

**SYLLABUS FOR B.Sc.
BOTANY
F.Y., S.Y., & T.Y.**

SYLLABUS FOR B.Sc. BOTANY (GENERAL & HONOURS) DEGREE PROGRAM UNDER CBCS w.e.f 2017-18
OF SEM-I & II

A. B.SC. GENERAL

First Year:

Semester I:

BCC – 1: Biodiversity I (Microbes, Algae, Fungi and Bryophytes) (4+2 credits)

Semester II:

BCC – 4: Biodiversity II (Vascular plants) (4+2 credits)

Second Year:

Semester III:

BCC – 7: Plant Anatomy and Embryology (4+2 credits)

Semester IV:

BCC – 10: Plant Physiology (4+2 credits)

B. B.SC. HONOURS

First Year:

Semester I:

BCC – 1: Biodiversity I (Microbes, Algae, Fungi and Bryophytes) (4+2 credits)

BCC – 2: Cell Biology (4+2 credits)

BCC – 3: Economic and Medicinal Botany (4+2 credits)

BGE – 1: Environmental Biotechnology (4 credits)

Semester II:

BCC – 4: Biodiversity II (Vascular plants) (4+2 credits)

BCC – 5: Plant Biochemistry (4+2 credits)

BCC – 6: Microbiology and Plant Pathology (4+2 credits)

BGE – 2: Coastal and Mangrove Ecology (4 credits)

Legend:

BCC = Botany Core Course;

BDSE = Botany Discipline Specific Elective;

BGE = Botany Generic Elective;

BSEC = Botany Skill Enhancement Course.

BCC - 1: Biodiversity I (Microbes, Algae, Fungi and Bryophytes)

Credits: 4 (Theory): 2 (Practical)

THEORY

Unit 1: Microbes (15 Lectures)

Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance; Bacteria – Discovery, General characteristics and cell structure; Types - archaeobacteria, eubacteria and mycoplasma. Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

Unit 2: Algae (15 Lectures)

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following: *Nostoc*, *Spirogyra*, *Sargassum*, *Polysiphonia*. Economic importance of algae with special reference to food, biofertilizers and medicine.

Unit 3: Fungi (15 Lectures)

Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition, nutrition, reproduction and classification; True Fungi - General characteristics, ecology and significance with special reference to medicine., life cycle of *Rhizopus* (Zygomycota) *Penicillium*, (Ascomycota), *Agaricus* (Basidiomycota); Symbiotic Associations-Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance.

Unit 4: Bryophytes (15 Lectures)

General characteristics, Classification, Range of thallus organization.

Classification (up to family), morphology, anatomy and reproduction of *Riccia*, *Anthoceros* and *Funaria*. (Developmental details not to be included). Ecology and economic importance of bryophytes with special mention of *Sphagnum*.

LABORATORY EXERCISES:

1. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle. **(2P)**
2. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation. **(2P)**
3. Monochrome and Gram staining. **(2P)**
4. Study of vegetative and reproductive structures of *Nostoc*, *Spirogyra*, *Sargassum*, *polysiphonia* through temporary preparations and permanent slides. **(4P)**
5. *Rhizopus* and *Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides. **(2P)**

6. **Agaricus:** Specimens of button stage and full grown mushroom; Sectioning of gills of *Agaricus*. **(1P)**
7. **Lichens:** Study of growth forms of lichens (Crustose, foliose and fruticose). **(1P)**
8. **Mycorrhiza:** ectomycorrhiza and endomycorrhiza – (slide preparation/Photographs). **(2P)**
9. **Riccia:** morphology and T. S. of thallus, W. M. rhizoids and scales, V. S. thallus through gemma cup, W. M. gemmae (all permanent slides), V. S. antheridiophore, archegoniophore, L. S. sporophyte (all permanent slides). **(1P)**
10. **Anthoceros:** morphology and T. S. of thallus and sporophyte. Sporophyte (permanent slides). **(1P)**
11. **Funaria:** morphology, W. M. leaf, rhizoids, sporophyte (permanent slides); permanent slides showing antheridial and archegonial heads, L. S. capsule and protonema. **(2P)**
12. Preparation of Jelly, Pudding and Custard using Agar- Agar. **(2P)**
13. Herbarium preparation of algae. **(2P)**
14. Conservation of at least one species of alga and bryophyte in the botanical garden ('Ex-situ' conservation/ Preparation of a Conservatory). **(2P)**
15. Preparation of spawn for Oyster mushroom cultivation. **(2P)**
16. Culturing of *Mucor* and *Aspergillus*. **(2P)**

SUGGESTED READINGS

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
 2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
 3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
 4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
 5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi.
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BCC - 2: Cell Biology
Credits: 4 (Theory): 2 (Practical)

THEORY

Unit 1: Techniques in Biology (10 Lectures)

Principles of microscopy; Light Microscopy; Phase contrast microscopy; Fluorescence microscopy; Confocal microscopy; Sample Preparation for light microscopy; Electron microscopy (EM) - Scanning EM and Scanning Transmission EM (STEM); Sample Preparation for electron microscopy; Micrometry; Use of ultracentrifugation.

Unit 2: Cell as a unit of Life (6 Lectures)

The Cell Theory; Cell as a unit of structure and function; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components; Origin of eukaryotic cell (Endosymbiotic theory).

Unit 3: Cell Organelles (24 Lectures)

Mitochondria: Origin of organelles; organelle structure and biogenesis; Structure, marker enzymes, composition; Semi-autonomous nature; Symbiont hypothesis; mitochondrial DNA and function.

Plastids: Types of plastids, Chloroplast structure, marker enzymes, composition; semi-autonomous nature, chloroplast DNA and functions.

Structure and functions of Endoplasmic Reticulum (ER), Golgi apparatus, Lysosomes.

Peroxisomes and Glyoxisomes: Structures, composition, functions in animals and plants and biogenesis; Cytoskeleton - Structure and role of microtubules, microfilaments and intermediary filament.

Nucleus: Nuclear Envelope - structure of nuclear pore complex; nuclear lamina, nuclear matrix, nucleoplasm, nucleosome; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin; DNA, RNA, histones and non-histone proteins; nucleolus and ribosome structure (brief).

Ribosome: structure of prokaryotic, eukaryotic and organelle ribosomes; functional significance.

Unit 4: Cell Membrane and Cell Wall (10 Lectures)

The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Selective permeability of membranes; Role of ion channels and pumps in cellular transport and signaling; endocytosis and exocytosis

Cell wall: Ultrastructure, chemical constituents and functions of cell wall.

Unit 5: Cell Cycle (10 Lectures)

Overview of Cell cycle, Mitosis and Meiosis; Molecular controls.

LABORATORY EXERCISES:

1. Introduction on handling, use and maintenance of microscopes and other laboratory equipments. (2P)
 2. Preparation of stains and staining techniques. (2P)
 3. Study of different mountants (Water, Glycerine, DPX, Lactophenol). (1P)
 4. Measurement of cell size by the technique of micrometry. (2P)
 5. To study prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light and Electron micrographs. (2P)
 6. Study of the photomicrographs of cell organelles. (1P)
 7. To study the structure of plant cell through temporary mounts of Onion and *Spirogyra*. (1P)
 8. Study of mitosis and meiosis (temporary mounts and permanent slides). (4P)
 9. Study the effect of temperature, organic solvent on semi permeable membrane. (2P)
 10. Demonstration of dialysis of starch and simple sugar. (1P)
 11. Study of plasmolysis and plasmoptysis on *Rhoeo* leaf. (1P)
 12. Study the structure of nuclear pore complex by photograph (from Gerald Karp). (1P)
 13. Cytochemical staining of: DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique. (2P)
 14. Histo-chemical test for cellulose, lignin, chitin and suberin in sections. (2P)
 15. Drawings of microscopic objects using camera lucida and photomicrography. (2P)
 16. Study of plastid types using microscope. (1P)
 17. Cell count using haemocytometry and optical density of cell suspension using spectrophotometry. (3P)
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SUGGESTED READINGS:

1. Alberts, B.; Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1999. Molecular Biology of Cell. Garland Publishing Co., Inc., New York, USA.
2. Avers, C.J. 1986. Molecular Cell Biology. Addison-Wesley Publishing Co., Massachusetts, USA.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Campbell, M.K. 1999. Biochemistry. Saunders College Publishing, Philadelphia, USA.
5. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C., Sinauer Associates, MA.
6. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
7. Gupta, P.K. 1999. A Text Book of Cell and Molecular Biology. Rastogi Publications, Meerut, India.
8. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
9. Kleinsmith, L.J. and Kish, V.M. 1995. Principles of Cell and Molecular Biology, (2nd Edition). Harper Collins College Publishers, New York, USA.
10. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. 2000. Molecular Cell Biology. W.H. Freeman & Co., New York, USA.

11. Nelson, D.L. and Cox, M.M. 2000. *Lehninger Principles of Biochemistry* (3rd Edition). Worth Publishers, New York, USA.
 12. Rawn, D.J. 1989. *Biochemistry*. Neil Patterson Publishers, North Carolina, USA.
 13. Stryer, L. 1995. *Biochemistry*. W.H. Freeman & Co., New York, USA.
 14. Wolfe, S.L. 1993. *Molecular and Cellular Biology*. Wadsworth Publishing Co., California, USA.
 15. Zubay, G. 1993. *Biochemistry* (3rd Edition). WCB Publishers, Iowa, USA.
 16. Dryer, R.L. and Lata, G.F. 1989. *Experimental Biochemistry*. Oxford University Press, NY.
 17. Gunning, B.E.S. and Steer, M.W. 1996. *Plant Cell Biology: Structure and Function*. Jones & Bartlett Publishers, Boston, Massachusetts.
 18. Harris, N. and Oparka, K.J. 1994. *Plant Cell Biology: A Practical Approach*. IRL Press, at Oxford University Press, Oxford, UK.
 19. Ninfa, A.J. and Ballou, D.P. 1998. *Fundamental Laboratory Approaches for Biochemistry and Biotechnology*. Fitzgerald Science Press, Inc., Maryland, USA.
 20. Wilson, K. and Goulding, K.H. (Eds.). 1986. *A Biologists Guide to Principles and Techniques of Practical Biochemistry*. Edward Arnold, London, UK.
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BCC – 3: Economic and Medicinal Botany
Credits: 4 (Theory): 2 (Practical)

THEORY

Economic Botany

Unit 1: Origin of Cultivated Plants (1 Lecture)

Concept of centres of origin, their importance with reference to Vavilov's work.

Unit 2: Cereals (3 Lectures)

Wheat, Rice and Maize - Origin, morphology, cultivation, uses.

Unit 3: Legumes (3 Lectures)

General account with special reference to Pea and Gram (Black/green).

Unit 4: Spices (4 Lectures)

General account with special reference to clove, black pepper, turmeric, cinnamon, capsicum (Botanical name, family, part used, morphology and uses).

Unit 5: Beverages (2 Lectures)

Tea, coffee, cocoa (morphology, processing, uses).

Unit 6: Oils and Fats (4 Lectures)

General description with special reference to extraction of groundnut, coconut, sunflower and sesame, and olive oil.

Unit 7: Fibre Yielding Plants (4 Lectures)

General description with special reference to Cotton, Jute, Coir, and Agave (Botanical name, family, part used, morphology, extraction, and uses).

Unit 8: Fruit crops (3 lectures)

Botanical name, family, part used, morphology and uses of mango, jackfruit, papaya, cashew, pineapple and banana.

Unit 9: Vegetable crops (3 Lectures)

Botanical name, family, part used, morphology, cultivation and uses of red amaranth, radish, brinjal, and okhra.

Unit 10: Timber plants (3 Lectures)

General description with special reference to matti, sailo, and bamboo.

Medicinal Botany

Unit 11: Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences; Definition and Scope-Ayurveda: Panchamahabhutas, Saptadhatu and Tridosha concepts, Rasayana, plants

used in ayurvedic treatments, Siddha: Origin of Siddha medicinal systems, Basis of Siddha system, plants used in Siddha medicine. Unani: Concept: Umoor-e-tabiya, tumors treatments/therapy, polyherbal formulations. **(10 Lectures)**

Unit 12: Conservation of endangered and endemic medicinal plants. Definition: endemic and endangered medicinal plants, Ethnomedicinal plant Gardens. Propagation of Medicinal Plants: A brief account of plant drugs and their chief constituents used in indigenous and allopathic systems of medicine with regard to: *Hemidesmus indicus*, *Garcinia indica*, *Andrographis paniculata*, *Catharanthus roseus*, *Aloe vera*, *Boerhaavia diffusa*, and *Adathoda vasica*. **(10 Lectures)**

Unit 13: Ethnobotany and Folk medicines; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases - Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases. **(10 Lectures)**

LABORATORY EXERCISES:

1. Identification (botanical name & family), description and utilization of plants and/or plant parts studied in theory, under each group **(15P)**
 2. Chemical test for sesame/groundnut oil. **(1P)**
 3. T.S. of *Eucalyptus* leaf to study oil glands. **(1P)**
 4. Properties of cotton, jute and coir fibres. **(1P)**
 5. Study of plants used as sources of drugs (live/herbarium specimens) studied in theory. **(2P)**
 6. Extraction of plant pigments (any 2) in water, ethanol and n-hexane: *Curcuma longa* (turmeric), *Bixa orellana* (annato), *Lawsonia inermis* (mehndi) and *Garcinia indica* (Kokum). **(1P)**
 7. Vegetative propagation techniques in fruit plants – cutting, grafting, layering and gooty. **(2P)**
 8. Preparation of a list of trees, shrubs and herbs (scientific name, common name and brief description) used for worship from different localities. **(2P)**
 9. Blood pressure and skin diseases (any one plant or formulation for each disease). **(2P)**
 10. Polyherbal formulation for cold (kasai). **(2P)**
 11. Extraction of starch from potato. **(1P)**
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SUGGESTED READINGS:

1. Kochhar, S.L. 2011. Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
1. Trivedi P C, 2006. Medicinal Plants: Ethnobotanical Approach, Agrobios, India.
2. Purohit and Vyas, 2008. Medicinal Plant Cultivation: A Scientific Approach, 2nd edn. - Agrobios, India.
3. Fuller, K.W. and Gallon, J.A. 1985. Plant Products and New Technology. Clarendon Press, Oxford, New York.

4. Nair, M.N.B. 1998. Wood Anatomy and Major Uses of Wood. Faculty of Forestry, Universiti Putra Malaysia, 43400 Serdang, Selangor D. E., Malaysia.
 5. Sambamurthy, A.V.S.S. and Subramanyam, N.S. 1989. A Textbook of Economic Botany. Wiley Eastern Ltd., New Delhi.
 6. Sharma, O.P. 1996. Hill's Economic Botany. Tata McGraw Hill Publishing Company Ltd., New Delhi.
 7. Simpson, B.B. and Conner-Ogorzaly, M. 1986. Economic Botany- Plants in Our World. McGraw Hill, New York.
 8. S. K. Jain. A manual of Ethnobotany. Scientific Publishers (India). Jodhpur.
 9. Trivedi P C, 2006. Medicinal Plants: Ethnobotanical Approach, Agrobios, India.
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BCC - 4: Biodiversity II (Vascular Plants)
Credits: 4 (Theory): 2 (Practical)

THEORY

Unit 1: Pteridophytes (12 Lectures)

General characteristics, classification, Early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris*. (Developmental details not to be included). Heterospory and seed habit, stelar evolution. Ecological and economical importance of Pteridophytes.

Unit 2: Gymnosperms (10 Lectures)

General characteristics, Classification (Coulter & Chamberlain), morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum*. (Developmental details not to be included). Ecological and economical importance.

Unit 3: Introduction to plant taxonomy (4 Lectures)

Identification, Classification, Nomenclature.

Unit 4: Identification (8 Lectures)

Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access.

Unit 5: Taxonomic evidences from palynology, cytology, photochemistry and molecular data. (6 Lectures)

Unit 6: Taxonomic hierarchy (2 Lectures)

Ranks, categories and taxonomic groups.

Unit 7: 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 8: Classification (10 Lectures)

Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series); study of families: Asteraceae, Solanaceae, Lamiaceae, Liliaceae and Poaceae.

Unit 9: Biometrics, numerical taxonomy and cladistics (4 Lectures)

Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

LABORATORY EXERCISES:

1. ***Psilotum*** – morphology, W. M. Synangium, T. S. Stem. (2P)
2. ***Selaginella*** - morphology, W. M. leaf with ligule, T. S. stem, W. M. strobilus, W. M. microsporophyll and megasporophyll (temporary slides), L. S. strobilus (permanent slide).(2P)
3. ***Equisetum*** - morphology, T. S. internode, L. S. strobilus, T. S. strobilus, W. M. sporangiophore, W. M. spores (wet and dry) (temporary slides); T. S. rhizome (permanent slide).(2P)
4. ***Pteris*** - morphology, T. S. rachis, V. S. sporophyll, W. M. sporangium, W. M. spores (temporary slides), T. S. rhizome, W. M. prothallus with sex organs and young sporophyte (permanent slide). (2P)
5. ***Cycas*** - morphology (coralloid roots, bulbil, leaf), T. S. coralloid root, T. S. rachis, V. S. leaflet, V. S. microsporophyll, W. M. spores (temporary slides), L. S. ovule, T. S. root (permanent slide). (2P)
6. ***Pinus***- morphology (long and dwarf shoots, W. M. dwarf shoot, male and female), W. M. dwarf shoot, T. S. needle, T. S. stem, , L. S. / T. S. male cone, W. M. microsporophyll, W. M. microspores (temporary slides), L. S. female cone, T. L. S. and R. L. S. stem (permanent slide). (3P)
7. 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): Asteraceae, Solanaceae, Lamiaceae, Liliaceae and Poaceae (Any two locally available plants per family). (10P)
8. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book). (2P)
9. Field Botany. (5P)

SUGGESTED READINGS:

1. Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta, S. Chand. Delhi, India.
 2. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
 3. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
 4. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
 5. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
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BCC - 5: PLANT BIOCHEMISTRY
Credits: 4 (Theory): 2 (Practical)

THEORY

Unit 1: Cellular chemistry: Molecular interactions; chemical bonds (primary and secondary) and their significance; peptide and disulphide bonds. Structure, properties and biological importance of water. pH, biological buffers and their significance. **(7 Lectures)**

Unit 2: Carbohydrates: Classification, properties and structure of monosaccharides; disaccharides; oligosaccharides and polysaccharides with one example each; biological role of carbohydrates. Synthesis and degradation of sucrose and starch in plants. **(7 Lectures)**

Unit 3: Lipids: Classification, properties and biological role of lipids; structure and functions of fatty acids. Synthesis and breakdown of triglycerides; β -oxidation. **(6 Lectures)**

Unit 4: Amino acids: Classification, structure and properties of amino acids; essential & non-essential amino acids; transamination; biological role of amino acids. **(4 Lectures)**

Unit 5: Proteins: Classification, properties and structure (primary, secondary, tertiary & quaternary) of proteins; denaturation and renaturation of proteins; biological role of proteins. **(6 Lectures)**

Unit 6: Nucleic acids: Structure of components of nucleic acids (nitrogen bases, nucleosides and nucleotides). Types of nucleic acids (DNA & RNA); structure of B-DNA; characteristics of other forms of DNA (A, C, D and Z). Types of RNA, structure of tRNA, role of RNA in protein synthesis. **(6 Lectures)**

Unit 7: Vitamins: Broad classification of vitamins; properties, structure, functions and deficiency symptoms of vitamins A, B complex, C, D, E, P and K. **(5 Lectures)**

Unit 8: Bioenergetics: Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions and redox reactions. ATP - the energy currency molecule. **(5 Lectures)**

Unit 9: Enzymes: Nomenclature, classification and importance of enzymes; physico-chemical properties; structure of enzyme molecule; isoenzymes; mechanism of enzyme action (lock and key hypothesis & induced-fit theory); Michaelis-Menten equation; enzyme specificity; enzyme inhibition; factors affecting enzyme activity. **(10 Lectures)**

Unit 10: Secondary metabolites: Broad classification of secondary metabolites; properties and functions of terpenoids, alkaloids, flavonoids. **(4 Lectures)**

LABORATORY EXERCISES:

1. Preparation of reagents (molar and normal solutions) (calculations). (1P)
 2. Preparation of buffers (calculations). (1P)
 3. Measurement of pH of C₃, C₄ and CAM plant extracts. (1P)
 4. Qualitative tests for biomolecules (carbohydrates, fats, amino acids and proteins). (4P)
 5. Micro-chemical detection of reducing sugars in floral nectar using Benedict's Reagent. (1P)
 6. Verification of Beer Lambert Law (Conc. v/s O.D.) (1P)
 7. Estimation of reducing sugars by DNSA method. (2P)
 8. Determination of acid value of fat. (1P)
 9. Estimation of proteins using Lowry's method. (2P)
 10. Estimation of proteins using Biuret method. (2P)
 11. Estimation of ascorbic acid. (1P)
 12. Study of amylase activity (effect of substrate concentration, enzyme concentration, pH, temperature – any 3). (3P)
 13. Study of lipase activity in germinating groundnut seeds. (1P)
 14. Separation of amino acids by TLC. (2P)
 15. Separation of photosynthetic pigments by paper chromatography. (2P)
 16. Estimation of DNA using Di-phenyl amine method. (1P)
 17. Estimation of RNA using Orcinol method. (1P)
 18. Localization of carbohydrates using PAS. (1P)
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SUGGESTED READINGS:

1. Campbell MK (2012). Biochemistry, 7th edition, Published by Cengage Learning.
2. Campbell PN and Smith AD (2011) Biochemistry Illustrated, 4th edition, Published by Churchill Livingstone
3. Verma SK and Verma M (2007). A textbook of Plant Physiology, Biochemistry and Biotechnology, 6th edition, Published by S. Chand and Company Ltd., New Delhi.
4. Jain JL, Jain S and Jain N (2007). Elementary Biochemistry, 3rd edition, Published by S. Chand and Company Ltd., New Delhi.
5. Tymoczko JL, Berg JM and Stryer L (2012). Biochemistry: A short course, 2nd edition, Published by W. H. Freeman.
6. Boyer R (2001). Modern Experimental Biochemistry, 3rd edition, Published by Pearson Education, Singapore.
7. Mathur R and Mehta M (2002). Biochemistry, 1st edition, Published by J L Kumar for Anmol Publications Pvt. Ltd., New Delhi.
8. Berg JM, Tymoczko JL and Stryer L (2011). Biochemistry, Published by W.H. Freeman and Company.
9. Nelson DL and Cox MM (2008). Lehninger Principles of Biochemistry, 5th edition, W. H Freeman and Company.
10. Hopkins WG and Huner A (2008). Introduction to Plant Physiology, 4th edition, John Wiley and Sons, U.S.A.
11. Taiz L, Zeiger E, Møller IM and Murphy A (2015). Plant Physiology and Development. 6th edition, Sinauer Associates Inc. USA.

12. Harborne JB (1973). *Phytochemical Methods*, John Wiley & Sons, New York.
 13. Stryer L (1995). *Biochemistry*, W. H. Freeman and Co., New York, USA.
 14. Sadasivam S and Manickam A (1996). *Biochemical Methods*, New Age International Publishers.
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BCC 6: MICROBIOLOGY AND PLANT PATHOLOGY

Credits: 4 (Theory): 2 (Practical)

THEORY

A. Microbiology:

Unit 1: Discovery of microorganisms: Miller's experiment; characteristic features of different groups of microorganisms; broad classification of bacteria based on *Bergey's Manual*. **(3 Lectures)**

Unit 2: Ultrastructure of microorganisms: Viruses (properties, classification - ICTV & Baltimore, replication); ultrastructure of prokaryotic cell (bacterial cell) and eukaryotic cell (plant cell); characteristics of prions, viroids, mycoplasma, actinomycetes, T₄ bacteriophage, and yeasts. **(8 Lectures)**

Unit 3: Methods in microbiology: Staining methods (simple, differential and special staining); methods of sterilization (physical and chemical); types of culture media; pure culture methods (streak plate, spread plate and pour plate); bacterial motility; methods for enumeration (direct and indirect); bacterial growth curve. **(8 Lectures)**

Unit 4: Preservation and maintenance of microbial cultures: Methods of preservation (periodic transfer, use of mineral oil and liquid nitrogen, lyophilisation); culture collection centres (culture banks) and their importance. **(4 Lectures)**

Unit 5: Microbial interactions and biogeochemical cycling of elements: Microorganisms associated with the plant roots and symbiotic nitrogen fixation; biofertilizers and their role in agriculture; mycorrhizae and their role in agriculture and forestry; plant microbe interaction in bioremediation. Biogeochemical cycling of nitrogen, phosphorus and carbon. **(7 Lectures)**

B. Plant Pathology:

Unit 6: General account of plant pathogens: General account of diseases caused by plant pathogens; symptomatology; identification of plant disease – Koch's postulates. **(3 Lectures)**

Unit 7: Pathogen attack and defence mechanisms: Stages of disease establishment; structural and biochemical defence mechanisms. **(5 Lectures)**

Unit 8: Plant disease epidemiology: Transmission and spread of plant pathogens; disease cycles, plant disease epidemics. **(4 Lectures)**

Unit 9: Plant disease management: Cultural, physical, chemical, biological and IPM systems; development of transgenics for disease management; biopesticides; plant disease clinics. **(8 Lectures)**

Unit 10: Genetics of resistance and susceptibility: Genes for virulence and avirulence, their application in resistance and susceptibility. **(3 Lectures)**

Unit 11: Molecular plant pathology: Molecular diagnosis; identification of genes and specific molecules in disease development (DNA and protein based diagnostic kits). **(4 Lectures)**

Unit 12: Application of Information Technology in plant pathology: Computer simulation of epidemics and disease forecasting; use of remote sensing and image analysis in plant pathology. **(3 Lectures)**

LABORATORY EXERCISES:

1. Introduction to microbiology laboratory, concept of sterilization, working and handling of laboratory equipments. **(2P)**
 2. Introduction to biosafety and biohazards in laboratory. **(1P)**
 3. Determination of microbial population (yeast) size by serial dilution technique. **(1P)**
 4. Preparation of liquid and solid (plates and slants) culture media – nutrient broth, nutrient agar and PDA. **(3P)**
 5. Isolation of microorganisms from air; study of colony characteristics and preparation of pure culture by streak plate method (plates and slants). **(2P)**
 6. Colony characteristics of bacteria and fungi in pure culture. **(2P)**
 7. Study of bacterial motility by hanging drop method. **(1P)**
 8. Turbidimetric determination of growth of a microorganism using spectrophotometer (*E. coli*/yeast). **(2P)**
 9. Screening for amylase producing microorganisms from soil using starch agar by serial dilution-spread plate method. **(2P)**
 10. Screening for antimicrobial activity of plant extracts by agar well diffusion/agar disc method (extracts of neem, garlic and lemon grass; positive and negative control). **(2P)**
 11. Isolation of AM spores from rhizosphere soil. **(2P)**
 12. Study of symptoms, disease cycle and control measures of plant diseases (viral, bacterial and fungal – one each). **(1P)**
 13. Anatomy/mounting of spores from fungus infected specimens (rust, blight & rot). **(1P)**
 14. Demonstration of Koch's postulates for a bacterial/fungal pathogen. **(3P)**
 15. Field Plant Pathology (Collection and identification of local crop diseases). **(5P)**
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SUGGESTED READING

1. Agrios, G.N. 1997. Plant Pathology. Academic Press, London.
2. Albajes, R., Gullino, M.L., van Lenteren, J.C. and Elad, Y. 2000. Integrated Pest and Disease Management in Greenhouse Crops. Kluwer Academic Publishers.
3. Aneja, K. R. 1993. Experiments in Microbiology, Plant Pathology and Tissue Culture. Wishwa Publication, New Delhi.
4. Bridge, P. et al. 1998. Molecular Variability of Fungal Pathogens. CAB International, UK.
5. Bridge, P. et al. 1999. Application of PCR in Mycology. CAB International, UK.

6. Bridge, P., Moore, D.R. and Scott, P.R. 1998. Informationa.i Technology, Plant Pathology and Biodiversity. CAB International, UK.
 7. Eklund, C. and Lankford, C.WE. 1967. Laboratory Manual for General Microbiology. Prentice-Hall, Inc., Engle-wood Cliffs, N.J.
 8. Gunasekaran, P. 1995. Laboratory Manual in Microbiology. New Age International Pvt. Ltd.
 9. Mahadevan, A. and Sridhar, R. 1986. Methods in Physiological Plant Pathology. Sivakami Publication, Madras.
 10. Meyneil, E. and Meynell, G.G. 1970. Theory and Practice in Experimental Bacteriology. University Press, Cambridge.
 11. Pawsey, R.K. 1974. Techniques with Bacteria - A Guidebook for Teachers. Hutchinson Educational.
 12. Pelezar, M.J. and Chan, E.C.S. 1972. Laboratory Exercises in Microbiology. McGraw Hill Book Co.
 13. Persley, G.J. 1996. Biotechnologies and Integrated Pest Management. CAB International, UK.
 14. Schaad, N. W. 1988. Plant Pathogenic Bacteria: Laboratory Guide for Identification of Plant Pathogenic Bacteria. Academic Press.
 15. Skeritt, J.H. and Apples, R. 1995. New Diagnostics in Crop Sciences. CAB International, UK.
 16. Sullia, S.B. 2001. General Microbiology, Oxford Publishers, New Delhi.
 17. Tauro, P.T. 1988. Introductory Microbiology.
 18. Vaidya, J.C. 2000. Biology of Fungi.
 19. Wistreich, G.A. and Lechtman, M.D. 1973. Laboratory Exercises in Microbiology. Glencoe Press, New York, Beverly Hills, Collier Macmillan Publishers, London.
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BGE 1 - Environmental Biotechnology
(Credits: Theory-4)
Lectures: 60

THEORY

Unit 1: Environment (4 lectures)

Basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management.

Unit 2: Environmental problems (6 lectures)

Environmental pollution - types of pollution, sources of pollution, measurement of pollution, methods of measurement of pollution, fate of pollutants in the environment, Bioconcentration, bio/geomagnification.

Unit 3: Microbiology of waste water treatment (8 lectures)

Aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process - anaerobic digestion, anaerobic filters, upflow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industries.

Unit 4: Xenobiotic compounds (10 lectures)

Organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganic (metals, radionuclides, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, decay behaviour and degradative plasmids, molecular techniques in bioremediation.

Unit 5: Role of immobilized cells/enzymes in treatment of toxic compounds (6 lectures)

Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control.

Unit 6: Sustainable Development (8 lectures)

Economics and Environment: Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost effectiveness analysis, WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics.

Unit 8: International and National Legislations, Policies for Pollution Management (10 lectures)

Stockholm Conference (1972) and its declaration, Ramsar Convention 1971, Kyoto Protocol-1997, Salient features of Wild life protection act 1972, Water Pollution (Prevention and Control) Act-1974, Forest conservation act 1980, Air Pollution (Prevention and Control) Act-1981,

National Environmental Policy -2006, Central and State Pollution Control Boards: Constitution and Power.

Unit 9: Public Participation for Environmental Protection (8 lectures)

Environmental movement and people's participation with special references to Gandhamardan, Chilika and Narmada Bachao Andolan, Chipko and Silent valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society.

Suggested Readings

1. Waste Water Engineering - Treatment, Disposal and Reuse (1991) Metcalf and Eddy Inc., Tata McGraw Hill, New Delhi.
 2. De, A. K. (1994) Environmental Chemistry, Wiley Eastern Ltd, New Delhi.
 3. Allsopp, D. and Seal, K. J. (2004) Introduction to Biodeterioration, ELBS / Edward Arnold.
 4. Baaker, K. H. and Herson D.S. (1994) Bioremediation, Mc.GrawHill Inc, NewYork.
 5. Ahmed, N., Qureshi E. M. and Khan, O. Y. (2006) Industrial and Environmental Biotechnology. Horizon Press.
 6. Paul, A, R. (2001) Environmental Molecular Biology. Horizon Press.
 7. Jadhav, H. V. and Bhosale, V.M. (1997) Environmental Protection and Laws Himalaya publication House 13.
 8. Trivedi, P. C. (2006) Biodiversity Assessment and Conservation. Agrobios, India.
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BGE 2 - Coastal and Mangrove Ecology
(Credits: Theory-4)
Lectures: 60

Unit 1 – Principles of coastal ecology: Sand dunes with emphasis on vegetation and ecological importance, mangrove biodiversity - Inter-relationships between ecosystems - Methods of assessing biodiversity - Importance of assessing species diversity and status - IUCN conservation species status - Status book. **(6 Lectures)**

Unit 2 - Distribution of Mangroves: Global distribution, Extent of mangroves in various countries - Past and present extent of distribution, damage and reclamation caused in the recent past. **(3 Lectures)**

Unit 3 - Biology of Mangroves: Taxonomy and genetics - Temporal and regional variations - Morphology and anatomy - temporal and regional variations; Physiology and biochemistry - Factors affecting various growth parameters. Pollination biology - Types of reproduction, seed propagation, dispersal and establishment. Ecological and environmental conditions that affect mangrove ecosystems **(15 Lectures)**

Unit 4 - Flora and fauna of Mangroves and Associated Environments: Bacteria, fungi and actinomycetes, microalgae, sea-grasses, salt-marsh and other flora - Collection, preservation and identification techniques - Factors Affecting biodiversity - Comparison of flora of mangroves and associated environments; general account of mangrove fauna. **(8 Lectures)**

Unit 5 - Ecological roles of Mangroves: Litter production and decomposition and nutrient enrichment; biomass, food web and energy fluxes; interaction of mangroves with other halophytes and agro-ecosystems; Importance - Damages caused - Need for conservation. **(8 Lectures)**

Unit 6 - Threat Factors Affecting Mangrove Systems: Water quality parameters, Anthropogenic pressure, Types of pollutants causing damage to mangroves - Sewage, industrial, and other organic and inorganic man-made pollutants, Extent of damage, Possible remedial measures. **(8 Lectures)**

Unit 7 - Conservation and Management Strategies Restoration Technology – Species selection, Propagation and plantation techniques; Conservation strategies. **(8 Lectures)**

Unit 8 – Advanced concepts to be learnt under teachers supervision by study visit to NIO. (4 Lectures)

Reference Books:

1. Chapman V.J. and Chapman D. J. (1975) The Algae, 2nd Edition, MacMillan Publications Inc. New York.
 2. Lembi, C.A. and Waaland, J. R. (1988) Algae and Human Affairs. Press Syndicate of the University of Cambridge.
 3. Lobban, C.S., Harrison, P. J. And Duncan, M. J. (1985). The Physiological ecology of Seaweeds. Cambridge University Press, New York.
 4. Roy, P.M. and Helfferich C. (1997) Seagrass Ecosystems, Maxel Dekker II, New York.
 5. Borse D. G. and D. J. Bhat (2012) Marine Fungi of India. BBC Publishers.
 6. Websites of NIO and Mangrove Society of India.
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Syllabus of S.Y.B.Sc. Botany Programme under CBCS

CODES	TITLES	CREDTTS
CORE		
BOC101(Sem I)	Biodiversity I (microbes, Algae, Fungi and Bryophytes)	4 T+2P =6
BOC102 (Sem II)	Biodiversity II (Vascular plants)	4 T+2P =6
BOC103(Sem III)	Plant anatomy and Embryology	4 T+2P=6
BOC104(Sem IV)	Plant Physiology	4 T+2P =6
SKILL ENHANCEMENT COURSES		
BOS101(Sem III)	Floriculture	3T+1P=4
BOS102 (Sem IV)	Herbal Technology	3T+1P=4
GENERAL ELECTIVES		
BOG101(Sem I)	Environmental Biotechnology	4 T
BOG102(Sem II)	Coastal and Mangrove Ecology	4 T

BOC103: PLANT ANATOMY AND EMBRYOLOGY

Credits: 4 (Theory) + 2 (Practical)

THEORY: (4 Credits)

Total Lectures: 60

Unit 1: Meristematic and permanent tissues: Root and shoot apical meristems; simple and complex tissues. **(4P)**

Unit 2: Primary Structure of organs: Structure of dicot and monocot root, stem and leaf. **(4P)**

Unit 3: Secondary Growth: Activity of Vascular cambium, Anomalous secondary growth in stems of *Boerhaavia*, *Bignonia* & *Dracaena*, Wood Anatomy- Wood Elements, heartwood and sapwood, Tension Wood, Economic importance of wood & wood elements. Periderm & Rhytidome: Structure & Functions **(10 L)**

Unit 4: Adaptive & Protective systems: Epidermis, cutin, cuticle & other types of coverings, epidermal appendages, stomatal types, adaptations in Hydrophytes, Xerophytes, Halophytes **(8P)**

Unit 5: Structural organization of flower: Flower as modified reproductive shoot; Structure of anther and pollen; development of male gametophyte, structure and types of ovules; development of female gametophyte; ultrastructure of mature embryo sac; types of embryo sacs: monosporic- *Polygonum* type, bisporic- *Allium* type, tetrasporic- *Peperomia* type **(15P)**

Unit 6: Pollination and fertilization: Pollination mechanisms and adaptations; insect pollination as an evolved mechanism, Double fertilization. **(5P)**

Unit 7: Embryo and endosperm, Seed Structure: Structure of Dicot and monocot embryo; Endosperm types and functions, structure of mature seed, Endospermous seeds. Fruit & Seed dispersal mechanisms & adaptations **(10P)**

Unit 8: Apomixis and Polyembryony: Concepts, types and practical applications. **(4 P)**

Practical (2 Credit)

LABORATORY EXERCISES:

1. Study of meristems (Permanent slides/ photographs) **(1P)**
2. Study of Simple tissues- Parenchyma, Chlorenchyma, Collenchyma & Sclerenchyma (Fresh specimens/permanent slides) **(1P)**
3. Primary structure: **(5P)**
 - Stem of *Helianthus annuus* / *Eupatorium odorum* & *Oryza sativa* / *Zea mays*
 - Roots of *Helianthus annuus* / *Eupatorium odorum* & *Oryza sativa* / *Zea mays*
 - Leaves of *Helianthus annuus* / *Eupatorium odorum* or of any other suitable dicot plant
 - Leaves of *Oryza sativa* or *Zea mays*
4. Maceration of wood, Structure of Xylem & Phloem (Permanent slides, photographs) **(2P)**
5. Structure of Periderm (Permanent Slide) **(1P)**

6. T.S. of Stems of *Boerhaavia*, *Bignonia* & *Dracaena* showing Anomalous secondary Growth (Fresh or Preserved specimens) (3P)
7. Epidermal appendages & stomatal types (Fresh/Permanent Slides) (2P)
8. Anatomical adaptations: Xerophyte (*Opuntia*); Hydrophyte (any hydrophyte –Anatomy of stem/root/leaf), Halophyte (Leaf & Pneumatophore of *Avicennia*), Epiphyte (Aerial root of any Epiphyte). (4P)
9. Structure of anther (young and mature); tapetum - amoeboid and secretory (Permanent slides/Pictures/Photographs). (2P)
10. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/campylotropous. (Permanent slides/Pictures/Photographs) (2P)
11. Female gametophyte: *Polygonum* (Monosporic), *Allium* (Bisporic) & *Fritillaria* or *Peperomia* (Tetrasporic) types of Embryo sac development (Permanent slides/photographs) (3P)
12. Pollination types and dispersal mechanisms of fruits/seeds (Any 4 types-Live/Preserved /Photographs and/ specimens. (3P)
13. Demonstration of Polyembryony using *Citrus* seeds. (1P)

SUGGESTED READINGS:

1. Esau K. 2006. Anatomy of Seed Plants. 2nd edition. Wiley Eastern Private Ltd., N. Delhi.
2. Arthur J. E. & MacDaniels L. H. 1977. *An Introduction to Plant Anatomy*. 2nd Edition. Tata McGraw-Hill Publishing Company Ltd.; Bombay-N. Delhi.
3. Bhojwani, S. S. & Bhatnagar, S. P. 2011. *Embryology of Angiosperms*. 5th edition. Vikas Publication House Pvt. Ltd. New Delhi.
4. A. Fahn. 1990. *Plant Anatomy*. 4th edition. Pergamon Press

BOC104: PLANT PHYSIOLOGY

Credits: 4 (Theory) + 2 (Practical)

THEORY: (4 Credits)

Total Periods: 60

Unit1: Plant-water relations: Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation. (8 P)

Unit 2: Mineral nutrition: Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport carriers, channels and pumps (8 P)

Unit 3: Translocation in phloem Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading (6 P)

Unit 4: Enzymes: Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition (4 P)

Unit 5: Photosynthesis:Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration. **(12 P)**

Unit 6: Respiration: Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway. **(6 P)**

Unit 7: Nitrogen metabolism: Biological nitrogen fixation; Nitrate and ammonia assimilation. **(4P)**

Unit 8: Plant growth regulators:Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene. **(6 P)**

Unit 9: Plant response to light and temperature:Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red-light responses on photomorphogenesis; Vernalization. **(6 P)**

PRACTICAL (2 Credit)

Laboratory exercises:

1. Determination of osmotic potential of plant cell sap by plasmolytic method. **(1P)**
2. To study the effect of two environmental factors (light and wind) on transpiration by excised twig. **(2P)**
3. Calculation of stomatal index and stomatal frequency of a mesophyte and xerophyte **(5P)**
4. Demonstration of Hill reaction. **(1P)**
5. Demonstration of deficiency symptoms of any two macro and micronutrients. **(1P)**
6. Role of light on germination of photoblastic seeds. **(1P)**
7. Demonstration of the activity of catalase to study the effect of pH and enzyme concentration. **(2P)**
8. To study the effect of light intensity and bicarbonate concentration on O₂ evolution in photosynthesis. **(2P)**
9. Comparison of the rate of respiration in any two parts of a plant. **(2P)**
10. Separation of amino acids by paper chromatography. **(1P)**
11. Anatomical feature of C3 and C4 plants. **(1P)**
12. Measurement of pH of different plant extracts (C3, C4 and CAM plants) **(1P)**
13. Determination of chlorophyll a and total chlorophyll in shade and sun plants. **(1P)**
14. Photo-oxidation of photosynthetic pigments. **(2P)**
15. Effect of pH and substrate concentration on the activity of enzyme amylase. **(2P)**
16. Determination of Q₁₀ from the germinating seeds. **(1P)**
17. Demonstration experiments (any four) **(4P)**
 - a) Bolting.
 - b) Effect of auxins on rooting.
 - c) Suction due to transpiration.
 - d) R.Q.
 - e) Respiration in roots.

SUGGESTED READINGS:

1. Taiz, L.; Zeiger, E. 2010. *Plant Physiology*. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, N.P. 2009. *Introduction to Plant Physiology*. John Wiley & Sons, U.S.A. 4th Edition.

3. Bajracharya, D.1999. *Experiments in Plant Physiology- A Laboratory Manual*. Narosa Publishing House, New Delhi.

BOS101: FLORICULTURE

Credits: 3 (Theory)+ 1 (Practical)

THEORY: (4 Credits)

Total Lectures: 45

Unit 1: Introduction, history, concept and scope of floriculture; Floriculture industry- Importance, global trend, trend in India and Goa – present scenario and future prospects. **(3P)**

Unit 2: Study of commercial plants: Flowering plants – Marigold, Gladiolus, Anthurium, Gerbera, Orchids and Jasmine; Cut green plants – Ferns, *Thuja*, Palm and *Asparagus*; Cacti; Water plants – *Hydrilla*, *Pistia* and *Nymphaea*. **(7 P)**

Unit 3: Flower arrangement: Importance, principle; styles and types of flower arrangements; preparation of floral bouquets, floral rangoli, Garlands, Crown, Wreaths, Baskets and Dry flower arrangements; Study of vertical garden and Bonsai: types and techniques (with respect flower plants). Topiary-a green sculpture. **(9 P)**

Unit 4: Nursery Management and Routine Garden Operations: Techniques: Preparation of beds, sowing of seeds, soil sterilization, planting and transplanting; Pricking, pinching, defoliation and mulching; Propagation: Types of Grafting, Layering, Cutting and Budding. **(8 P)**

Unit 5: Role of plant growth regulators and fertilizers: Auxins, Gibberellins, Cytokinins and ABA; Fertilizers and Manures. **(3 P)**

Unit 6: Commercial floriculture: Factors affecting flower production; Post harvest technology - Harvesting, conditioning, storing, packing and prolonging shelf life of flowers; dehydration technique for drying of flowers; Irrigation: Advanced irrigation system (drip, sprinklers and micro tubes); fragrance and flavour industry; bio-colour. **(8 P)**

Unit 7: Pathology: Identification of pests and diseases, symptoms and control; (viral, fungal, mycoplasmic, bacterial and insects **(2 P)**

Unit 8: Garden Implements: Different garden tools and their operations; Green house and Polyhouse **(2 P)**

Unit 9: Scope: Floriculture as an industry; Current status, government initiatives (SCHEMES) and constraint of the commercial floriculture in India; marketing and export. **(3P)**

PRACTICAL: (2 Credits)

Laboratory exercises:

1. Soil preparation and sterilization of Nursery beds and pots. **(2P)**
2. Garden implements and their operations. **(1P)**
3. Methods of vegetative propagations: Grafting, Layering, Cutting and Budding. **(2P)**
4. Handling and propagation of seeds, bulbs and corms. **(1P)**
5. Identification of plant diseases and pest. **(1P)**
6. Identification and description of plants:**(2P)**
Flowers (any 05); Cut greens (any 05); Cacti (any 02); Water plants (any 02); Lawns (any 02)
7. Styles of flower arrangements: **(3P)**
Garlands (any Two); Bouquets (any Two); Crown (any One); Wreath (any One); Baskets (any One);
Dry flower arrangement (any One)
8. Harvesting, packing and prolonging shelf life of flowers. **(1P)**
9. Mulching, Pricking, Topping, Trimming and Pinching.**(1P)**
10. Cultivation of Orchids and Anthuriums .**(1P)**

SUGGESTED READINGS:

1. Daniel Hall, A. 2002. *Fertilizers and Manures*. Biotech ooks Delhi.
 2. Gorner, R. 1978. *The growth of gardens*. Faber and Faber. London.
 3. Hariman, H.T. and Kestler., D.F. 1976. *Plant propagation: Principles and practicals*. Prentice & Hall of India. New Delhi.
 4. *Publications of Directorate of Agriculture*, Govt. of Goa and ICAR, Old Goa.
 5. Swarup, V. 1997. *Ornamental Horticulture*. Macmillan India Ltd.
 6. Randhawa, G.S. and Mukhopadhyay. A. 1986. *Floriculture in India*. Allied Publishers.
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BOS 102: HERBAL TECHNOLOGY

Credits: 3 (Theory) + 1 (Practical)

THEORY: (3 Credits)

Total Lectures: 45

Unit 1: Herbal medicines: Importance of medicinal plants; use of medicinal plants in indigenous / traditional systems of medicine - Siddha, Unani, Ayurveda and Homeopathy. Herbal remedies for holistic health. Collection and processing (harvesting, drying, garbling, packing, storage) of crude drugs and their marketing. **(7 P)**

Unit 2: Pharmacognosy: Plant morphology and organoleptic characters, biological source, chemical constituents and medicinal uses of the following herbs:

Aloe (*Aloe vera*), Jungli pyaz (*Urginea indica*), Kirayat (*Andrographis paniculata*), Lemon grass (*Cymbopogon citratus*), Mint (*Mentha piperita*), Coriander (*Coriandrum sativum*), Garlic (*Allium sativum*), Tulsi (*Ocimum sanctum*), Ginger (*Zingiber officinale*), Turmeric (*Curcuma longa*), Sarpagandha (*Rauwolfia serpentina*) and Periwinkle (*Catharanthus roseus*). **(12 P)**

Unit 3: Phytochemical analysis: General methods of preparation of crude herbal extracts – decoction, maceration, infusion, hot continuous extraction, distillation and supercritical fluid extraction. Histochemical tests for screening of phytoconstituents in natural drugs – alkaloids, flavonoids, steroids, terpenoids, tannins, glycosides and volatile oils. Drug adulteration – deliberate and indeliberate adulteration; types of adulterants. Need for quality control of herbal drugs; microscopic evaluation for quality control. **(11 P)**

Unit 4: Herbal cosmetics & Nutraceuticals: Herbal plants used in cosmetic formulations for skin care (cream, lotion and sunscreen), hair care (oil, shampoo, conditioner and dye) and oral care (toothpaste and mouthwash). Advantages of herbal formulations over synthetic cosmetics. Study of various oils used in aromatherapy with special reference to its applications in inhalation, local application and bath. Herbal nutraceuticals and their health benefits; culinary uses of herbs. **(8 P)**

Unit 5: Conservation of medicinal plants: Conservation and sustainable use of medicinal plants; in-situ and ex-situ conservation methods. Centres for conservation of medicinal plants – CIMAP and FRLHT; TKDL. Plant tissue culture as a source of phytopharmaceuticals. **(7 P)**

PRACTICAL: (1 Credit)

1. Study of biological source, organoleptic characters, chemical constituents and medicinal uses of the following herbs: *Andrographis paniculata*, *Mentha piperita*, *Allium sativum*, *Ocimum sanctum*, *Rauwolfia serpentina* and *Catharanthus roseus*. **(2P)**
2. Study of organoleptic and microscopic characters, chemical constituents and medicinal uses of the following herbs: *Aloe vera* (leaf), *Zingiber officinale* (rhizome), *Curcuma longa* (rhizome), *Urginea indica* (bulb scale), *Cymbopogon citratus* (leaf) and *Coriandrum sativum* (fruit). **(3P)**
3. Detection of alkaloids (*Datura* / *Sadafuli* / *Tirphal*), flavonoids (*Green Tea* / *Onion*) and saponins (*Karando* / *Godekashtha*) or from other suitable plant materials. **(1P)**
4. Microscopic evaluation and chemical tests (metanil yellow test and chalk powder test) to detect adulteration of turmeric powder. **(1P)**
5. Preparation of herbal mouthwash (demonstration). **(1P)**
6. Preparation of herbal soap (demonstration). **(1P)**
7. Preparation of herbal formulation for common cold (demonstration). **(1P)**
8. Preparation of lemon grass medicinal tea (demonstration). **(1P)**
9. Preparation of coriander chutney or any other herbal dish (demonstration). **(1P)**
10. Oral presentation and submission of one herbal plant grown by the student (to be evaluated during regular practical - 3 marks). **(3P)**

SUGGESTED READINGS:

1. Kokate, C.K.; Purohit, A.P. and Gokhale, S.B. 2010. *Pharmacognosy* (45th ed.). Nirali Prakashan, Pune.
2. Anonymous. 1999. *The Ayurvedic Pharmacopoeia of India*. Vol. I & II. Ministry of Health and Family Welfare, Govt. of India, New Delhi.
3. Jackson, B.P. and Snowdon, D.W. 1992. *Atlas of Microscopy of Medicinal Plants, Culinary herbs and Spices*. CBS Publishers, New Delhi.
4. Sivarajan, V.V. and Balachandran, I. 1994. *Ayurvedic Drugs and Their Plant Sources*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
5. Rosaline, A. 2011. *Pharmacognosy*. MJP Publishers, Chennai.
6. Trease and Evans. 2009. *Pharmacognosy* (16th ed.). W.B. Saunders Co. Ltd., London.
7. Kar, A. 2003. *Pharmacognosy & Pharmacobiotechnology*. New Age International (P) Ltd.
8. Fuller, K.W. and Gallon, J.A. 1998. *Plant Products and New Technology*. Clarendon Press, New York.
9. Sachs, M. *Ayurvedic Beauty Care: Ageless Techniques to Invoke Natural Beauty*. ISBN: 9788120818804. 2014.
10. Miller, L. and Miller, B. 1998. *Ayurveda and Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing*. Lotus Press, United States.
11. Akerele, O.O.; Heywood, V. and Singe, H. 1991. *Conservation of Medicinal Plants*. Cambridge University Press, U.K.
12. Harborne, J.B. 1984. *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis* (2nd ed.). Chapman and Hall, New York.
13. Khandelwal, K.R. 2002. *Practical Pharmacognosy: Techniques and Experiments* (9th ed.). Nirali Prakashan, Pune.
14. Bakhru, H.K. 2010. *Foods That Heal: The Natural Way to Good Health*. Orient Paperbacks, New Delhi.
15. Mendonsa, G. 2010. *The Best of Goan Cooking*. UBS Publishers & Distributors Pvt. Ltd.
16. Kapoor, S. 2000. *Khana Khazana*. Popular Prakashan Pvt. Ltd., Mumbai.

Code Numbers for Botany Courses (CBCS)

CODES	COURSE TITLES	CREDTTS
DISCIPLINE SPECIFIC CORE COURSES		
BOC101 (Sem I)	Biodiversity I(Microbes, Algae, Fungi and Bryophytes)	4T+2P =6
BOC102 (Sem II)	Biodiversity II (Vascular plants)	4T+2P =6
BOC103 (Sem III)	Plant anatomy and Embryology	4T+2P=6
BOC104 (Sem IV)	Plant Physiology	4T+2P =6
BOC105 (Sem V)	Classical Taxonomy and Phylogeny	4T+2P=6
BOC106 (Sem V)	Cell Biology and Plant Biochemistry	4T+2P=6
BOC107 (Sem V)	Microbiology and Plant pathology	4T+2P=6
BOC108 (Sem VI)	Genetics and Plant Breeding	4T+2P=6
BOC109 (Sem VI)	Molecular Biology and Genetic Engineering	4T+2P=6
BOC110 (Sem VI)	Plant Ecology and Phytogeography	4T+2P=6
SKILL ENHANCEMENT COURSES		
BOS101(Sem III)	Floriculture	3T+1P=4
BOS102 (Sem IV)	Herbal Technology	3T+1P=4
BOS103 (Sem V)	Mushroom Culture Technology	3T+1P=4
BOS104 (Sem V)	Nursery and Gardening	3T+1P=4
BOS105 (SemVI)	Horticultural practices and Postharvest Technology	3T+1P=4
GENERAL ELECTIVES		
BOG101 (Sem I)	Environmental Biotechnology	3T+1P=4
BOG102 (Sem II)	Coastal and Mangrove Ecology	3T+1P=4
DISCIPLINE SPECIFIC ELECTIVES		
BOD101 (Sem V)	Plant Tissue culture	3T+1P=4
BOD102 (Sem V)	Research Methodology, Bioinformatics and Biostatistics	3T+1P=4
BOD103 (Sem V)	Economic and Medicinal Botany	3T+1P=4
BOD104 (SemVI)	Biofertilizers	3T+1P=4
BOP101(SemVI)	PROJECT	

- **CORE COURSES**

BOC105: CLASSICAL TAXONOMY AND PHYLOGENY

Credits: 4 (Theory) + 2 (Practical)

Course Objective: Plant taxonomy is an ever evolving field and is considered as never ending synthesis. Though, its scope varies from morphology to molecular phylogenetics, the latter is of no use unless morphological base is strong. This course is designed to achieve both along with the knowledge of plant families that are either common or economically useful.

Learning outcome: At the end of the course students not only will be able to understand the morphological terms but also understand the use of them in Floras and monographs and use their knowledge for the identification of plants and write descriptions. Will be able to identify the common and economically important families. In addition, they will be able to understand the massive phylogenetic literature that is being produced.

THEORY: (4 Credits)

Total Lectures: 60

Unit 1. Morphology of Angiosperms: Definition, Characteristics and functions; different types and modifications of following: Roots- Tap, fibrous and adventitious, etc; Stem- Aerial and underground; Leaf- phyllotaxy and its significance, forms/shapes of leaves, leaf incision/types, leaf margins, leaf apex, leaf surface, leaf texture, leaf venation, types of leaves, associated outgrowths, modification of stipules; leaf modifications, vernation; buds; Inflorescence types; Flower- parts, symmetries, characters, types, functions of different parts of the flower, aestivation types; Fruit - types: Simple, Aggregate, Multiple; Seeds - different types. **(25 P)**

Unit 2. Systematic position (Bentham and Hookers classification), diagnostic features and important ornamental/ economical/ medicinal species of the following families: Annonaceae, Capparidaceae, Brassicaceae, Tiliaceae, Rutaceae, Myrtaceae, Leguminosae (Caesalpinaceae, Papilionaceae, Mimosaceae), Cucurbitaceae, Rubiaceae, Apocynaceae, Asclepiadaceae, Verbenaceae, Amarantaceae, Moraceae, Orchidaceae, Araceae, Arecaceae, Musaceae, Commelinaceae. **(21P)**

Unit 3. Origin and evolution of Angiosperms: A general account with special reference to Bennettitalean, Gnetalean, Caytonialean and Herbaceous origin theories; primitive living angiosperms; evolution of flower; co-evolution of flowers and insects. **(7P)**

Unit 4. Phylogeny of Angiosperms: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram). **(7 P)**

PRACTICAL (2 CREDITS)

Laboratory Exercises.

1. To study different types of root. **(1P)**
2. To study different types of stem. **(1P)**

3. To study different characters of leaves with respect to
 - a) Vernations, Phyllotaxy, leaf incision, Leaf surface, Venation types. (2P)
 - b) Shapes, Margins and Apex types. (2P)
 - c) Associated outgrowths. (1P)
 - d) Modification of stipules and Modification of leaves. (1P)
4. To study various kinds of buds, parts of the flower and types of inflorescences. (2P)
5. To study types of fruits, seed types. (2P)
6. To study the classification, distinguishing characters, diagnostic characters, LS flower, T.S Ovary, floral formula and any 5 economically important plants each of families mentioned in the theory. (16P)
7. Field visit to study morphological characters of the plants. (2P)

* Preferably fresh specimens to be shown or to be studied with preserved specimen, herbarium, photographs, etc. mentioned in the theory.

Suggested readings:

1. Davis, P.H., & Heywood, V.H. (1963). *Principles of Angiosperm Taxonomy*. London: Oliver & Boyd.
2. Heywood, V.H., & Moore, D.M. (1984). *Current Concepts in Plant Taxonomy*. London: Academic Press.
3. Jones, Jr. S.B., & Luchsinger, A.E. (1986). *Plant Systematics* (2nd Edition). New York, NY: McGraw-Hill Book Co.
4. Lawrence, G.H.M. (1951). *Taxonomy of Vascular Plants*. New York, NY: MacMillan.
5. Naik, V.N. (1984). *Taxonomy of Angiosperms*. New Delhi: Tata McGraw Hill.
6. Radford, A.E., & Caddell, G.M. (1986). *Fundamentals of Plant Systematics*. New York, NY: Harper & Row.
7. Singh, G. (2012). *Plant Systematics: Theory and Practice* (3rd Edition). New Delhi: Oxford & IBH Pvt. Ltd.
8. Jeffrey, C. (1982). *An introduction to Plant Taxonomy* (2nd Edition). Cambridge, London: Cambridge University Press.
9. Stace, C.A. (1989). *Plant Taxonomy and Biosystematics* (2nd Edition). London: Hodder Arnold.
10. Woodland, D.W. (1991). *Contemporary Plant Systematics*. New Jersey: Prentice Hall.
11. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F., & Donoghue, M.J. (2002). *Plant Systematics - A Phylogenetic Approach* (2nd Edition). Cary, NC: Sinauer Associates Inc.
12. Maheshwari, J.K. (1963). *Flora of Delhi*. New Delhi: CSIR.

BOC106: CELL BIOLOGY & BIOCHEMISTRY

Credits: 4 (Theory) + 2 (Practical)

Course objectives: The course is aimed at providing a detailed discussion on how cellular structure and function arise as a result of the properties of cellular macromolecules. Techniques

used in the study of cell structure together with experiments supporting cell structure and functioning will also be dealt with.

Learning outcome: Students will understand the various techniques used in cell biology and the structure and functions of cell components and cell division. It will also help to understand the chemical structure and properties of biomolecules and secondary metabolites and their role in living organisms.

THEORY: (4 Credits)

Total Lectures: 60

Cell Biology:

Unit 1: Techniques in cell biology: Principle, working and applications of the following techniques: Phase contrast microscopy; Fluorescence microscopy; Electron microscopy (SEM and TEM); Micrometry and Photomicrography. **(6 P)**

Unit 2: Cell and its components: Cell - Cell theory; structure of prokaryotic and eukaryotic cells. Cell wall - chemical composition, ultrastructure and functions. Cell Membrane - chemical composition, structure (Fluid Mosaic Model) and functions; fluidity of membrane. Nucleus - structure of nuclear envelope, nucleoplasm, chromatin (euchromatin and heterochromatin) and nucleolus. Plastids - types of plastids; morphology, ultrastructure and function of Chloroplast. Mitochondria - origin, morphology, ultrastructure and function. Ribosomes - structure of prokaryotic and eukaryotic ribosomes and their functions. Cytoskeleton - structure and function of microtubules, microfilaments and intermediate filaments. Other cell organelles - structure and functions of Endoplasmic Reticulum, Golgi apparatus, Lysosomes, Peroxisomes and Glyoxisomes. **(20 P)**

Unit 3: Cell Division : Overview of cell cycle; cell division (mitosis and meiosis) and its significance. **(4 P)**

Plant Biochemistry:

Unit 4: Biomolecules

Carbohydrates : Classification and biological role of carbohydrates; structure and properties of monosaccharides (glucose and fructose), oligosaccharides (sucrose and maltose) and polysaccharides (starch and cellulose); synthesis and degradation of starch in plants. **(5 P)**

Amino acids and Proteins: Amino acids - classification, structure, properties and biological role of amino acids; essential and non-essential amino acids; transamination. **Proteins** - classification, structure (primary, secondary, tertiary and quaternary), properties and biological role of proteins; protein synthesis (transcription and translation); post translational changes **(10 P)**

Lipids: Classification, structure, properties and biological role of fatty acids and lipids; synthesis and breakdown of triglycerides; β -oxidation. **(4 P)**

Nucleic acids: Structure of nucleic acids (nitrogen bases, nucleosides and nucleotides); structure of B-DNA; alternate forms of DNA (A, C, D and Z); RNA and its types **(4 P)**

Vitamins: Broad classification of vitamins; properties, occurrence, functions and deficiency symptoms of vitamins A, B complex, C, D, E and K. (4 P)

Unit 5: Secondary metabolites: Broad classification of secondary metabolites; properties and functions of terpenoids, alkaloids and phenolics. (3 P)

PRACTICAL (2 CREDITS)

Laboratory Exercises.

1. Measurement of plant cell dimensions (length and breadth) using micrometry. (2P)
2. Study of cell organelles using electron micrographs. (1P)
3. Micro-chemical detection of reducing sugars in floral nectar using Benedict's reagent. (1P)
4. Study of starch grains of wheat, potato and rice using I₂KI reagent. (1P)
5. Localization of carbohydrates using Periodic Acid Schiff's reagent. (1P)
6. Localization of lipids using Sudan III reagent. (1P)
7. Histochemical tests for detection of cellulose, lignin, cutin & suberin in plant sections. (2P)
8. Qualitative tests for biomolecules (carbohydrates, proteins and lipids). (2P)
9. Extraction and estimation of total sugars using phenol sulphuric acid. (2P)
10. Extraction and estimation of reducing sugars by Nelson-Somogyi method. (2P)
11. Extraction and estimation of amino acids using ninhydrin reagent. (2P)
12. Extraction and estimation of proteins by Lowry's method. (2P)
13. Extraction and estimation of ascorbic acid by titrimetric method. (2P)
14. Isolation and comparison of casein content of different milk samples using acetate buffer. sodium (2P)
15. Determination and comparison of acid value of fresh and rancid fat samples by method. titrimetric (2P)
16. Separation of lipids by thin layer chromatography. (2P)
17. Extraction and separation of chlorophyll pigments by paper chromatography. (2P)
18. Study of structure of DNA and RNA with the help of models. (1P)

Suggested Readings:

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

2. Gupta, P.K. (1999). *A Text Book of Cell and Molecular Biology*. Meerut, UP: Rastogi Publications.
3. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments* (6th edition). Hoboken, NJ: John Wiley & Sons. Inc.
4. Avers, C.J. (1986). *Molecular Cell Biology*. Boston, MA: Addison-Wesley Publishing Co.
5. Becker, W.M., Kleinsmith, L.J., Hardin, J. & Bertoni, G.P. (2009). *The World of the Cell* (7th edition). San Francisco: Pearson Benjamin Cummings Publishing.
6. Campbell, M.K. (2012). *Biochemistry* (7th edition). Boston, MA: Cengage Learning.
7. Campbell, P.N., & Smith, A.D. (2011). *Biochemistry Illustrated* (4th edition). London: Churchill Livingstone.
8. Jain, J.L., Jain, S., & Jain, N. (2007). *Elementary Biochemistry* (3rd edition). New Delhi: S. Chand and Company Ltd.
9. Mathur, R. & Mehta, M. (2002). *Biochemistry* (1st edition). New Delhi: Anmol Publications Pvt. Ltd.
10. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2011). *Biochemistry*. New York, NY: W.H. Freeman and Company.
11. Nelson, D.L., & Cox, M.M. (2008). *Lehninger Principles of Biochemistry* (5th edition). New York, NY: W. H. Freeman and Company.
12. Stryer, L. (1995). *Biochemistry*. New York, NY: W.H. Freeman and Co.
13. Campbell, M.K. (1999). *Biochemistry*. Philadelphia: Saunders College Publishing.
14. Verma, S.K., & Verma, M. (2007). *A textbook of Plant Physiology, Biochemistry and Biotechnology* (6th edition). New Delhi: S. Chand and Company Ltd.
15. Sadasivam, S., & Manickam, A. (1996). *Biochemical Methods*. New Age International Publishers.
16. Boyer, R. (2001). *Modern Experimental Biochemistry* (3rd edition). Singapore: Pearson Education.
17. Wilson, K., & Goulding, K.H. (1986). *A Biologists Guide to Principles and Techniques of Practical Biochemistry*. London: Edward Arnold.
18. Rao, B.R. & Deshpande, S. (2005). *Experimental Biochemistry*. New Delhi: I.K. International Pvt. Ltd.
19. Nigam, A. & Ayyagari (2007). *Lab Manual in Biochemistry, Immunology and Biotechnology*. New Delhi: Tata McGraw-Hill Publishing Company Limited.

BOC107: MICROBIOLOGY & PLANT PATHOLOGY

Credits: 4 (Theory) + 2 (Practical)

Course objectives: To familiarize students with basic and advanced concepts of microbiology and plant pathology. The course is aimed to make students aware of the presence of microbes in the environment, their interaction with the environment and plants and methods to control them. The laboratory exercises will provide training in basic skills in isolation and handling of microorganisms and its relevant applications.

Learning outcome: On successful completion of this course, students will understand the various sterilization methods and biosafety measures in the microbiology laboratory; methods for cultivation, preservation and maintenance of microbial cultures; the role of microorganisms in the environment and their various applications. They will also understand the fundamental basis of plant-microbe interaction leading to plant diseases and plant health management. The practical component will help students to explore the relevance of microbes in day to day life situations.

THEORY: (4 Credits)
60

Total Lectures:

Microbiology:

Unit 1: Introduction to microbiology: Terms and definitions; aseptic technique and concept of sterilization; physical and chemical methods of sterilization; biosafety levels and biohazards in the laboratory; disposal of laboratory wastes and cultures. **(5P)**

Unit 2: Methods in microbiology: Types and preparation of culture media; methods of obtaining pure cultures of microorganisms (streak plate, spread plate and pour plate); enumeration of microorganisms (direct and indirect methods); bacterial motility; bacterial growth curve. **(6P)**

Unit 3: Preservation and maintenance of microbial cultures: Methods of preservation (periodic transfer, lyophilisation, use of mineral oil and liquid nitrogen); culture collection centres (culture banks) and their importance. **(3P)**

Unit 4: Microbiology of air, soil and water: Occurrence of microorganisms in air. Microorganisms in soil; role of microorganisms in decomposition of plant residues. Microorganisms in water; microorganisms as indicators of water pollution; bacteriological determination of potability of water (standard multiple tube fermentation and membrane filtration technique); methods of purification of water. **(7P)**

Unit 5: Applications of microorganisms: Role of microorganisms in typical fermentation processes - fermented food and dairy products (bread, yoghurt and cheese); organic acids (citric acid and vinegar); alcoholic beverages made from fruit juices (grape and cashew apple); antibiotics (penicillin and streptomycin). Role of microorganisms in bioremediation; biodegradable plastics; production of biogas. **(9P)**

Plant Pathology

Unit 6: Introduction to Plant Pathology: Terms and concepts; classification of plant diseases; disease symptoms caused by bacterial, fungal and viral plant pathogens; identification of plant disease – Koch's postulates. **(5P)**

Unit 7: Pathogen attack and defense mechanisms: Stages of disease establishment - the disease cycle; structural and biochemical defense mechanisms in plants (pre-existing and induced). **(5P)**

Unit 8: Plant disease epidemiology: Transmission and spread of plant pathogens; development of disease in plants - the disease triangle; plant disease epidemics (monocyclic and polycyclic). **(4P)**

Unit 9: Plant disease management: Physical, cultural, chemical, biological and IPM systems; development of transgenics for disease management; biopesticides; plant disease clinics. **(9P)**

Unit 10: Genetics of Pathogenicity: Genes for virulence and avirulence and their role in susceptibility and resistance; molecular diagnosis - identification of genes and specific molecules in disease development (DNA and protein based diagnostic kits). **(3P)**

Unit 11: Application of Modern Technologies in Plant Pathology: Computer simulation of epidemics and disease forecasting; use of remote sensing and image analysis in plant pathology. **(4P)**

PRACTICAL (2 CREDITS)

Laboratory Exercises.

1. Working and handling of equipment used in microbiology laboratory. **(1P)**
2. Determination of microbial (yeast) population size using serial dilution technique and total count using haemocytometer; relationship between dilution and cell count. **(2P)**
3. Preparation of liquid and solid (plates and slants) culture media – Nutrient Broth, Nutrient Agar and Potato Dextrose Agar. **(2P)**
4. Study of bacterial motility by hanging drop method. **(2P)**
5. Isolation of microorganisms from air; study of colony characteristics of bacteria and fungi; preparation of pure culture of bacteria by streak plate method to obtain isolated colonies; streaking on slants. **(2P)**
6. Evaluation of effectiveness of different agents on hand washing (sanitizer, handwash, dettol and alcohol). **(2P)**
7. Screening for amylase producing microorganisms in soil using starch agar by serial dilution-spread plate method. **(2P)**
8. Analysis of water sample to determine its potability (presumptive test, confirmed test and completed test). **(3P)**

9. Demonstration of fermentation by yeast for preparation of idli and *sanna*.
(2P)
10. Testing quality of milk by methylene blue dye reduction test. (2P)
11. Screening for antimicrobial activity of plant extracts by agar well/disc diffusion method (extracts of neem, garlic and lemon grass; positive and negative control).
(2P)
12. Study of causal organism, symptoms, disease cycle and control measures of plant diseases (viral, bacterial and fungal – one each). (2P)
13. Anatomy/mounting of spores of fungus infected specimens (rust, blight and rot).
(2P)
14. Demonstration of Koch's postulates for a bacterial/fungal pathogen.
(3P)
15. Image analysis of infected field.
(1P)

Suggested Readings:

1. Dubey, R.C., & Maheshwari, D.K. (1999). *A text book of Microbiology*. New Delhi: S. Chand and Company Ltd.
2. Sullia, S.B. (2001). *General Microbiology*. New Delhi: Oxford Publishers.
3. Sharma, K. (2011). *Text book of Microbiology*. New Delhi: Anne Books Pvt. Ltd.
4. Kalaichelvan, P.T., & Pandi, A. (2007). *Bioprocess Technology*. Chennai: MJP Publishers.
5. Moshrafuddin, A., & Basumatany, S.K. (2006). *Applied Microbiology*. Chennai: MJP Publishers.
6. Meyneil, E., & Meynell, G.G. (1970). *Theory and Practice in Experimental Bacteriology*. Cambridge: Cambridge University Press.
7. Agrios, G.N. (1997). *Plant Pathology*. London: Academic Press.
8. Mehrotra, R.S. (1995). *Plant Pathology*. New Delhi: Tata McGraw-Hill Publishing Company Limited.
9. Sambamurty, A.V.S.S. (2006). *Text Book of Plant Pathology*. New Delhi: I.K. International Publishing House.
10. Albajes, R., Gullino, M.L., van Lenteren, J.C., & Elad Y. (2000). *Integrated Pest and Disease Management in Greenhouse Crops*. Kluwer Academic Publishers.
11. Persley, G.J. (1996). *Biotechnologies and Integrated Pest Management*. UK: CAB International.
12. Bridge, P. *et al.* (1998). *Molecular Variability of Fungal Pathogens*. UK: CAB International.

13. Skerriitt, J.H., & Apples, R. (1995). *New Diagnostics in Crop Sciences*. UK: CAB International.
14. Bridge, P. *et al.* (1999). *Application of PCR in Mycology*. UK: CAB International.
15. Bridge, P., Moore, D.R., & Scott, P.R. (1998). *Information Technology, Plant Pathology and Biodiversity*. UK: CAB International.
16. Eklund, C., & Lankford, C.W.E. (1967). *Laboratory Manual for General Microbiology*. Engle-wood Cliffs, N.J: Prentice-Hall, Inc.
17. Gunasekaran, P. (1995). *Laboratory Manual in Microbiology*. New Age International Pvt. Ltd.
18. Pawsey, R.K. (1974). *Techniques with Bacteria - A Guidebook for Teachers*. Hutchinson Educational.
19. Pelczar, M.J., & Chan, E.C.S. (1972). *Laboratory Exercises in Microbiology*. McGraw Hill Book Co.
20. Wistreich, G.A., & Lechtman, M.D. (1973). *Laboratory Exercises in Microbiology*. Glencoe Press, New York, Beverly Hills, Collier Macmillan Publishers, London.
21. Dubey, R.C., & Maheshwari, D.K. (2002). *Practical Microbiology*. New Delhi: S. Chand & Company Ltd.
22. Kale, V., & Bhusari, K. (2001). *Practical Microbiology: Principles & Techniques.*, Mumbai: Himalaya Publishing House.
23. Garg, N., Garg, K.L., & Mukerji, K.G. (2010). *Laboratory Manual of Food Microbiology*. New Delhi: I.K. International Publishing House Pvt. Ltd.
24. Aneja, K.R. (1993). *Experiments in Microbiology, Plant Pathology and Tissue Culture*. New Delhi: Wishwa Publication.
25. Mahadevan, A., & Sridhar, R. (1986). *Methods in Physiological Plant Pathology*. Chennai: Sivakami Publication.
26. Schaad, N.W. (1988). *Plant Pathogenic Bacteria: Laboratory Guide for Identification of Plant Pathogenic Bacteria*. Academic Press.

Journals / Series:

1. Methods in Microbiology; Methods in Enzymology; Methods in Biochemistry.
2. Indian Journal of Mycology & Plant Pathology, Jodhpur.
3. Mycorrhiza News Letter, TERI, New Delhi.
4. Indian Journal of Microbiology.

BOC108: CYTOGENETICS AND PLANT BREEDING

(Credits: Theory-4, Practical-2)

Course Objectives: The paper provides the students with basic concepts of Cytogenetics and Plant breeding along with their applications.

Learning Outcome: This paper will provide basic knowledge in plant breeding exercises.

THEORY: (4 Credits)

Total periods:

60

Unit 1: Cell cycle: Mitosis, Meiosis; Significance (2 P)

Unit 2: Mendelian genetics and its extension: Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Backcross and test cross; Incomplete dominance, codominance and lethal alleles; Gene interactions (Epistasis) – Dominant, Recessive, Complementary, Supplementary, Duplicate; Multiple alleles (blood groups in humans, self-incompatibility in plants), Pleiotropy, Penetrance and Expressivity (9 P)

Unit 3: Extrachromosomal Inheritance: Characteristics of extrachromosomal inheritance; Cytoplasmic inheritance in *Mirabilis jalapa*; Kappa particles in *Paramecium*; Mitochondria in yeast; Maternal effects in snail (shell coiling). (4 P)

Unit 4: Linkage, crossing over and chromosome mapping: Linkage, crossing over types and significance; Cytological basis of crossing over; Recombination frequency, two-point and three-point test crosses and their significance in chromosome mapping; Interference and coincidence (6 P)

Unit 5: Autosomes and sex chromosomes: Mechanisms of sex determination; Balance concept of sex determination in *Drosophila*; Sex-linked inheritance; Sex-limited characters. (4 P)

Unit 6: Alteration in chromosome number and structure: Deletion, Duplication, Inversion, Translocation, meiosis in structural heterozygote; Position effect; Euploidy and Aneuploidy. (8 P)

Unit 7: Gene mutations: Types of mutations; Mutagens - physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Molecular basis of Mutations; Detection of mutations: CLB method. (6 P)

Unit 8: Introduction to Plant Breeding: Introduction and objectives; Important achievements and undesirable consequences of plant breeding. Centres of origin and domestication of crop plants. (3 P)

Unit 9: Methods of crop improvement: Introduction and Acclimatization; Selection methods - for self-pollinated, cross-pollinated and vegetatively propagated plants; Hybridization: For self- and cross-pollinated plants – Procedure, advantages and limitations. Role of mutation, polyploidy; Distant hybridization in crop improvement. (11 P)

Unit 10: Quantitative inheritance: Concept, mechanism, Monogenic V/s Polygenic Inheritance. Examples - Inheritance of kernel colour in wheat, ear length in maize (4 P)

Unit 11: Inbreeding depression and heterosis: Inbreeding depression, Heterosis; Applications. (3 P)

PRACTICAL (2 CREDITS)

Laboratory Exercises.

1. Mendel's laws through seed ratios. (2P)
2. Problem's on monohybrid, dihybrid cross and modified dihybrid ratios. (4P)
3. Preparation of chromosome map using three-point test cross data. (4P)
4. Study of stages in mitosis using *Allium cepa* root tips. (3P)
5. Study of stages in meiosis using *Allium cepa* /*Rheo bicolor* flower buds. (3P)
6. Preparation of karyotype from dividing *Allium cepa* root tip cells. (2P)
7. Photo/Permanent slides showing translocation ring, laggards and inversion bridge. (2P)
8. Emasculation and bagging of flowers of Brassicaceae and Malvaceae, pollinating them manually, estimating fruit and seed set. (3P)
9. Estimation of pollen fertility in any two locally grown crop plants (e.g. Chilly, Brinjal). (2P)
10. Estimation of pollen-ovule ratio and its bearing on pollination system. (2P)
11. Colchicine induced polyploidy. (1P)
12. Colchicine induced mutation (root/ shoot/ germination/ chromosomes). (2P)

Suggested Readings:

1. Acquaah, G. (2007) Principles of Plant Genetics & Breeding. Blackwell Publishing.
2. Chaudhari, H.K. (1984) Elementary Principles of Plant Breeding (2nd edition). Oxford – IBH.
3. Gardner, E.J., Simmons, M.J. and Snustad, D.P. (1991) Principles of Genetics (8th edition). John Wiley & sons, India.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S. B. and Doebley, J. (2010) Introduction to Genetic Analysis (10th edition). W. H. Freeman and Co., U.S.A.
5. Goswami, H.K. and Goswami, R. (1993) Practical Cytology, Applied Genetics and Biostatistics (2nd Revised Edition). Himalaya Publishing House, Mumbai.
6. Klug, W.S., Cummings, M.R. and Spencer, C.A. (2009) Concepts of Genetics, (9th edition). Benjamin Cummings, U.S.A.
7. Singh, B.D. (2005) Plant Breeding: Principles and Methods (7th edition). Kalyani Publishers, Ludhiana.
8. Snustad, D.P. and Simmons, M.J. (2010) Principles of Genetics, (5th edition). John Wiley & Sons Inc., India.

9. Verma, P.S., Agarwal, V.K. (2009) Genetics, (9th Revised Edition). S. Chand and Co., New Delhi.

BOC109: MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Credits: 4 (Theory) + 2 (Practical)

Course objective: The paper deals with various molecular biological processes, recombinant DNA technology and genetic engineering. The structure of DNA, its synthesis and regulation of gene expression is discussed. Further the paper provides deeper understanding of various methods of recombinant DNA technology and applications of genetic engineering in various organisms.

Learning outcome: Students should be able to apply the knowledge of various molecular biology processes of DNA replication, transcription and translation to various other organisms. Also molecular biology of DNA recombination and genetic engineering could be employed in various situations and applications

THEORY: (4 Credits)

Total Lectures: 60

Unit 1: Nucleic acids: Carriers of genetic information : Historical perspective; DNA/RNA as genetic material (Griffith's, Hershey & Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiment). (2 P)

Unit 2: The Structures of DNA and RNA / Genetic Material : DNA Structure: Salient features of double helix (Watson and Crick), Types of DNA, Types of RNA, denaturation and renaturation, cot curves; Organization of DNA - Prokaryotes, Viruses, Eukaryotes. Structure of nuclear DNA v/s Organelle DNA. (5 P)

Unit 3: The replication of DNA: Genetic code; Central and revised dogma of molecular biology; General principles–Modes of replication, bidirectional replication. Models of DNA replication (Rolling circle, Theta replication and semi-discontinuous replication). Replication of linear ds DNA, Enzymes involved in DNA replication. (7P)

Unit 4: Transcription: Enzymes in transcription; Basic features of transcription- initiation, elongation and termination, promoters and enhancers. (4P)

Unit 5: Translation: Enzymes in translation; Basic features of translation- initiation, elongation and termination, Post translational processing and modification. (4P)

Unit 6: Gene structure, regulation and modification of RNA: Gene organisation in prokaryotes and Eukaryotes; gene regulation in prokaryotes and Eukaryotes. Split genes - concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, alternative splicing; Eukaryotic mRNA processing and stability (5' cap, 3' poly A tail); Ribozymes; RNA silencing. (10 P)

Unit 7: Recombinant DNA technology: Definition of gene and recombinant DNA, steps in genetic engineering. Enzymes used in DNA recombinant technology (Restriction enzymes, DNA ligases. DNA modifying enzymes); Cloning Vectors: pBR322, Ti plasmid, YAC; λ phage, M13 phage, Cosmid; DNA Isolation and sequencing (Sanger & Coulson, Maxam & Gilbert). **(10 P)**

Unit 8: Methods of gene transfer: Gene transfer (*Agrobacterium*- mediated and gene gun); Selection of transformants; selectable marker (Antibiotic resistant markers, herbicide resistant markers) and reporter genes (Luciferase, GUS, GFP). Hairy root culture. **(5 P)**

Unit 9: Gene Cloning: Construction of genomic and cDNA libraries, screening of DNA libraries; complementation, colony hybridization; Southern, Northern and Western blotting; Polymerase Chain Reaction. Techniques of DNA fingerprinting (RFLP, RAPD, AFLP) **(8 P)**

Unit 10: Applications of Genetic Engineering : Pest resistant (Bt-cotton); herbicide resistant plants (Round Up Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Protease, Lipase); Genetically Engineered Products – Human Growth Hormone; Humulin; Superweeds; Bioethics and Biosafety concerns. **(7 P)**

PRACTICAL (2 CREDITS)

Laboratory Exercises.

1. General laboratory methods and safety procedures. **(2P)**
2. Extraction of DNA from cauliflower. **(2P)**
3. Estimation of DNA by diphenylamine method. **(1P)**
4. Demonstration of separation of DNA by gel electrophoresis. **(2P)**
5. Extraction of RNA from plant material. **(2P)**
6. Estimation of RNA by Orcinol reagent. **(1P)**
7. Study of DNA replication mechanisms through models/photographs (Rolling circle, Theta replication and semi-discontinuous replication). **(2P)**
8. Study of structures of pBR322, Ti plasmid, YAC, λ phage through models/ photographs. **(2P)**
9. Culture of plasmid and maintenance of culture. **(2P)**
10. Isolation of plasmid DNA. **(2P)**
11. Photographs establishing nucleic acid as genetic material (Avery et al, Griffith's, Hershey

& Chase's and Fraenkel & Conrat's experiments). **(2P)**

12. Study of spliceosome machinery and alternative splicing mechanism through photographs.**(1P)**

13. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, microprojectile bombardment (gene gun).**(1P)**

14. Study of steps of genetic engineering for production of Bt cotton, Golden rice, FlavrSavr tomato and humulin production through photographs.**(2P)**

15. Deciphering DNA sequence from a sequencing gel photograph by Maxam and Gilberts method.**(2P)**

16. Deciphering DNA sequence from a sequencing gel photograph by Sangers method. **(2P)**

17. Working of restriction enzyme and calculating the size of the fragments by use of maps. **(2P)**

Suggested Readings

1. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R. (2007). *Molecular Biology of the Gene* (6th edition). New York, NY: CSHL Press.
2. Snustad, D.P., & Simmons, M.J. (2010). *Principles of Genetics* (5th edition). U.S.A.: John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., & Spencer, C.A. (2009). *Concepts of Genetics* (9th edition). U.S.A: Benjamin Cummings.
4. Russell, P. J. (2010). *i-Genetics- A Molecular Approach* (3rd edition). U.S.A.: Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., & Doebley, J. (2010). *Introduction to Genetic Analysis* (10th edition). U.S.A.: W. H. Freeman and Co.
6. Glick, B.R., & Pasternak, J.J. (2003). *Molecular Biotechnology- Principles and Applications of recombinant DNA*. Washington D.C.: ASM Press.
7. Stewart, C.N. Jr. (2008). *Plant Biotechnology & Genetics: Principles, Techniques and applications*. U.S.A.: John Wiley & Sons Inc.
8. Dubey, R.C. (1993). *A Textbook of Biotechnology*. New Delhi: S. Chand & Company Pvt. Ltd.
9. Verma, P.S., & Agarwal, V.K. (2009). *Molecular Biology*. New Delhi: S. Chand & Company Ltd.
10. Purohit, S.S. (2008). *Biotechnology: Fundamentals and Applications*. Jodhpur: Agrobios.
11. Nagar, Santosh., & Adhav, Madhavi. (2009). *Practical Biotechnology and Plant tissue culture*. New Delhi: S. Chand & Company Ltd.

BOC 110: Plant Ecology and Phytogeography

Credits: 4 (Theory) + 2 (Practical)

Objectives: Knowledge of ecology is very essential especially when the whole biodiversity loss is happening at a rapid rate and climate change has become a greater threat to humanity and every leaving species than any other. Generally, lack of ecological knowledge is considered as the major reason for the present state. Hence, it is imperative that students understand ecology in proper perspective and understand the interaction between the components. This course is designed to provide these fundamentals.

Learning outcome: At the end of the course students would have learned all fundamental aspects of ecology including abiotic and biotic components, their structure, interrelationship and function.

THEORY: (4 Credits)

Total Lectures: 60

Unit 1: Introduction: Concept of Ecosystem, components and organization, Structure and function, trophic organization. **(3 L)**

Unit 2: Soil: Importance; Origin; Formation; Composition: Physical, chemical and biological components. Soil profile: type of soil; its effect on vegetation. **(8L)**

Unit 3: Water: Importance; States of water in the environment: Water in soil, Water table; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological cycle **(4L)**

Unit 4: Ecological Factors : Atmospheric humidity and precipitation in relation to plants. **(3L)**

Unit 5: Biotic interaction: Basic source of energy, autotrophy, heterotrophy, symbiosis, commensalism, parasitism; food chain; ecological pyramids; biomass; standing crop. **(5L)**

Unit 6: Plant communities: Definition, Analytic, quantitative and synthetic characteristics; life forms; habitat and niche; Ecotone and edge effect; Dynamics; succession- processes, types; climax concepts. **(8L)**

Unit 7: Ecosystems : Aquatic, terrestrial, manmade (agricultural). Ecosystems of west coast and Western Ghats with special reference to Goa: Wetlands, Mangroves, coastal, sand dunes , Plateaus and Forests **(9L)**

Unit 8: Functional aspects of ecosystem: Principles and models of energy flow; production and productivity; Ecological efficiencies; Biogeochemical cycles; cycling of carbon, nitrogen and phosphorus. **(8L)**

Unit 9: Phytogeography: Principles: Continental drift; theory of tolerance; Endemism; Brief description of major terrestrial biomes (tropical, temperate and tundra); Phytogeographical division of India; Local vegetation – forest, agriculture **(12L)**

PRACTICAL (2 CREDITS)

Laboratory Exercises.

1. Study of instruments used to measure microclimatic variables; Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter. (2P)
2. Determination of pH of various soil and water samples (pH meter, universal indicator/lovibond comparator and pH paper). (2P)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests. (2P)
4. Determination of organic matter of different soil samples by Walkley & black rapid titration method. (2P)
5. Determination of soil conductivity and water holding capacity in soils of three habitats (2P)
5. Study of dissolved oxygen of water samples from polluted and unpolluted sources. (2P)
6. (a) Study of aquatic ecosystem of phytoplanktons and hydrophyte diversity. (3P)
(b) Study of morphological and anatomical adaptation of hydrophytes and xerophytes (two each). (2P)
- (c) Study of biotic interaction of the following: Stem parasite (*Loranthus* & *Cuscuta*), Epiphytes (Orchids), Predation (Insectivorous plants– *Utricularia/Drosera/Pitcher* plant) (3P)
7. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed). (2P)
8. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution laws. (2P)
9. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus. (2P)
10. To prepare map of India with respect to (i) major climatic zones (ii) forest type (iii) biogeographical regions. (2P)
11. To prepare map of Goa to show its vegetation types as specified in theory. (2 P)

Suggested Reading:

1. Odum E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt.Ltd., New Delhi. 5th edition.
2. Singh, J.S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi, India
3. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publication, Meerut. India. 8th edition

4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth System Approach. Oxford University press. U.S.A.
5. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.

- **DISCIPLINE SPECIFIC ELECTIVES:**

BOD101: PLANT TISSUE CULTURE

Credits: 3 (Theory) + 1 (Practical)

Course objectives: The aim of this course is to give students a basic understanding of the principles and techniques involved plant tissue culture; to familiarize them with PTC laboratory setup and to provide training in plant tissue culture and micropropagation techniques including preparation of culture media, growing entire plants from tissues and their hardening.

Learning outcome: After successful completion of this course, students will understand the principles involved plant tissue culture and gain proficiency in PTC techniques for plant regeneration from cells and tissues and from protoplasts using somatic hybridization. They will also have an understanding of the various applications of plant tissue culture including *in-situ* and *ex-situ* conservation.

THEORY: (3 Credits)

Total Lectures: 45

UNIT 1: Introduction to Plant Tissue Culture: Concept and history of plant tissue culture; pioneering work and significant achievements of Indian scientists. Plant tissue culture laboratory design; basic requirements and sterilization practices. **(5L)**

UNIT 2: Plant Tissue Culture Technique: Washing, packing and sterilization of glassware; composition, types, preparation and sterilization of culture media; selection, isolation, surface sterilization and inoculation of explants; establishment of invitro cultures, ideal conditions for incubation of cultures, maintenance of cultures and subculture; regeneration of plantlets; acclimatization of tissue cultured plantlets in greenhouse/polyhouse. **(6L)**

UNIT 3: Cellular Totipotency and Differentiation: Concept of cellular totipotency and differentiation (dedifferentiation and redifferentiation); role of plant growth regulators in tissue culture; role of meristems in tissue culture; characteristics of callus tissue; somaclonal variation; organogenesis and somatic embryogenesis. Preparation of synthetic seeds. **(7L)**

UNIT 4: Types of Cultures: Principle, protocol and applications of the following types of culture: callus culture, meristem culture, embryo culture, root culture, anther and pollen culture;

micropropagation. Cell Suspension Culture - methods for isolation of single cells, testing viability of cells, protocol for cell suspension culture, types of suspension cultures (batch and continuous), growth pattern of cells in batch culture, methods for measurement of growth of cells in suspension and applications of cell suspension cultures. **(13L)**

UNIT 5: Somatic Hybridization: Introduction to somatic hybridization; role of enzymes in protoplast isolation, mechanical and enzymatic isolation of plant protoplasts, testing viability of isolated protoplasts, spontaneous and induced fusion of protoplasts, selection of hybrid protoplasts, culture of hybrid protoplasts and applications of somatic hybridization. Cybrids and their applications **(9L)**

UNIT 6: Applications of Plant Tissue Culture: Role of plant tissue culture for crop improvement in agriculture, forestry and horticulture; production of secondary metabolites in culture (callus culture and cell suspension culture); cryopreservation and germplasm conservation (*in-situ* and *ex-situ* methods) **(5L)**

PRACTICALS: (1 Credit)

Total Practicals: 15

1. Familiarization with working and handling of laboratory instruments and equipment; washing, packing and sterilization of glassware. **(2P)**
2. Preparation of plant tissue culture medium (MS) and its sterilization. **(2P)**
3. Surface sterilization and *in vitro* seed germination of *Brasasica* sps. / suitable seeds. **(1P)**
4. Induction of callus from *Daucus carota* cambium and hypocotyl segments as explants. **(2P)**
5. Morphological and microscopic study of callus. **(1P)**
6. Enzymatic isolation of plant protoplasts. **(2P)**
7. Encapsulation of somatic/true embryos to prepare synthetic seeds. **(1P)**
8. Embryo culture of *Zea mays*. **(2P)**
9. Regeneration of shoot and root from callus. **(2P)**

Suggested Readings:

1. Collins, H.A., & Edwards, S. (1998). *Plant Cell Culture*. Oxford: Bios Scientific Publishers.
2. Misra, S.P. (2009). *Plant Tissue Culture*. New Delhi: Ane Books Pvt. Ltd.

3. Singh, S.K., & Srivastava, S. (2006). *Plant Tissue Culture*. New Delhi: Campus Books International.
4. Bhojwani, S.S. (1990). *Plant Tissue Culture: Applications and Limitations*. New York, NY: Elsevier Science Publishers.
5. Vasil, I.K., & Thorpe, T.A. (1994). *Plant Cell and Tissue Culture*. The Netherlands: Kluwer Academic Publishers.
6. Bhojwani, S.S., & Razdan, M.K. (1996). *Plant Tissue Culture: Theory and Practice*. Amsterdam: Elsevier Science.
7. Razdan, M.K. (2003). *An Introduction to Plant Tissue Culture*. New Delhi: Oxford & IBH Publishing Co.
8. Chawla, H.S. (2000). *Introduction to Plant Biotechnology*. New Delhi: Oxford and IBH Publishers.
9. De, K.K. (1992). *Plant Tissue Culture*. Calcutta: New Central Book Agency (P) Ltd.
10. Jha T.B. and Ghosh B. (2005) *Plant Tissue Culture*. Universities Press Pvt. Ltd., Hyderabad.
11. Ramawat, K.G. (2004). *Plant Biotechnology*. New Delhi: S. Chand & Company Ltd.
12. Prakash, M., & Arora, C.K. (2005). *Cell and Tissue Culture*. New Delhi: Anmol Publications Pvt. Ltd.
13. Chawla, H.S. (2002). *Introduction to Plant Biotechnology*. USA.: Science Publishers Inc.
14. Narayanswamy, S. (1994). *Plant Cell and Tissue Culture*. New Delhi: Tata McGraw-Hill Publishing Company Ltd.
15. Joshi, R. (2006). *Agricultural Biotechnology*. New Delhi: Gyan Books.
16. Kumar, H.D. (2005). *Agricultural Biotechnology*. New Delhi: Daya Publishing House.
17. Gautam, H. (2006). *Agricultural and Industrial Applications of Bio-technology*. New Delhi: Rajat Publications.
18. Harikumar, V.S. (2006). *Advances in Agricultural Biotechnology*. New Delhi: Regency Publishers.
19. Raghavan, V. (1986). *Embryogenesis in Angiosperms: A Developmental and Experimental Study*. New York: Cambridge University Press.

20. Chawla, H.S. (2003). *Plant Biotechnology: A Practical Approach*. New Delhi: Oxford & IBH Publishers.
21. Kumar, U. (2011). *Methods in Plant Tissue Culture*. Agro-Bios.
22. Nair, L.N. (2010). *Methods in Microbial and Plant Biotechnology*. Kolkata: New Central Book Agency (P) Ltd.

BOD 102: Research Methodology, Bioinformatics and Biostatistics

Credits: 3 (Theory) + 1 (Practical)

Course objectives: Modern biology primarily depends on molecules and numbers. Generating, handling, analyzing and interpreting these numbers (and molecules) is the fundamental part of the research. This course is designed to expose the students to these basic components.

Learning outcome: Students will learn to understand the basic tenets of research, laboratory safety measures, importance of maintaining records, writing of research ideas, search, download and use the molecular data for their own research and will be able to apply basic statistical techniques.

THEORY:

Total Lectures: 45

Unit 1: Basic concepts of research and general laboratory practices : Research- definition and types of research (library, field and laboratory). Research methods; Literature-review and its consolidation. Access to laboratory; laboratory practices and cleanliness; laboratory hazards (chemical, fire, electrical, noise, radiation), safety measures. **(8 P)**

Unit 2: Data collection and documentation of observations: Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars, Importance of photography. **(3 P)**

Unit 3: Scientific writing and presentation: Numbers, units, abbreviations and nomenclature used in scientific writing. Reference writing. Scientific presentation, writing and ethics; introduction to copyright - academic misconduct/plagiarism. **(5 P)**

Unit 4: Bioinformatics; databases and their sequencing: Introduction, Aim, Scope and Research areas of Bioinformatics; Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System. National Center for Biotechnology Information (NCBI): Tools and Databases, Database Sequence Submission to NCBI, Basic Local Alignment Search Tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. Protein Information Resource (PIR): Introduction of PIR, Resources, Swiss Prot: Introduction and salient features. **(12 P)**

Unit 5: Applications of Bioinformatics: Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement. (6 P)

Unit 6: Introduction to Biostatistics: Statistical methods- basic principles, sampling methods (random and stratified sampling); Collection of primary and secondary data, its tabulation and presentation. (5P))

Unit 7: Measures of central tendency: Mean, median, mode, standard deviation, standard error, correlation, regression, chi square analysis, Students 't' test; merits and demerits of measures of central tendency. (6P)

PRACTICAL (1 Credit)

Laboratory Exercises:

1. Study of technique of Microphotography and field photography. (2P)
2. Preparation of poster on defined topic. (1P)
3. Analysis of data for mean, mode, median, standard deviation and standard error using suitable plant material. (1P)
4. Determination of correlation and regression using suitable plant material. (3P)
5. Chi square analysis. (1P)
6. Analysis of Students' 't' test using suitable example. (1P)
7. Study of nucleic acid and protein databases. (2P)
8. Study of sequence retrieval from nucleic acid and protein databases. (1P)
9. Study of unknown DNA and protein sequences using sequence alignment tool from NCBI/BLAST. (2P)
10. Study of species affinity based on given phylogenetic tree. (1P)

Suggested Readings:

1. Danniel, W.W. (1987). *Biostatistics*. New York, NY: John Wiley Sons.
2. Campbell, A.M., & Heyer, L.J. (2006). *Discovering Genomics, Proteomics and Bioinformatics* (2nd edition). Cold Spring Harbor Laboratory Press and Benjamin Cummings.
3. Campbell, R.C. (1974). *Statistics for Biologists*. Cambridge University Press.

4. Dawson, C. (2002). *Practical research methods*. New Delhi: UBS Publishers.
5. Freedman, P. (1949). *The Principles of scientific research*. Washington DC.: Macdonald And Company Limited.
6. Ghosh, Z., & Bibekanand M. (2008). *Bioinformatics: Principles and Applications*. Oxford University Press.
7. Gurumani, N. (2006). *Research Methodology for Biological sciences*. Chennai, TN: MJP Publishers.
8. Pevsner, J. (2009). *Bioinformatics and Functional Genomics* (2nd Edition). Wiley-Blackwell.
9. Ruzin, S.E. (1999). *Plant micro technique and microscopy*. New York, NY: Oxford University Press.
10. Selvin, S. (1991). *Statistical Analysis of epidemiological data*. New York, NY: New York University Press.
11. Stapleton, P., Yondeowei, A., Mukanyange, J., & Houten, H. (1995). *Scientific writing for agricultural research scientists - a training resource manual*. Hong Kong: West Africa Rice Development Association.
12. Sundarrao, P.S.S., & Richards, J. (2012). *An introduction to Biostatistics, and Research Methods* (5th edition). New Delhi: PHI learning Pvt. Ltd.

BOD 103: ECONOMIC AND MEDICINAL BOTANY

Credits: 3 (Theory) + 1 (Practical)

Objectives: While botanists are more interested in structure and function of the plants, others are more interested in economic prospects of the botany. Livelihood of the people also depend on these plants, especially the ones used as staple food and medicines. This course gives a broader exposure to these very important economic plants in addition to their origin, general information, conservation and ethnobotany.

Learning outcome: The students who have opted for this course will be knowledgeable on several economically important plants including medicinal plants. This will help them to pursue their career as economic botanist, conservation biologist, medicinal plants biologist, etc. Will be able to deal with ethnobotanist, agricultural and horticultural scientist and social scientists.

THEORY: (3 Credits)

Total Lectures: 45

Unit 1: Origin of plants: Vavilov's concept of centre of origin; wild relatives of cultivated plants. (1L)

Unit 2: General account of economically important plants: Identification, brief botanical description, cultivation practices and utilization of the following plants and/or plant parts:

a. Cereals & Millets - Rice, wheat, maize and ragi. (4 L)

b. Pulses - Red gram, black gram and green gram. (2 L)

c. Spices & condiments - Chillies, black pepper, cinnamon, ginger, turmeric and cardamom. (4 L)

d. Beverages - Tea and coffee (including processing). (2 L)

e. Vegetable oil sources - Sesame, groundnut, soybean, coconut and mustard (including extraction) (4 L)

f. Fibre Yielding Plants - Cotton, coir, jute and agave (including types of fibres and extraction). (3 L)

g. Fruit crops - Mango, jackfruit, banana, cashew, pineapple and papaya (4 L)

h. Vegetable crops - Red amaranth, radish, knol-khol & okhra (3 L)

i. Sugar & starch crops - Sugarcane (including processing, products and by-products of sugarcane industry), potato and yam. (3 L)

j. Rubber yielding plants - *Hevea brasiliensis* (including tapping and processing). (1 L)

k. Timber plants - Matti, Sailo, Shisham and Bamboo (including wood properties) (3 L)

l. Miscellaneous - Dye (*Bixa orellana*), Essential oil (*Eucalyptus*), Insecticidal (Neem)(2L)

Unit 3: Popular medicinal plants and plant drugs: A brief account of the chief chemical constituents and uses of the following plant drugs used in indigenous and allopathic systems of medicine: *Hemidesmus indicus*, *Garcinia indica*, *Boerhaavia diffusa*, *Alstonia scholaris*, *Datura metel*, *Holarrhena antidysenterica*, *Piper longum*, *Syzygium cumini*, *Strychnos nux-vomica*, *Terminalia bellerica*, *Adathoda vasica* and *Tinospora cordifolia* (5L)

Unit 4: Crop research organisations: Brief account of research organisations involved in improvement of different crops in India: ICAR (Indian Council of Agricultural Research); ICRISAT (International Crops Research Institute for the Semi-Arid Tropics); CRRI (Central Rice Research Institute) and SBRI (Sugarcane Breeding Research Institute) (4L)

PRACTICAL (1 Credit)

LABORATORY EXERCISES: (1 Credit)**Total Practicals: 15**

1. Identification (botanical name and family), description and utilization of plants and/or plant parts studied in theory under each group. (6 P)
2. Chemical tests for sesame and groundnut oil and study of oil glands in T.S. of Eucalyptus leaf. (1P)
3. Study of properties and measurement of diameter of plant fibres: cotton, jute and coir. (2P)
4. Study of plants used as sources of drugs as in theory. (3 P)
5. Preparation of *Holi* colours using natural ingredients. (1 P)
6. Identification and medicinal value of locally available plants (field visit) (2 P)

Suggested Readings:

1. Kochhar S.L. (2012) Economic Botany in the Tropics. MacMillan India Ltd., New Delhi.
2. Wickens G.E. (2001) Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
3. Chrispeels M.J. and Sadava D.E. (1994) Plants, Genes and Agriculture. Jones & Bartlett Publishers.
4. Sambamurty A.V.S.S. and Subramanyam N.S. (1989) A Textbook of Economic Botany. Wiley Eastern Ltd., New Delhi.
5. Trivedi P.C. (2006) Medicinal Plants: Ethnobotanical Approach, Agrobios, India.
6. Purohit and Vyas (2008) Medicinal Plant Cultivation: A Scientific Approach. Agrobios, India.
7. Fuller K.W. and Gallon J.A. (1985) Plant Products and New Technology. Clarendon Press, Oxford, New York.
8. Hill A.F. (1952) Economic Botany: A Textbook of useful plants and plant products. McGraw Hill Publishing Company Ltd., New Delhi.
9. Sen S. (2009) Economic Botany. NCBA Publishers, New Delhi.
10. Sharma O.P. (1996) Hill's Economic Botany. Tata McGraw Hill Publishing Company Ltd., New Delhi.
11. Simpson B.B. and Conner-Ogorzaly M. (1986) Economic Botany- Plants in Our World. McGraw Hill, New York.
12. Singh, V; Pande, P.C. and Jain. D.K. (2009). A text book of Economic Botany, Rastogi Publications.

BOD 104: BIOFERTILIZERS

Credits: 3 (Theory) + 1 (Practical)

Course Objectives: This course is designed to give students an understanding of the various types of biofertilizers and the benefits of their application. The practical component is designed to let students explore and handle the various organisms used in biofertilizer formulations and to prepare biofertilizers from these isolates. The course will provide knowledge of principles and practices of organic agriculture and its role in sustainable crop production.

Learning Outcome: On successful completion of the course students will understand the concept of biofertilizers, the types, formulation, method of field application and the benefits associated with their use. The practical component of the course will help students to explore the proficiency of organisms used in biofertilizer preparation and train them in formulating biofertilizers. This will enable students to develop an eco-friendly approach for improving the nutrient management system of agricultural land in a cost-effective manner.

THEORY: (3 Credits)

Total Lectures: 45

UNIT 1: Introduction to biofertilizers: Concept of biofertilizers; various types of microbes used as biofertilizers; role of effective microorganisms and Plant Growth Promoting Rhizobacteria (PGPR) and their mode of action; benefits and limitations of usage of biofertilizers. **(5 P)**

UNIT 2: Symbiotic nitrogen fixing microbes: *Rhizobium*-root nodule symbiosis; identification, isolation, mass multiplication, production of carrier-based inoculants, techniques of field application and crop response to rhizobial inoculants; *Frankia* and actinorrhizal symbiosis; *Azolla-Anabaena* symbiosis; mass cultivation and field application of *Azolla* and its role as a green manure-cum-biofertilizer. **(8P)**

UNIT 3: Free living nitrogen-fixing microbes: Cyanobacteria - diversity, identification, isolation, inoculum preparation, techniques of field application and crop response to cyanobacterial inoculants. *Azospirillum* and *Azotobacter* - identification, isolation, mass multiplication, production of carrier-based inoculants, techniques of field application and crop response. Algalization technology **(8 P)**

UNIT 4: Phosphate solubilizing microbes: Occurrence, isolation, mass production, field application and crop response to phosphate solubilizing microorganisms. **(2P)**

UNIT 5: Mycorrhizae as biofertilizers: Types of mycorrhizal association and their characteristics; ectomycorrhizae as biofertilizers; morphology and identification of AM fungal genera; isolation, mass production and field application of AM inoculum; role of mycorrhizae helper bacteria; significance of mycorrhizae in forestry and agriculture. **(7 P)**

UNIT 6: Organic farming: Principle, need and benefits of organic farming; crop rotation and its advantages; types of manure - green manure, farmyard manure and neem-coated urea.

Recycling of biodegradable municipal, agricultural and industrial wastes into biocompost; problems associated with presence of heavy metals and pathogens in biocompost. Method of vermicomposting, its advantages and disadvantages. **(7 P)**

UNIT 7: Quality control of biofertilizers: Standard parameters for quality control; quality management procedures; storage conditions and shelf life of biofertilizers; government support and programmes. **(4 P)**

UNIT 8: Future of biofertilizers: Biofertilizers for sustainable agriculture; farmers' acceptance and utilization of biofertilizers; selection of competitive and multi-functional biofertilizers – case study of *Piriformospora indica*. **(4 P)**

PRACTICALS: (1 Credit)

Total Practicals: 15

1. Identification of any two cyanobacteria from rice fields. **(1P)**
2. Isolation of cyanobacteria using Fogg's medium and preparation of starter culture. **(2P)**
3. Mass culture of cyanobacterial inoculum by trough method. **(1P)**
4. Isolation of *Rhizobium* from root nodules using YEMA medium. **(2P)**
5. Preparation of carrier-based inoculum of *Rhizobium*. **(1P)**
6. Induction of root nodules in a leguminous plant using *Rhizobium* sps. (Demonstration). **(1P)**
7. Study of *Anabaena-Azolla* symbiosis in *Azolla* leaf sections. **(1P)**
8. Isolation of AM spores from soil by wet-sieving and decanting method. **(1P)**
9. Testing for ammonification by soil microbes using Nessler's reagent. **(2P)**
10. Determination of phosphate solubilising efficiency of soil microbes using Pikovskaya agar. **(2P)**
11. Preparation of compost (Demonstration). **(1P)**

Suggested Readings:

1. Vyas S.C., Vyas S. and Modi H.A. (1998) Bio-fertilizers and Organic Farming. Akta Prakashan, Nadiad.
2. NIIR Board (2004) The Complete Technology Book on Biofertilizer and Organic Farming (2nd Revised Edition).
3. Panda H. (2011) Manufacture of Biofertilizer and Organic Farming. NIIR Board.
4. Sathe T.V. (2004) Vermiculture and Organic Farming. Daya Publishers.

5. Subha Rao N.S. (2000) Soil Microbiology, Oxford & IBH Publishers, New Delhi.
6. Dubey R.C. (2005) A Text book of Biotechnology. S. Chand & Company, New Delhi.
7. John Jothi Prakash E. (2004) Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
8. Kumaresan V. (2005) Biotechnology. Saras Publications, New Delhi.
9. Rai M.K. (2006) Handbook of Microbial Biofertilizers. Food Products Press, New York.
10. Gupta P.K. (1999) Soil, Plant, Water and Fertilizer Analysis. Agro Botanica, Bikaner.
11. Bisen P.S. (2014) Laboratory Protocols in Applied Life Sciences. CRC Press, Boca Raton.
12. Sharma K. (2007) Manual of Microbiology: Tools and Techniques. 2nd edition. Ane Books Pvt. Ltd., New Delhi.
13. Dubey R.C. and Maheshwari D.K. (2002) Practical Microbiology. Revised Edition. S. Chand & Company, New Delhi.

• **SKILL ENHANCEMENT COURSES**

BOS103: Mushroom Culture Technology

Credits: 3 (Theory) + 1 (Practical)

Objectives: To make students aware in the field of diversity and biology of mushrooms. Paper also deals with biotechnology of mushrooms, their production, marketing and Post harvest technology on commercial scale.

Learning Outcome: Students will be able to analyse mushroom production and marketing trends. They are expected to be able to work in a mushroom industry and research laboratory.

THEORY: (3 Credits)

Total Lectures: 45

Unit 1: Introduction, history. Edible and non-edible mushrooms (Poisonous). Types of edible mushrooms available in India – *Volvariell avolvacea* (paddy straw), *Pleurotus* spp (Oyster), *Agaricus bisporus* (Button). Nutritional value and medicinal importance. Key to differentiate edible from poisonous mushrooms. Mushroom classification based on occurrence, habitat, colour, morphology, fruit bodies; Recent classification - 8th edition of Ainsworth & Bisby's Dictionary of fungi. **(6 P)**

Unit 2: Biology of Mushroom: Button, Straw and Oyster mushrooms: Morphology, Diagnostic characters, reproduction, spore germination and life cycle of button mushroom. **(5 P)**

Unit 3: Cultivation Technology: Mushroom laboratory; infrastructure- facilities and materials; Substrates (locally available - paddy straw, sugarcane trash, maize straw, banana leaves), Mushroom bed preparation (Composting technology, platform, equipments & facilities); pasteurization room & growing rooms. Mushroom spore isolation & spore culture; Culture media (PDA medium, Malt extract agar medium); pileus tissue culture. Preparation of spawn-substrate, sterilization, multiplication & storage. Conservation of mushroom cultures. **(10 P)**

Unit 4: Cultivation techniques: Cultivation of Button, Oyster and Paddy straw mushrooms - Collection of raw materials, compost and composting, spawn & spawning, casing, cropping, picking and packing. **(6 P)**

Unit 5: Post Harvest Technology and storage: Short-term preservation, conventional packaging, modified atmosphere packaging (MAP), controlled atmosphere packaging (CAP), modified humidity packaging (MHP). Storage of fresh mushrooms (Refrigeration, vacuum cooling) Long term storage (canning, pickles, papads), drying. Transport of fresh mushrooms. **(7 P)**

Unit 6: Management of diseases, pests and fungal attacks: Button mushroom- fungal diseases (dry bubble, wet bubble); weed fungi (olive green mould, brown plaster mould); bacterial diseases (brown blotch, ginger blotch). Oyster mushroom- fungal diseases (Cladobotryum soft rot (cobweb), Gilocladium brown rot); bacterial (bacterial rot, yellow blotch). Paddy straw mushroom- fungal (wet bubble), bacteria (button rot). Pests (Sciarid flies, Phorid flies, Spring tails and mites) **(6 P)**

Unit 7: Economics in mushroom cultivation: Cost for site, spawn production, compost unit, machinery for small scale farm. Cost benefit ratio - Marketing in India and abroad, Export Value, Low cost technology **(5 P)**

PRACTICAL (1 CREDIT)

Laboratory Exercises.

1. Mushroom Cultivation, laboratory requirements and layout. (1 P)
2. Mushroom morphology – L.S of Basidiocarp (Button mushroom), section through gill and mounting of spores. (2 P.)
3. Preparation of culture media (Malt Extract Agar) and petriplates, spore isolation and culture. (2 P)
4. Preparation of spawn for oyster mushroom. (2 P.)
5. Cultivation of Oyster mushroom. (2 P)
6. Mushroom preservation – Drying. Storage in brine and pickle making. (2 P)
7. Study of bacterial, fungal diseases and Pests for Oyster and Button as mentioned in theory with help of preserved specimens and permanent slides. (2 P.)
8. Visit to a relevant farm or Institute. (2 P.)

Suggested Readings

1. Marimuthu, T., Krishnamoorthy, A.S., Sivaprakasam, K., & Jayarajan, R. (1991). *Oyster Mushrooms*. Coimbatore, TN: Department of Plant Pathology, Tamil Nadu Agricultural University.
2. Swaminathan, M. (1990). *Food and Nutrition*. Bengaluru: The Bangalore Printing and Publishing Co. Ltd.
3. Nita, Bahl. (1984-1988). *Hand book of Mushrooms* (2nd edition). Vol. I & Vol. II.
4. Tewari, Pankaj Kapoor, S.C. (1988). *Mushroom cultivation*. New Delhi: Mittal Publication.
5. Dubey, R.C (1993). *A textbook of Biotechnology*. New Delhi: S. Chand & Company Pvt. Ltd.
6. Biswas, S., Datta, M., & Ngachan, S.V. (2012). *Mushrooms, a manual for cultivation*. New Delhi: PHI learning Private Limited.
7. Tripathi, D.P. (2005). *Mushroom Cultivation*. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.
8. *Handbook of cultivation, Processing and packing*, published by Engineers India Research Institute, 4449, Nai Sarah, Main Road, Delhi 110006.
9. Kannaiyan, S., & Ramasamy, K. (1980). *A handbook of edible mushroom*. New Delhi: Today & Tomorrows printers & publishers.
10. Atkinson, G.F. (1961). *Hand book of Mushrooms* (2nd edition) Vol-1 and II. New York, NY: Hafner Publishers.

BOS104: NURSERY AND GARDENING

Credits: 3 (Theory) + 1 (Practical)

Learning outcome and objective

Theory: 3 Credits

Total Lectures: 45

Unit 1: Nursery: Definition, objectives and scope, nursery layout, building up of infrastructure for nursery, management of nursery - planning and seasonal activities - Planting - direct seeding and transplants, potting seedlings, manuring & irrigation, plant protection measures.

(7 L)

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 and processing - seed testing and certification.

(6 L)

Unit 3: Vegetative propagation: Methods of vegetative propagation-Layering, grafting, budding, division, offset, suckers, runners, bulbs, corms, bulbils, Cuttings. Hardening of plants. Green house, mist chamber, shed roof, shade house.

(6 L)

Unit 4: Gardening: Definition, objectives and scope - different types of gardens – landscape, avenue plantation and home gardening - parks and its components - plant materials and design - computer applications in landscaping; different features of a garden –fencing, steps, drives and paths, hedge, edging, arches, pergolas, lawns, carpet bedding, flower beds, shrubbery, borders, topiary, rock garden, water garden, garden adornments.

(10 L)

Unit 5: Routine Garden Operations – Preparation of soil, manuring, watering, pruning, staking, defoliation, pinching, etc., management of pests and diseases and harvesting.

(4 L)

Unit 6: Indoor gardening: Selection and cultivation of house plants; gardening in tubs or urns, hanging baskets, window boxes; gardening in troughs, dishes, bowls and trays; vertical garden; jar, bottle and terrarium gardening. **bonsai**.

(5 L)

Unit 6: Kitchen garden: kitchen garden layout; classification of vegetables, vegetables in different seasons; organic manures and substrates; preparation of beds, Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: local leafy vegetables (Red amaranth and spinach), chillies, cluster beans, cabbage, brinjal, lady's finger, onion, turmeric, ginger, knol khol, sweet potatoes, cucurbits, tomatoes and carrots - Storage and marketing procedures.

(7 L)

PRACTICALS: (1 Credit)

1. Different methods of vegetative propagation – Grafting, layering, cutting, budding, division, runners, suckers, corms, bulbs, bulbils, tubers.
(2P)
2. Study of some nursery operations - raising seedlings in trays, preparation of potting mix, transplantation of seedlings in pots, care and maintenance of plants till flowering or fruiting.
(2P)
3. Treatment of seeds (any two types) to break seed dormancy and to find germination percentage of treated seeds.
(2P)
4. To prepare a garden in bowls, urns, tubs, troughs, hanging baskets, jars, bottles, terrarium gardening (any 3).
(1P)
5. To prepare a sketch of Kitchen garden layout / Nursery layout plan.
(1P)

6. To prepare a Landscape design plan for a small home ground. (1P)
7. Cultivation of any five local vegetables. (2P)
8. Identification and description of avenue plants, hedge plants, flower beds (any 3), lawn (any 2), ornamental shrubs (any 3) and trees (any 3), rock garden plants (any 3), water garden plants (any 3), indoor plants (any 2 of each). (2P)
9. Field visit to a plant nursery / landscaped public place / kitchen garden / local vegetable cultivation. (2P)

Suggested Readings

1. Bose T.K. & Mukherjee, D., 1972, Gardening in India, Oxford & IBH Publishing Co., New Delhi.
2. Sandhu, M.K., 1989, Plant Propagation, Wile Eastern Ltd., Bangalore, Madras.
3. Kumar, N., 1997, Introduction to Horticulture, Rajalakshmi Publications, Nagercoil.
4. Edmond Musser & Andres, Fundamentals of Horticulture, McGraw Hill Book Co., New Delhi.
5. Agrawal, P.K. 1993, Hand Book of Seed Technology, Dept. of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi.
6. Janick Jules. 1979. Horticultural Science. (3rd Ed.), W.H. Freeman and Co., San Francisco, USA.
7. Rao, K. Manibhushan, 2005, Textbook of Horticulture, (2nd Ed.), Macmillan India Limited.
8. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India, Allied Publishers limited.
9. Trivedi P.P., 1987, Home Gardening, Indian Council of Agricultural Research, New Delhi.
10. Rao, P.S., 2016, Vegetable Crops Production, Sonali publications, New Delhi.
11. Zingare A.K., 2013, A Manual of Gardening, Satyam Publishers & Distributors, Jaipur.

BOS105: HORTICULTURAL PRACTICES AND POST-HARVEST TECHNOLOGY

Credits: 3 (Theory) + 1 (Practical)

Course objectives: People, who have been living in rural natural landscapes have been shifting to urban landscapes in great number. However, they try to reconstruct the greenery by planting ornamental plants. In addition, the horticultural industry is growing in leaps and bounds, thus

bringing myriads of opportunities for young graduates to grow as horticulturist including landscape designer. This course provides all the necessary knowledge and hands on training.

Learning outcome: At the end of the course students will be able to identify horticultural crops, propagate and cultivate them, landscape the given area, manage them, minimize the post harvesting damages and accumulate all that is required to become a young horticulturist.

Theory: - (3 Credits)

Lectures 45

Unit 1: Introduction: Scope and Importance, Branches of Horticulture, Role in Rural Economy and Employment Generation, Importance in food and nutritional security, Urban Horticulture and Ecotourism. **(4 P)**

Unit 2: Horticultural Techniques : Application of manure, fertilizers and nutrients. Weed control: Biofertilizers, Biopesticides, Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation methods – vegetative (grafting, cutting, layering, budding) and Serial (seed propagation), scope and limitations. **(6 P)**

Unit 3: Ornamental Plants: Types- annuals, perennials, climbers and trees; salient features of some ornamental plants - Rose, Marigold, *Gladilolus*, Carnations, Orchids, Poppies, Gerberas, Tuberose, Cacti and succulents (*Opuntia*, *Agave*, *Kalanchoe*), *Cassia fistula*, *Delonix regia*, *Nyctanthes arbor-tristis*, *Lawsonia inermis*, *Plumeria rubra*, *Saraca indica*, *Michelia champaca*. **(4 P)**

Unit 4: Horticultural crops: Fruits and Vegetables : Origin and distribution, Identification-varieties and cultivars; distribution of some fruits and vegetable varieties (banana, mango, cashew, jackfruit, chillies, brinjal, Cucurbits) and their economic products. Management and marketing of vegetable and fruit crops. **(6 P)**

Unit 5: Conservation and Management of horticultural Crops: Documentation and conservation, Micropropagation and tissue culture techniques; IPR issues, Local conservation strategies. **(4 P)**

Unit 6: Landscaping and garden design: Planning and layout of gardens (kitchen garden, rock garden, terrace garden, water garden, lawn making). Gardening traditions – Ancient Indians, European, Mughal and Japanese gardens **(5 P)**

Unit 7: Disease Control and Management: Field and post harvest diseases; Identification of deficiency symptoms; remedial measures and nutritional management practices; crop sanitation; IPM strategies' (genetic, biological and chemical methods for post control); Quarantine practices; Identification of common diseases and pests of ornamentals, fruits and vegetables crops. **(6 P)**

Unit 8: Post Harvest Technology: Importance of PHT in Horticultural crops, Evaluation of quality traits, harvesting and handling of fruits, vegetables; Methods of preservation and processing; minimizing losses during storage and transportation; Food irradiation – advantages and disadvantages; food safety. **(10 P)**

Practical (1 Credit)

LABORATORY EXERCISES:

- 1) Identification (botanical name and family), description, salient features of ornamental plants (Based on unit 3) **(2P)**
- 2) Identification of Horticultural crops (botanical name and family) varieties, cultivars and description and their economic products.(Based on Unit 4) **(2 P)**
- 3) Identification and description of (Symptoms and remedial measures) common diseases and pests of ornamentals, fruits and vegetables crops. **(2 P)**
- 4) Demonstration of Vegetative propagation **(1 P)**
- 5) Demonstration of Hydroponics **(1 P)**
- 6) Study of preservation techniques **(1 P)**
- 7) Study of the preparation of traditional economic products of Horticultural Crops of Goa (1 fruit- jam/squash; 1 vegetable crop- pickle) **(2 P)**
- 8) Graphic lay out of Kitchen garden, terrace garden, water garden and list of plants used therein. **(2 P)**
- 9) Field visit to ICAR/Kulagar/Garden/Nursery/Park. **(2 P)**

Suggested Readings:

1. Singh D. and Mannivannan S. (2009) Genetic Resources of Horticultural Crops. Ridhi International, Delhi, India.
2. Swaminathan M.S. and Kochhar S.L. (2007) Grooves of Beauty and plenty: An atlas of major flowering trees in India, Macmillan, Publishers, India.
3. NIIR Board (2005) Cultivation of fruits, vegetables and floriculture. National Institute of Industrial Research Board, Delhi.
4. Kader A.A. (2002) Post Harvest Technology of Horticultural Crops. UCANR Publications, U.S.A.
5. Rao K. Manibhhusan (2005) Textbook of Horticulture (2nd Edition). Macmillan Publishers, India.