BOC 101	BIODIVERSITY I (Microbes, Algae, Fungi and Bryophytes)	Credits: 6 4 (Theory) + 2 (Practical)

Course Objectives:

1. To acquire knowledge about microbes and non-vascular plants
2. To understand Microbes and non-vascular plants with regards to their morphological and anatomical features, reproductive structures and their ecological and economic importance.
3. To develop skills in identifying microbes, handling various plant specimens and their conservation.

THEORY	
Unit 1. Microbes: 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 - archaebacteria, eubacteria and mycoplasma. Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.	15 P
Unit 2. Algae: General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following: Nostoc, Spirogyra, Sargassum and Polysiphonia. Economic importance of algae with special reference to food, biofertilizers and medicine.	15P
Unit 3. Fungi: 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) and Agaricus (Basidiomycota); Symbiotic Associations - Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance.	15P
Unit 4. Bryophytes: 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.	15P
PRACTICAL	
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 and 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, Whole mount (W.M.) of rhizoids and scales, V.S. of thallus through gemma cup, W.M. of gemmae (all permanent slides), V.S. of antheridiophore and archegoniophore, L.S. of sporophyte (all permanent	60 H (30P)

slides). (1P) 10. Anthoceros: Morphology and T.S. of thallus and sporophyte (permanent slides). (1P) 11. Funaria: Morphology, W.M. of leaf, rhizoids, sporophyte (permanent slides); permanent slides showing antheridial and archegonial heads, L.S. of 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)	
Learning outcome: On completion of this course, students will: ¬ Gain basic knowledge of microbes with respect to their discovery, structure, reproduction and economic importance. ¬ Understand morphological and anatomical features and reproductive structures of lower groups of plants such as algae, fungi and bryophytes. ¬ Appreciate plant diversity and their economic and ecological importance. ¬ Develop basic skills in handling and sectioning of plant specimens. ¬ Develop specific skills in handling and culturing of microbes. ¬ Use practical knowledge for preparation of value-added edible plant products.	
Books: 1. Kumar, H.D. 1999. Introductory Phycology. 2 nd edition. Affiliated East-West Press Pvt. Ltd. Delhi. 2. Tortora, G.J., Funke, B.R., Case, C.L. 2010. Microbiology: An Introduction. 10th edition. Pearson Benjamin Cummings, U.S.A. 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. and Blackwell, M. 1996. Introductory Mycology. 4 th edition. John Wiley and Sons (Asia), Singapore. 5. Raven, P.H., Johnson, G.B., Losos, J.B. and Singer, S.R., 2005. Biology. Tata McGraw Hill, Delhi.	

BOC 102	**BIODIVERSITY II (Vascular Plants)**	**Credits: 6 4 (Theory) + 2 (Practical)**
Course Objectives: 1. To acquire knowledge about Vascular plants such as Pteridophytes, Gymnosperms & Angiosperms. 2. To understand Vascular plants with regards to their morphological and anatomical features, reproductive structures and their ecological and economic importance. 3. To develop skills in identifying and handling various plant specimens.		
THEORY		
Unit 1: Pteridophytes: 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, stellar evolution. Ecological and		15 P

economical importance of Pteridophytes	
Unit 2. Gymnosperms: General characteristics, Classification (Coulter & Chamberlain), morphology, anatomy and reproduction of Cycas, Pinus and Gnetum (developmental details not to be included). Ecological and economic importance.	10P
Unit 3. Introduction to plant taxonomy: Identification, classification & nomenclature.	4P
Unit 4. Identification: Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access.	8P
Unit 5. Taxonomic evidences from palynology, cytology, photochemistry and molecular data	6P
Unit 6. Taxonomic hierarchy: Ranks, categories and taxonomic groups	2P
Unit 7. Botanical nomenclature: Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.	6P
Unit 8. Classification: 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.	10P
Unit 9. Biometrics, numerical taxonomy and cladistics: Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).	4P
PRACTICAL	
1. Psilotum – morphology, W.M. of Synangium, T.S. of stem. (2P) 2. Selaginella - morphology, W.M. of leaf with ligule, T.S. of stem, W.M. of strobilus, W.M. of microsporophyll and megasporophyll (temporary slides), L.S. of strobilus (permanent slide). (2P) 3. Equisetum - morphology, T.S. of internode, L.S. of strobilus, T.S. of strobilus, W.M. of sporangiophore, W.M. of spores (wet and dry) (temporary slides); T.S. of rhizome (permanent slide). (2P) 4. Pteris - morphology, T.S. of rachis, V.S. of sporophyll, W.M. of sporangium, W.M. of spores (temporary slides), T.S. of rhizome, W.M. of prothallus with sex organs and young sporophyte (permanent slide). (2P) 5. Cycas - morphology (coralloid roots, bulbil, leaf), T.S. of coralloid root, T.S. of rachis, V.S. of leaflet, V.S. of microsporophyll, W.M. of spores (temporary slides), L.S. of ovule, T.S. of root (permanent slide). (2P) 6. Pinus - morphology (long and dwarf shoots, W.M. of dwarf shoot, male and female), W.M. of dwarf shoot, T.S. of needle, T.S. of stem, L.S./T.S. of male cone, W.M. of microsporophyll, W.M. of microspores (temporary slides), L.S. of female cone, T.L.S. and R.L.S. of stem (permanent slide). (3P) 7. Study of vegetative and floral characters of the following families (description, V.S. of 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)	60 H (30P)
Learning outcome: On completion of this course, students will: ¬ Gain knowledge of different members of pteridophytes, gymnosperms and angiosperms. ¬ Understand the morphological and anatomical features of pteridophytes and gymnosperms.	

¬ Identify and classify plants of different angiosperm families. ¬ Appreciate the economic and ecological importance of the above mentioned plant groups.
Books: 1. Vashishta, P.C., Sinha, A.K. and 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. 3 rd edition. Oxford & IBH Pvt. Ltd., New Delhi. _____

BOC 103	**Plant anatomy and embryology**	**Credits: 6 4 (Theory) + 2 (Practical)**
Course Objectives: 1. To acquire basic knowledge and fundamental concepts of Anatomy & Embryology of plants. 2. To understand various tissue organization in primary and secondary structure of plants, anatomical adaptations, embryo, endosperm and seed structure.		
THEORY		
Unit 1. Meristematic and permanent tissues: Root and shoot apical meristems; simple and complex tissues. (4P		15 P
Unit 2. Primary structure of organs: Structure of dicot & monocot root, stem and leaf.		4P
Unit 3. Secondary growth: Activity of vascular cambium, Anomalous secondary growth in stems of Boerhaavia, Bignonia and Dracaena; Wood Anatomy - Wood Elements, heartwood and sapwood, Tension Wood; Economic importance of wood and wood elements. Periderm and Rhytidome: Structure and Functions.		10P
Unit 4. Adaptive & protective systems: Epidermis, cutin, cuticle and other types of coverings, epidermal appendages, stomatal types, adaptations in Hydrophytes, Xerophytes and 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 and seed dispersal mechanisms and adaptations.		10P
Unit 8. Apomixis and polyembryony: Concepts, types and practical applications.		4P
PRACTICAL		
1. Study of meristems (permanent slides/photographs). (1P) 2. Study of simple tissues - parenchyma, chlorenchyma, collenchyma and sclerenchyma (fresh specimens/permanent slides). (1P) 3. Primary structure: (5P) * Stems of Helianthus annus / Eupatorium odorum and Oryza sativa / Zea mays. * Roots of Helianthus annus / Eupatorium odorum and		60 H (30P)

Oryza sativa / Zea mays. * Leaves of Helianthus annus / Eupatorium odorum or 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 and Dracaena showing anomalous secondary growth (fresh or preserved specimens). (3P) 7. Epidermal appendages and stomatal types (fresh/permanent slides). (2P) 8. Anatomical adaptations: Xerophyte (Opuntia); Hydrophyte (any hydrophyte – anatomy of stem/root/leaf)), Halophyte (leaf and 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) and 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)	
Learning outcome: On completion of this course, students will: ¬ Gain knowledge of plant cellular organization into tissues and their specific functions. ¬ Understand the primary structure of root, stem and leaf as well as secondary growth in plants. ¬ Analyze the anatomical adaptations and protective systems in plants. ¬ Understand the structural organization of flower and functions of reproductive whorls. ¬ Evaluate mechanisms and adaptations for pollination and fertilization. ¬ Understand the structure of embryo, endosperm and seed. ¬ Analyze mechanisms and adaptations for fruit and seed dispersal . ¬ Develop basic skills in sectioning of plant specimens to study anatomical adaptations and analyze various embryological features.	
Books: 1. Esau, K. 2006. Anatomy of Seed Plants. 2 nd edition. Wiley Eastern Private Ltd., New Delhi. 2. Arthur, J.E. & Mac Daniels L.H. 1977. An Introduction to Plant Anatomy. 2nd edition. Tata Mc Graw-Hill Publishing Company Ltd., New Delhi. 3. Bhojwani, S.S. & Bhatnagar, S.P. 2011. Embryology of Angiosperms. 5th edition. Vikas Publication House Pvt. Ltd., New Delhi. 4. Fahn, A. 1990. Plant Anatomy. 4th edition. Pergamon Press.	

BOC 104	Plant Physiology	Credits: 6 4 (Theory) + 2 (Practical)

Course Objectives:

1. To acquire basic knowledge and fundamental concepts about physical, chemical and biological functioning of plants.
2. To understand mechanism of photosynthesis, respiration, translocation & nitrogen metabolism in plants.
3. To understand the use of physical and chemical factors available to the plants from nature.

THEORY	
Unit 1. 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, macronutrients 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.	8P
Unit 3. Translocation in phloem: Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading.	6P
. Unit 4. Enzymes: Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.	4P
Unit 5. Photosynthesis: Photosynthetic Pigments (Chl. a, b, xanthophylls, carotenes); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.	12P
Unit 6. Respiration: Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway.	6P
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.	46
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.	6P
PRACTICAL	
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 a xerophyte. (5P) 4. Demonstration of Hill's reaction. (1P) 5. Demonstration of deficiency symptoms of any two macronutrients 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)	60 H (30P)

10. Separation of amino acids by paper chromatography. (1P) 11. Anatomical features 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 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.	

Learning outcome:

On completion of this course, students will:

¬ Understand plant-water relation with respect to various physiological processes.

¬ Examine the role of macronutrients and micronutrients in plant growth.

¬ Understand the process of photosynthesis, respiration and biological nitrogen fixation in plants.

¬ Analyze the role of enzymes, plant growth regulators, light and temperature in plant growth and development.

Books:

1. Taiz, L. and Zeiger, E. 2010. Plant Physiology. 5 th edition. Sinauer Associates Inc., U.S.A.
2. Hopkins, W.G. and Huner, N.P. 2009. Introduction to Plant Physiology. 4 th edition. John Wiley & Sons, U.S.A.
3. Bajracharya, D. 1999. Experiments in Plant Physiology - A Laboratory Manual. Narosa Publishing House, New Delhi.

BOC 105	**Classical Taxonomy And Phylogeny**	**Credits: 6 4 (Theory) + 2 (Practical)**

Course Objectives:

Plant taxonomy involves collection, identification, description, classification and naming of plants. This course is designed to give students knowledge of morphological characters of vegetative and reproductive structures of different plants belonging to different families and their origin and evolutionary relationship.

THEORY

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. • Follow details as mentioned below in: 'General introduction to the parts of Angiospermic plant'.	25P
Unit 2. Systematic position (Bentham and Hooker's classification), diagnostic features and important ornamental/economical/medicinal species of the following	21P

families: Annonaceae, Capparidaceae, Brassicaceae, Tiliaceae, Rutaceae, Myrtaceae, Leguminosae (Caesalpiniaceae, Papilionaceae, Mimosaceae), Cucurbitaceae, Rubiaceae, Apocynaceae, Asclepiadaceae, Verbenaceae, Amarantaceae, Moraceae, Orchidaceae, Araceae, Arecaceae, Musaceae, Commelinaceae.	
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).	7P
PRACTICAL	
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) Vernation, 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, L.S. of flower, T.S. of ovary, floral formula and any 5 economically important plants each of families mentioned in theory. (16P) 7. Field visit to study morphological characters of plants. (2P)	60 H (30P)

Learning outcome:

On completion of this course, students will:

¬Understand various morphological terms and apply the same to describe plants.

¬ Generalize characters of families to identify common and economically important plants according to Bentham & Hooker's system of classification.

¬ Describe the floral structure and infer the floral formula.

¬ Gain knowledge about the origin and phylogeny of angiosperms.

Books:

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. 2 nd 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. 3 rd edition. New Delhi: Oxford & IBH Pvt. Ltd.
8. Jeffrey, C. 1982. An introduction to Plant Taxonomy. 2 nd edition. Cambridge, London: Cambridge University Press.
9. Stace, C.A. 1989. Plant Taxonomy and Biosystematics. 2 nd 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. 2 nd edition. Cary, NC: Sinauer Associates Inc.
12. Maheshwari, J.K. 1963. Flora of Delhi. New Delhi: CSIR.

BOC106:	**CELL BIOLOGY AND PLANT BIOCHEMISTRY**	**Credits: 6** **4 (Theory) +** **2 (Practical)**
Course Objectives: This course is designed to provide an overview of how cellular structure and function arise as a result of the properties of cellular macromolecules. The practical component of the study deals with experiments supporting cell structure and functioning principles as well as applications of bio-analytical techniques.		
THEORY		
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.		6P
Unit 2. Cell and its components: (20P) 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.		21P
Unit 3. Cell Division: Overview of cell cycle; cell division (mitosis and meiosis) and its significance.		4P
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. 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); posttranslational changes. (10P) Lipids: Classification, structure, properties and biological role of fatty acids and lipids; synthesis and breakdown of triglycerides; β-oxidation. 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.		5P 10P 4P 4P 4P

Vitamins: Broad classification of vitamins; properties, occurrence, functions and deficiency symptoms of vitamins A, B complex, C, D, E and K.	
Unit 5. Secondary metabolites: Broad classification of secondary metabolites; properties and functions of terpenoids, alkaloids and phenolics.	3P
PRACTICAL	
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 sodium acetate buffer. (2P) 15. Determination and comparison of acid value of fresh and rancid fat samples by titrimetric method. (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)	60 H (30P)

Learning outcome:

On completion of this course, students will:

¬ Gain knowledge about the various cell organelles and their role in cell functioning.

¬ Understand the chemical structure and properties of biomolecules and their role in living organisms.

¬ Develop skills in various techniques used in cell biology studies.

¬ Be proficient in handling various instruments used in biochemistry related experiments.

Books:

1. Kleinsmith, L.J., & Kish, V.M. 1995. Principles of Cell and Molecular Biology. 2 nd 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. 6 th 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. 7 th edition. San Francisco: Pearson Benjamin Cummings Publishing.

6. Campbell, M.K. 2012. Biochemistry. 7 th edition. Boston, MA: Cengage Learning.

7. Campbell, P.N., & Smith, A.D. 2011. Biochemistry Illustrated. 4 th edition. London: Churchill Livingstone.

8. Jain, J.L., Jain, S., & Jain, N. 2007. Elementary Biochemistry. 3 rd edition. New Delhi: S. Chand and Company Ltd.

9. Mathur, R. & Mehta, M. 2002. Biochemistry. 1 st 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. 5 th 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. 6 th 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. 3 rd edition. Singapore: Pearson Education. Goa University, Taleigao Plateau, Goa. Page 2

BOC107:	**MICROBIOLOGY AND PLANT PATHOLOGY**	**Credits: 6** **4 (Theory) +** **2 (Practical)**
Course Objectives: This course deals with basic and advanced concepts of microbiology and plant pathology. It aims to make students aware of the occurrence and economic value of various microbes; their interactions with the environment and impact on living organisms. The laboratory exercises provide training in basic skills in isolation and handling of microorganisms and its relevant applications.		
THEORY		
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 Goa University,		**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		9P

streptomycin). Role of microorganisms in bioremediation; biodegradable plastics; production of biogas.	
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	
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)**	60 H (30P)

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)**	

Learning outcome:

On completion of this course, students will:

¬Gain knowledge of sterilization methods, biohazards and biosafety measures.

¬Gain knowledge of methods for cultivation, preservation and maintenance of microbial cultures.

¬Understand the role and relevance of beneficial microorganisms and their applications in day to day life.

¬Understand the fundamental basis of plant-microbe interaction that leads to plant diseases and measures to be adopted for plant health management.

¬Acquire skills in isolation and handling of microbes.

Books:

1. Dubey, R.C., & Maheshwari, D.K. 1999. *A text book of Microbiology*. S. Chand and Company Ltd., New Delhi.
2. Sullia, S.B. 2001. *General Microbiology*. Oxford Publishers, New Delhi.
3. Sharma, K. 2011. *Text book of Microbiology*. Anne Books Pvt. Ltd., New Delhi.
4. Kalaichelvan, P.T., & Pandi, A. 2007. *Bioprocess Technology*. MJP Publishers, Chennai.
5. Moshrafuddin, A., & Basumatany, S.K. 2006. *Applied Microbiology*. MJP Publishers, Chennai.
6. Meyneil, E., & Meynell, G.G. 1970. *Theory and Practice in Experimental Bacteriology*. Cambridge University Press, Cambridge.
7. Agrios, G.N. 1997. *Plant Pathology*. Academic Press, London.
8. Mehrotra, R.S. 1995. *Plant Pathology*. Tata McGraw-Hill Publishing Company Limited, New Delhi.
9. Sambamurty, A.V.S.S. 2006. *Text Book of Plant Pathology*. I.K. International Publishing House, New Delhi.
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*. CAB International, UK.
12. Bridge, P. *et al*. 1998. *Molecular Variability of Fungal Pathogens*. CAB International, UK.
13. Skerritt, J.H., & Apples, R. 1995. *New Diagnostics in Crop Sciences*. CAB International, UK.
14. Bridge, P. *et al*. 1999. *Application of PCR in Mycology*. CAB International, UK.
15. Bridge, P., Moore, D.R., & Scott, P.R. 1998. *Information Technology, Plant Pathology and Biodiversity*. CAB International, UK.
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.* S. Chand & Company Ltd., New Delhi.

22. Kale, V., & Bhusari, K. 2001. *Practical Microbiology: Principles & Techniques.*, Himalaya Publishing House, Mumbai.
23. Garg, N., Garg, K.L., & Mukerji, K.G. 2010. *Laboratory Manual of Food Microbiology*. I.K. International Publishing House Pvt. Ltd., New Delhi.
24. Aneja, K.R. 1993. *Experiments in Microbiology, Plant Pathology and Tissue Culture*. Wishwa Publication, New Delhi.
25. Mahadevan, A., & Sridhar, R. 1986. *Methods in Physiological Plant Pathology*. Sivakami Publication, Chennai.
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: 6** **4 (Theory) +** **2 (Practical)**

Course Objectives:

This course deals with basic and advanced concepts in Cytogenetics and Plant breeding along with their applications. Laboratory exercises provide training in understanding genetics through problem solving and skills of plant breeding such as emasculation and artificial pollination and its relevant applications in crop improvement..

THEORY

Unit 1. Cell cycle: Mitosis, Meiosis; Significance.	2P
Unit 2. Mendelian genetics and its extension: Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Backcross and test cross; Incomplete dominance, co-dominance 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.	9P
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).	4P
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.	6P
Unit 5. Autosomes & sex chromosomes: Mechanisms of sex determination; Balance concept of sex determination in *Drosophila*; Sex-linked inheritance; Sex-limited characters.	4P
Unit 6. Alteration in chromosome number and structure: Deletion, Duplication, Inversion, Translocation, meiosis in structural heterozygote; Position effect; Euploidy and Aneuploidy.	8P
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.	6P
Unit 8. Introduction to Plant Breeding: Introduction and objectives; Important achievements and undesirable consequences of plant breeding.	3P

Centres of origin and domestication of crop plants.	
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.	11P
Unit 10. Quantitative inheritance: Concept, mechanism, Monogenic v/s Polygenic Inheritance. Examples - Inheritance of kernel colour in wheat, ear length in maize.	4P
Unit 11. Inbreeding depression and heterosis: Inbreeding depression, Heterosis; Applications.	3P
PRACTICAL	
Laboratory Exercises: Mendel's laws through seed ratios. **(2P)** 2. Problems 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 2 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)**	60 H (30P)

Learning outcome:

On completion of this course, students will:

¬ Learn about basic and advanced concepts in cytogenetics.

¬ Understand Mendelian genetics through problem solving exercises.

¬ Apply the knowledge of cytogenetics in plant breeding.

¬Understand the molecular basis of mutation and its phenotypic effect on the organism.

¬ Learn about the various methods of crop improvement.

¬ Develop skills in plant breeding such as emasculation, artificial pollination and induction of polyploidy.

Books:

1. Kleinsmith, L.J., & Kish, V.M. 1995. Principles of Cell and Molecular Biology. 2 nd 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. 6 th 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. 7 th edition. San Francisco: Pearson Benjamin Cummings Publishing.

6. Campbell, M.K. 2012. Biochemistry. 7 th edition. Boston, MA: Cengage Learning.

7. Campbell, P.N., & Smith, A.D. 2011. Biochemistry Illustrated. 4 th edition. London: Churchill Livingstone.

8. Jain, J.L., Jain, S., & Jain, N. 2007. Elementary Biochemistry. 3 rd edition. New Delhi: S. Chand and Company Ltd.

9. Mathur, R. & Mehta, M. 2002. Biochemistry. 1 st 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. 5 th 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. 6 th 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. 3 rd edition. Singapore: Pearson Education. Goa University, Taleigao Plateau, Goa. Page 2

BOC109:	**MOLECULAR BIOLOGY AND GENETIC ENGINEERING**	**Credits: 6** **4 (Theory) +** **2 (Practical)**
Course Objectives: This course is designed to give students a basic understanding of the fundamental concepts of molecular biology such as structure of DNA, its synthesis and regulation of gene expression and to apply the knowledge in recombinant DNA technology. The theoretical and practical components of this course will provide students with a deeper understanding of various techniques in obtaining recombinant DNA and the varied applications of genetic engineering		
THEORY		
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).		2P
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.		5P
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 dsDNA, Enzymes involved in DNA replication.		7P
Unit 4. Transcription: Enzymes in transcription; Basic features of transcription - initiation, elongation and termination, promotors 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 organization 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		10P

silencing.	
Unit 7. Recombinant DNA technology: Definition of gene and recombinant DNA, steps in genetic engineering. Enzymes used in recombinant DNA 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 & bert). **(10P)**	10P
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.	5P
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).	7P
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.	6P
PRACTICAL	
Laboratory Exercises: 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, Flavr Savr tomato and humulin production through photographs. **(2P)** 15. Deciphering DNA sequence from a sequencing gel photograph by Maxam and Gilbert's method. **(2P)** 16. Deciphering DNA sequence from a sequencing gel photograph by Sanger's method. **(2P)** 17. Working of restriction enzyme & calculating the size of the fragments by	60 H (30P)

use of maps. **(2P)**	

Learning outcome:

On completion of this course, students will:

¬ Gain knowledge on the concepts of molecular biology such as structure of nucleic acids, replication, transcription and translation.

¬Understand gene structure, regulation and modification of RNA.

¬Understand the concepts of recombinant DNA technology and gene cloning and its various applications.

Books:

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

BOC110:	**PLANT ECOLOGY AND PHYTOGEOGRAPHY**	**Credits: 6 4 (Theory)**

Course Objectives:

Knowledge of ecology is essential for understanding the plants around us and their interaction between other components of the ecosystem. This course is designed to provide knowledge of the basic concepts of ecosystems and the interaction amongst its biotic and abiotic components. Students will also gain knowledge of the different ecosystems of Goa and their functional aspects. The practical component will help in developing skills in measurement of various ecological parameters.

THEORY

Unit 1. Introduction: Concept of Ecosystem, components and organization, Structure and function, trophic organization.	3P

Unit 2. Soil: Importance; Origin; Formation; Composition: Physical, chemical and biological components. Soil profile: type of soil; its effect on vegetation.	8P
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.	4P
Unit 4. Ecological Factors: Atmospheric humidity and precipitation in relation to plants.	3P
Unit 5. Biotic interaction: Basic source of energy, autotrophy, heterotrophy, symbiosis, commensalism, parasitism; food chain; ecological pyramids; biomass; standing crop.	5P
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.	8P
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.	9P
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.	8P
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.	12P
PRACTICAL	
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 & water holding capacity in soils of three habitats. **(2P)** 6. Study of dissolved oxygen of water samples from polluted and unpolluted sources. **(2P)** 7. a) Study of aquatic ecosystem of phytoplanktons and hydrophyte diversity. **(3P)** b) Study of morphological and anatomical adaptations 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)** 8. Determination of minimal quadrate size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed). **(2P)**	60 H (30P)

9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution laws. **(2P)** 10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus. **(2P)** 11. To prepare map of India with respect to (i) major climatic zones (ii) forest type (iii) biogeographical regions. **(2P)** 12. To prepare map of Goa to show its vegetation types as specified in theory. **(2P).**	
Learning outcome: On completion of this course, students will: ¬ Learn fundamental aspects of ecology including abiotic and biotic components, their structure, interrelationship and function. ¬ Understand the ecosystems of Goa. ¬ Gain knowledge of phytogeography with reference to continental drift, endemism and biomes. ¬ Develop skills in qualitative and quantitative measurement of various ecological parameters.	
Books: 1Odum E.P. 2005. *Fundamentals of ecology*. 5th edition. Cengage Learning India Pvt. Ltd., New Delhi. 2. Singh, J.S., Singh, S.P. & Gupta, S. 2006. *Ecology, Environment and Resource Conservation*. Anamaya Publications, New Delhi, India. 3. Sharma, P.D. 2010. *Ecology and Environment*. 8th edition. Rastogi Publication, Meerut. India. 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*. 4th edition. PHI Learning Pvt. Ltd., Delhi, India.	

BOG 101	**ENVIRONMENTAL BIOTECHNOLOGY**	**Credits: 4(Theory)**
Course Objectives: This course is designed to give students a basic understanding of environmental problems and their impact and the approaches for management through legislations, policies and public participation for sustainable development.		
THEORY		
Unit 1. Environment: 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.		4P
Unit 2. Environmental problems: Environmental pollution - types of pollution, sources of pollution, measurement of pollution, methods of measurement of pollution, fate of pollutants in the environment, Bio-concentration, bio/geo-magnification.		6P
Unit 3. Microbiology of waste water treatment: 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 water of dairy, distillery, tannery, sugar and antibiotic industries.		8P

Unit 4. Xenobiotic compounds: 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.	10P
Unit 5. Role of immobilized cells/enzymes in treatment of toxic compounds: Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control.	6P
Unit 6. Sustainable Development: 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.	8P
Unit 7. International and National Legislations, Policies for Pollution Management: 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.	10P
Unit 8. Public Participation for Environmental Protection: Environmental movement and people's participation with special references to Gandhamardan, Chilika and Narmada Bachao Andolan, Chipko and Silent valley Movement; Women & Environmental Protection, Role of NGO in bringing environmental awareness and education in the society.	8P

Learning outcome:

On completion of this course, students will:

¬ Develop an understanding of the global environmental problems and their impact.

¬ Have an insight into the microbiology of waste water treatment.

¬ Enhance their understanding on xenobiotic compounds and its bioremediation.

¬ Understand the role of bio-techniques for management of environmental pollution.

¬ Understand the approaches for pollution management through legislations, policies and public participation.

¬ Develop a deeper understanding of economics and environment with reference to sustainable development.

Books:

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.
8. Trivedi, P. C. 2006. Biodiversity Assessment and Conservation. Agrobios, India.

BOG 102	COASTAL AND MANGROVE ECOLOGY	Credits: 4(Theory)

Course Objectives:

This course is designed to provide basic as well as advanced understanding of the principles of coastal ecology in relation to sand dune and mangrove biodiversity. It will also create an awareness of the various threat factors causing damage to mangroves and the various conservation and management strategies that can be employed for their restoration.

THEORY

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.	6P
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.	3P
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.	15P
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.	8P
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.	8P
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.	8P
Unit 7. Conservation and Management Strategies Restoration Technology: Species selection, Propagation and plantation techniques; Conservation strategies.	8P
Unit 8. Advanced concepts to be learnt under teachers supervision by study visit to NIO.	4P

Learning outcome:

On completion of this course, students will:

¬ Understand the role of coastal ecology in relation to sand dune vegetation and mangrove diversity.

¬ Learn about the diverse flora and fauna of mangrove ecosystem.

¬ Understand about the various threats to mangrove ecosystem and strategies for their conservation, restoration and management.

Books:

1. Chapman, V.J. and Chapman D. J. 1975. The Algae. 2 nd 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.

BOS 101:	**FLORICULTURE**	**Credits: 4 3(Theory) + 1 (Practical)**
Course Objectives: Floriculture, a branch of horticulture, deals with the cultivation of flowers and ornamental plants from the time of planting to the time of harvesting. The theoretical and practical components of this course will provide students detailed knowledge of nursery bed preparation, use of various methods of plant propagation, cultivation, care, harvesting and marketing of flowers and designing floral arrangements.		
THEORY		
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)		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.		7P
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 to flower plants). Topiary - a green sculpture.		9P
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.		8P
Unit 5. Role of plant growth regulators and fertilizers: Auxins, Gibberellins, Cytokinins and ABA; Fertilizers and Manures.		3P
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.		8P
Unit 7. Pathology: Identification of pests and diseases, symptoms and control (viral, fungal, mycoplasmic, bacterial and insects.		2P
Unit 8. Garden Implements: Different garden tools and their operations; Green house and Polyhouse.		2P
Unit 9. Scope: Floriculture as an industry; Current status, government initiatives (SCHEMES) and constraint of commercial floriculture in India; marketing and export.		3P
PRACTICAL		
Laboratory Exercises:		30 H (15P)

1. Soil preparation and sterilization of nursery beds and pots. (2P) 2. Garden implements and their operations. (1P) 3. Methods of vegetative propagation: 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 5); Cut greens (any 5); Cacti (any 2); Water plants (any 2); Lawns (any 2). 7. Styles of flower arrangements: (3P) Garlands (any 2); Bouquets (any 2); Crown (any 1); Wreath (any 1); Baskets (any 1); Dry flower arrangement (any 1). 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)	
Learning outcome: On completion of this course, students will: .¬ Understand the concept of floriculture and cultivation of commercial ornamental plants. ¬ Develop basic skills in techniques and different styles flower arrangement. ¬ Learn routine nursery management practices, garden operations and plant propagation techniques. ¬ Understand the concept of plant growth, practical problems and plant care. ¬ Have knowledge of use of phytohormones & postharvest technology for ornamental plants. ¬ Have an insight to various government schemes in floriculture industry. ¬ Be able to establish start-ups in floriculture business.	
Books: 1. Daniel Hall, A. 2002. Fertilizers and Manures. Biotech Books, Delhi. 2. Gorner, R. 1978. The growth of gardens. Faber and Faber, London. 3. Hariman, H.T. and Kestler, D.F. 1976. Plant propogation: 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.	

BOS 102:	**HERBAL TECHNOLOGY**	**Credits: 4** **3 (Theory) +** **1 (Practical)**
Course Objectives: Natural plant products are the most commonly used complementary and alternative therapies for a healthy lifestyle. This course deals with basic phytopharmacognosy, providing information on medicinal, tonic and culinary uses of plants. It also involves the use of technology in the manufacturing of value-added plant products like herbal cosmetics, nutraceuticals and herbal drugs. This course also involves hands-on training on preparation of herbal soap, mouthwash and formulations.		
THEORY		
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.		7P
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		12P

sativum), Tulsi (Ocimum sanctum), Ginger (Zingiber officinale), Turmeric (Curcuma longa), Sarpagandha (Rauwolfia serpentina) and Periwinkle (Catharanthus roseus).	
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.	11P
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.	8P
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.	7P
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.	8P
PRACTICAL	
Laboratory Exercises: 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)	30 H (15P)
Learning outcome: On completion of this course, students will: ¬ Gain knowledge of the importance of herbal medicines, their collection, processing and marketing.	

¬ Learn about various herbs, their botanical names, chemical constituents and medicinal uses.
¬ Develop skills in preparation of crude herbal extracts, cosmetic formulations and detect drug adulteration.
¬ Understand the importance of herbal nutraceuticals for a healthy lifestyle.
¬ Learn about medicinal plant conservation methods.

Books:

1. Kokate, C.K., Purohit, A.P. and Gokhale, S.B. 2010. Pharmacognosy. 45th edition. 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 edition. 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. 2 nd edition. Chapman and Hall, New York.
13. Khandelwal, K.R. 2002. Practical Pharmacognosy: Techniques and Experiments. 9 th edition. 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

BOD 101:	**PLANT TISSUE CULTURE**	**Credits: 4 3(Theory) + 1 (Practical)**

Course Objectives:

This course is designed to provide an overview of the concept of Plant Tissue Culture and the laboratory setup needed for culturing plant tissues. It provides handson training in the basic protocols of plant tissue culture, micro-propagation, preparation of culture media, regeneration of plantlets from tissues and acclimatization in greenhouse/ polyhouse.

THEORY

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)	5P
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,	6P

maintenance of cultures and subculture; regeneration of plantlets; acclimatization of tissue cultured plantlets in greenhouse/polyhouse.	
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.	7P
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; micro-propagation. 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.	13P
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.	9P
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).	5P
PRACTICAL	
Laboratory Exercises: 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 & 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)	30 H (15P)
Learning outcome: On completion of this course, students will: ¬Gain knowledge of the basic techniques involved in plant tissue culture. ¬ Understand the concept of cellular totipotency and differentiation as well as the role of plant growth regulators in plant tissue culture. ¬ Gain proficiency in techniques of plant regeneration. ¬ Have an insight of the applications of plant tissue culture in crop improvement.	
Books: 1.Collins, H.A., & Edwards, S. 1998. Plant Cell Culture. Bios Scientific Publishers, Oxford. 2. Misra, S.P. 2009. Plant Tissue Culture. Ane Books Pvt. Ltd., New Delhi. 3. Singh, S.K., & Srivastava, S. 2006. Plant Tissue Culture. Campus Books International, New Delhi. 4. Bhojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, NY.	

5. Vasil, I.K., & Thorpe, T.A. 1994. Plant Cell and Tissue Culture.Kluwer Academic Publishers, The Netherlands.
6. Bhojwani, S.S., & Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice. Elsevier Science, Amsterdam.
7. Razdan, M.K. 2003. An Introduction to Plant Tissue Culture. Oxford & IBH Publishing Co., New Delhi.
8. Chawla, H.S. 2000. Introduction to Plant Biotechnology. Oxford and IBH Publishers, New Delhi.
9. De, K.K. 1992. Plant Tissue Culture. New Central Book Agency (P) Ltd., Calcutta.
10. Jha, T.B. and Ghosh B. 2005. Plant Tissue Culture. Universities Press Pvt. Ltd., Hyderabad.
11. Ramawat, K.G. 2004. Plant Biotechnology. S. Chand & Company Ltd. New Delhi.
12. Prakash, M., & Arora, C.K. 2005. Cell and Tissue Culture. Anmol Publications Pvt. Ltd., New Delhi.
13. Chawla, H.S. 2002. Introduction to Plant Biotechnology. Science Publishers Inc., USA.
14. Narayanswamy, S. 1994. Plant Cell and Tissue Culture. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
15. Joshi, R. 2006. Agricultural Biotechnology. Gyan Books, New Delhi.
16. Kumar, H.D. 2005. Agricultural Biotechnology. Daya Publishing House, New Delhi.
17. Gautam, H. 2006. Agricultural and Industrial Applications of Bio-technology. Rajat Publications, New Delhi.
18. Harikumar, V.S. 2006. Advances in Agricultural Biotechnology. Regency Publishers, New Delhi.
19. Raghavan, V. 1986. Embryogenesis in Angiosperms: A Developmental and Experimental Study. Cambridge University Press, New York.
20. Chawla, H.S. 2003. Plant Biotechnology: A Practical Approach. Oxford & IBH Publishers, New Delhi.
21. Kumar, U. 2011. Methods in Plant Tissue Culture. Agro-Bios. 22. Nair, L.N. 2010. Methods in Microbial and Plant Biotechnology. New Central Book Agency (P.) Ltd., Kolkata.

BOD 103:	**ECONOMIC AND MEDICINAL BOTANY**	**Credits: 4** **3(Theory) +** **1 (Practical)**
Course Objectives: This course is designed to give an overview of how plants are indispensable to humans. It gives a broad exposure of the various aspects of plants such as their origin, plant resource utilization, conservation and ethnobotany.		
THEORY		
Unit 1. Origin of plants: Vavilov's concept of centre of origin; wild relatives of cultivated plants.		1P
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. (4L) b. Pulses - Red gram, black gram and green gram. (2L) c. Spices and condiments- Chillies, black pepper, cinnamon, ginger, turmeric and cardamom. (4L) d. Beverages - Tea and coffee (including processing). (2L) e. Vegetable oil sources - Sesame, groundnut, soybean, coconut and mustard (including extraction) (4L) f. Fibre Yielding Plants - Cotton, coir, jute and agave (including types of fibres and extraction). (3L)		

g. Fruit crops - Mango, jackfruit, banana, cashew, pineapple and papaya (4L) h. Vegetable crops - Red amaranth, radish, knol-khol and okhra (3L) i. Sugar & starch crops - Sugarcane (including processing, products and by-products of sugarcane industry), potato and yam. (3L) j. Rubber yielding plants - Hevea brasiliensis (including tapping and processing). (1L) k. Timber plants - Matti, Sailo, Shisham and Bamboo (including wood properties) (3L) 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 nuxvomica, Terminalia bellerica, Adathoda vasica and Tinospora cordifolia.	5P
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)	4P
PRACTICAL	
Laboratory Exercises: 1. Identification (botanical name and family), description and utilization of plants and/or plant parts studied in theory under each group. (6P) 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. (3P) 5. Preparation of Holi colours using natural ingredients. (1P) 6. Identification and medicinal value of locally available plants (field visit). (2P)	30 H (15P)
Learning outcome: On completion of this course, students will: ¬Gain knowledge of various economically and medicinally important plant species. ¬ Utilize the knowledge of cultivation and uses of plants in day to day life. ¬ Have an insight on crop research organizations involved in improvement of different economically important crops.	
Books: 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: 4 3(Theory) + 1 (Practical)**
Course Objectives: This course is designed to give students an exposure to various types of biofertilizers and the benefits of their use. The practical component of the course is designed to let students explore and handle the various organisms used in biofertilizer formulations and to prepare biofertilizers from these isolates. These biofertilizers can be used for practicing organic agriculture for sustainable crop production.		
THEORY		
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.		5P
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.		8P
Unit 4. Phosphate solubilizing microbes: Occurrence, isolation, mass production, field application and crop response to phosphate solubilizing microoganisms.		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.		7P
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.		7P
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.		4P
Unit 8. Future of biofertilizers: Biofertilizers for sustainable agriculture;		4P

farmers' acceptance and utilization of biofertilizers; selection of competitive and multi-functional biofertilizers – case study of Piriformospora indica.	
PRACTICAL	
Laboratory Exercises: 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)	30 H (15P)
Learning outcome: On completion of this course, students will: ¬ Develop an insight on the concept of biofertilizers. ¬ Develop an understanding of the types, formulation, method of field application and the benefits associated with the use of biofertilizers. ¬ Acquire skills in preparation of compost and carrier based bio-inoculum. ¬ Develop an eco-friendly approach for management of agricultural land and crops in a costeffective manner.	
Books: 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. 2 nd 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. Goa University, Taleigao Plateau, Goa. Page 62 of 66 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.	