PANSKURA BANAMALI COLLEGE
(AUTONOMOUS)

Bachelor of Science (Hons) Botany

(Effective from Academic Year 2018-19)

Preamble

The PAnskura Banamali College (autonomous) envision educational programaes in the best interest of their students and in this endeavour it offers Under Graduate courses in Botany. This imbibes a Learning Outcome-based Curriculum Framework (LOCF).

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The Under-Graduate Programmes will prepare the students for both, academia and employability.

The new curriculum of B.Sc. (Hons) Botany offer essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core and elective papers.

STRUCTURE OF B.SC. HONOURS BOTANY PROGRAMME UNDER CBCS

Part	Year	Semester (July to November)	Semester (January to May)
Part – I	First Year	Semester I	Semester II
Part – II	Second Year	Semester III	Semester IV
Part – III	Third Year	Semester V	Semester VI

Core Courses

1. Microbiology and Phycology
2. Biomolecules and Cell Biology
3. Mycology and Phytopathology
4. Archegoniatae
5. Anatomy of Angiosperms
6. Economic Botany
7. Genetics
8. Molecular Biology
9. Ecology
10. Plant Systematics
11. Reproductive Biology of Angiosperms
12. Plant Physiology
13. Plant Metabolism
14. Plant Biotechnology

Discipline Specific Electives	
Semester-V	DSE-1. Analytical Techniques in Plant Sciences DSE-2. Biostatistics DSE-3. Natural Resource Management
Semester-VI	DSE-4. Industrial and Environmental Microbiology DSE-5. Bioinformatics DSC-6. Plant Breeding
Generic Electives (Four) Offered to the students of other Departments	
Semester –I GE-I	GE-I (Any one) 1. Biodiversity (Microbes, Algae, Fungi and Archegoniatae) 2. Plant Anatomy and Embryology
Semester –II GE-II	GE-II 3. Plant Ecology and Taxonomy
Semester –III GE-III	GE-III (Any one) 4. Plant Physiology and Metabolism 5. Environmental Biotechnology
Semester –IV GE-IV	GE-IV : 6. Economic Botany and Biotechnology
Skill Enhancement Cources: Elective	
Semester-III	1. Ethnobotany 2. Intellectual Property Rights 3. Plant Diversity and Human Welfare 4. Floriculture
Semester-IV	5. Biofertilizers 6. Medicinal Botany 7. Mushroom Culture and Technology 8. Nursery and Gardening
Ability Enhancement Compulsory Course (AEC).	
AEC-1. English/MIL Communication AEC-2. Environmental Science	

COURSE TEACHING-LEARNING PROCESS

The learning experiences gained for cognitive development in every student. The practical exercises help to develop an important aspect of the teaching-learning process. The important relevant teaching and learning processes involved in this course are;

1.Class lectures
2.Seminars
3. Tutorials
4. Group discussions and Workshops
5. Question framing
6. Short answer type questions
7. Long answer type questions
8. Objective type questions
9. Multiple choice questions
10. Statement, reasoning and explanation
11. Project-based learning
12. Field-based learning
13. Practical component and experiments

THEORY:

1. Lesson plan of each week will be prepared before the commencement of the session and followed during the session.
2.The theory topics are covered in lectures with the help of both conventional (chalk board and Charts) and modern (ICT) methods, including animations. .
3. Emphasis is given on interactive class room environment so as to encourage students ask questions/ doubts/ queries for clarification/explanation and discussion.
4. Students are encouraged to refer to reference books in library to inculcate reading habit for better grasp and understanding on the subject.
5. Emphasis is given to illustrations- neat, well-labelled outline and cellular diagrams/ flowcharts for improving creative skills and to substantiate the text content.
6. On completion of theory syllabus, previous years' question papers are discussed so as to apprise students about the general format of semester exam question papers.
6. Assignment (10), Test (10) and Theory Attendance (5) are components of Internal Assessment Scheme for compilation of Internal Assessment Score of each student out of 25 marks.

PRACTICAL:

1. Practical plan of each week will be prepared before the commencement of the session and followed during the session.
2. Every practical session begins with instructions, followed by students doing table work for detailed microscopic plant study.
3. Plant study is done using fixed plant materials, museum and herbarium specimens, photographs and permanent slides.

4. The students are instructed about maintaining practical records, which includes comments and diagrams.
5. Students are asked to submit practical records regularly, on a continuous basis, for checking.
6. On completion of practical syllabus, Practical Exam Guidelines are discussed to apprise students about the formant of Practical exam.
7. As part of Continuous Evaluation guidelines, total score for each student is calculated out of 25 marks, taking into consideration
8 Practical Records (10), Practical Test/ Assessment (10) and Practical Attendance (5)

Assessment Methods

A number of appropriate assessment methods of botany will be used to determine the extent to which students demonstrate desired learning outcomes. Involving students in highlighting the salient features/summary a topic through digital media such as Power Point presentationsand animations enhance their communication skill. Making drawings should be compulsory part of practical record books. A continuous assessment method throughout the programme shall inculcate regular reading habit in the students and provide continuous observation learning abilities and challenges of the students'

Following assessment methodology will be adopted:

- Oral and written examinations
- Closed-book and open-book tests,
- Problem-solving exercises,
- Practical assignments and laboratory reports,
- Observation of practical skills,
- Evaluation of answer scripts and discussion on the mistakes committed

Microbiology and Phycology
(BOTHCC1)
Core Course - (CC) Credit:6

Course Objective (2-3)

To gain knowledge of diversity, life forms, life cycles, morphology and importance of micro-organisms (Bacteria and algae).

Course Learning Outcomes

Students would have understanding of the classification, characteristic features, cell structure and growth and reproduction in viruses, bacteria, and various groups of marine and fresh water algae and their ecological and economic importance.

Unit 1
Introduction to microbial world.

Unit 2
Viruses (7 lectures): Discovery, physiochemical and biological characteristics;classification (Baltimore)General structure with special reference to viroids and prions, General account of replication, DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV). Viral diseases

Unit 3
Bacteria (8 lectures): Discovery, general characteristics, types-archaebacteria, eubacteria, wall-less forms(mycoplasma and spheroplasts), Cell structure, nutritional types, Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction), Bacterial diseases

Unit 4
Applied Microbiology (4 lectures): Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, and as causal organisms of plant diseases. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

Unit 5

Algae (7 lectures): General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; Methods of reproduction, classification;
Criteria, system of Fritsch, and evolutionary classification of Lee (only up to groups); significant contributions of important phycologists (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P.Iyengar).

Unit 6
Cyanophyta (6 lectures): Ecology and occurrence, range of thallus organization, cell structure, heterocyst,reproduction.economic importance; role in biotechnology. Morphology and life-cycle of Nostoc.

Unit 7
Chlorophyta (5 lectures): General characteristics, occurrence, range of thallus organization, cell structure and reproduction.Morphology and life-cycles of *Chlamydomonas, Volvox, Oedogonium, Coleochaete*.Evolutionary significance of *Prochloron*.

Unit 8
Charophyta (2 lectures): General characteristics; occurrence, morphology, cell structure and life-cycle of *Chara*;evolutionary significance.

Unit 9

Xanthophyta (3 lectures): General characteristics; range of thallus organization;Occurrence, morphology and life-cycleof *Vaucheria*.
Unit 10
Phaeophyta (6 lectures): Characteristics, occurrence, range of thallus organization, cell structure and reproduction.Morphology and life-cycles of *Ectocarpus* and *Fucus*.

Unit 11

Rhodophyta (6 lectures): General characteristics, occurrence, range of thallus organization, cell structure and reproduction.Morphology and life-cycle of *Polysiphonia*.

Unit 12: **Applied Phycology** (4 lectures): Role of algae in the environment, agriculture, biotechnology and industry.

Practical

Microbiology

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule.
3. Gram staining.

Phycology

4. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas, Volvox, Oedogonium,Coleochaete, Chara, Vaucheria, Ectocarpus, Fucus* and *Polysiphonia, Procholoron* through electron micrographs, temporary preparations and permanent slides

Biomolecules and Cell Biology
(BOTHCC2)
Core Course - (CC) Credit:6

Biomolecules and Cell biology study will help the students to gain knowledge on the activities in which the giant molecules and miniscule structures that inhabit the cellular world of life are engaged. This will provide inside into the organization of cell, its features and regulation at different levels. Through the study of biomolecules (i.e protein, carbohydrate, lipid and nucleic acid) and cell organelles, they will be able to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life.

Course Learning Outcomes
This course will be able to demonstrate foundational knowledge in understanding of:

1. The relationship between the properties of macromolecules, their cellular activities and biological responses

2. Understanding of Cell metabolism, chemical composition, physiochemical and functional organization of organelle
3. Contemporary approaches in modern cell and molecular biology.

Unit 1

Biomolecules (18 lectures): Types and significance of chemical bonds; Structure and properties of water; pH and buffers. **Carbohydrates**: Nomenclature and classification; Role of monosaccharides (glucose, fructose, sugar alcohols – mannitol and sorbitol); Disaccharides (sucrose, maltose, lactose), Oligosaccharides and polysaccharides (structural-cellulose, hemicelluloses, pectin, chitin, mucilage; storage – starch, inulin). **Lipids**: Definition and major classes of storage and structural lipids. Storage lipids: Fatty acids structure and functions,Structural lipid: Phosphoglycerides; Building blocks, General structure, functions and properties. Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers, bilayers.
Proteins: Structure of amino acids; Peptide bonds; Levels of protein structure-primary, secondary, tertiary and quarternary; Isoelectric point; Protein denaturation and biological roles ofproteins
Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleic acids

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Unit 2

Bioenergenetics (4 lectures): Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as a energy currency molecule.

Unit 3

Enzymes (6 lectures): Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; mechanism of action (activation energy, lock and key hypothesis, induced - fit theroy), enzyme inhibition and factors affecting enzyme activity (in brief).

Unit 4

The cell (2 lectures): Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin ofeukaryotic cell (Endosymbiotic theory).

Unit 5

Cell wall and plasma membrane (4 lectures): Chemistry, structure and function of Plant Cell Wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.

Unit 6

Cell organelles (22 lectures): Nucleus:Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin;nucleolus.
Cytoskeleton:role and structure of microtubules, microfilaments and intermediary filament.
Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.
Endomembrane system: Endoplasmic Reticulum – Structure and function of RER and SER, protein folding, processing in ER, export of proteins and lipids; Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes

Unit 7
Cell division (4 lectures)
Eukaryotic cell cycle, mitosis and meiosis. Regulation of cell cycle

Practical

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo*/*Crinum*.
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Separate chloroplast pigments by paper chromatography.

5. Demonstrate the activity of any two enzymes (Urease, Amylase, Catalase).
6. Study of cell and its organelles with the help of electron micrographs.
7. Study the phenomenon of plasmolysis and deplasmolysis.
8. Study the effect of organic solvent and temperature on membrane permeability.
9. Study different stages of mitosis.

References

1. Becker, W.M., Kleinsmith, L.J., Hardin, J., Bertoni, G. P. (2009). *The World of the Cell*, 7th edition. San Francisco, Cambridge: Pearson Benjamin Cummings Publishing.
2. Berg, J.M., Tymoczko, J.L., Stryer, L. (2011). *Biochemistry.* New York, NY: W. H. Freeman and Company.
3. Campbell, M.K. (2012). *Biochemistry*, 7th edition. Boston, Massachusetts: Cengage Learning.
4. Campbell, P.N., Smith, A.D. (2011). *Biochemistry Illustrated*, 4th edition. London, UK: Churchill Livingstone.

Additional Resources:

1. Cooper, G.M., Hausman, R.E. (2009). *The Cell: A Molecular Approach*, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA.
2. Karp, G. (2010). *Cell Biology*, 6th edition. New Jersey, U.S.A.: John Wiley & Sons.
3. Majumdar, R., Sisodia, R. (2019). *Laboratory Manual of Cell Biology, with reference to Plant Cells.* New Delhi, Delhi: Prestige Publication.
4. Nelson, D.L., Cox, M.M. (2008). *Lehninger Principles of Biochemistry*, 5th edition. New York, NY: W.H. Freeman and Company.
5. Reven, F.H., Evert, R.F., Eichhorn, S.E. (1992). *Biology of Plants.* New York, NY: W.H.Freeman and Company.
6. Tymoczko, J.L., Berg, J.M., Stryer, L. (2012). *Biochemistry: A short course*, 2nd edition. New York, NY: W.H.Freeman and Company.

Mycology and Phytopathology
(BOTHCC3)
Core Course - (CC) Credit:6

Course Objective(2-3)

1. To introduce students with various fungal groups and lichens, their ecology, classification, characteristics, reproduction and economic Importance
2. To introduce students with the phytopathology, its concepts and principles\
3. To acquaint with various plant diseases, causal organisms and their control

Course Learning Outcomes

Upon completion of this course, the students will be able to:

1. Understand the world of fungi, lichens and pathogens of plants
2. Appreciate the characteristics of the fungi and lichens
3. Understand the ecological and economic significance of lichen
4. Understand the application of mycology in various fields of economic and ecologica
5. Significance
6. Understand the economic and pathological importance of fungi, bacteria and viruses
7. Identify common plant diseases and their control measures

Unit 1

Introduction to true fungi (6 lectures)
Definition, General characteristics; Affinities with plants and animals; Thallus organization;Cell wall composition; Heterokaryosis and parasexuality; Nutrition; Classification.

Unit 2

General account of Chytridiomycetes (1 lecture)

Unit 3
Zygomycota (4 lectures)
General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.

Unit 4

Ascomycota (10 lectures)
General characteristics; Ecology; Life cycle, life cycle and classification with reference to *Saccharomyces, Penicillium, Alternaria* and *Neurospora* and *Peziza.*

Unit 5
Basidiomycota (8 lectures)
General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), *Ustilago* (loose and covered smut, symptoms only), *Agaricus*;
Bioluminescence, Fairy Rings and Mushroom Cultivation.

Unit 6
Mixomycota (Allied Fungi) (3 lectures)
General characterises; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.

Unit 7: Oomycota (4 lectures)
General characteristic; Ecology; Life cycle and classification with reference to *Phytophthora, Albugo*.

Unit 8: Symbiotic associations (4 lectures)
Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Economic importance of lichens. ; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Unit 9: Applied Mycology (10 Lectures)

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

Unit 10: Phytopathology (10 lectures)
Terms and concepts; General symptoms; Geographical distribution of diseases; Host- Pathogen relationships;disease cycle and environmental relation; Methods of control of plant diseases, and role of quarantine. Bacterial diseases – Citrus canker and angular leaf spot disease of Cotton.Viral diseases – Tobacco Mosaic viruses, vein clearing.

Practical

1. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, asocarps & basidiocarps).
2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus* and Penicillium: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. *Peziza*: sectioning through ascocarp.
5. *Alternaria*: Specimens/photographs and temporary mounts.
6. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
7. *Agaricus:* Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*, fairy rings and bioluminescent mushrooms to be shown.
8. Study of phaneroplasmodium from actual specimens and /or photograph. Study of *Stemonitis* sporangia.
9. Albugo: Study of symptoms of plants infected with Albugo; asexual phase study throughsection/ temporary mounts and sexual structures through permanent slides.
10. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endo mycorrhiza (Photographs)
11. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.

References

1. Agrios, G.N. (1997). *Plant Pathology*, 4th edition. Cambridge, U.K.: Academic Press.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology*, 4th edition. Singapore, Singapore: John Wiley & Sons.
3. Sethi, I.K. and Walia, S.K. (2011). *Text book of Fungi and Their Allies.* Noida, U.P.: Macmillan Publishers India Ltd.
4. Reven, F.H., Evert, R. F., Eichhorn, S.E. (1992). *Biology of Plants.* New York, NY: W.H. Freeman and Company.

Additional Resources

1. Sharma, P.D. (2011). *Plant Pathology.* Meerut, U.P.: Rastogi Publication.
2. Webster, J., Weber, R. (2007). *Introduction to Fungi*, 3rd edition. Cambridge, U.K.: Cambridge University Press.

Archegoniatae
(BOTHCC4)
Core Course - (CC) Credit:6

Course Objective(2-3)

This course aims at making a familiarity with special groups of plants joined together by a common feature of *sexual reproduction involving Archegonia*.
Creating an understanding by observation and table study of representative members of phylogenetically important groups should be able to make students learn the process of evolution in a broad sense.
Study of *morphology, anatomy, reproduction and developmental changes*therein through typological study should create a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants.

Course Learning Outcomes

The students will be made aware of the group of plants that have given rise to land habit and the flowering plants. Through field study they will be able to see these plants grow in nature and become familiar with the biodiversity. to my knowledge students should create their small digital reports where they can capture the zoomed in and zoomed out pictures as well as videos in case they are able to find some rare structure or phenomenon related to these plants.

Unit 1
The entire team feels that we need to update our concepts of the adaptations that lead to land habit. this should also include the evolution that occurred after land habit get established. Thereis also need to teach undergrads, APG system of classification for each of the three groups.

Unit 2
Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum and *Funaria* (Developmental details not to be done). Comparative and evolutionary trends in liverworts, hornworts and mosses.
Progressive sterilization of the sporophyte.
Ecological and economic importance with special reference to *Sphagnum*.besides economic importance new research in field of bryophytes could be done such as whole genome of *Marchantia polymorpha* has been sequenced to elucidate evolution.

Unit 3
Classification: Recent phylogenetic classification to be followed

Unit 4

Classification: Recent phylogenetic classification to be followed. Concept of double fertilization to be introduced taking example of *Ephedra and Gnetum gnemone. While teaching Cycas, a brief mention of Ginkgo may also be made (only similarity between Cycas and Ginkgo such as motile sperms).*Comparison of Cycadales with ferns on one hand and *Gnetum* with angiosperms should be made.

Practical

1. *Riccia* – Morphology of thallus.
2. *Marchantia*- Morphology of thallus, whole mount of rhizoids & Scales, vertical sectionof thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).
3. *Anthoceros*- Morphology of thallus, dissection of sporophyte (to show stomata, spores,pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).
4. *Pellia, Porella*- Permanent slides.
5. *Sphagnum*- Morphology of plant, whole mount of leaf (permanent slide only).
6. *Funaria*- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus,spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.
7. *Psilotum*- Study of specimen, transverse section of synangium (permanent slide).
8. *Selaginella*- Morphology, whole mount of leaf with ligule, transverse section of stem,whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
9. *Equisetum*- Morphology, transverse section of internode, longitudinal section ofstrobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
10. *Pteris*- Morphology, transverse section of rachis, vertical section of sporophyll, wholemount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
11. *Cycas*- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll,transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).
12. *Pinus*- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones, transverse section of Needle, transverse section of stem, longitudinal/ transverse section of male cone, whole mount of microsporophyllwhole mount of Microspores(temporary slides), longitudinal section of female cone, tangential longitudinal section & radial longitudinal sections stem (permanent slide). 13. *Gnetum*- Morphology (stem, male & female cones), transverse section of stem, verticalsection of ovule (permanent slide),
14. Botanical excursion

References

1. Kaur I.D., Uniyal P.L. (2019).*Text Book of Gymnosperms*.New Delhi, Delhi: Daya Publishing House.
2. Parihar, N.S. (1972). *An Introduction to Embryophyta. Vol. II: Pteridophyta*. Allahabad, UP: Central Book depot.
3. Parihar, N.S. (1991). *An Introduction to Embryophyta. Vol. I: Bryophyta*. Allahabad, UP: Central Book Depot.
4. Puri, P. (1985). *Bryophytes*. New Delhi, Delhi, Atma Ram and Sons.

Additional Resources

1. Bhatnagar, S.P., Moitra, A. (1996). *Gymnosperms*. New Delhi, Delhi: New Age International (P) Ltd Publishers.
2. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2008). *Biology.* San Francisco, SF: Pearson Benjamin Cummings.
3. Coulter, J.M., Chamberlain,C.J. (1910). *Morphology of Gymnosperms.* Chicago, University of Chicago Press.
4. Kaur I.D., Uniyal P.L.*Text Book of Bryophytes.* New Delhi, Delhi: Daya Publishing House (in Press).
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). *Biology*. New Delhi, Delhi:Tata McGraw Hill.
6. Singh, H. (1978). *Embryology of Gymnosperms.* Berlin, Germany. Gebruder Borntraeger.
7. Singh,V., Pandey, P.C., Jain, D.K. (2001) *A Text Book of Botany*. Meerut, UP: Rastogi and Co.
8. Vashistha, B.R., Sinha, A.K., Kumar, A. (2011).*Botany For Degree Students, Bryophyta*. New Delhi, Delhi: S Chand Publication.
9. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). *Botany For Degree Students Pteridophyta*, New Delhi, Delhi: S. Chand Publication. Delhi, India.

Anatomy of Angiosperms
(BOTHCC5)
Core Course - (CC) Credit:6

Course Objective (2-3)

1. To acquaint the students with internal basic structure and cellular composition of the plant body.
2. To correlate structure with important functions of different plant parts.
3. Study of various tissue systems and their development and functions in plants

Course Learning Outcomes

1. Knowledge of various cells and tissues, meristem, epidermal and vascular tissue system in plants.
2. Various aspects of growth, development of the tissues and differentiation of various plant organs.Knowledge of basic structure and organization of plant parts in angiosperms.
3. Correlation of structure with morphology and functions.

Unit 1

Tissues (12Lectures): Classification of tissues; Simple and complex tissues (no phylogeny); Pits and plasmodesmata; Wall ingrowths and transfer cells; Ergastic substances.

Unit 2

Stem and leaf(12Lectures): Organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cyto-histological zonation); Types of vascular bundles; Structure of dicot and monocot stem; Shoot Chimeras; Structure of dicot and monocot leaf, Kranz anatomy; Development of Leaf.

Unit 3

Root (6Lectures) : Organization of root apex (Apical cell theory, Histogen theory, Korper- Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

Unit 4

Vascular Cambium(7 Lectures): Structure (Axially and radially oriented elements); function and seasonal activity of cambium; Secondary growth in root and stem, Anomalies in secondary growth in stem: Included phloem and Phloem wedges.

Unit 5

Wood(8Lectures): Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology.

Unit 6

Periderm (3Lectures): Development and composition of periderm;rhytidome and lenticels.

Unit 7

Adaptive and Protective Systems (8Lectures): Epidermal tissue system; cuticle; epicuticular waxes;trichomes (uni-and multicellular, glandular and non-glandular, two examples of each); stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

Unit 8

Secretory System (3Lectures): Hydathodes, cavities, lithocysts and laticifers.

Unit 9: Scope of Plant Anatomy (1 Lectures)

Applications in systematics, forensics and pharmacognosy**.**

Practical

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

1. Apical meristem of root, shoot and vascular cambium.
2. Distribution and types of parenchyma, collenchyma and sclerenchyma.
3. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
4. Wood: ring porous; diffuse porous; tyloses; heartwood and sapwood.
5. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
6. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
7. Root: monocot, dicot, secondary growth.
8. Stem: monocot, dicot - primary and secondary growth; phloem wedges in *Bignonia*, included phloem in *Leptadenia*/*Salvadora*; periderm; lenticels.
9. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
10. Adaptive Anatomy: xerophytes, hydrophytes.
11. Secretory tissues: cavities, lithocysts and laticifers.

References

1. Dickison, W.C. (2000).*Integrative Plant Anatomy.* Cambridge, U.K.: Harcourt Academic Press.
2. Esau, K. (1977).*Anatomy of Seed Plants.* New Delhi, Delhi: John Wiley & Sons, Inc.
3. Evert, R.F., Eichhorn, S. E. (2006). *Esau's Plant anatomy: Mersitems, Cells, and tissues of the Plant Body: their structure, function and development.* New Jersey, U.S.: Wiley- Liss.

Additional Resources:

1. Mauseth, J.D. (1988). *Plant Anatomy*. San Francisco, California: The Benjammin Cummings Publisher.
2. Raven, F.H., Evert, R. F., Eichhorn, S.E. (1992). *Biology of Plants*. New York, NY: W.H. Freeman and Company.

Economic Botany
(BOTHCC6)
Core Course - (CC) Credit:6

Course Objective(2-3)

To make the students familiar with economic importance of diverse plants that offer resources to human life. It emphasize the plants used as- food for man, fodder for cattle, feed for poultry, plants having medicinal value and also plant source of huge economic value etc

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Course Learning Outcomes

After studying Economic Botany, students would have first hand information of plants used as food, the various kinds of nutrients available in the plants. The dietary requirements of proteins, fats, amino-acids, vitamins etc that can be met by plants. The students will learn to perform the micro-chemical tests to demonstrate various components. The students will learn about the use of fibre plants, beverages, fruits and vegetables that are integral to day to day life of plants. Students will learn to explore the regional diversity in food crops and other plants and their ethno-botanical importance as well.

Unit 1

Origin of Cultivated Plants(4 lectures): Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity (Only conventional plant breeding methods); Importance of germplasm diversity.

Unit 2

Cereals (6 lectures): Wheat and Rice (origin, evolution, morphology, post-harvest processing & uses); Green revolution; Brief account of millets and pseudocereals.
Unit 3

Unit 3: Legumes (3 lectures): General accounts (including chief pulses grown in India); Importance to man and ecosystem.
Unit 4
Fruits (3 lectures): Mango and Citrus (Origin, morphology, anatomy and uses)

Unit 5

Sugars and Starches (5 lectures): Morphology, ratooning, evolution (nobilization) and processing of sugarcane, products and by-products of sugarcane industry; Potato – morphology, tuber anatomy, propagation (conventional and TPS) and uses.

Unit 6

Spices (6 lectures): Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper

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Unit 7

Beverages (4 lectures): Tea, Coffee (morphology, processing & uses)

Unit 8

Oils and fats (8 lectures): General description, classification, extraction, their uses and health implications; groundnut, coconut, linseed, mustard (Botanical name, family & uses).

Unit 9

Essential Oils (4 lectures): General account, extraction methods, comparison with fatty oils and otheir uses.

Unit 10

Natural Rubber (3 lectures): Para-rubber: tapping, processing and uses.

Unit 11

Drug-yielding plants (5 lectures): Therapeutic and habit-forming drugs with special reference to *Cinchona*, *Digitalis*, *Papaver* and *Cannabis.*

Unit 12

Tobacco (Morphology, processing, uses and health hazards).**(3 lectures)**

Unit 13

Fibers (6 lectures): Classification based on the origin of fibers; Cotton (origin of tetraploid cotton, morphology, extraction and uses) and Jute (morphology, extraction and uses).

Practicals

1. Cereals: Wheat (habit sketch, L.S/T.S. grain, starch grains, micro-chemical tests), Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests). Millets and Pseudocereals (specimens / photographs and grains)
2. Legumes: Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. Fruits: Mango (habit sketch, L.S. fruit, micro-chemical tests in ripe fruit); Citrus (habit sketch, T.S. hesperidium, W.M. vesicle, micro-chemical tests including test for vitamin C)
4. Sugars and starches: Sugarcane (habit sketch; cane juice- micro-chemical tests); Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, W.M. starch grains, micro-chemical tests).
5. Spices: Black pepper, Fennel and Clove (habit and sections L.S./T.S.).
6. Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
7. Oils and fats: Coconut- T.S. nut, Mustard–plant specimen, seeds
8. **Essential oil-yielding plants**: Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and *Eucalyptus* (specimens/photographs).
9. Rubber: specimen, photograph/model of tapping, samples of rubber products.
10. Drug-yielding plants: Specimens of *Cinchona*, *Digitalis*, *Papaver* and *Cannabis* (male & female plant).
11. Tobacco: specimen and products of Tobacco.
12. Fiber-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test forcellulose and lignin on transverse section of stem and fiber).

References

1. Kochhar, S.L. (2012). *Economic Botany in Tropics*. New Delhi, India: MacMillan & Co.
2. Wickens, G.E. (2001). *Economic Botany: Principles & Practices*.The Netherlands: Kluwer Academic Publishers.
3. Chrispeels, M.J. and Sadava, D.E. (1994) *Plants, Genes and Agriculture.*Jones & Bartlett - Publishers.

Genetics
(BOTHCC7)
Core Course - (CC) Credit:6

Course Objective(2-3)

To have knowledge of Mendelian and non-Mendelian inheritance, Chromosome biology and structure and function of genes.

Course Learning Outcomes

To generate interest among the students in Genetics and make them aware about the importance and opportunities in higher education and research, the first unit should be Introductory dealing with how this area has revolutionized all aspects of our life from its growth from Mendel to Genetic Engineering. Modes of inheritance of traits/ phenotypes and Phenotype-genotype corelation are the basic learning.

Unit 1

Mendelian genetics and its extension (16 L): Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; sex determination (briefly with reference to Humans and Drosophilla); Probability and Pedigree analysis; Incomplete dominance and co- dominance; Multiple allelism; lethal alleles; Epistasis; Pleiotropy; Penetrance and expressivity; Polygenic inheritance; numericals.Basics of epigenetics, DNA Methylation and epigenetic code.

Unit 2

Extra-chromosomal Inheritance (6L): Chloroplast Inheritance: Variegationin Four O` clock plant; Mitochondrial inheritance in yeast; Maternal effect- shell coiling in snails; Infective heredity- Kappa particles in Paramecium.

Unit 3

Linkage, crossing over and chromosome mapping (12L): Linkage and crossing over-Cytological basis of crossing over (eg. Maize); Recombination frequency: two factor and three

factor crosses; interference and coincidence; Numericals based on gene mapping; Sex linkage (Drosophilla). QTL mapping and its significance

Unit 4

Variation in Chromosome number and structure (8L): Deletion; Duplication; Inversion; Translocation; Position effect; Euploidy and aneuploidy.

Unit 5

Gene mutations (7L): Mutation types; Molecular basis of mutation; Mutagens- Physical and chemical mutagens (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutation (CLB method); role of Transposon in mutation; DNA repair mechanisms (light dependent repair, excision repair, mismatch repair and SOS repair), Transposable genetic elements and its significance; Bacteria-IS elements, The Tn3 family Eukaryotes L Yeast TY elements, Maize transposones, Drosophila transposones; transposones in human genome; *Alu*, Retro-transposones (LINEs and SINEs)

Unit 6

Fine structure of gene (5L): Classical vs molecular concepts of gene; Cis – Trans complementation test for functional allelism; Structure of phage T4, rII locus.

Unit 7

Population and evolutionary genetics (6L): Allele frequencies, genotype frequencies, Hardy-Weinberg law, role of natural selection, mutation,genetic drift, genetic variation and speciation(modes of speciation and genetics of speciation)

Practical

1. To study male meiosis in *Allium cepa* (two stages to be shown)
2. To understand the genetic interaction involved using the seed mixture given. Genetic ratio to be calculated using Chi square analysis.
3. To do problems based on Hardy-Weinberg`s law.
4. Pedigree analysis
5. To study/list human dominant and recessive traits and to observe the listed physical traits among the students present in the class. Data thus generated may be used for calculating allelic and genotypic frequencies using Hardy- Weinberg's principle.
6. To study the syndromes (Downs, Klinefelter/Turner/Patau/Edwards)
7. To study colour blindness/ hemophilia (Ishihara cards may be used to study colour blindness)
8. Chromosomal aberrations : Complex translocation ring, quadrivalents, lagging chromosomes, diccentric/inversion bridge

9. Xeroderma / Pigmentosum/ Sickle cell anemia

References

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). *Principles of Genetics*, 8th edition. New Delhi, Delhi: John Wiley & sons.
2. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). *Introduction to Genetic Analysis*, 10th edition. New York, NY: W.H. Freeman and Co.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*, 10th edition. San Francisco, California: Benjamin Cummings.
4. Raven, F.H., Evert, R. F., Eichhorn, S.E. (1992).*Biology of Plants*. New York, NY: W.H. Freeman and Co.

Additional Resources

1. Hartl, D.L., Ruvolo, M. (2012). *Genetics: Analysis of Genes and Genomes*, 8th edition. New Delhi, Delhi: Jones and Bartlett Learning.
2. Snustad, D.P., Simmons, M.J. (2010). *Principles of Genetics*, 5th edition. New Delhi, Delhi: John Wiley & sons.

Molecular Biology
(BOTHCC8)
Core Course - (CC) Credit:6

Course Objective (2-3)

To gain the knowledge of structure and functions of DNA and RNA

Course Learning Outcomes

1. Understanding of nucleic acid, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.
2. Processing and modification of RNA and translation process, function and regulation of expression.
3. Application in biotechnology

Unit 1. Nucleic acids as carriers of genetic information 3 lectures

Historical perspective; Experiments that established nucleic acids (DNA & RNA) as the carrier of genetic information: Griffith's,Hershey & Chase, Avery, McLeod & McCarty and Fraenkel-Conrat 's experiment .

Unit 2. The Structureand organisation of the genetic material 9 lectures

DNA Structure: Miescher to Watson and Crick- a historic perspective.DNA structure , salient features of double helix ; Types of DNA: A,B & Z conformations . Genome complexity:Concept of C-value paradox, denaturation and renaturation, $C_o t$ curves; Organization of DNA- in Prokaryotes, Viruses & Eukaryotes. Organelle DNA -- mitochondria and chloroplast DNA; Chromatin structure- Nucleosome, Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin . RNA : types of RNA molecules , structure and function of mRNA, tRNA and rRNA

Unit 3. Central Dogma and Genetic Code 3 lectures

Key experiments establishing-The Central Dogma,Genetic code (salient features & experiments that deciphered the correlation between mRNA codon and amino acid).

Unit 4. The Replication of DNA 9 lectures

Mechanism - initiation, elongation and termination, Kornberg's discovery; Enzymes and other proteins involved in DNA replication; General principles – bidirectional, semiconservative and semi discontinuous replication (Replisome), RNA priming (primase & Primosome); Various modes of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA. Replication of the 5'end of linear chromosome (end replication problem & Telomerase).

Unit 5. Mechanism of Transcription 9 lectures

Transcription in prokaryotes and eukaryotes ; Understanding the steps in process of transcription: Initiation, Elongation and Termination. Enzymes and factors involved in transcription.

Unit 6. Processing and modification of RNA 7 lectures

Split genes-concept of introns and exons, Splicing pathways, group I & group II intron splicing, Spliceosome and assembly of the spliceosome machinery , Alternative splicing, Eukaryotic mRNAprocessing (5' cap, 3' poly A tail) ; Ribozymes, RNA Editing

Unit 7. Mechanism of Translation 10 lectures

Translationin prokaryotes and eukaryotes ; Understand the steps in process of translation - Initiation, Elongation and Termination. Enzymes and factors involved in translation. Ribosome structure and assembly (in prokaryotes and eukaryotes);charging of tRNA, aminoacyl tRNA synthetases; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

Unit 8. Gene Regulation in prokaryotes and eukaryotes 10 lectures

Basic principles of transcriptional regulation: Positive & negative; Inducible & Repressible; Activators and Repressors ; Prokaryotes: Operon concept & regulation of lactose metabolism (positive and Negative) and tryptophan synthesis (Repression-Derepression and Attenuation) in *E.coli;* Eukaryotes: Gene silencing: Methylation, RNAi, Imprinting.

Practicals

1. Preparation of LB medium and raising *E. coli*

2. DNA isolation from cauliflower heads
3. Quantification of unknown DNA by diphenylamine reagent.
4. Study of experiments establishing nucleic acid as genetic material (Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)through photographs
5. Numericals based on DNA re-association kinetics (melting profiles and $C_o t$ curves)
6. Study of DNA replication through photographs: Modes of replication - Rolling circle, Theta and semi-discontinuous ; Semiconservative model of replication (Messelson and Stahl's experiment); Telomerase assisted end-replication of linear DNA
7. Study of structures of : tRNA (2D and 3D); prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozymes and Alternative splicing
9. Understanding the regulation of lactose (*lac*) operon (positive & negative regulation) and tryptophan (*trp*) operon (Repression and De-repression & Attenuation) through photographs.
10. Understanding the mechanism of RNAi by photographs.

Suggested Readings

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc.,U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). iGenetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.

Additional Resources

1. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.
2. Micklos D A., Freyer G.A. (2003) DNA Science: A First Course (2nd Edition), Cold Spring Harbor Laboratory; Greg A.,CSHL Press, USA

Ecology
(BOTHCC9)
Core Course - (CC) Credit:6

Course Objective(2-3)

To introduce the students with environmental factors affecting the plants, the basic principles of ecology and phytogeography. To make them understand complex community patterns and processes, and ecosystem functioning.

Course Learning Outcomes

It acquaint the students with complex interrelationship between organisms and environment; make them understand methods to studying vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography. This knowledge is critical in evolving strategies for sustainable natural resource management and biodiversity conservation.

Unit 1

Introduction (4 lectures): Brief History, Basic concepts, Levels of organization, Inter-relationships between the living world and the environment, the components and dynamism, homeostasis (with reference to Ecosystem).

Unit 2

Soil (8 lectures): Importance; Origin; Formation; Composition: Physical, Chemical and Biological components; Soil profile; Role of climate in soil development.

Unit 3

Water (3 lectures): Importance; States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table.

Unit 4

Light, Temperature, Wind andFire (6 lectures): Variations; adaptations of plants to their

variation.

Unit 5

Bioticinteractions (2 lectures): Definition; types of biotic interactions

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Unit 6

Population ecology (4 lectures): Distribution and characteristics of populations; population growth; population dynamics; Ecological Speciation (Ecads, ecotypes, ecospecies, etc)

Unit 7

Plantcommunities(9 lectures): Concept of ecological amplitude; Habitat (types) and Ecological niche (types); Community characters (analytical and synthetic); Ecotone and edge effect; Methods to studying vegetation; Dynamics of communities; Succession: processes, types (Lithosere, Hydrosere); climax concepts.

Unit 8

Ecosystems (5 lectures): Structure; Types; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids.

Unit 9

Functional aspects ofecosystem **(9 lectures):** Principles and models of energy flow; Production and productivity; Measurement of productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.

Unit 10

Phytogeography (10 lectures): Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Vegetation of Delhi.

Practical

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovi bond comparator and pH paper)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.
5. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
6. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
7. (a). Study of morphological adaptations of hydrophytes and xerophytes (four each).

(b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Rootparasite (Orobanche), Epiphytes, Predation (Insectivorous plants).

8. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
11. Field visit to familiarize students with ecology of different sites.

References

1. Odum, E.P. (2005). *Fundamentals of Ecology*. New Delhi, India: Cengage Learning India Pvt. Ltd., 5th edition.
2. Kormondy, E.J. (1996). *Concepts of Ecology*. New Delhi, India:PHI Learning Pvt. Ltd. 4th edition.
3. Sharma, P.D. (2010). *Ecology and Environment*. Meerut, India: Rastogi Publications. 8th edition
4. Singh, J.S., Singh, S.P., Gupta, S.R. (2014). *Ecology, Environmental Science and Conservation.* New Delhi, India: S. Chand.

Additional Resources:

1. Ambasht, R.S. and Ambasht, N.K. (2008). *A text book of Plant Ecology*, CBS Publishers & Distributors PVT. LTD.
2. Majumdar, R and Kashyap, R (2019). *Practical Manual of Ecology and Environmental Science*, New Delhi, India: Prestige Publishers
3. Singh, J.S., Singh, S.P., Gupta, S. (2006). *Ecology, Environment and Resource Conservation.* New Delhi, India: Anamaya Publications.
4. Wilkinson, D.M. (2007). *Fundamental Processes in Ecology.* USA: An Earth Systems Approach.Oxford University Press.

Plant Systematics
(BOTHCC10)
Core Course - (CC) Credit:6

Course Objective (2-3)

To gain the knowledge on the taxonomy, phylogeny of plants

Course Learning Outcomes

Understanding of systematics its importance in bioresource utilization and biodiversity management.Nomenclature pattern, Phylogeny, Classification systems of the plants.

Unit 1

Plant identification, Classification, Nomenclature, Biosystematics (2 lectures)

Unit 2

Identification (6 lectures)
Field inventory; Herbarium Techniques; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual Herbarium; E-flora: Flora, Monographs, Journals; Keys: Single Access and Multi-access.

Unit 3

Systematics-an interdisciplinary science (6 lectures)
Evidence from palynology, cytology, phytochemistry [Alkaloids, Phenolics, Glucosides, terpenes and Semantides (in brief)] and molecular data (cp.DNA, mt-DNA, nuclear DNA, PCR amplification, sequence data analysis)

Unit 4

Taxonomic hierarchy (6 lectures)
Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary)

Unit 5

Botanical nomenclature (10 lectures)
Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids and cultivated plants.

Unit 6

Systems of classification (10 lectures)
Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Benthan and Hooker (up to series) and Engler and Prantl (up to series); Brief references of Angiosperm Phylogeny Group (APG IV) classification.

Unit 7

Biometrics and numerical taxonomy (8 lectures)
Characters; Variations; OTUs, character weighing and coding; cluster analysis; Phenograms

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Unit 8

Phylogeny of Angiosperms (12 lectures)
Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Cladistics; methods of illustraring evolutionary relationships (phylogenetic tree, cladogram)

Practical

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formul/e and systematic position according to Bentham and Hooker's system of classification)
Ranunculaceae- *Ranunculus, Delphinium*
Brassicaceae- *Brassica, Alyssum/ Iberis*
Myrtaceae- *Eucalyptus, Callistemon*
Umbelliferae-*Coriandrum/ Anethum/ Foeniculum*
Asteraceae- *Sonchus/ Launaea, Veronia/ Ageratum, Elipta/ Tridax*
Solanaceae- *Solanum nigrum/ Withania*
Lamiaceae- *Salvia/Ocimum*
Euphorbiaceae-*Euphorbia hirta/ E.milli, Jatropha*
Liliaceae- *Asphodelus/ Lilium/ Allium*
Poaceae- *Triticum/ Hordeum/ Avena*
Malvaceae-*Abutilon/ Hibiscus/ sida*

Caryophyllaceae-*Stellaria/ Dianthus*

Apocyanaceae- *Vinca rosea*
Asclepediaceae- *Calotropis procera*
Moraceae- *Morus alba*
Chenopodiaceae- Chenopodium alba
Cannaceae- *Canna indica*
Ten familes should be selected out of the given list of seveteen families representing the following
Class/ Subclass as mentioned below:
Polypetalae- Any 3 families
Gamopetalae- Any 3 families
Monochlamydeae- Any 2 families
Monocotyledons- Any 2 families
2. Field visit (local)- Subject to grant funds from the University
3. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

References

1. Reven, F.H., Evert, R. F., Eichhorn, S.E. (1992). *Biology of Plants*. New York, NY: W.H. Freeman and Company.
2. Singh, G. (2012). *Plant Systematics: Theory and Practice*, 3rd edition. New Delhi, Delhi: Oxform and IBH Pvt. Ltd.

Reproductive Biology of Angiosperms
(BOTHCC11)
Core Course - (CC) Credit:6

Course Objective(2-3)

To have knowledge of the flowering and fruiting, reproduction process, role of pollinators, ovule and seed development.

Course Learning Outcomes

Student would have an understanding of

1. Induction of flowering and molecular and genetic aspects of flower development.
2. Pollen development, dispersal and pollination
3. Ovule development and fertilization,
4. Endosperm development and its importance
5. alternation pathways of reproduction
6. Student would be able to apply this knowledge for conservation of pollinators and fruit development

Unit 1

Introduction (2 lectures)
History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope of Reproductive Biology.

Unit 2

Anther (4 lectures)
Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance.

Unit 3

Pollen biology (8 lectures)

Micro-gametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system (no details but table to be included); Palynology and scope (a brief account); Pollen wall proteins;

Pollen viability, storage and germination; Unique features: Pseudomonads, polyads, massulae, pollinia.

Unit 4

Ovule (8 lectures)
Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac; Female germ Unit

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Unit 5

Pollination and fertilization (6 lectures)
Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; structure of pollen tube; double fertilization.

Unit 6

Self incompatibility (8 lectures)
Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intraovarian and in vitro pollination; Modification of stigma surface, parasexual hybridization; Cybrids(in brief with examples) , in vitro fertilization.

Unit 7

Endosperm (4 lectures)
Types (2 examples each), development, structure and functions.

Unit 8

Embryo (6 lectures)
Six types of Embryogeny (no details) ; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia***.**

Unit 9

Seed (4 lectures)

Structure, importance and dispersal mechanisms(Adaptations – Autochory, Anemochory, Hydrochory, Zoochory with 2 examples each).

Units 10

Polyembryony and apomixes (6 lectures)
Introduction; Classification (given by Bhojwani and Bhatnagar); Causes and applications.

Unit 11

Germline transformation (4 lectures)
Pollen grain and ovules through pollen tube pathway method

Practical

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. Pollen grains: Fresh pollen showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall(micrograph); Pollen viability: Tetrazolium test.germination: Calculation of percentage germination in different media using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
4. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
5. Intra-ovarian pollination; Test tube pollination through photographs.
6. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
7. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.
8.Seed dispersal mechanisms (adaptations through photographs / specimens)
9.Flourescent Microscopes can be purchased for the colleges.
(a) Study of pollen cytology to see 2-celled and 3-celled pollen grains.
(b) To perform pollen culture.
(c) To isolate protoplast from pollen grains.
(d) To study pollen-pistil interactions (fluorescent microscopes).

References

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). *The Embryology of Angiosperms*, 5th edition. New Delhi, Delhi: Vikas Publishing House.
2. Johri, B.M. (1984). *Embryology of Angiosperms.* Netherlands: Springer-Verlag.

3. Raghavan, V. (2000). *Developmental Biology of Flowering plants.* Netherlands: Springer

4. Shivanna, K.R. (2003). *Pollen Biology and Biotechnology*. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Plant Physiology
(BOTHCC12)
Core Course - (CC) Credit:6

Course Objective(2-3)

The course aims at making students realize how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.

Course Learning Outcomes

The students are able to correlate morphology, anatomy, cell structure and biochemistry with plant functioning. The link between theory and practical syllabus is established, and the employability of youth would be enhanced. The youth can also begin small-scale enterprises.

Unit 1

Plant water relationship (10 lectures)
Water potential and its components, water absorption by roots, aquaporins, pathway of water movement--symplast, apoplast, transmembrane pathways, root pressure, guttation, ascent of sap--cohesion-tension theory, transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement--starch-sugar hypothesis, proton transport theory, blue light stimulated response.

Unit 2

Mineral nutrition (8 lectures)
Essential and beneficial elements, macro- and micronutrients, methods of study and use of nutrient solutions (ash analysis, hydroponics, aeroponics), criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents (includingphytosiderophores).

Unit 3

Nutrient uptake (8 lectures)
Soil as a nutrient reservoir, transport of ions across cell membrane--passive absorption: simple (Fick's law) and facilitated diffusion (carrier and channel proteins), active absorption, proton

ATPase pump, electrochemical gradient, ion flux, uniport, co-transport (symport, antiport), role of mycorrhizae (in brief).

Unit 4

Translocation in the phloem (6 lectures)
Experimental evidence in support of phloem as the site of sugar translocation, composition of phloem sap, aphid stylet technique, Pressure-Flow Model, phloem loading and unloading, source-sink relationship.

Unit 5

Plant growth regulators (16 lectures)
Discovery, chemical nature (basic structure, precursor), bioassay, physiological roles and commercial applications of Auxins, Gibberellins, Cytokinins, Abscisic Acid, Ethylene; brief introduction: mechanism of action of auxins; Brassinosteroids and Jasmonic acid (brief introduction).

Unit 6

Physiology of flowering (6 lectures)
Photoperiodism, concept of florigen, CO-FT Model for long-distance transport of flowering stimulus, ABC model of flowering (in brief), vernalization, seed dormancy (causes and methods to overcome dormancy).

Unit 7

Phytochrome (6 lectures)
Discovery, chemical nature, role of phytochrome in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Determination of water potential of given tissue (potato tuber) by falling drop method.
4. Study of the effect of light on the rate of transpiration in excised twig/ leaf.
5. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and a xerophyte.
6. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and a xerophyte (any one surface).
7. To study the phenomenon of seed germination (effect of light and darkness).

8. To study the induction of amylase activity in germinating barley grains.

Demonstration experiments

1. To demonstrate suction due to transpiration.
2. Fruit ripening.
3. Rooting from cuttings.
4. Bolting experiment.
5. To demonstrate the delay of senescence by cytokinins

References

1. Bajracharya, D. (1999). *Experiments in Plant Physiology: A Laboratory Manual*. New Delhi, Delhi: Narosa Publishing House.
2. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism*. Singapore: Springer Nature, Singapore Pvt. Ltd.
3. Hopkins, W. G., Huner, N. P. A. (2009). *Introduction to Plant Physiology*, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.
4. Kochhar, S.L., Gujral, S.K. (2017). *Plant Physiology: Theory and Applications*. New Delhi, Delhi: Foundation Books, Cambridge University Press India Pvt, Ltd.

Additional Resources:
6. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). *Plant Physiology and Development*, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.

Plant Metabolism
(BHCC13)
Core Course - (CC) Credit:6

Course Objective(2-3)

1. A comprehensive study of different pathways including their biochemistry and to some extent the molecular details.
2. Current understanding of regulation and integration of metabolic processes in plants with reference to crop productivity.
3. Significance of metabolic pathways for metabolic engineering in producing transgenics.
4. To gain the knowledge of physiological and biochemical processes in the plant system

Course Learning Outcomes

- Concept and significance of metabolic redundancy in plants.
- Students will also be able to learn the similarity and differences in metabolic pathways in animals and plants.
- To have understanding of water and nutrient uptake and movement in plants, role of minerl elements, translocation of sugars, Role of various plant growth regulatoras, phytochrome cytochromes and phototropins, and flowering stimulus.

Unit 1

Concept in Metabolism (4lectures)
Introduction, anabolic and catabolic pathways, Principles of thermodynamics, coupled reactions

Unit 2

Enzymes (10 lectures)
Historical Background, structure, nomenclature and classification of enzymes, Mechanism of action (activation energy, lock and key, induced fit model), Michaelis Menten equation, enzyme inhibition (competitive, non-competitive and uncompetitive), factors affecting enzyme activity, role of regulatory enzymes, allosteric regulation and covalent modulation, isozymes and alloenzymes

Unit 3

Carbon assimilation (14 lectures)

Historical background, concept of light-action and absorption spectra, photosynthetic pigments, role of photosynthetic pigments (chlorophyll and accessory pigments (no structural details), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, photophosphorylation, PSI, PSII, Q cycle, CO_2 reduction, photorespiration, C4 pathways, Crassulacean acid metabolism, factors affecting CO_2 reduction

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Unit 4

Carbohydrate metabolism (2lectures)
Metabolite pool and exchange of metabolites, synthesis and catabolism of sucrose and starch (no structural details)

Unit 5

Carbon Oxidation (10 lectures)
Historical Background of Glycolysis and Krebs cycle, Glycolysis, fate of pyruvate- aerobic and anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of Kerbs cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Unit 6

ATP synthesis (4lectures)
Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyer's conformational model, Racker's experiement, Jagendorf's experiement, role of uncouplers, P/O ratio

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Unit 7

Lipid Metabolism (8 lectures)
Synthesis and breakdown of triglycerides, -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination, -oxidation.

Unit 8

Nitrogen Metabolism (8 lectures)
Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes), Physiology and biochemistry of nitrogen fixation, Ammonia assimilation (GS-GOGAT), reductive amination and transamination.

Practical

1.To study the activity of urease enzyme and effect of substrate concentration and temperature on enzyme activity.
2. To study the activity of catalase enzyme and effect of heavy metal and pH on enzyme activity.
3. To study the activity of peroxidase and tryosinase and effect of inhibitor (phenylthiourea of tryosinase and sodium azide of peroxidase) on any one of the enzymes.
4. Chemical separation of photosynthetic pigments.
5. Experimental demonstration of Hill's reaction.
6. To demonstrate and verify Blackman's law of limiting factors.
7. To compare the rate of respiration in different parts of a plant (at least 3 parts).
8. To study activity of Nitrate reductase in leaves of two plant sources.
9. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
10. Demonstration of fluorescence by isolated chlorophyll pigments.
11. Demonstration of absorption spectrum of photosynthetic pigments.
12. Demonstration of respiratory quotient (RQ).

References

1. Bhatla, S.C., Lal,M.A. (2018). *Plant Physiology, Development and Metabolism.* Singapore: Springer.
2. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). *Biochemistry and Molecular Biology of Plants*, 2nd edition. New Jearsey, U.S.: Wiley Blackwell.
3. Hopkins, W.G., Huner, N. (2008). *Introduction of Plant Physiology*, 4th edition. New Jearsey, U.S.: John Wiley and sons.
4. Jones, R.,Ougham, H., Thomas,H.,Waaland, S. (2013). *The molecular life of plants.* Chichester, England: Wiley-Blackwell.

Additional Resources:

5. Nelson, D.L., Cox, M.M. (2017). *Lehninger Principle of Biochemistry*, 7th edition. New York, NY: W.H. Freeman, Macmillan learning.
6. Taiz, L., Zeiger, E., MØller, I.M., Murphy, A. (2015). *Plant Physiology and Development*, 6th edition. Massachusetts: Sinauer Associates Inc.Sunderlands.

Plant Biotechnology
(BHCC14)
Core Course - (CC) Credit:6

Course Objective(2-3)

1. The objective of the course is to give students new knowledge and widening of the knowledge acquired in other course by handling of classical and modern plant biotechnology processes, including tissue culture for healthy plants, plants with improved characteristics.
2. This course explores the use of biotechnology to both generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation.
3. Understanding of biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals (vaccines, antibodies, antibiotics etc.), food industry (transgenic crops with improved qualities (nutraceuticals, industrial enzymes etc.), agriculture (biotic and abiotic stress tolerant plants, disease and pest resistant plants, improved horticultural varieties etc.), ecology (plants role in bioremediation). This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.
4. In the laboratory classes, students will perform some of the techniques currently used to generate information and detect genetic variation.

Course Learning Outcomes

The successful students will be able to:

- Learn the basic concepts, principles and processes in plant biotechnology.
- Have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.
- Use basic biotechnological techniques to explore molecular biology of plants
- Explain how biotechnology is used to for plant improvement and discuss the biosefty concern and ethical issue of that use.

Unit 1

Plant Tissue Culture (12 lectures)
Historical perspective, Composition of media; Nutrient and hormone requirements (role of

vitamins and hormones); Plasticity andTotipotency; Organogenesis; Embryogenesis (somatic and zygotic);

Unit 2

Protoplast isolation, culture and fusion; Tissue culture applications(micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and cybrids; Cryopreservation; Germplasm Conservation).

Unit 3

Recombinant DNA technology (32 lectures)
Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (PUC 18 and pUJC19, pBR322. Ti plasmid, BAC); Lambda phage, Ml 3 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC and briefly PAC,).

Unit 4

Gene Cloning (Recombinant DNA. Bacterial Transformation and selection of recombinant clones, PCR and RT-PCRmediated gene cloning); Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, PCR; Methods of gene transfer-Agrohacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment: Selection of transgenics— selectable marker and reporter genes (Luciferase, GUS, GFP).DNA fingerprinting by RAPD and RFLP;

Unit 5

Applications of Biotechnology (16 lectures)
Engineering plants to overcome abiotic (drought and salt stress) and biotic stress Pest resistant (Bt-cotton) and herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato. Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug)

Unit 6

Molecular farming(Plants as bioreactors)for edible vaccines, antibodies, polymers, biodegradable plastics(PHA), biomass utilization andindustrial enzymes) (- amylase, phytase, lignocelluloses

degrading enzymes); Biosatety concerns.

Practical

l. (a) Preparation of Murashige & Skoog's (MS) medium.
(b) Demonstration of in vitro sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
2. Study of anther. embryo and endosperm culture, micropropagation. somatic embryogenesis & artificial seeds through photographs.
3. Isolation of protoplasts.
4. Construction of restriction map of circular and linear DNA from the data provided.
5. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
6. Study of steps of genetic engineering for production of *Bt* cotton, Golden rice, FlavrSavr tomato through photographs.
7. Isolation of plasmid DNA.
8. Restriction digestion and gel electrophoresis of plasmid DNA (demonstration/ photograph).
9. Calculate the percentage similarity between different cultivars of a species using RAPD profile. Construct a dendrogram and interpret results.

References

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). *The Embryology of Angiosperms*, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
2. Bhojwani, S.S., Razdan, M.K., (1996). *Plant Tissue Culture: Theory and Practice.* Amsterdam, Netherlands: Elsevier Science.
2. Glick, B.R., Pasternak, J..J.(2010). *Molecular Biotechnology: Principles and Applications.* Washington, U.S.: ASM Press.
4. Snustad, D.P.,Simmons, M.J. (2010). *Principles of Genetics*, 5th edition. Chichester, England: John Wiley and Sons.

Additional Resources

1. Stewart, C.N. Jr. (2008). *Plant Biotechnology and Genetics: Principles, Techniques and Applications.* New Jearsey, U.S.: John Wiley & Sons Inc.

Analytical Techniques in Plant Sciences
(BOTHDS1)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

To gain the knowledge on various techniques and instruments used for the study of plant biology

Course Learning Outcomes

Understanding of principles and use of light, confocal transmission and electron microscopy, centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques

Unit 1

Imaging and related techniques (15 lectures)
Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescencemicroscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2

Cell fractionation (8 lectures)
Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CaCl2 gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3

Radioisotopes (4 lectures)
Use in biological research, auto-radiography, pulse chase experiment.

Unit 4

Spectrophotometry (4 lectures)
Principle and its application in biological research.

Unit 5

Chromatography (8 lectures)
Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6

Characterization of proteins and nucleic acids (6 lectures)
Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE

Practical

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Demonstration of ELISA.
3. To separate nitrogenous bases by paper chromatography.
4. To separate sugars by thin layer chromatography.
5. Isolation of chloroplasts by differential centrifugation.
6. To separate chloroplast pigments by column chromatography.
7. To estimate protein concentration through Lowry's methods.
8. To separate proteins using PAGE.
9. To separation DNA (marker) using AGE.
10. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
11. Preparation of permanent slides (double staining).

References

1. Plummer, D.T. (1996). *An Introduction to Practical Biochemistry*, 3rd edition. New Delhi, Delhi: Tata McGraw-Hill Publishing Co. Ltd.
2. Ruzin, S.E. (1999). *Plant Microtechnique and Microscopy.* New York, NY: Oxford University Press.

Bioinformatics
(BOTHDS3)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

A computer-based approach is now central to biological research. Bioinformatics operates at the intersection of biology and informatics and has a strong mathematical component. Training students in various aspects of Bioinformatics is the objective of this course.

Course Learning Outcomes

With a working knowledge of the practical and theoretical concepts of bioinformatics, you will be well qualified to progress onto advanced graduate study. The portfolio of skills developed on the programme is also suited to academic research or work within the bioinformatics industry as well as range of commercial settings.

Unit 1

Introduction to Bioinformatics (10 lectures)
Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.

Unit 2

Biological databases (5 lectures)
Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol).

Unit 3

Data Generation and Data Retrieval (5 lectures)
Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)

Unit 4

Basic concepts of Sequence alignment (10 lectures)
Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and BLOSUM), and CLUSTALW.

Unit 5

Phylogenetic analysis (10 lectures)
Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.

Unit 6

Applications of Bioinformatics (20 lectures)
Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

Practical

1. Sequence retrieval (protein and gene) from NCBI.
2. Structure download (protein and DNA) from PDB.
3. Molecular file formats - FASTA, GenBank, Genpept, GCG, CLUSTAL, Swiss-Prot, FIR.
4. Molecular viewer by visualization software.
5. Translate a nucleotide sequence and select the correct reading frame of the polypeptide from the output sequences.
6. Predict the structure of protein from its amino acid sequence.
7. BLAST suite of tools for pairwise alignment.
8. Sequence homology and Gene annotation.

9. Construction of phylogenetic tree.

10. Generating phylogenetic tree using PHYLIP.
11. Gene prediction using GENSCAN and GLIMMER.

References

1. Ghosh, Z., Mallick, B. (2008). *Bioinformatics – Principles and Applications*, 1st edition. New Delhi, Delhi: Oxford University Press.
2. Baxevanis, A.D. and Ouellette, B.F., John (2005). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, 3rd edition. New Jersey, U.S.: Wiley & Sons, Inc.
3. Roy, D. (2009). *Bioinformatics*, 1st edition. New Delhi, Delhi: Narosa Publishing House.
4. Andreas, D., Baxevanis, B.F., Francis, Ouellette. (2004). *Bioinformatics: A practical guide to the analysis of genes and proteins*, 3rd edition. New Jersey, U.S.: John Wiley and Sons.

Additional Resources:

1. Pevsner J. (2009). *Bioinformatics and Functional Genomics*, 2nd edition. New Jersey, U.S.: Wiley Blackwell.
2. Xiong J. (2006). *Essential Bioinformatics*,1st edition. Cambridge, U.K.: Cambridge University Press.

Biostatistics
(BOTHDS2)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

To have knowledge of analysis of scientific data

Course Learning Outcomes

Understanding of interpreting the scientific data that is generated during scientific experiments. It is the responsibility of biostatisticians and other experts to consider the variables in subjects to understand them, and to make sense of different sources of variation. In essence, the goal of biostatistics is to disentangle the data received and make valid inferences that can be used to solve problems in public health. Biostatistics uses the application of statistical methods to conduct research in the areas of biology, public health, and medicine. Many times, experts in biostatistics collaborate with other scientists and researchers.

Unit 1

Biostatistics - definition - statistical methods - basic principles. Variables -measurements, functions, limitations and uses ofstatistics. (8 lectures)

Unit 2
Collection of data primary and secondary - types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data – sampling methods. (12 lectures)

Unit 3

Measures of central tendency - mean, median, mode, merits & demerits of harmonic and geometric mean - . Measures of dispersion - range, standard deviation, mean deviation, standard error, skewness and kurtosis, quartile deviation –merits and demerits; Co- efficient of variations. (13

lectures)

Unit 4

Correlation - types and methods of correlation, regression, simple regression equation,

fitting prediction, similarities and dissimilarities of correlation and regression.
(10 lectures)

Unit 5

Statistical inference - hypothesis - simple hypothesis - student't' test - chi square test, Ftest.
(10 lectures)

Unit 6

Basic concept of probability, Introduction to bionomial, poisson and Normal distribution; Uses of advance softwares (MS-excel, SPSS, Sigmaplot and R) in modern biostatistics. (6 Lectures)

Practical

1) Classification - tabulation and presentation of data
2) Calculation of mean, mode, median, standard deviation, quartile deviation, standard error and coefficient of variance
3) Calculation of correlation coefficient values by Karl Pearson's and Spearman Rank methods
4) Statistical inference - hypothesis – student 't' test - chi square test
5) Addition and multiple rules of probability
6) One way analysis of variance
7) Uses of software in biostatistics

References

1. Bishop, O.N., (1967). *Statistics for Biology.* Boston, Massachusetts: Houghton Mifflin Company.
2. Campbell, R.C. (1998). *Statistics for Biologists.* Cambridge, U.S.A.: Cambridge University Press.
3. Danniel, W.W. (1987). *Biostatistic.* New York,NY: John Wiley Sons.
4. Freedman, P. (1949). *The Principles of scientific research.* New York, NY: Pergamon Press.
5. Khan, I.A., Khanum, A. (2004). *Fundamentals of Biostatistics,* 5th edition. Hyderabad: Ukaaz publications.

Additional Resources:
6. Pandey, M. (2015). *Biostatistics Basic and Advanced.* New Delhi, Delhi: M V Learning.

7. Selvin, S., (1991). *Statistical Analysis of epidemiological data.* New York, NY: New York

University Press.

8. Sundarrao, P.S.S., Richards, (1996). *An introduction to Biostatistics*, 3rd edition. Vellore, Tamil Nadu: J. Christian Medical College.

9. Zar, J.H. (2012). *Biostatistical Analysis*, 4th edition. London, London: Pearson Publication.

Plant Breeding
(BOTHDS4)
Discipline Specific Elective - (DSE) Credit:6

Course Objectives

To gain knowledge on commercially important plants, their breeding systems and strategies employed for crop improvement.

Course Learning Outcomes

Student would be able to understand the experimental steps and methods involved in generating new varieties using classical and contemporary breeding practices.

Unit 1:

An introduction to Plant Breeding (10 lectures)

Introduction and objectives. Breeding systems: modes of reproduction in crop plants. **Self-incompatibility, male sterility and apomixis.**Important achievements and undesirable consequences of plant breeding.

Unit 2: Methods of crop improvement (20 lectures)
Introduction: Centers of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross pollinated and vegetatively propagated plants;, Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.

Unit 3: Quantitative inheritance (10 lectures)

Concept, mechanism, Monogenic vs polygenic Inheritance, **QTL and QTL Mapping,**
Case studies in inheritance of Kernel colour in wheat, Fruit quality in tomato.

Unit 4: Inbreeding depression and heterosis (10 lectures)

History, genetic basis of inbreeding depression and heterosis; Applications.

Unit 5: Crop improvement and breeding (10 lectures)

Role of mutations; Polyploidy; Distant hybridization, **Molecular Breeding, Marker assisted selection**, Role of biotechnology in crop improvement.

Practicals (tentative species: Pea, *Brassica*, Chickpea, Wheat*)

1. Introduction to field /controlled pollinations in field and laboratory (temporal details of anthesis, anther dehiscence, stigma receptivity and pollen viability, emasculation, bagging).
2. Analysis of the breeding system of chosen crop species by calculating Pollen:Ovule Ratio
3. Calculation of Index of self-incompatibility (ISI) and Confirmation of Self-Incompatibility.
4. Study of Quantitative and qualitative characters in select crops.
6. Study of Pollinators.
7. Assessment of genetic diversity by using Molecular Markers.

References

1. Acquaah, G. (2007). *Principles of Plant Genetics & Breeding*.New Jearsey, U.S.: Blackwell Publishing.

3. Singh, B.D. (2005). *Plant Breeding: Principles and Methods,* 7th edition. New Delhi, Delhi: Kalyani Publishers.

2. Chaudhari, H.K. (1984). *Elementary Principles of Plant Breeding,* 2nd edition. New Delhi, Delhi: Oxford – IBH.

Biofertilizers
(BOTHSE2)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

To gain the knowledge on the following aspects

1. Eco-friendly fertilizers like Rhizobium, Azospirilium Azotobactor, cyanobacteria and mycorrhizae, their identification, growth multiplication
2. Organic farming and recycling of the organic waste

Course Learning Outcomes

The student would have a deep understanding of ecofriendly fertilizers. They will be able to understand the growth and multiplication conditions of useful microbes such as Rhizobium, cyanobacteria, mycorrhizae, Azotobactor etc, their role in mineral cycling and nutrition to plants. The can also think of the methods of decomposition of biodegradable waste and convert into the compost

Unit 1

General account about the microbes used as biofertilizer – Rhizobium – isolation,identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis. (4 lectures)

Unit 2

Azospirillum: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms.Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication. (8 lectures)

Unit 3

Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation. (4 lectures)

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolationand inoculum production of VAM, and its influence on growth and yield of crop plants. (8 lectures)

Unit 5

Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application. (6 lectures)

References

1. Dubey, R.C. (2005). *A Text book of Biotechnology.* New Delhi, Delhi: S.Chand & Co.
2. John Jothi Prakash, E. (2004). *Outlines of Plant Biotechnology.* New Delhi, Delhi: Emkay Publication.
3. Kumaresan, V. (2005). *Biotechnology.* New Delhi, Delhi: Saras Publication.
4. Sathe, T.V. (2004). *Vermiculture and Organic Farming.* New Delhi, Delhi: Daya publishers.
5. Subha Rao, N.S. (2000). *Soil Microbiology.* New Delhi, Delhi: Oxford & IBH Publishers.

Additional Resources:
6. Vayas,S.C, Vayas, S., Modi, H.A. (1998). *Bio-fertilizers and organic Farming.* Nadiad, Gujarat: Akta Prakashan.

Floriculture
(BOTGSE53)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

To have knowledge of gardening and cultivation of ornamental plants and knowledge of landscaping, soil condition.

Course Learning Outcomes

Students would be able to identify the ornamental plants, They will have an understanding of cultivation methods, landscaping and making the flower arrangement.

Unit 1

Unit 1: Introduction: History of gardening; Importance and scope of floriculture and landscape gardening. (2 Lectures)

Unit 2

Unit 2: Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators. (8 lectures)

Unit 3

Unit 3: Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms andCycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai. (4lectures)

Unit 4

Unit 4: Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India. (4 lectures)

Unit 5

Unit 5: Landscaping Places of Public Importance: Landscaping highways and Educational institutions. (4 lectures)

Unit 6

Unit 6: Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold,Rose,Lilium, Orchids). (6 lectures)

Unit 7:Diseases and Pests of Ornamental Plants.**(2 lectures)**

Practical

1. Study of flower with reference to stamens and gynoecium
2. Study of Soil sterilization process
3. Seed sowing and transplantation methods
4. Garden designing and hedge preparation methods
5. patterns of flower arrangement in vase
6. study of disease and pastes of ornamental plants

References

1. Randhawa, G.S., Mukhopadhyay, A. (1986). *Floriculture in India.* New York, NY: Allied Publishers.

Mushroom Culture Technology
(BOTGSE4)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

Objective of this paper to make aware student about the mushroom growing techniques.
Mushrooms have medicinal and nutritional value students will be make aware of that.
National and international market that helps in economy of country students will be make aware about this also as this is low cost input process but benefits/outcomes are high.

Course Learning Outcomes

As mushroom cultivation is a booming field Goverment of India is also supporting this type of work because students can learn the techniques and small scale and large scale industries can be established by the students. Hand on experience will be given to students so they can utilize this training in long run. In small area also they can establish the bussiness..

Unit 1

Introduction, history, Nutritional and medicinal value of edible mushrooms, Poisonous mushrooms, Types of edible mushrooms availablein India: *Volvariella,Volvacea , Pleurotus citrinopileatus, Agaricus bisporus.*

Unit 2

Cultivation technology,Infrastructure substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculationloop, low cost stove, sieves, culture rack, mushroomunit (Thatched house) water sprayer, tray, small polythene bags, Pure culture, Medium psterlization , preperation spawn, multiplication, mushroom bed preperation, paddy straw, sugarcane trash, maize straw, banana leaves, Factors affecting the mushroom bed preperation -- low cost technology, compostingtechnology in mushroom production.

Unit 3

Storage and nutrition,short term storage (Refrigeration upto 24 hours) long term storage (canning, pickels and papads) drying, storage in salt solutions, . Nutrition- proteins, amino acids, mineral elements nutrition- carbohydrates, crude fibre content- vitamins.

Unit 4

Food preperation , Types of food prepared from mushroom. Research centers-- National level and Regional level ,, Cost benefit ratio-- Marketing in India and abroad, Export value.

Practical

1. Principle and functioning of instruments used in the various techniques.
2. Preperation of various types of media.
3. Preperation of spawn.
4. Study of poisnous and non poisonous mushroom
5. Study of diseases of mushroom.
6. Nutritional and market value of mushroom
7. Centres of mushroom
8. Techniques for the cultivation of *Agaricus , Pleurotus and Ganoderma*
9. *Visit to Institute and* cultivation centre.

References

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan, R. (1991) Oyster Mushrooms,Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan , M. (1990) Food and Nutrition. Bappco, The Banglore Printing and Publishing Co. LTD, No. 88, Mysore Road, Banglore- 560018.
3. Tewari, Pankaj Kappor, S.C.(1998) Mushroom cultivation, Mittal Publications , Delhi.
4. Nita Bahi (1984-1988) Hand book of Mushrooms, II Edition, vol. I& II.

Nursery and Gardening(BOTHSE1)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To gain knowledge of gardening , cultivation, multiplication , raising of seedlings of ornamental plants

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Course Learning Outcomes

Students would have an understanding of
How nursery of the plants is prepared?
How rooting is promoted in the stem cuttings?
How seeds are stored and what are the soil conditions for seed sowing and seedling growth?
How landscaping is designed?

Unit 1
Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.(4 Lectures)

Unit 2
Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion - Seed production technology - seed testing and certification. (6 Lectures)

Unit 3
Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants - green house - mist chamber, shed root, shade house and glass house. (6Lectures)

Unit 4
Gardening: definition, objectives and scope - different types of gardening - landscape and home gardening - parks and its components - plant materials and design - computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting. (8 Lectures)

Unit 5
Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage

and marketing procedures. **(6 Lectures)**

Practical

1. Breaking of seed dormancy
2. Seed viability tests
3. Preparation of stem cutting, air layering
4. soil layering and manuring
5. compost preparation
6. Diseases and pests of plants

References

1. Agrawal, P.K. (1993). *Hand Book of Seed Technology*. New Delhi, Delhi: Dept. of Agriculture and Cooperation, National Seed Corporation Ltd.
2. Bose T.K., Mukherjee, D. (1972). *Gardening in India*. New Delhi, Delhi: Oxford & IBH Publishing Co.
3. Jules, J. (1979). *Horticultural Science*, 3rd edition. San Francisco, California: W.H. Freeman and Co.
4. Kumar, N. (1997). *Introduction to Horticulture*. Nagercoil, Tamil Nadu: Rajalakshmi Publications.

Additional Resources:

1. Musser E., Andres. (2005). *Fundamentals of Horticulture*. New Delhi, Delhi: McGraw Hill Book Co.
2.Sandhu, M.K. (1989). *Plant Propagation.* Madras, Bangalore: Wile Eastern Ltd.

Biodiversity (Microbes, Fungi, Algae and Archegoniates)
(BOTHGE1)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

Biodiversity generally refers to the variety and variability of life on earth. Plants are relevant to humans as they provide us with food, shelter, clothing, energy, health, aesthetic beauty, environment and even economy. This paper is relevant to ALL students.

1. Introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi, to various plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms).
2. Information on the Ecological and Economic Importance of Microbes, Fungi and various plant groups to enable students understand and appreciate relevance of Microbes and Plants to environment and human well-being.
3. Insight into the line of Plant Evolution on Earth and the consequent Biodiversity is instrumental in creating Awareness on the threats to biodiversity and sensitize young minds towards the Biodiversity Conservation for sustainable development.

Course Learning Outcomes

1. Combination of Theoretical and Practical components will provide comprehensive information and insight into the fascinating world of Microbes and Plants.
2. Hands on Training will help students learn use of microscope, mounting, section-cutting and staining techniques for the study of plant materials.
3. Making Drawings in Practical Records will enhance understanding morphological and structural details and related functional aspects in diverse plant groups.
4. Use of Illustrations, Photographs, Charts, Permanent Slides, Museum and Herbarium Specimens along with ICT Methods will provide an interesting insight into the beautiful world of microbes and plants.
5. Scope of Biodiversity includes Medicinal field, Industry, Agriculture, Research and Study, Job Opportunities and Environmental Conservation. This paper is both informative and interesting and will enable students to learn about Biodiversity not only as a plant or nature lover, but also for higher academic pursuits, particularly in the field ofBiological Sciences, Environment and Biodiversity Conservation.

Unit 1

MICROBES (14 Lectures)

a) **Viruses** – Discovery; General Structure- RNA virus (TMV) and DNA virus (T-phage); Replication-Lytic and Lysogenic Cycle; Economic Importance.
b) **Bacteria** – Discovery; General Characteristics and Cell Structure; Reproduction-Vegetative, Asexual and Genetic Recombination (Conjugation, Transformation and Transduction); Economic Importance.

Unit 2
FUNGI (8 Lectures)
General Characteristics; Outline Classification (Webster); Economic Importance; Thallus Organization and Reproduction in *Rhizopus*, *Penicillium*, *Alternaria* and *Puccinia*.

Unit 3
ALGAE (8 Lectures)
General Characteristics; Outline Classification (Fritsch); Economic Importance; Thallus Organization and Reproduction in *Nostoc*, *Chlamydomonas*, *Vaucheria* and *Ectocarpus*.

Unit 4
ARCHEGONIATAE(**30 Lectures)**
a) Bryophytes (10 Lectures)
General Characteristics; Outline Classification; Ecological and Economic Importance; Morphology, Structure and Reproduction in Marchantia, Anthoceros and Funaria.
b) Pteridophytes (10 Lectures)
General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Selaginella*, *Equisetum* and *Pteris*.
c) Gymnosperms (10 Lectures)
General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Cycas* and *Pinus*.

Practical

1. **Viruses-** Structure of TMV and T-Phage (EMs/ Models/ Photographs); Lytic and Lysogenic Cycle (Line Drawings/ Photographs).
2. **Bacteria**-Types and Structure (Permanent Slides/ Photographs); EM Bacterium; Binary Fission and Conjugation (Photographs).
3. ***Rhizopus***, ***Penicillium*** and ***Alternaria***- Asexual Stage from Temporary/ Tease Mounts, ***Puccinia***-Black Stem Rust of Wheat and Infected Barberry Leaves (Herbarium Specimens/ Photographs), Tease Mounts of Spores on Wheat, Section of infected portion of Wheat and Barberry (Permanent Slides).
4. ***Chlamydomonas***-E.M., ***Nostoc***, ***Vaucheria*** and ***Ectocarpus***- Study of Vegetative and

Reproductive Structures through Temporary Preparations and Permanent Slides.

5. **Bryophytes :*Marchantia***-Morphology of Thallus, W.M. Rhizoids, V.S. Thallus through Gemma Cup, W.M. Gemma (all Temporary Slides), L.S. Sporophyte (Permanent slide).

Anthoceros*-** Morphology of Thallus, W.M. Rhizoids, L.S./ T.S. Capsule, W.M. Spores, W.M. Pseudoelaters, (all Temporary Slides), L.S. Sporophyte (Permanent slide).Funaria*-** Morphology of Gametophyte bearing Sporophyte, W.M. Rhizoids, W.M. Leaf, W.M. Operculum, W.M. Peristome, W.M. Spores (all Temporary Slides), L.S. Capsule (Permanent Slide).

6. **Pteridophytes:** ***Selaginella*-** Morphology, T.S. Stem, W.M. Strobilus, W.M. Microsporophyll and Megasporophyll (all Temporary Slides), L.S. Strobilus (Permanent Slide).

   ***Equisetum*-** Morphology, T.S. Stem (Internode), L.S./ T.S. Strobilus, W.M. Sporangiophore, W.M. Spores (Wet and Dry) (all Temporary Slides).

   ***Pteris*-** Morphology, V.S. Sporophyll, W.M. Sporangium, W.M. Spores (all Temporary Slides), W.M. Prothallus with Sex Organs (Permanent Slide).

7. **Gymnosperms:** ***Cycas*-** Morphology (Coralloid Roots, Leaf, Microsporophyll, Megasporophyll), T.S. Coralloid Root (Permanent Slide), V.S. Leaflet, V.S. Microsporophyll, W.M. Spores (all Temporary Slides), L.S. Ovule (Permanent Slide). ***Pinus*-** Morphology (Long and Dwarf Shoots, Male and Female Cones), W.M. Dwarf Shoot, T.S. Needle, L.S/ T.S. Male Cone, W.M. Microsporophyll, W.M. Microspores (all Temporary Slides), L.S Female Cone (Permanent Slide).

References

1. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology.* Singapore, Singapore: John Wiley and Sons (Asia).
2. Fritsch, F.E. (1965). *The Structure and Reproduction of the Algae. Vol.1, 2*. Cambridge: Cambridge University Press.
3. Kaur, I..D., Uniyal, P.L. (2019).*Text Book of Gymnosperms*. New Delhi,ND: Daya Publishing House,
4. Parihar, N.S. (1972). *An Introduction to Embryophyta. Vol. II: Pteridophyta*. Allahabad, UP: Central Book depot.

Additional Resources:

1. Bhatnagar, S.P., Moitra, A. (1996). *Gymnosperms*. New Delhi, ND: New Age International (P) Ltd Publishers.
2. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2008). *Biology*. San Francisco, SF: Pearson Benjamin Cummings.
3. Kumar, H.D. (1999). *Introductory Phycology*. New Delhi,Delhi: Affiliated East-West. Press Pvt. Ltd.
4. Parihar, N.S. (1991). *An Introduction to Embryophyta. Vol. I. Bryophyta*. Allahabad, UP: Central Book Depot.
5. Puri, P. (1985) *Bryophytes*. New Delhi, Delhi. Atma Ram and Sons, Delhi

Plant Anatomy and Embryology
(BHGE2)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

The Objective of this paper is to provide basic knowledge of plant internal architecture and cellular composition and reproduction.This help them to understand how different plant tissue structure evolve and modify their functions with respect to their environment.

Course Learning Outcomes

Knowledge regarding anatomy equipped the students to identify different types of tissues and make them able to correlate their physiology in a better away.This will also help them to understand how different plant tissue evolve and modify their structure and functions with respect to their environment. Knowledge regarding embryology make them understand how reproduction play significant role in defining population structure, natural diversity and sustainability of ecosystem in a better way.

Unit 1

Meristematic and permanent tissues (8 lectures)
Simple (parenchyma, collenchyma, sclerenchyma) and complex tissues (xylem, phloem), Root and shoot apical meristems (describe theories in brief with special reference to Tunica Corpus and Korper-Kappe theory)

Unit 2
Organs (4 lectures)
Structure of dicot and monocot root stem and leaf.

Unit 3

Secondary Growth (8 lectures)
Vascular cambium: structure and function, seasonal activity. Secondary growth in root and stem,

Wood (heartwood and sapwood)

Unit 4
Adaptive and protective systems (8 lectures

Epidermis (trichomes and hair), cuticle, stomata: structure and type (Metcalf and Chalk Classification); General account of adaptations in xerophytes and hydrophytes (Examples maybe cited from *Nerium, Opuntia, Hydrilla* and *Nymphaea*).

Unit 5

Introduction to Reproduction (5 lectures)

Modes of reproduction in plants: vegetative options - natural and artificial; introduction and Significance of sexual reproduction.

Unit 6

Structural organization of flower (10 lectures)

Organization of flower, Structure; Anther and Pollen (No developmental stage); Ovules: Structure and types; Embryo sac: Types special reference to Polygonum type.

Unit 7

Pollination and fertilization (10 lectures)

Pollination mechanisms and adaptations; Double fertilization and triple fusion; Seed: Structure (Dicot and Monocot, No developmental stages) appendages and dispersal mechanisms.

Unit 8

Embryo and endosperm (10 lectures)

Endosperm types (one example of each type), structure and functions; Dicot and Monocot embryo; Embryo endosperm relationship (General account).

Practical

1. Study of meristems through permanent slides and photographs.
2.Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: *Zea mays;* Dicot: *Helianthus*.
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*.
5. Leaf: Dicot and Monocot (only Permanent slides).
6. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem).
7. Structure of anther (young and mature).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac (Permanent slides/photographs).
11. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) Photographs/specimens).

12. Dissection of embryo/endosperm from developing seeds.
13. Calculation of percentage of germinated pollen in a given medium.

References

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas. Publication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
3.Raven P. et al. Biology of plants Seventh edition (2005). W. H. Freeman, New York

Additional Resources:

1. Dickison,W.C.(2000).Integrated Plant anatomy .Academic press Inc.
2. Fahn, A. (1982).Plant anatomy.Pergamon Press, Oxford.

Plant Ecology and Taxonomy
(BOTHGE3)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

Objectives: To make students understand ecology and basic ecological concepts, inter-relation between the living world and environment. Also to make them aware about identification, nomenclature and classification.

Course Learning Outcomes

After successful completion of the course the student shall have adequate knowledge about the basic principals of environment and taxonomy.

Unit 1
Introduction (1 lecture)
Inter-relation between the living world and environment

Unit 2
Ecological factors (11 lectures)
Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance.

Unit 3
Plant communities (6 lectures)
Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)

Unit 4
Ecosystem (8 lectures)
Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids

production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous

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Unit 5
Phytogeography (4 lectures)

Principle biogeographical zones; Endemism (definition and types)

Unit 6
Introduction to plant taxonomy (1 lecture)
Identification, Classification, Nomenclature.

Unit 7
Identification (5 lectures)
Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access

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Unit 8
Taxonomic evidences from palynology, cytology, phytochemistry and molecular data. (6 lectures)

Unit 9
Taxonomic hierarchy (2 lectures)
Ranks, categories and taxonomic groups

Unit 10

Botanical nomenclature (6 lectures)
Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit 11
Classification (6 lectures)
Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (up to series).

Unit 12
Biometrics, numerical taxonomy and cladistics (4 lectures)
Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

Practical

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer, hygrometer, rain gauge and lux meter.
2. Determination of pH, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.

3 (a) Study of morphological adaptations of hydrophytes and xerophytes (four each).

(b)Study of biotic interactions of the following: Stem parasite (Cuscuta), Root parasite (Orobanche), Epiphytes, Predation (Insectivorous plants)

4. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. \(species to be listed)

5. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law

6. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):Brassicaceae - Brassica,Alyssum / Iberis; Asteraceae - Sonchus/Launaea, Vernonia/Ageratum,Eclipta/Tridax; Solanaceae -Solanum nigrum, Withania; Lamiaceae -Salvia, Ocimum; Liliaceae - Asphodelus / Lilium / Allium.

7. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted on the herbarium sheet with appropriate label.)

References

1. Kormondy, E.J. (1996). Concepts of Ecology.Prentice Hall, U.S.A. 4th edition.
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
3. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
4. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi

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Plant Physiology and Metabolism
(BOTHGE4)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

The course aims at making students realize how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.

Course Learning Outcomes

The students are able to correlate morphology, anatomy, cell structure and biochemistry with plant functioning. The link between theory and practical syllabus is established, and the

employability of youth would be enhanced. The youth can also begin small-scale enterprises.

Unit 1

Plant-water relations **(8 Lectures)**

Importance of water, water potential and its components, pathway of water movement, ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation, stomatal movements – only ion theory.

Unit 2

Mineral nutrition **(8 Lectures)**

Essential elements, macro- and micronutrients, criteria of essentiality of elements, methods of studying mineral requirement (Hydroponics, Aeroponics), role of essential elements, transport of ions across membrane, active and passive transport, carriers, channels and pumps.

Unit 3

Translocation in phloem **(6 lectures)**

Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading.

Unit 4

Photosynthesis **(10 Lectures)**

Historical contribution of Julius von Sachs, Blackman, Emerson, Engelmann, Hill. Arnon; photosynthetic pigments (chlorophyll a and b, xanthophyll, carotene); photosystem I and II,

reaction centre, antenna molecules; electron transport and mechanism of ATP synthesis, C3 pathway; C4 and CAM plants (in brief, no pathways); photorespiration.

Unit 5

Respiration **(6 Lectures)**

Glycolysis, anaerobic respiration, TCA cycle, oxidative phosphorylation, glyoxylate cycle, RQ.

Unit 6

Enzymes **(4 Lectures)**

Structure and properties, Km (no derivation), mechanism of enzyme catalysis and enzyme inhibition.

Unit 7

Nitrogen metabolism **(6 Lectures)**

Biological nitrogen fixation - nodulation in detail, nitrate and ammonia assimilation, dinitrogenase, NR, NiR, transamination.

Unit 8

Plant growth regulators **(6 Lectures)**

Discovery, physiological roles of auxins, gibberellins, cytokinins and ethylene.

Unit 9

Plant response to light and temperature **(6 Lectures)**

Photoperiodism - discovery (SDP, LDP, day neutral plants); phytochrome (discovery and structure), red and far-red light response on photomorphogenesis (general account), florigen (brief account).

***NO STRUCTURES AND FORMULAE TO BE ASKED IN THE EXAM**

Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of the environmental factor light on transpiration by excised twig.
3.Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. To Study Hill's reaction.
5. To study the activity of catalase and study the effect of pH and enzyme concentration.
6. To study the effect of light intensity on O2evolution in photosynthesis.
7. Comparison of the rate of respiration in any two parts of a plant.

Demonstration experiments

1. Bolting.
2. Effect of auxins on rooting.

3. Suction due to transpiration.
4. Hydroponics (using a photograph).
5. To demonstrate the delay of senescence by cytokinins.
6. To study the phenomenon of seed germination (effect of light and darkness)

References

1. Bajracharya, D. (1999). *Experiments in Plant Physiology: A Laboratory Manual*. New Delhi, Delhi: Narosa Publishing House.
2. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism*. Singapore: Springer Nature, Singapore Pvt. Ltd.
3. Hopkins, W. G., Huner, N. P. A. (2009). *Introduction to Plant Physiology*, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.
4. Kochhar, S.L., Gujral, S.K. (2017). *Plant Physiology: Theory and Applications*. New Delhi, Delhi: Foundation Books, imprint of Cambridge University Press India Pvt, Ltd.

Additional Resources:
1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). *Plant Physiology and Development International*, 6th edition. New York, NY: Oxford University Press,Sinauer Associates.
