab VI

Course Type: Practical
Course Code: BOTY4306
Credit: 2
L-T-P: 0-0-4

List of Experiments

Economic Botany

1. Identify the major edible plant species that have played an important role in human affairs.
2. Study of major legumes and vegetables that are cultivated in the region.
3. Study of some local industrial crops.
4. Identification, systematic position and uses of spices and medicinal plants of the region.

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Semester IV

Course Title: Plant Biotechnology

Course Type: Core
Course Code: BOTY4401
Credits: 4
L-T-P: 4-0-0

Contact hours: 40

Unit I

History of plant tissue culture; Concepts of totipotency and cell differentiation; Micropropagation, *in-vitro* regeneration, composition of tissue culture media; Culture initiation, maintenance and subculture techniques, culture environment; clonal propagation using nodal and shoot tip cultures; Callus mediated plant regeneration, induction and maintenance of callus culture

Unit II

Organogenesis, adventitious organogenesis; Embryogenesis, zygotic and somatic, embryo rescue, synthetic seed production; somaclonal variation ; Haploid plants, their utility and application in genetics and plant breeding; androgenesis and gynogenesis; Protoplast culture and somatic hybridization

Unit III

Development of new cell line; Meristem culture for disease free plants, somatic hybrids and cybrids for crop improvement; cryopreservation and germplasm storage; Plant cell cultures for secondary metabolite production, molecular pharming - concept of plants as bio-factories; production of industrial enzymes and pharmaceutically important compounds

Unit IV

Principles and methods of genetic transformation; direct gene transfer methods: particle bombardment, electroporation, PEG-mediated and floral-dip; Agrobacterium mediated gene delivery; Ti and Ri plasmids; T-DNA transfer; disarmed Ti plasmid; cointegrate and binary vectors and their utility

Unit V

Applications of genetic transformation; Integration and fate of transgene, Transgenic Plant Analysis; Transgenic plants, Herbicide Resistance; Insect Resistance; Nutritional Improvements; edible vaccines; Genome editing for crop improvement

Suggested Reading

1. Stewart C.N., “Plant Biotechnology and Genetics: Techniques and Applications”, Wiley-Interscience’ 2008.
2. Bhojwani S.S., Dantu P.K., “Plant Tissue Culture: An Introductory Text”, Springer, 2013.
3. Oksman-Caldentey K-M., “Plant Biotechnology and Transgenic Plants; CRC Press, 2002.

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Semester III/IV

Course Title: Industrial Microbiology

Course Code: BOTY4001
Course Type: Discipline Specific Elective
Credit: 4
L-T-P: 4-0-0

Contact Hours : 40

Unit I
Introduction and History; Scope of microbes in industry; Isolation and screening of microbes, Production media, Inoculum Development, Sterilization and Disinfection

Unit II
Fermentation processes and Bioreactors / Fermenters; Fermentation process and its uses; Introduction of fermenters, Fermenter design, Components; Type of fermenters - laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, air-lift fermenter, fixed bed and fluidized bed bioreactors.

Unit III
Microbial production of industrial products; Downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, Lyophilization and spray drying.
Industrial products from microorganisms-
Antibiotics: Penicillin, Streptomycin, Vaccines
Enzymes: Amylase, Protease
Organic acids: Citric acid, Acetic acid
Amino acids: Glutamic acid, Lysine
Biofuels: ethanol, methane, biogas

Unit IV
Microbial enzymes of industrial interest and enzyme immobilization; Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis.
Methods of immobilization, Application and advantages of immobilization in pharmaceutical, food and fine chemical industries.

Unit V
Modern trends in microbial production; Microbial production of bioplastics, bioinsectices, biopolymer, Biofertilizers (Nitrogen fixing and Phosphate solubilizing microorganisms), Single Cell Protein and Biological weapons.

Suggested Readings

1. Black JG, Black LJ (2015). Microbiology Principles and Explorations. 9th Edition, John Wiley & Sons, Inc.
2. El-Mansi EMT, Bryce CFA, Dahhou B, Sanchez S, Demain AL, Allman AR (2012). Fermentation Microbiology and Biotechnology. CRC Press Taylor & Francis Group, USA
3. Glazer AN, Nikaido H (2007). Microbial Biotechnology: Fundamentals of Applied Microbiology, Second Edition. Cambridge University Press, UK
4. Okafor N, Okeke BC (2018). Morden Industrial Microbiology and Biotechnology, 2nd Edition. CRC Press Taylor & Francis Group, USA
5. Pelzar MJ Jr., Chen ECS, Krieg NR (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
6. Tortora GJ, Funke BR, Case CL (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, USA
7. Willey J, Sherwood L, Woolverton C (2013). Prescott's Microbiology 9th Edition. McGraw-Hill Higher Education, New Delhi

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Semester: III/IV

Course Title: Plant Virology

Course Code: BOTY 4002
Course type: Discipline Specific Elective
Credit: 4
L-T-P: 4-0-0

Contact hours: 40

Unit I

Introduction: History, definition, classification and nomenclature, Structure: Components of virus: nucleic acid, proteins and other components, architecture of ssRNA virus, ds RNA, DNA virus, enveloped and non-enveloped virus and their geometry.
Assay, detection and diagnosis, Isolation; ecology, epidemiology and control of plant viruses, plant viruses and technology Disease symptoms in plants, host range, Ecology, economic importance

Unit II

Genome composition, organisation and expression: Replication, Transmission and movement; Generalised outline of the replication of small ssRNA virus, the strategies of plant viral genomes, replication Mechanism of replication of virus with ssRNA genome (monopartite, bipartite, tripartite), DNA viruses, reoviridae, enveloped virus, viroids, regulation of replication, control mechanism, mixed virus assembly in vitro and in vivo. Origin and evolution of virus,

Unit III

Plant-Virus interaction: RNA silencing, movement of virus within plants, mechanism of Plant virus interaction in permissive and non-permissive host. Host defence mechanism
Plant virus movement: Direct passage in living higher plants, transmission by organism other than higher plants, mechanical transmission, role of insects.; Plant virus viromics, Involvement of genomes of three organism-virus, host and vector

Unit IV

Effect on plant metabolism: Effect of virus on nucleic acid, protein, carbohydrate, cell wall component, respiration, photosynthesis, transpiration, enzymes, hormones.
Disease development: Effect on growth, chloroplast, mechanism for the limitation of virus infection, leaf ontogeny, mosaic disease, role of membranes; factor influencing the course of infection and disease.

Unit V

Transmission of disease: concept of vectors, role of vectors in disease dissemination. Different types of vector. Molecular mechanism of virus entry and maintenance in vector.

Suggested Readings

1. Field's virology, David W knipe and Peter M. Howley, 6th edition, Wolter Kluwer press
2. Principles of Virology: 2 Vol set, by S. Jane Flint, Lynn W. Enquist, Vincent R. Racaniello, Glenn F. Rall, Anna-Marie Skalka.
3. Plant Virology, Roger Hull, 5th edition
4. Plant virology R E F Mathew, 2nd edition, academic press.

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Semester: III/IV

Course Title: Advances in Plant Breeding

Course Code: BOTY4003
Course Type: Discipline Specific Elective
Credit: Theory-4
L-T-P: 4-0-0

Contact Hours : 40

Unit I
History of Plant Breeding (Ancient and Modern era); Objectives of plant breeding; Trait improvement through plant breeding; Centres of origin of crop diversity; Contribution of Vavilov and Harlan; Gene pool concept-primary, secondary and tertiary gene pool.

Unit II
Self and cross pollinated crops; Asexually/clonally propagated crops; Selection in plant breeding: Mass selection, Pureline selection, Clonal selection, Procedure, merits, demerits and achievements of different selection techniques.

Unit III
Hybrid breeding: Hybridization and hybrid vigour; Different types of hybrid crosses; Special techniques in crop breeding: Mutation breeding: mutagenic agents, plant material, procedure, limitations and achievements; Backcross breeding: Breeding for stress tolerance and disease resistance; Horizontal and vertical resistance.

Unit IV
Plant/Germplasm collection and introduction: objectives and methodology; Quarantine regulations; Acclimatization.
Induction of polyploidy: role of colchicine; Auto and allopolyploids; Haploidy and polyploidy in crop improvement. Origin of bread wheat, *Brassica,* upland cotton and triticale.

Unit V
Role of biotechnology to plant breeding- embryo rescue, somaclonal variation, double haploid, protoplast fusion. Production and applications of transgenics in crop improvement: Bt cotton, Bt brinjal, Flavrsavr tomato; transgenic papaya; transgenic potato; Golden rice.
Participatory plant breeding: role of farmer in crop breeding.

Suggested Readings
1. Singh R.J. Plant Cytogenetics 3rd edition CRC Press.
2. Sharma JR. Principles and Practice of Plant Breeding. Tata McGraw-Hill.

3. Singh B.D. Essentials of Plant Breeding. Kalyani Publisher.

4. Klug and Cummins. Concepts of Genetics, Pearson.

5. Allard RW. Principles of Plant Breeding. John Wiley & Sons.

6. Chopra VL. Breeding Field Crops. Oxford & IBH.

7. Singh S & Pawar IS. Genetic Basis and Methods of Plant Breeding. CBS.

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(Established by an Act of Parliament)
Chanakya Parisar, Zila School Campus, Motihari, District: East Champaran, Bihar – 845401
Department of Botany

Semester: III/IV

Course Title: Molecular Stress Biology of plants

Course Code: BOTY4004
Course Type: Discipline specific elective
Credits: 4
L-T-P: 4-0-0

Contact Hours : 40

Unit I
Defining stress, Types of environmental stresses; Cyanobacterial/plant responses to abiotic and biotic stresses, acclimatization and adaptation.

Unit II
Drought and salt stress, osmotic adjustment and its role, acid soil stress, metal stress, water logging, light, cold and heat stress, stress-inducible proteins and genes.

Unit III
Biotic stress, Pathogenicity, pathogen penetration and entry, colonization in the host, factors affecting infection. Enzymes in plant diseases; cell wall degrading enzyme, toxins in relation to plant diseases, defense mechanism. Genetics of plant-pathogen interaction, Hyper sensitive response (HR), systemic acquired response(SAR), disease resistance by jasmonate.

Unit IV
The role of plant growth regulators in stress tolerance mechanisms, nutrient deficiency stress and disorders, adaptation in plants and cyanobacteria; changes in root/shoot ratio, arenchyma development, osmotic adjustment, compatible solute production.

Unit V
Signalling molecules and their surface receptor and functions, secondary messenger, role of nitric oxide, calcium modulation, phospholipid signalling, signal transduction pathway; MAPK pathway, CDPK, and other pathways. Transcriptional regulation of stress tolerance, MYB, WRKY, NAC, bZIP and other factors. Stress responsive gene expression and phenotypic responses; ROS generation and scavenging mechanism, programmed cell death.

Suggested Readings

1. Shabala, and Sergey (Ed.). Plant stress physiology. Cabi.
2. Tuteja, N., Gill, S. S., Tiburcio, A. F., & Tuteja, R. (Eds.). Improving crop resistance to abiotic stress. John Wiley & Sons.
3. Mehrotra, R. S. *Fundamentals of plant pathology*. Tata McGraw-Hill Education.

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Department of Botany

Semester: III/IV

Course Title: Applied phycology

Course Code: BOTY4006
Course Type: Discipline specific elective
Credits: 4
L-T-P: 4-0-0

Contact Hours : 40

Unit I
General characteristic and life history of the selected members of following groups of algae: Chlorophyceae, Bacillariophyceae, Phaeophyceae, Rhodophyceae and Cyanophyceae.

Unit II
Algal bloom and toxic algae, algal biofertilifers, Algae as a food and feed, fossil algae.

Unit III
Role of algae in industry (Alginic acid, Agar, Carrageenan), pharmaceutical and cosmeceutical development, types of biofuels and role of algae in biofuel production.

Unit IV
Cell structure of algae and cyanobacteria, Basic tools for genetic engineering of algae and cyanobacteria, Vectors: specific for cloning and expression in algae and cyanobacteria.

Unit V
Introduction of gene into cyanobacteria- Target cell preparation, natural gene transfer methods, Triparental and biparental conjugation in cyanobacteria. Selection, and screening of recombinant clones, reporter genes and promoter for high expression of the transgene

Suggested Readings

1. Fritsch, F.E. the structure and reproduction of algae volume I and II
2. Morris, I; Nan introduction to algae
3. Bold, H. C. and Wynne, M.D.; Introduction to the algae structure and reproduction.
4. H.D. Kumar; Introductory phycology

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Department of Botany

Semester: III/IV

Course Title: Nanomaterials in Plant Sciences

Course Code: BOTY 4005
Course Type: Discipline Specific Elective
Credit: 4
L-T-P: 4-0-0

Contact hours: 40

Unit I
From Biotechnology to Nanobiotechnology, nanomaterials-Properties, characterization and application

Unit II
Seed treatment using nanomaterials to improve crop stand; Controlled release nanocarriers for delivery of plant nutrients; Improvement of plant growth for better yield by using nanomaterials

Unit III
Different kinds of pest and diseases; Types of nanocides for fungus, insects and weeds; methods of formation of nanocides; Recent developments in the field

Unit IV
Introduction to precision farming, use of various nano-sensors in precision farming, use of sensor for plant health diagnostics.

Unit V
Remediation of contaminated agricultural soils, water and air using nanoparticles; Groundwater treatment of recalcitrant contaminants using nanoscale catalysts, nanoadsorbents, nano-porous membranes, nanoporous /microporous zeolites, mesoporous carbon, nano-alumina. Safety issues related to nanomaterial use in agriculture.

Suggested Readings

1. Prasad R, Jha A and Prasad K (2018) Exploring the Realms of Nature for Nanosynthesis. Springer International Publishing (ISBN 978-3-319-99570-0) https://www.springer.com/978-3-319-99570-0
2. Abd-Elsalam K and Prasad R (2019) Nanobiotechnology Applications in Plant Protection. Volume 2. Springer International Publishing (ISBN 978-3-030-13295-8) https://www.springer.com/gp/book/9783030132958
3. Thangadurai D, Sangeetha J, and Prasad R (2020) Nanotechnology for Food, Agriculture, and Environment. Springer International Publishing (ISBN 978-3-030-31938-0) https://www.springer.com/gp/book/9783030319373

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Department of Botany

Semester: III/IV

Course Title: Medicinal and Aromatic Plants

Course Code: BOTY 4007
Course Type: Discipline Specific Elective
Credit: 4
L-T-P: 4-0-0

Contact hours: 40

Unit I

Importance and scope of medicinal and aromatic plants; Problems of overexploitation and deforestation; Rare and endangered species of medicinal and aromatic plants; Conservation techniques, Regeneration and sustainable use. Novel extraction technique of phytochemicals and in vitro evaluation.

Unit II

History and status of medicinal plant cultivation in India, Soil: components, types, physical and chemical properties, fertility and productivity, management and maintenance; Cultivation of medicinal plants: season and time, selection and preparation of land for cultivation, tillage (different types), planting density, planting patterns; Methods of propagation: sexual and asexual (vegetative, budding, grafting, layering)

Unit III

Extraction, purification and scaling up production technique: Artemisia, Sarapagandha, Isubgol, Bacopa monniera; Lemon grass

Unit IV

Role of indigenous plant in disease control,Important herbal formulations and application.

Unit V

Bioassays related to active principle from plants: anti- bacterial and anti-fungal; anti-malarials; immune-modulators; mediators of inflammation; anti- hepatotoxic agents; platelets aggregating factors; cardio-vascular agents; anti- inflammatory agents; diuretic agents; anti-allergic principles; fertility regulating agents; hypo lipidaemic and hypo glycaemic agents; acute toxicity testing.

Suggested Readings

1. S.K. Jain (2008) Medicinal Plants. National Book Trust, India, New Delhi. (ISBN 13: 9788123707525)
2. P. Pushpangadan and K.N. Nair (1997) Medicinal Plants. In: The Natural Resources of Kerala
3. A. Máthé (2015) Medicinal and Aromatic Plants of the World: Scientific, Production, Commercial and Utilization Aspects. Springer Nature
4. M. Paz Arraiza, A. González-Coloma, J. Burillo, C. Calderón-Guerrero (2017) Medicinal and Aromatic Plants: The Basics of Industrial Application (Frontiers in Horticulture).

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Department of Botany

Semester: III/IV

Course Title: Herbal Drug Technology and Development

Course Code: BOTY 4008
Course Type: Discipline Specific Elective
Credit: 4
L-T-P: 4-0-0

Contact hours: 40

Unit I

General methods of extraction, isolation and purification of phytoconstituents Isolation, identification tests and estimation methods for the following phytoconstituents with special emphasis on HPLC, HPTLC and other advanced techniques Aloin from Aloes; Andrographolides from *Andrographis paniculata*

Unit II

Chemistry, isolation, estimation and biogenesis of alkaloids, glycosides, plant phenols, resins, terpenes and terpenoids, phospholipids and steroids.

Unit III

Sources, identification and authentication of herbs; Different methods of processing of herbs like collection, harvesting, garbling, packing and storage conditions; Methods of drying – Natural and artificial, merits and demerits.

Unit IV

Principles of extraction and selection of suitable extraction method; Different methods of extraction including maceration, percolation, hot continuous extraction, pilot scale extraction and supercritical fluid extraction with their merits and demerits; Purification and Recovery of Solvents.

Unit V

Different methods (including industrial) for isolation and estimation of phytoconstituents from the following drugs (with special emphasis on HPLC and HPTLC. Catechins from Green tea, Papaverine from Opium poppy, Herbal Formulation Development: Selection of herbal ingredients. Different dosage forms of herbal drugs. Evaluation of different dosage forms. Stability studies of herbal formulations. Ethnomedicine for herbal antiviral agents and their value in drug discovery.

Suggested Readings

1. Screening methods in pharmacology (vol I & II)–R.A. Turner
2. Drug Discovery and Evaluation in Pharmacology assay: Vogel
3. Animal and Clinical pharmacologic Techniques in Drug Evaluation-Nodine and Siegler
4. Fundamentals of experimental Pharmacology- Ghosh M.N.
5. Handbook of Experimental Pharmacology- Goyal R.K.
6. Harborne - Comparative Biochemistry of Flavonoids.
7. Garatt -The Quantitative Analysis of Drugs.

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Department of Botany

Semester: IV

Course Title: Lab VII

Course Type: Practical
Course Code: BOTY4405
Credit: 2
L-T-P: 0-0-4

List of Experiments

Plant Biotechnology

1. Tissue culture media stock preparation
2. Preparation of MS medium.
3. Preparation of White's medium
4. Establishment of aseptic cultures following appropriate sterilization procedures using seeds.
5. Establishment of a callus culture

*** DSE**

Industrial Microbiology

1. Industrial Microbiology Principles and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques
3. Preparation of various culture media.
4. Isolation and Purification of bacteria from various sources
5. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

Plant Virology

1. Study of symptoms of various plant diseases
2. Transmission of plant viruses.
3. Assay of viruses, PCR
4. Physical properties, purification

Advances in Plant Breeding

1. Floral biology in self and cross pollinated species.
2. Selfing and crossing techniques.
3. Hybridization: emasculation, bagging, tagging.
4. Maintenance of experimental records.
5. Designs used in plant breeding experiments.

Stress Biology of Plants

1. Proteins isolation and estimation from the given sample
2. Isolation of DNA/RNA and their estimation from given sample.
3. Isolation of lipid and their estimation from given sample.
4. Estimation of chlorophyll from the control and stressed sample.
5. Estimation of antioxidant enzymes /ROS from the control and stressed cyanobacterial sample.
6. Analysis of DNA in control and stressed cyanobacterial /plant sample.
7. Analysis of lipid content in control and stressed sample of cyanobacteria/plant.

Nanomaterials in Plant Sciences

1. Preparation of biological nanomaterial synthesis and characterization
2. Study the effect of seed treatment with nanomaterials on germination
3. Study of interaction between nanomaterials and plant or microbes or drugs

Applied Phycology

1. Identification of the genera from various groups of algae.
2. Identification of bloom forming algae
3. Identification of algal biofertilizers
4. Identification of toxic algae.
5. Demonstration of triparental conjugation in cyanobacteria

Medicinal and Aromatic Plants

1. Studies of medicinal, aromatic, spice and toxic plant species: To promotes ethnobotanical surveys.
2. Method of extraction and phytochemical screening of medicinal plants
3. In vitro evaluation techniques for antibacterial, antifungal, antimalarial etc.

Herbal Drug Technology and Development

1. Preparation of Ayurvedic formulation like Asava, Arista, Bhasma, Ghrita and Gutika.
2. General methods of screening of natural products for the following Biological activities. a. Anti-inflammatory Activity. d. Cardiac Activity. b.Hypoglycemic. e. Antibacterial Activity. c. Diuretic. In vitro evaluation techniques for antibacterial, antifungal, antimalarial etc.
3. Acute toxicity Study. Determination of LD50 and ED50. General methods of screening of natural products for the following Biological activities. a. Antifertility Activity. b. Screening of In-vitro Antioxidant Activity. c. Antiulcer Activity. d. Hepatoprotective Activity.
4. Determination of ascorbic acid (vitamin C) by UV spectroscopic method in various herbal formulations.
5. Determination of natural herbal products by UV Spectroscopic method.
6. Preparation of some important extracts by using preliminary Scale Extraction Plant.