SIKKIM UNIVERSITY

(A Central University established by an Act of Parliament in 2007 and accredited by NAAC in 2015)

SYLLABUS
FOR
SCHOOL OF LIFE SCIENCES

DEPARTMENT OF BOTANY

DEPARTMENT OF HORTICULTURE

DEPARTMENT OF MICROBIOLOGY

DEPARTMENT OF ZOOLOGY

FOREWORD

Sikkim University, a central university established by an Act of Parliament, has completed twelve years of its establishment in July, 2019. The duration of course, is not a long period in the institution building process but certainly Sikkim University has become a new destination for higher learning in this short span.

One of the focused areas of the University since inception has been curriculum development. There has been a tradition of bringing in the best minds in academia from all over the country including people with lot of experiences for developing curriculum for the courses offered in Sikkim University.

Sikkim University has a standard policy of reviewing/ revising curriculum of all programmes after every three years. Such revision is to bring in fresh ideas and recent trends in learning process and, we believe, it opens up a new vista in learning and research. The last revision/review of curriculum of all the programmes took place in 2017 under the supervision of the Deans of School of Studies.

The idea to print syllabi of all departments under each School of Study is to document the syllabus of each course for future reference and to have an authentic version in circulation. This initiative received instant encouragement from Prof. Jyoti Prakash Tamang, Dean School of Life Sciences when he was officiating as the Vice-Chancellor and also from the present Vice-Chancellor Prof. Avinash Khare.

A lot of efforts have been put by Sh. Gagan Sen Chettri, UDC in Academic Section in compiling, editing and formatting under supervision of Dr. Suresh Kr. Gurung, Joint Registrar. All Deans of Schools and the Head(s)/In-charge(s) of all departments have taken pains in going through each and every word and making corrections in the draft versions and also going through the final version. Sometimes even their help was sought in making corrections. It was therefore, possible to bring out the print version of the syllabi.

(T.K Kaul)
Registrar

Contents

DEPARTMENT OF BOTANY

PG-Syllabus (M.Sc.)

Course code	Course	Sessional Marks	End-sem Marks	Credit
Semester-I				
BOT-PG-T101	Core Theory -1	25 + 25	50	4
BOT-PG-T102	Core Theory- 2	25 + 25	50	4
BOT-PG-T103	Core Theory- 3	25 + 25	50	4
BOT-PG-P104	Core Practical-4	50	50	4
Semester-II				
BOT-PG-T201	Core Theory-5	25 + 25	50	4
BOT-PG-T202	Open Theory-1	25 + 25	50	4
BOT-PG-T203	Core Theory-6	25 + 25	50	4
BOT-PG-P204	Core Practical-7	50	50	4
Semester-III				
BOT-PG-T301	Core Theory-8	25 + 25	50	4
BOT-PG-T302	Open Theory-2	25 + 25	50	4
BOT-PG-T303	Elective Theory-1	25 + 25	50	4
BOT-PG-P304	Elective Practical-2	50	50	4
Semester-IV				
BOT-PG-T401	Elective Theory-3	25 + 25	50	4
BOT-PG-T402	Elective Theory-4	25 + 25	50	4
BOT-PG-P403	Elective Practical-5	50	50	4
BOT-PG-D404	Dissertation and *Viva-voce*		75 +25 (Project work + Viva)	4

SEMESTER-I (Theory): CORE PAPER-I

BOTPG-CT-101: CRYPTOGAMIC BOTANY, PALAEOBOTANY, GYMNOSPERMS

Total Marks - 100 **Total Credit – 04**

Unit I: PHYCOLOGY

Algal classification and criteria. General account of different classes of algae, Thallus organization and reproduction in algae. Algae in diverse habitats, Algal blooms, Algal biotechnology, Economic importance of Algae.

Unit II: BRYOLOGY

Distribution, Morphology, structure, reproduction and life history; Classification of Bryophytes. Evolution of gametophytes and sporophytes. Ecological and economic importance of bryophytes. Detailed study of types from the three classes (Hepaticopsida, Anthocerotopsida and Bryopsida)

Unit III: PTERIDOLOGY AND PALEOBOTANY

General characters of pteridophytes, Classification of Pteridophytes. Structure and reproduction in ferns, Telome concept, Stelar evolution, Heterospory and seed habit. Economic importance of Pteridophytes, Study of Fossil Pteridophytes and Gymnosperms: Rhynia, Calamites, Lepidodendron, Pteridospermales and Cycadeodiales

Unit IV: GYMNOSPERMS

Classification of Gymnosperms. Comparative study of vegetative, anatomical and reproductive structures of Cycadophyta, Coniferophyta and Gnetophyta. Evolutionary trends and phytogenetic relationship among various groups of Gymnosperms. Economic importance of Gymnosperms.

Suggested Readings:

1. Sharma, O.P. (1986) Textbook of Algae
2. Pandey, B. P. (1994) Textbook of Botany – Algae
3. Morris, J. 1986. An Introduction to the Algae. Cambridge University Press, U.K.
4. Sharma, O.P. (1989): Textbook of Fungi
5. Ainsworth, G. G. and A.S. Sussman: The Fungi Vols. I, II, III, IV- A and IV-B
6. Parihar, N.S. 1991. Bryophytes. Central Book Depot, Allahabad
7. Trivedi, A. N. (2002) - Advances in Pteridology
8. Sporne, K.R. The Morphology of Gymnosperme. B.I. Publications, New Delhi.
9. Bhatnagar, S.P. and Moitra, A. 1996. Gymnosperms, New Age Int. Pvt. Ltd., New Delhi
10. Sporne, K.R. 1991. The Morphology of Pteridophytes. B.I. Publ. Pvt. Ltd

SEMESTER-I (Theory): CORE PAPER-II

BOTPG-CT-102: ANGIOSPERM TAXONOMY, PLANT ECOLOGY AND PLANT ANATOMY

Total Marks - 100 **Total Credit – 04**

UNIT I: TAXONOMY AND SYSTEMATICS **15 Hrs**

History of developments in taxonomy: merits and demerits of major systems of classification. Angiosperm Phylogeny Group (APG) system of classification (APG III and IV); biosystematics; concepts and components; Aims of systematics; direct and indirect methods of plant identification; practice of taxonomic key; diversity and taxonomic studies of flowering plants of North-Eastern India with special reference to primitive and advanced taxa.

UNIT II: TAXONOMIC HIERARCHY **15 Hrs**

Introduction: concept of species, and speciation; theories relating to evolution of angiosperms; important Indian and world herbaria; taxonomic literature (floras, taxonomic accounts, revisionary studies); computer aided studies. Salient features of International Code of Botanical Nomenclature (ICN); principles of the code; ranks of taxa; rules of priority and limitations of principles of priority; effective and valid publications; *nomen nudum*, later homonym; type method and typification; *nomen alternatum*.

UNIT III: FUNDAMENTALS OF ECOLOGY **15 Hrs**

Introduction to ecology; evolutionary ecology, environmental concepts – laws and limiting factors, ecological models. Competition and coexistence; specific interactions, ecological niche, keystone species, ecotypes. Nature of ecosystem, production, food webs, energy flow through ecosystem, biogeochemical cycles, resilience of ecosystem, ecosystem management. The biosphere, biomes and impact of climate on biomes.

UNIT IV: PLANT ANATOMY **15 Hrs**

Anatomy in relation to taxonomy; secondary growth and nodal anatomy, the node-internode transition, formation of leaf and branch traces. Wood histology, growth rings, tracheids, vessels and wood rays, longitudinal parenchyma and its arrangement, grain and texture, knots, formation of resin cavities and tyloses. Anatomy of floral axis and the whorls, the leaf, origin of carpel, types and distribution of lactifers and lenticels, anatomy in relation to their physiological roles. Applications (in brief) of anatomical studies in systematics, climate studies, pharmacology, forensic sciences.

Suggested Readings

1. Angiosperm Phylogeny Group. (2003). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. Botanical Journal of the Linnean Society 141:399-436
2. Carlquist S (2001). Comparative Wood Anatomy, Springer-Verlag, Germany.
3. Conklin, A.R. Jr. 2004. Field Sampling: Principles and Practices in Environmental Analysis.
4. Cutler DF (1978). Applied Plant Anatomy, Longman, United Kindom
5. Cutter EG (1978). Plant Anatomy, Part I & II, Edward Arnold, United Kingdom.
6. Cutter, E.G. (1971). Plant anatomy: Experiments and Interpretation, Part II, Organs Edward Arnold, London.

7. Cronquist A (1981). An integrated system of classification of flowering plants. Columbia University Press, New York.

8. Davis, P.H. and Heywood, V.H. (1965). Principles of Angiosperm Taxonomy. D Van Nostrand Co., New York.

9. Dickinson WC (2000). Integrative Plant Anatomy, Harcourt Academic Press, USA.

10. Eames, A.J. and MacDaniels, L.H. (1947). An Introduction to the Plant Anatomy (2nd Ed.), McGraw Book Comp., New York. Elsevier Academic Press, USA.

SEMESTER-I (Theory): CORE PAPER-III

BOTPG-CT-103: PLANT DEVELOPMENT AND REPRODUCTION

Total Marks - 100 **Total Credit – 04**

UNIT I: GENERAL FEATURES OF PLANT DEVELOPMENT

Plant growth kinetics and patterns of growth. Seedling growth: Tropisms; Photomorphogenesis of seedling; Shoot Development: Organization of shoot apical meristem (SAM); tissue differentiation in the shoot.

UNIT II: LEAF, ROOT AND FLOWER DEVELOPMENT

Leaf growth and differentiation: Determination; phyllotaxy; control of leaf form; differentiation of epidermis (with special reference to stomata & trichomes) and mesophyll.

Root Development: Organization of root apical meristem (RAM); vascular tissue differentiation; lateral root hairs; root microbe interactions. Flower Development: Physiology of flowering, florigen concept and photoperiodism, Pollination mechanisms and vectors.

UNIT III: DEVELOPMENT OF REPRODUCTIVE STRUCTURES

Male Gametophyte: Structure of anther, microsporogenesis, tapetum; pollen development and gene expression; male sterility; sperm dimorphism; pollen germination; pollen tube growth and guidance. Female Gametophyte: Ovule types; megasporogenesis; organization of embryo sac; structure of embryo sac cells. Pollen-pistil interaction, self-incompatibility and fertilization; Structure of the pistil; pollen-stigma interactions, double fertilization; in vitro fertilization.

UNIT IV: FRUIT AND SEED DEVELOPMENT

Seed Development and fruit growth: Endosperm development; embryogenesis; ultrastructure and nuclear cytology; storage proteins of endosperm and embryo; polyembryony; apomixes; embryo. Fruit development and growth. Dormancy; Importance and types of dormancy; seed dormancy; overcoming seed dormancy; bud dormancy.

Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.
2. Fageri, K. and Van der Pol, L. 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford. 3) Fahn, A. 1982.
3. Fosket, D.E. 1994. Plant Growth and Development.A molecular Approach. Academic Press, San Diego.
4. Howell, S.H. 1998, Molecular Genetics of Plant Development. Cambridge University Press, Cambridge.
5. Leins, P., Tucker, S.C. and Endress, P.K. 1988. Aspects of Floral Development. J. Cramer, Germany.
6. Lyndon, R.F., 1990. Plant Development.The Cellular Basis. Unnin Hyman, London.
7. Murphy, T.M. and Thompson, W.F. 1988. Molecular Plant Development. Prentice Hall, New Jersey.
8. Proctor, M. and Yeo, P. 1973. The Pollination of Flowers.William Collins Sons, London. 10) Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
9. Raghavan, V. 1999. Developmental Biology of Flowering Plants. Springer -Verlag, New York.
10. Raven, P.H., Evert, R.F. and Eichhorn, S.E. 1992. Biology of Plants (5th Edition).Worth, New York.

SEMESTER-I (Practical): CORE PAPER-IV

BOTPG-CP-104: TAXONOMY, CRYPTOGAMS AND ANATOMY LAB

Max. Marks-100 **Total Credit-04**

1. Use of floras and manuals for plant identification.
2. Field herbarium methods and preparation of herbarium, museum specimens. (Students are required to submit at least twenty digital specimens).
3. Handling of taxonomic softwares.
4. Field visits for taxonomic study (minimum -2).
5. Morphological study of representative members of bryophytes: *Riccia ,Marchantia, Porella, Anthoceros, Sphagnum, Funaria, Polytrichum, Bryum.*
6. Observation of morphological, anatomical and reproductive structures of representative members of Pteridophytes – *Psilotum, Lycopodium, Selaginella, Equisetum, Gleichenia, Pteris, Marsilea, Isoetes, Azolla, Cyathea.*
7. Observation of anatomical (through C.S., RLS & TLS) structure of gymnosperms – *Cycas, Cupressus, Pinus, Araucaria, Ephedra, Gnetum*.
8. Study of paleobotany through permanent slides and fossil specimens
9. Study of anomalous secondary growth of monocotyledon and dicotyledon root, stem and leaf.
10. Anatomical basis of identification of C3 & C4 sub types in grasses.
11. Anatomy of lenticels and periderm in plants.
12. Study of stomatal types.

Suggested Readings

1. Angiosperm Phylogeny Group (2003) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. Botanical Journal of the Linnaean Society 141: 399-436.
2. Cracknell AP, Hayes L (2009) Introduction to Remote Sensing. CRC Press, Boca Raton, USA (Special Indian Edition).
3. Judd WS, Campbell CS, Kellogg EA, Stevens PA and Donoghue MJ (2002) Plant Systematics: A Phylogenetic Approach. Sinauer Associaes, Inc., Massachusetts.
4. Parihar, N.S (1991). Bryophytes. Central Book Depot, Allahabad.
5. Parihar, N.S. (1996). The Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad.
6. Puri, P. (1980). Bryophytes. Atma Ram & Sons, New Delhi.
7. Semple C and Steel MA (2003) Phylogenetics. Oxford University Press, Oxford.
8. Simpson MG (2006) Plant Systematics. Elsevier, Amsterdam.
9. Sporne, K.R. (1991). The Morphology of Pteridophytes. B.I. Publ. Pvt. Ltd
10. Sporne, K.R. The Morphology of Gymnosperme. B.I. Publications, New Delhi.

SEMESTER II (Theory): CORE PAPER-V

BOTPG-CT-201: CYTOGENETICS, PLANT BREEDING, EVOLUTION, BIOSTATISTICS

Total Max. Marks-100 **Total Credit-04**

UNIT-I: CELL BIOLOGY AND CYTOGENETICS **15 Hrs**

Ultra structure of plant cell organelles, cell cycle, cytoskeleton in plants. Inheritance- classical and modern perspectives, linkage and crossing over, multiple allelism, gene interaction, Pleiotropy and epistasis.

UNIT-II: PLANT BREEDING **15 Hrs**

Domestication, genetic variability, selection, hybridization, self and cross pollination, apomixis and back cross technique & importance; heterosis breeding, wide hybridization, GXE interactions, Importance and applications of plant breeding.

UNIT-III: EVOLUTION **15 Hrs**

Origin and evolution of life - theories of evolution: Lamarckism, Darwinism and principles of Hugo *de* Vries. Mechanisms of evolution- natural selection, gene flow, Hardy-Weinberg equilibrium, genetic drift. Modes of speciation-sympatric, peripatric, parapatric and allopatric. Population genetics, methods of studying population structure.

UNIT-IV: BIOSTATISTICS **15 Hrs**

General concepts and terminology; Sampling methods; Measures of location, scale and shape, contingency tables and chi-square test; comparison of means: t-test, multiple range tests; Simple experimental design and analysis of variance; Correlation and regression analysis; Introduction to multivariate methods.

Suggested Readings

1. Kulas JT (2008) SPSS Essential: Managing and Analyzing Social Science Data. John Wiley & Sons, New York.
2. Pagano M, Gauvreau K (2007) Principles of Biostatistics. Thomson India Edition, New Delhi.
3. Randal Schwartz, Tom Phoenix and Brian d Foy (2005) Learning Perl (4th edition), O'Reilly & Associates, ISBN: 0-596-10105-8.
4. Rex A. Dwyer (2004) Genomic Perl: From Bioinformatics Basics to Working Code, Cambridge University Press, 1st South Asian Edition.
5. Kulas JT (2008). SPSS Essential: Managing and Analyzing Social Science Data. John Wiley & Sons, New York.
6. Pagano M, Gauvreau K (2007). Principles of Biostatistics. Thomson India Edition, New Delhi.
7. Randal Schwartz, Tom Phoenix and Brian d Foy (2005). Learning Perl (4th edition), O'Reilly & Associates, ISBN: 0-596-10105-8.
8. Rex A. Dwyer (2004). Genomic Perl: From Bioinformatics Basics to Working Code, Cambridge University Press, 1st South Asian Edition.

SEMESTER II (Theory) : OPEN PAPER-I

BOTPG-OT-202: BIODIVERSITY, PHYTOGEOGRAPHY, ENVIRONMENTAL SCIENCE

Total Max. Marks-100 **Total Credit-04**

UNIT I: BIODIVERSITY **15 Hrs**

Biodiversity scenario at global, national and regional level. Biodiversity monitoring and assessment; Biodiversity act of India and related international conventions. Estimating changes in biodiversity. The future of biodiversity. Hotspots of biodiversity; threats to biodiversity (IUCN categories); Biodiversity conservation-Indian case studies on conservation.

Unit II: CONSERVATION PLANNING AND CLIMATE CHANGE **15 Hrs**

Conservation planning and Climate change. Bioclimatic envelope Model for individual species; Climate Change - Integrated strategies for conservation; Climate change prediction, REDD+, Synergies between sustainable use of biodiversity and climate change, consequence of climate, ozone layer depletion.

UNIT II: PHYTOGEOGRAPHY **15 Hrs**

Dynamic or interpretative plant geography; principles and concepts of phytogeography; Botanical provinces of India; Vegetation of India. Floristic regions of India; Endemism-centre of origin, vicariance, theories of endemism, factors for endemism, endemic plants; continental drift.

UNIT IV: ENVIRONMENTAL SCIENCE **15 Hrs**

Introduction to environmental science and sustainability, environmental laws. EIA, general guidelines for the preparation of environmental impact statement. Scope and types of environmental audit, energy audit, cost benefit analysis. Environmental management plan, ISO 14000 standards and certification, Environmental risk management and environmental safety norms, International summits and treaties related with environment, Applications of GIS and RS technology in environmental studies.

Suggested Readings

1. Adams LW. (1994). Urban Wildlife Habitats. Minneapolis: University of Minnesota Press.
2. Albert et al. (2003). Integrating Humans into Ecology: Opportunities and Challenges for Studying Urban Ecosystems. Bioscience 53(12): 1169-1179.
3. Barnes, R.S.K. (1998). Diversity of living organisms. Blackwell Sciences Ltd., U.K.
4. Barthlott, W. and Winiger, W. (2001). Biodiversity. Springer-Verlag, New York.
5. Champion HG, Seth SK. (1968). A revised survey of the forest types of India. (Reprinted in 2005). Dehradun, India: Natraj Publishers. p. 251–337.
6. Cracknell AP, Hayes L (2009). Introduction to Remote Sensing. CRC Press, Boca Raton, USA (Special Indian Edition).
7. Dallimer M., Irvine K.N., Skinner A.M.J., Davies Z.G., Armsworth P.R., Rouquette J.R., Maltby L.L., Warren P.H., Gaston K.J. (2012). Biodiversity and the feel-good factor: understanding associations between self-reported human well-being and species richness. BioScience 62: 47-55

8. David Briggs, Stuart Max Walters (1997). Plant Variation and Evolution, Cambridge University Press.

9. Eldredge, N. (1992). Systematics, Ecology and Biodiversity Crisis. Cambridge University Press, New York.

10. Ellis, E. C. (2013). Sustaining biodiversity and people in the world's anthropogenic biomes Current Opinion in Environmental Sustainability, 5:368–372

SEMESTER II (Theory): CORE PAPER-VI

BOTPG-CT-203: MICROBIOLOGY, MYCOLOGY, PLANT PATHOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT- I: INTRODUCRTION TO MICROBIOLOGY **15 Hrs.**

History, branches and scope of Microbiology. Study about major groups of microorganisms. Characterization: Morphological characteristics, chemical characteristics, cultural characteristics, metabolic characteristics, antigenic characteristics, genetic characteristics, pathogenicity, ecological characteristics of microorganisms. Classification, nomenclature and identification of microorganisms. Culture media, culture methods, Pure culture techniques, Maintenance and preservation of pure culture. Reproduction and growth of bacteria.

UNIT-II: MYCOLOGY **15 Hrs.**

Historical introduction of mycology. General characteristics of fungi, Fungal classification (Ainsworth and Alexopoulos), General accounts of Myxomycotina, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Dueteromycotina with representative classes. Lichens: Thallus structure, reproduction and economic importance, Economic importance of Fungi.

UNIT-III: PLANT PATHOLOGY **15 Hrs.**

Historical and developmental aspects of Plant pathology, Outline of classification of plant diseases. Pathogenesis: penetration; development inside the host tissue, Defense mechanisms of plants against infection: Preexisting and postexisting structural defense, Biochemical defense, hypersensitive reaction, SAR, role of phytoalexins and other phenolic compounds, Plant/microbes/pests interaction.

UNIT-IV: PLANT DISEASES **15 Hrs.**

Symptoms, etiology and control measures of some important diseases of the following crops: Rice, Wheat, Potato, Sugarcane and Tea.

Suggested Readings

1. R.C.Dubey and Maheshwari.D.K.2002. A Text book of Microbiology, S.Chand and Company, Ltd. Ramnagar, New Delhi.
2. S.B.Sullia and Shantharam. S.1998. General Microbiology. Oxford and IBH publishing Co.Pvt.Ltd. New Delhi.
3. Sharma. P.D.1999. Microbiology and Plant Pathology. Rastogi publications. Meerut, India.
4. Ananthnarayan, R and Jayaram Panikar, C.K. 1986. Text book of Microbiology. Orient Longman ltd. New Delhi.
5. Brook, T.D. Smith, D.W and Madigan, M.T. 1984. Biology of Microorganisms, 4th ed. Eaglewood Cliffts. N.J. Prentice- Hall. New Delhi.
6. Claus, William, G.1989. Understanding microbes. A laboratory text book for Microbiology. W.H.Freeman and Company. New York.
7. Ketchum, PA. 1988. Microbiology, concepts and applications. John Wiley and Sons. New York.
8. Stainer, Roger, Y. Ingrahan, John, L. Wheelis, Mark,L and Painter, Page,R. 1990. Microbial World 5th edition. Prentice-Hall India, Pvt.Ltd. New Delhi.
9. Schlegel, H.G.1986. General Microbiology. Cambridge University Press. London, 587pp.
10. Sharma, R.2006. Text book of Microbiology. Mittal Publications. New Delhi. 305pp.

SEMESTER II (Practical): CORE PAPER-VII

BOTPG-CP-204: CYTOLOGY, MICROBIOLOGY AND PLANT PATHOLOGY LAB

Total Max. Marks-100 **Total Credit-04**

CYTOLOGY

1. Preparation of pre-treating and fixative agents in the laboratory
2. Preparation of some cytological stains in the laboratory
3. Preparation and study of mitosis [*Allium cepa* (Onion), *Allium sativum* (Garlic), *Pisum sativum* (Pea), *Cicer arietinum* (Gram), *Nigella sativa* (Black cumin), *Vicia faba* (Broad bean), *Aloe indica*].
4. Preparation and study of meiosis (Family Liliaceae, Ranunculaceae/Papaveraceae, Solanaceae)
5. Study of giant chromosome
6. Demonstration of hybridization techniques

MICROBIOLOGY AND PLANT PATHOLOGY LAB

1. Culture media preparation: Solid media: PDA, NA; Liquid media: NB. Preparation of agar slants, method of inoculum transfer.
2. Sterilization with moist heat, dry heat, filtration, radiation.
3. Different types of bacterial staining - Simple, Gram's, Endospore staining Negative staining.
4. Pure culture technique of bacteria: Streak plate method/poor plate method.
5. Study of Symptoms, Causes and control measures of the following diseases related to local crops: Large Cardamom, Ginger, banana, Bacterial leaf blight of rice, bacterial leaf streak of rice, stem rot of rice, any other locally relevant crops.
6. Collection and submission of plant disease samples.

Suggested Readings

1. S.C.Santra, T.P.Chatterjee & A.P.Das (2012). College Botany-Practical (Vol.1).New Central Book Agency (P) Ltd. 8/1 Chintamoni Das Lane, Kolkata-700009.
2. S.C.Santra, T.P.Chatterjee & A.P.Das (2010). College Botany-Practical (Vol.2).New Central Book Agency (P) Ltd. 8/1 Chintamoni Das Lane, Kolkata-700009.
3. Mehrotra, R.S and Ashok Aggarwal, 2004. Plant pathology
4. Mukta Bhargava, 2003. The latest portfolio of theory and practice in Fungi, A.S Saini Dominant publications.
5. Sambamurthy A.V. S.S. 2006. A Textbook of Plant Pathology. I.K. International Pvt. Ltd., New Delhi.
6. Ananthanarayanan, R. and CKJ. Paniker, 2004. Textbook of Microbiology. Orient Longman.
7. Dubey, R.C. and D.K. Maheswari, 2007. A Textbook of Microbiology, S. Chand & Company.

SEMESTER-III (Theory): CORE PAPER-VIII

BOTPG-CT-301: BIOCHEMISTRY, PHYSIOLOGY & MOLECULAR BIOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT-I: PLANT PHYSIOLOGY **15 Hrs.**

Water relations: water absorption and transport, membrane transport

Photochemistry: Light harvesting system, mechanism of electron and proton transport in photosynthesis, Calvin-Benson cycle, C2 and C4 carbon cycle, CAM

Respiration: Glycolysis, Citric acid cycle, Electron transport chain

Biological nitrogen fixation; Biology of nodule formation; Mechanism of nitrate uptake, reduction and ammonium assimilation, sulphate uptake and assimilation.

Sensory Photobiology: Structure, function and mechanisms of action of phytochromes and cryptochromes .

UNIT-II: BIOCHEMISTRY **15 Hrs.**

Carbohydrates: Mono, di and polysaccharides, glycoproteins

Proteins: Primary structure of protein, secondary, tertiary and quaternary structures, prediction of secondary structure of protein, prions.

Lipids: classification, chemical structures and physical properties.

Enzymes: Nature and classification of enzymes, kinetics, bisubstrate reactions.

UNIT-III INTRODUCTION TO MOLECULAR BIOLOGY **15 Hrs.**

History of DNA molecule & discoveries, structure of nucleic acids, physical and chemical stability of nucleotides, bonding, double helix and features, Factors affecting the DNA structure, concept of gene structure, Functional attributes of genes at molecular level, DNA replication.

UNIT-IV: PROTEIN BIOSYNTHESIS **15 Hrs.**

Transcription: mechanism in prokaryotes & eukaryotes – RNA-Polymerases, initiation, elongation and termination. Post transcriptional modifications. Translation - mRNA organization, the genetic code, translation machinery, deciphering the code, translation in *E. coli* and differences in eukaryotes. Post translational modifications.

Suggested Readings

1. Cooper Jeoffrey M-2013: Cell-A Molecular Approach, 6th Edition. Sinauer Assoc. Inc. USA
2. Jocelyn E Krebs et al. 2010. Lewin's Gene X. Jones And Bartlett Publishers, Inc USA.
3. Watson and others – 2004 : Molecular Biology of the gene (V); Pearses Educatias, Inc India
4. P.C. Turner and others – 2002: Molecular Biology (II); Viva Books, Pvt. Ltd., New Delhi.
5. W. Ream and KG. Field – 1999: Molecular Biology Techniques; Academic Press, London.

6. Brace Alberts et al – 1983: Molecular Biology of the cell; Garland Publ. Inc., New Yorsk.

7. Buchanan B, Gruissem G and Jones R. (2000) Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, Rockville, USA.

8. C. K. Matthews, K. E. Van Holde and K. G. Ahern. (2007).Biochemistry, 3rd Edition, Pearson Education, New Delhi

9. Nelson DL and Cox MM. (2004) Lehninger Principles of Biochemistry, 4th Edition, W.H. Freeman and Company, New York, USA.

10. D. R. Ferrier. (2015). Lippincott's illustrated Reviews: Biochemistry, 6th Edition. Wolters Kluwer (India) Pvt Ltd, New Delhi

SEMESTER-III (Theory): OPEN PAPER- II BOTPG-OT-302: PLANT RESOURCES UTILIZATION

Total Max. Marks-100 **Total Credit-04**

UNIT-I: PLANT RESOURCES UTILIZATION **15 Hrs**

Diversity and distribution of exploited/underexploited/unexploited plants of economic value of Himalaya and the north eastern region; Use of plants by indigenous communities in Himalaya and the north eastern India for subsistence, medicine and cultural and religious rituals; value addition and product development of some economically important plants.

UNIT-II: BIOPROCESS DEVELOPMENT **15 Hrs**

Plant cell culture platforms; Plant growth regulators and elicitors; cell suspension culture system: methodology, kinetics of growth and nutrient optimization; stoichiometric consideration, production of secondary metabolites by plant suspension cultures; Hairy root culture; transgenic plants; plant products of industrial importance. Production of biomass, bioreactor types; Industrial application of chromatographic and membrane based bioseparation methods; Immobilization of biocatalysts (enzymes and cells) for bioconversion processes; Bioremediation.

Unit III: TRADITIONAL KNOWLEDGE **15Hrs**

Traditional knowledge system of different indigenous communities of Sikkim and North Eastern India. Application and practices of traditional knowledge system in agriculture, healthcare and livelihood. Sustainable utilization of biological resources and biodiversity conservation. Protection of traditional knowledge, National biodiversity protection initiatives; Convention on Biological Diversity, Nagoya protocol.

UNIT-IV: INTELLECTUAL PROPERTY RIGHTS **15 Hrs**

Intellectual property rights, types of Intellectual Property Rights and Intellectual Property protection, patents and methods of application of patents, Copyrights, Trade Marks, legal implications; protection of plant variety and farmers rights PPVFR, plant breeder's rights. Acquisition and management of IPRs.

Suggested Readings

1. Wickens GE (2004) Economic Botany: Principles and Practices, Springer, ISBN 978-0-7923- 6781-9.
2. Sasson A. Biotechnologies in developing countries present and future, UNESCO publishers, 1993.
1. B.P. Pandey 2014. Economic Botany. S. Chand & Company Private Limited, Ram Nagar, New Delhi 110055.
2. Rashtra Vardhana.2009. Economic Botany. Sarup Book Publishers Pvt. Ltd, New Delhi -110002
3. Ramesh Umrani (2009). Basics of Economic Botany. Anmol Publications Pvt.Ltd, New Delhi – 110002.
4. Ashwini Dutt (2008). Economic Botany. Adhyayan Publishers & Distributors, New Delhi-110002.
5. K.V. Krishnamurthy (2003). An Advanced Text book on Biodiversity: Principles and Practice. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
6. Ganguli P (2001). *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
7. Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publishing House, New Delhi.

SEMESTER III (Theory): ELECTIVE PAPER-I

BOTPG-ET-303-1: PLANT SYSTEMATICS

Total Max. Marks-100 **Total Credit-04**

UNIT – I: APPROACHES TO PLANT SYSTEMATICS

Difference in Systematics and Taxonomy; Principles and procedures of plant systematics; Plant speciation: Allopatric, abrupt, sympatric, hybrid, apomictic speciation, Isolating mechanisms; Biosystematics: Steps in biosystematics, Biosystematic categories, Importance of biosystematic studies.

UNIT-II: DEVELOPING CLASSIFICATION

Systems of Angiosperm Classification: Phenetic versus phylogenetic systems. Principles of Taxometrics. Cladistics in taxonomy-Phylogenetic terms; plesiomorphic and apomorphic characters; homology and analogy; parrellelism and convergence; monophyly, paraphyly, polyphyly; phylogenetic diagram; phylogenetic data analysis.

UNIT-III: VARIATION TYPES AND CAUSES

Types of variation; variance analysis; reproductive system-types; outbreeding; Hybridization- introgressive hybridization; recognition of hybrids; stabilization of hybrids; outbreeders with internal barriers; inbreeding. Evolution-mutation; random genetic drift; natural selection; Darwinian fitness and fitness coefficient; molecular evolution.

UNIT-IV: PHYLOGENY OF ANGIOSPERMS

Origin of angiosperms; age of angiosperm; molecular dating. Monophyletic and polyphyletic origin of angiosperms; possible ancestor and theories; origin of monocots, basal living angiosperms. Evolutionary trends- evolution of inferior ovary.

Suggested Readings

1. Angiosperm Phylogeny Group (2003) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. Botanical Journal of the Linnaean Society 141: 399-436.
2. Cracknell AP, Hayes L (2009) Introduction to Remote Sensing. CRC Press, Boca Raton, USA (Special Indian Edition).
3. Crawford DJ (2003) Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
4. Cronquist A (1981). An integrated system of classification of flowering plants. Columbia Evolution. Taylor and Francis, London.
5. Jain S.K. (1995). Manual of Ethnobotany. Scientific Publisher; Second edition (1995).
6. Judd WS, Campbell CS, Kellogg EA, Stevens PA and Donoghue MJ (2002). Plant Systematics: A Phylogenetic Approach. Sinauer Associaes, Inc., Massachusetts.
7. Nei M and Kumar S (2000). Molecular Evolution and Phylogenetics. Oxford University Press, New York.
8. Raven PH, Begr LR, Hassenzahl DM (2008). Environment. 6th edition. John Wiley & Sons, Inc., New York.
9. Semple C and Steel MA (2003). Phylogenetics. Oxford University Press, Oxford.
10. Simpson MG (2006). Plant Systematics. Elsevier, Amsterdam.

SEMESTER-III (Theory): ELECTIVE PAPER-I

BOTPG-ET-303-2: MICROBIOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT-I: FUNDAMENTALS OF MICROBIOLOGY **15 Hrs.**

Early history, milestone discoveries and developmental aspects of microbiology. The study of microbial structure; Microscopy and specimen preparation. Prokaryotic cell structure and Eukaryotic cell structure. Properties and structure of viruses and viroid. Nutritional requirements and Nutritional types of bacteria.

UNIT –II: PATHOGENICITY AND CONTROL OF MICROORGANISMS **15 Hrs.**

Host parasite relationship. Bacterial and viral pathogenesis. Toxigenecity, pathogenic types of toxins. Host defence against microbial invasion-non-specific and specific defense mechanisms. Control of microorganisms by physical agents, chemical agents, antibiotics and other chemotherapeutic agents.

UNIT-III: AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY **15 Hrs.**

Microorganisms of soils, rhizospheres and phylloplane. Biological nitrogen fixation- symbiotic and asymbiotic and phosphate solubilizing bacteria. Biological control agent for plant disease control. Modern waste water treatment (primary, secondary and tertiary). Drinking water purification. The concept of indicator microorganisms (total coliforms). Criteria for an ideal indicator organism. Biodegradation of xenobiotics- pesticide catabolism, reductive dechlorination, aerobic dechlorination.

UNIT-IV: FOOD AND INDUSTRIAL MICROBIOLOGY **15 Hrs.**

Fermentation and fermentation techniques, Microbiology and production of (kinema, soysauce, cheese, wine, beer, whisky, sausages, vitamins, antibiotics). Food preservation methods, Quality assurance: Microbiological quality standards of food, Government regulatory practices and policies, HACCP, Probiotics: definition, characteristic, gut microbiota, beneficial effects of probiotic bacteria; prebiotics and synbiotics.

Suggested Readings

1. R.P. Singh, (2005) Plant Pathology. Kalyani Publishers, Ludhiana.
2. Singh D.P & Singh A. 2007. Disease and Insect Resistance in Plants. Oxford & IBH, New Delhi Biotechnology. Oxford & IBH, New Delhi.
3. Upadhyay R.K. & Mukherjee KG. 1997. Toxins in Plant Disease Development and Evolving Biotechnology
4. Fry W.E. 1982. Principles of Plant Disease Management. Academic Press, New York
5. Hewitt H.G. 1998. Fungicides in Crop Protection. CABI, Wallington.
6. Marsh R.W. 1972. Systemic Fungicides. Longman, New York.
7. Nene Y.L. & Thapliyal P.N. 1993. Fungicides in Plant Disease Control. Oxford & IBH, New Delhi.
8. Palti J. 1981. Cultural Practices and Infectious Crop Diseases. Springer- Verlag, New York.
9. Vyas S.C. 1993 Handbook of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

SEMESTER III (Theory): ELECTIVE PAPER-I

BOTPG-ET-303-3: GENE EXPRESSION AND GENETIC ENGINEERING

Total Max. Marks-100 **Total Credit-04**

UNIT-I: REGULATION OF GENE EXPRESSION **15 Hrs.**

Regulation of gene expression in prokaryotes and Eukaryotes. Expression of *lac*, *trp* and *gal* operons. Attenuation, Antitermination, Methylation, Yeast GAL regulatory pathway, alteration of gene expression by DNA sequence rearrangements, transcriptional regulation in Eukaryotes.

UNIT-II: RECOMBINATION AND TRANSPOSABLE ELEMENTS **15 Hrs.**

Bacterial Recombination: Homologous recombination, Generalized & Site specific recombinations, Transposable elements, Genomic instability caused by Transposable elements, Bacterial transposable elements, Eukaryotic transposable elements, Biological significance of recombination & transposable elements.

UNIT-III: INTRODUCTION TO GENETIC ENGINEERING **15 Hrs.**

An introduction to genetic engineering, Enzymes used in genetic engineering Restriction endonucleases, DNA polymerase, Reverse transcriptase, Polynucleotide kinase, DNA ligase, Terminal deoxynucleotidyl transferase, Alkaline phosphatase. Ligation of DNA fragments with vectors Homopolymer tailing, Linkers, Adaptors. Vectors for cloning - Plasmids, Bacteriophage ë, Filamentous phage vectors, cosmids, BAC and YAC vectors, Shuttle vectors, Expression vectors.

UNIT-IV: APPLICATIONS OF GENETIC ENGINEERING **15 Hrs.**

Gene transfer techniques in plants. Application of genetic engineering, transgenic plants for insect, fungal, bacterial disease resistance, lignin, modification, abiotic stress tolerance, production of useful products, molecular farming.

Suggested Readings

1. Desmond S T Nicholl. 2008. An Introduction to Genetic Engineering. Cambridge Univ. press, USA.
2. P S Verma and V K Agarwal. 2009.Genetic Engineering. S Chand & Company Ltd. New Delhi
3. Kurnaz I A.2015. Techniques in Genetic Engineering. CRC Press. Taylor & Francis Gp. USA
4. T A Brown. 2016. Gene Cloning and DNA analysis (2nd Edition), John Wiley & Sons Inc.,UK
5. J K Setlow. 2010. Genetic Engineering: Principles & Methods, Springer, Germany.
6. Lal R. and Lal S. 1993, Genetic engineering of plants for crop improvement. CRC Press.
7. Winkler, U. Ruger W. and Wackernagel W. 1979. Bacterial phage and molecular genetics.
8. Gustafson J. P. 1990 Gene manipulation in plant improvement I and II. Plenum Press, London.
9. Old R. W. and Primrose S. B. 1989 Principles of Gene Manipulation. Blackwell Scientific Publ Oxford UK.

SEMESTER III (Theory): ELECTIVE PAPER-I BOTPG-ET-303-4: FUNDAMENTALS OF ECOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I: ECOLOGY: AN INDIAN PERSPECTIVE **15 Hrs**

Ecology in India, Evolution of ecological thoughts, Ecologists of India, Environmental issues of India. Environmental movements of India. India's initiatives for environmental problems.

UNIT II: POPULATION ECOLOGY AND SPECIES INTERACTIONS **15 Hrs**

Characteristics of populations, Population growth forms, Population regulation, r and k selection strategies, species interaction types, Lotka-Voltera model of competition,Theory of resource capture and sharing, Herbivores counter measures, Model of predator prey dynamics, parasitic vascular plants.

UNIT III: PRODUCTIVITY AND ECOLOGICAL SUCCESSION **15Hrs**

Concept of primary production, Measurements of primary productivity, plant biomass and turnover, Litterfall in terrestrial ecosystems, food chain and food web, energy flow models, Secondary productivity, Ecological Succession types,Theories and Models of succession, climax concept, Changes involved in succession.

UNIT IV: VEGETATION SAMPLING METHODS AND DATA ANALYSIS **15Hrs**

Sampling approaches, Releve method, quadrat method, line transect method, point frame method, and plotless method. Vegetation analysis –classification , species association.

Suggested Readings

1. Chapman, J.L.& M.J. Reiss. 1998. Ecology: Principles and Applications. Cambridge Univ. press. 2nd edition. 336 pgs.
2. Krebs, C.J. 2008. Ecology: The experimental Analysis of Distribution and Abundance (6th Edition), Benjamin Cummings Publ. 688pgs.
3. Miller, G.T. 2004. Environmental Science. Thomson, California. 538 pgs.
4. Singh, J.S., Singh, S.P & Gupta, S.R. 2006. Ecology, Environment and Resource conservation. Anamaya Publ., New Delhi, 688 pp.
5. Begon, M. ; Harper, J.L. and Townsend, C.R. 2006. Ecology: individuals, populations and communities. Blackwell Scientific Publications.
6. Dash, M.C and Dash, S.P. 2009. Fundamentals of ecology (3rd edition). Tata McGraw-Hill Publishing Co., New Delhi.

SEMESTER III (Theory): ELECTIVE PAPER-I BOTPG-ET-303-5: ADVANCED PLANT PHYSIOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT-I: PLANT GROWTH REGULATORS **15 Hrs.**

Concept of hormones as chemical messenger; Physiological effects and mechanism of action of brassinosteroids, jasmonic acid and salicylic acid; Role of hormones in defense against biotic and abiotic stress; synthetic regulatory compounds and their uses.

UNIT-II: PROGRAMMED CELL DEATH (PCD) AND SENESCENCE **15 Hrs**

Programmed Cell Death: Basic concepts; types of cell death, Programmed Cell Death in plants; Aerenchyma formation and HR; Reactive oxygen species and PCD; Apoptosis and PCD;

Senescence: Introduction to senescence; Metabolic changes associated with senescence and its regulation; Pigment breakdown during senescence, Nucleic acid degradation during senescence; Protein metabolism during senescence.

UNIT-III: REPRODUCTIVE PHYSIOLOGY **15 Hrs.**

Flowering: floral induction, evocation and morphogenesis, ABC model of flowering, manipulation of flowering and floriculture. Fruit ripening: physiology of ripening, biochemical changes during ripening; Deposition of reserves during seed development; Germination: metabolic changes during seed germination

UNIT-IV: STRESS PHYSIOLOGY **15Hrs.**

Plant responses to abiotic stresses; Water deficit and its physiological consequences; Osmotic adjustment in response to drought and salinity; Drought tolerance mechanisms; Salinity stress and plant responses; Heat stress and low temperature stress, antioxidant mechanisms.

Suggested Readings:

1. Buchanan B.B, Gruissem W. and Jones R.L 2007. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists Maryland, USA.
2. Moore T.C. 1989. Biochemistry and Physiology of Plant Hormones Springer – Verlag, New York, USA.
3. Nobel P.S 1999. Physiochemical and Environmental Plant Physiology (Second Edition) Academic Press, San Diego, USA.
4. Taiz L. and Zeiger E. 2010. Plant Physiology (5th Edition). Sinauer Associates, Inc. Publishes, Massachusetts, USA.
5. Barrett SCH (2008) Major Evolutionary Transitions in Flowering Plant Reproduction. Univ.of Chicago Press.
6. Harder LD & Barrett SCH (2006) Ecology and Evolution of Flowers, Oxford Univ. Press.
7. Shivanna KR (2003) Pollen Biology and Biotechnology. Enfield, New Hampshire, U.S.A., Science Publishers.

SEMESTER III (Theory): ELECTIVE PAPER-I

BOTPG-ET-303-6: ETHNOBIOLOGY AND ETHNOPHARMACOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT- I ETHNOBOTANY **15 Hrs.**

Ethnobotany: concept, history, evolution and scope; Indigenous knowledge and traditional practices of some Himalayan communities; Taxonomic epidermal characters and pharmacognostical studies to check adulteration. Problems and prospects of value addition applicable to plant resources. Scope for development of plant resources.

UNIT II: ETHNOBIOLOGY OF NORTH EAST INDIA **15 Hrs.**

Major ethnic groups in North East India India, their social institutions, livelihood, cultural and religious practices Shamanism and other belief systems, sacred grooves and methods of biological resource conservation. Current status of Ethnobiolgoy; Ethnobiology, biodiversity and traditional knowledge;

UNIT- III ETHNOPHARMACOLGY **15 Hrs.**

Role of Ethnobotany in drug discovery. Ayurvedic drug preparation and drug adulteration. Chemical composition of few medicinal and aromatic plants, extraction and uses pertaining to typical Indian formulation of drugs. Ethnopharmacological validation of traditional medicine; approaches to drug discovery from ethnobotanical leads.

UNIT- IV NATURAL PRODUCTS FROM PLANTS **15 Hrs.**

Definition, importance and systematics and characterization of natural products. Phenolic acids, alkaloids, glycosides, terpenoids, flavonoids, steroids, tannins in plants kingdom. Functions of secondary metabolites for plant defense and protection.

Suggested Readings

1. Cotton, C.M. (1997). Ethnobotany – Principles and applications. John Wiley and Sons – Chichester.
2. Das, T.S. (1986). Tribal life of North - Eastern India. Gian Publishing House.
3. Das, A.P. and Pandey, A.K. (2007). Advances in Ethnobotany. Bishen Singh and Mahendra Pal Singh, Dehradun.
4. Dhar, U. (1993). Himalayan Biodiversity: Conservation Strategies. Gyanodaya Prakashan.
5. Jain, S.K. (1995). Manual of Ethnobotany, Scientific Publishers, Jodhpur.
6. Jain, S.K. (1990). Contributions of Indian Ethnobotany. Scientific publishers, Jodhpur.
7. Subba, T. B. and Ghosh , G. C. (2003). Anthropology of North-East India. Orient Longman Limited, New Delhi.

SEMESTER III (PRACTICAL): ELECTIVE PAPER-II BOTPG-EP-304-1: TAXONOMY LAB

Total Max. Marks-100 **Total Credit-04**

1. Live plants/ Herbarium specimens of the following families will be provided in the class for description and identification (classification based on APG II, 2003):
2. Basal Angiosperm and Magnoliids: Nymphaeaceae, Magnoliaceae
3. Basal Monocots: Araceae, Alismataceae
4. Petaloid monocots: Liliaceae, Smilacaceae, Alliaceae, Orchidaceae
5. Commelinids: Commelinaceae, Poaceae, Cyperaceae
6. Basal Eudicots and Caryophyllids: Ranunculaceae, Caryophyllaceae
7. Rosids: Euphorbiaceae, Rosaceae, Fabaceae, Cucurbitaceae
8. Asterids: Solanaceae, Lamiaceae, Apiaceae, Asteraceae
9. Writing exercise
10. Nomenclature exercise
11. Classification exercise
12. Cladogram construction and analysis

Suggested Readings

1. Angiosperm Phylogeny Group (2003) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. Botanical Journal of the Linnaean Society 141: 399-436.
2. Cracknell AP, Hayes L (2009) Introduction to Remote Sensing. CRC Press, Boca Raton, USA (Special Indian Edition).
3. Crawford DJ (2003) Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
4. Cronquist A (1981). An integrated system of classification of flowering plants. Columbia
5. Evolution. Taylor and Francis, London.
6. Jain S.K. (1995). Manual of Ethnobotany. Scientific Publisher; Second edition (1995).
7. Judd WS, Campbell CS, Kellogg EA, Stevens PA and Donoghue MJ (2002). Plant Systematics: A Phylogenetic Approach. Sinauer Associaes, Inc., Massachusetts.
8. Nei M and Kumar S (2000). Molecular Evolution and Phylogenetics. Oxford University Press, New York.
9. Raven PH, Begr LR, Hassenzahl DM (2008). Environment. 6th edition. John Wiley & Sons, Inc., New York.
10. Semple C and Steel MA (2003). Phylogenetics. Oxford University Press, Oxford.

SEMESTER-III (PRACTICAL): ELECTIVE PAPER-II

BOTPG-ET-304-2: MICROBIOLOGY LAB

Total Max. Marks-100 **Total Credit-04**

1. Laboratory Rules, tools, equipments and other requirements in microbiological laboratory.
2. Microscopy and Micrometry.
3. Preparation of culture media and methods of sterilization.
4. Maintenance of pure cultures.
5. Isolation of microorganisms by pour plate/serial dilution method. 6 . Identification of bacteria by biochemical methods
7. Bacterial staining: Acid fast staining of bacteria, Bacterial cell wall staining, Cytoplasmic membrane staining, Capsule staining.
8. Isolation of food poisoning bacteria from contaminated foods, Dairy products.
9. Preservation of industrially important bacteria by lyophilization.
10. Determination of gas, acid production by the bacteria during fermentation.
11. Determination of hydrolysis starch, fat, protein.
12. Antibiotic susceptibility

Suggested Reading

1. Harrigan, W.F. 1998. Laboratory Methods in Food Microbiology. 3 rd edition. Academic Press, London.
2. Roberts, D. and Greenwood, M. 2002. Practical Food Microbiology. 3 rd edition, WileyBlackwell.
3. Hurst, C. J., Crawford, R. L., Knudsen, G. R., McInerey, M. J. and Stetzenbach, L. D. 2002. Manual of Environmental Microbiology, Second edition. ASM Press, Washington DC.
4. Cappuccino, J. G. and Sherman, N. 2007. Microbiology- A Laboratory Manual, Seventh Edition, Pearson Education, Inc. and Dorling Kindersley (Indi) Pvt Ltd, Delhi, India.

5 Aneja, K.R. 1996. Experiments in Microbiology, plant pathology and tissue culture.

SEMESTER III (Practical): ELECTIVE PAPER-II

BOTPG-ET-304-3: MOLECULAR BIOLOGY AND GENETIC ENGINEERING LAB

Total Max. Marks-100 **Total Credit-04**

1. Isolation of plasmid DNA (Ti Plasmid) from *E.coli* cells.
2. Isolation of plant DNA from leaf tissue.
3. Isolation of RNA from leaf tissue.
4. Isolation of total proteins from seed sample.
5. Agarose gel electrophoresis for separation of DNA.
6. Purity checking and Quantification of nucleic acids.
7. SDS-PAGE for separation of protein mixtures.
8. Restriction digestion.
9. Polymerase Chain Reaction and DNA amplification.
10. Transformation of *E.coli.*
11. Southern hybridization.
12. Western blotting.

Suggested Readings

1. Mitra ,Sandhya 1996, Genetic Engineering Macmillan India Ltd.
2. Lal R. and Lal S. 1993, Genetic engineering of plants for crop improvement. CRC Press.
3. Winkler U., Ruger W. and Wackernagel W. 1979. Bacterial phage and molecular genetics. Narosa Publication New Delhi.
4. Gustafson, J. P. 1990 Gene manipulation in plant improvement I and II. Plenum Press London.
5. Old R. W. and Primrose S. B. 1989 Principles of Gene Manipulation. Blackwell Scientific Publ Oxford UK.
6. Razdan M. K. and Cocking E. C. 2000 Conservation of plant genetic recourses in vitro.Oxford and IBH publishing Co. Pvt. Ltd.
7. Razdan M. K. and Bhojwani S. S. 1996, Plant tissue culture: Theory and practice a revised edition. Elsevier Science.
8. Trigiano R. N. and Gray D. J. 2000 Plant tissue culture concepts and laboratory exercises. CRS press LLC.
9. Gustafson J. P. 2000 Genomes. Kluwer Academic Plenum Publishers New York USA.
10. Brown T. A. 1999 Genomes. John Wiley and Sons Pvt. Ltd. Singapore.

SEMESTER III (Practical): ELECTIVE PAPER-II

BOTPG-ET304-4: ECOLOGY LAB

100 Marks **Total credits-04**

1. Determination of leaf area Index (LAI)
2. Determination of water holding capacity of soil
3. Preparation of Raunkiar's normal frequency diagram
4. Determination of minimum size of quadrat by species area curve
5. Studies of physico - chemical properties of soil

(a) Texture (b) Porosity (c) Water holding capacity (d) organic matter content

6. Determination of primary productivity by harvest method in grassland
7. To calculate the concentration of dominance (cd) of different species.
8. To calculate diversity index of different species.
9. To evaluate the importance value Index (IVI) of different species.
10. Determination and categorization of forest floor litter mass.
11. Study of soil profile in a forest.
12. Study of clump characteristics of bamboo

Suggested Readings

1. Brewer, R. and McCann, M.T. (1982). Laboratory and field manual of ecology, Saunders College Publishing.
2. Michael, P. (1984).Ecological methods for field and laboratory investigation. Tata McGraw- Hill, New Delhi.
3. Moore, P.D. and Chapman, S.B. (1986). Methods in plant ecology. Blackwell Scientific Publications.
4. Misra, R. (1968).Ecology work book, Oxford and IBH Publishing Co. Calcutta.
5. Mueller-Dombois, D and Ellenberg, H. (1974). Aims and methods of vegetation ecology. John Wiley and Sons, New York

SEMESTER III (Practical): ELECTIVE PAPER-II BOTPG-ET-304-5: PLANT PHYSIOLOGY LAB

Total Max. Marks-100 **Total Credit-04**

1. Determination of Osmotic pressure of plant tissue
2. Estimation of total Chlorophyll from leaves of different chronological ages
3. Study on Seed viability by Tetrazolium [TZ] test
4. Preparation of standard curve of a known protein (Bovine Serum Albumin) and estimation of an unknown protein by Lowry's method
5. Extraction and estimation of Peroxidase from plant sample.
6. Extraction and estimation of free amino acids from plant sample
7. PAGE for separation of Protein mixtures.
8. Determination of the absorption spectrum of chlorophylls
9. Determination of free amino acids from plant sample with paper chromatography or TLC
10. Determination of sugars in germinating seeds by TLC
11. Analysis of proline in normal and water stressed or salt stressed plants
12. Study of á- amylase activity in germinating seeds

Suggested Readings

1. Sadasivam S and Manickam A. 2010. Biochemical methods, New Age International Publishers, New Delhi
2. Bewly JD and Black E. 1980. Seeds: physiology of development and germination. Plenum Publishing Corporation.
3. Darwin Fand Hamilton Acton E. 2011. Practical Physiology of Plants (Reissue edition), Cambridge University Press, Cambridge, UK
4. MacDougal DT. 2009. Practical Text-Book of Plant Physiology, University of Michigan Library, Michigan, USA
5. Nobel P.S 1999. Physiochemical and Environmental Plant Physiology (Second Edition) Academic Press, San Diego, USA.

SEMESTER III (PRACTICAL): ELECTIVE PAPER-II BOTPG-ET-304-6: CRUDE DRUG ANALYSIS LAB

Total Max. Marks-100 **Total Credit-04**

1. Study of powdered drugs – physical, chemical and microscopic examinations.
2. Quantitative microscopy of leaf drug – stomatal frequency and stomatal index,
3. Determination of palisade ratio and vein islet number.
4. Qualitative determination of alkaloids, tannins, steroids and saponins from medicinal plants
5. Determination of water soluble and water insoluble ash from crude drugs.
6. Determination of foaming index from crude drugs
7. Determination of titratable organic acids from leaves and fruits
8. Determination of ascorbic acid from plant sample
9. Estimation of phytic acid
10. Determination of total phenol content from powdered drugs.
11. Determination of free radical scavenging activity of methanolic extracts of powdered drugs.
12. Quantitative estimation of total flavanols content of drugs.

Suggested Readings

1. Bajracharya D. (1998). Experiments in Plant Physiology, Narosa Publishing House, New Delhi.
2. Bhattacharya A and Vijay Laxmi (2015). Methods and techniques in plant physiology, New India Publishing Agency, New Delhi
3. Mandal S.C., Mandal V and Das A. K. (2015), Essentials of Botanical Extraction, Academic Press, London
4. Evans W. C. (2009). Trease and Evans Pharmacognosy, Saunders Elsevier, Edinburgh

SEMESTER-IV (Theory): ELECTIVE PAPER-III BOTPG-ET-401-1:
MODERN TRENDS IN SYSTEMATICS

Total Max. Marks-100 **Total Credit-04**

UNIT-I- CHEMO AND CYTOTAXONOMY **15 Hrs**

Cytotaxonomy: Chromosome number, basic chromosome number, polyploidy, aneuploidy, chromosome morphology, karyotypes, chromosome banding, meiotic analysis, scope and limitations. Chemotaxonomy: Origin of chemotaxonomy, classes of compounds and their biological significance, stages in chemotaxonomic investigations; techniques, use of chemical criteria in plant taxonomy.

UNIT-II-NUMERICAL TAXONOMY AND PALYNOLOGY **15 Hrs**

Numerical Taxonomy: Principles, construction of taxonomic groups, OUTs, unit characters, character coding, measurement of resemblances, cluster analysis, phenons and ranks, discrimination, nomenclature and numerical taxonomy, merits and demerits.

Palyotaxonomy: Pollen morphology-Polarity, symmetry, NPC of pollen, exine stratification, excrescences, L/O pattern, palynogram; pollen characters of taxonomic importance.

UNIT-III: EMBRYOLOGY AND ANATOMY **15 Hrs**

Embryology in relation to taxonomy: Embryological characters of taxonomic importance, utilization of embryological data in solving taxonomic problems.

Anatomy in relation to taxonomy: Vegetative, wood and floral anatomy, anatomical characters of taxonomic importance, use of anatomical data in understanding interrelationship and evolution of angiosperms and solving taxonomic problems.

UNIT-IV: MOLECULAR SYSTEMATICS **15 Hrs**

Introduction to molecular systematics; Generating molecular data, types of molecular data, conserved genes for taxonomic analyses – Nuclear, Plastid and mitochondrial genes; molecular characters; homoplasy, phylogeny reconstruction, methods of estimating genetic diversity using molecular data and its modifications. Applications of molecular systematics in plant taxonomy.

Suggested Readings

1. Angiosperm Phylogeny Group 2003. An update of the Angiosperm Phylogeny Group
2. Crawford, D.J. 2003. Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
3. Judd, W.S., C.S. Campbell, E.A. Kellogg, P.F. Stevens and M.J. Donoghue 2002. Plant Systematics: A phylogenetic Approach. Sinauer Associates, Inc., Massachusetts.
4. Nei, M. and S. Kumar 2000. Molecular Evolution and Phylogenetics. Oxford University Press, New York.
5. Semple, C. and M.A. Steel 2003. Phylogenetics. Oxford University Press, Oxford.
6. Michael,G. Simpson. Plant Systematics. 2006. Elsevier Academic Press, Burlington, MA.
7. Gurcharan Singh, Plant Systematics, (2 ed.), 2004. Ox. & IBH Publ. Co, Pvt. Ltd., New Delhi.
8. Hillis, D.M., Mortiz,C. & Mable, B.K. (eds.) 1996, Mol. Systematics, Sinaver Associates, Sunderland, USA.
9. Judd Walter S., Cmpbell C. S., Kollogg, E. A., Stevens P.F. and M. J. Donoghue 2008. Plant Systematics. Sinauer Associates, INC, Publishers, Sunderland, Massachusetts, USA.

SEMESTER IV (Theory): ELECTIVE PAPER-III BOTPG-ET-401-2:
PLANT DISEASES AND PROTECTION

Total Max. Marks-100 **Total Credit-04**

UNIT –I: PATHOGENS AND DISEASES **15 Hrs.**

Plant diseases and pathogens, mode of infection, Role of enzymes and toxins in Plant diseases. Koch's postulates. Disease cycle. Defense mechanisms of plant diseases against infection. Structural defense and biochemical defense. Enzymes and toxins in plant disease.

UNIT-II: DISEASE FORECASTING AND EPIDEMICS **15 Hrs.**

Disease diagnosis and assessment, Plant disease epidemics, Disease forecasting and its importance. Methods used in diseases forecasting. Dispersal of plant pathogens. Effect of environmental factors in disease development. Molecular methods for detection of plant pathogens.

UNIT-III: STUDY OF IMPORTANT PLANT DISEASES: **15 Hrs.**

Study of plant diseases caused by fungi, bacteria, viruses, nematodes and mycoplasma like organisms: Fungal: Wart disease of potato, Rhizome rot of ginger, blight of *Colocasia*, Smut of maize. Bacterial: Wilt and brown rot of potato, Citrus greening, Blight disease if rice, wilt disease of maize. Viral: Chirkey and foorkey disease of large cardamom, *Potato spindle tuber viroid* (PSTVd), Leaf curl of tomato. Nematodes: Citrus nematode, Root knot of vegetables. Mycoplasmas: Grassy shoot disease (GSD) of sugarcane, Little leaf of brinjal, coconut root wilt.

UNIT-III: MANAGEMENT OF PLANT DISEASES **15 Hrs.**

Cultural methods, Chemical methods. Breeding for disease resistance, types of resistance. Methods of Selection of resistant genotypes. Breeding wheat for disease resistance, Breeding rice for resistance, breeding sugarcane for resistance, breeding potato for resistance. Innovative methods of plant disease control.

Suggested Readings

1. Agrios, G.N. (1997). Plant Pathology. Academic Press, New York.
2. Ainsworth, G.C. Sparrow, F.K., and Sussman A.S. (1973). The Fungi- An Advanced Treatise.Vols. IV A. Academic Press, London.
3. Mehrotra, R.S. (1980). Plant Pathology. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
4. Mehrotra, R.S. and Aneja, K.R. (1990). An Introduction to Mycology. New Age International Publishers, New Delhi.
5. Webster, J. (1980). Introduction to Fungi. Cambridge University Press, Cambridge, London.
6. Vashista, B.R. and Sinha, A.K. (2008) Botany for degree students-Fungi. S. Chand and Company Ltd, New Delhi-pp 1-752.

SEMESTER-IV (Theory): ELECTIVE PAPER-III

BOTPG-ET-401-3: GENOMICS AND PROTEOMICS

Total Max. Marks-100 **Total Credit-04**

UNIT-I- GENOME ORGANIZATION **15 Hrs.**

Important features of bacterial and eukaryotic genome organization. Organellar genome: Mitochondiria and Chloroplast genome. C-Value Paradox. Plant Genome Analysis: Classes of molecular markers & applications, genetic and physical mapping.

UNIT-II- GENOME SEQUENCING **15 Hrs.**

Strategies for genome sequencing: Chain termination method, automated sequencing, pyro- sequencing. Sequence assembly: Next Generation Sequencing (NGS) methods, data analysis, bioinformatics tools. Plant genome project and its applications. Applications of DNA sequencing to crop improvement.

UNIT-III- FUNCTIONAL GENOMICS **15 Hrs.**

Determination of the functions of genes: gene inactivation (knock-out, anti-sense and RNA interference) and gene over expression. Approaches to analyze global gene expression: transcriptome, Serial Analysis of Gene Expression (SAGE), Expressed Sequence Tags (ESTs), Massively Parallel Signature Sequencing (MPSS), microarray and its applications, gene tagging, Metagenomics. Genome editing-CRISPR-cas9 system.

UNIT-III- PROTEOMICS **15 Hrs.**

Introduction and scope of proteomics; Protein extraction, separation, detection and quantification methods. Protein sequencing and modification. Protein-protein interaction (Two hybrid interaction screening); Protein engineering; Protein chips and functional proteomics. Application of proteomics to plant sciences; Proteome database; Proteomics industry.

Suggested Readings

1. JD Wale, 2002. From Genes to Genomes: Concepts and Applications of DNA Technology. Wiley-Blackwell Publishers.
2. Primrose and Twyman. 2002. Principles of Genome Analysis and Genomics. Blackwell publishing, USA. R.M.Twyman, Principles of Proteomics, BIOS Scientific Publishers, 2004.
3. P.Michael Conn, Handbook of Proteomic Method. Humana Press, Totowa,New Jersay, USA, 2003.
4. De Robertis and De Robertis, 1990, Cell and Molecular Biol., Saunders College, Philadelphia, USA
5. Weaver, R.F. and Hedrick,P.W., 1989, Genetics. Wm, C. Brown Pub, Dubuque.

SEMESTER IV (Theory): ELECTIVE PAPER-III

BOT-PG-CT-401(4): COMMUNITY ECOLOGY AND CLIMATE CHANGE

Total Max.Mark-100 **Total credits-04**

UNIT-I: ECOSYSTEM ECOLOGY **15 Hrs**

Ecosystem structure-Biotic and Abiotic components, Ecosystem functions, Ecosystem Processes- Respiration, Decomposition, Nature of plant community-Discrete

View, Continuum view and synthetic approach, community structure and attributes, Keystone species.

UNIT-II: NATURAL RESOURCES AND PLANT ADAPTATIONS **15 Hrs**

Types of natural resources, Human impact on natural resources and mangement, Energy resources, Mineral Resources, Law of tolerance, Ecotypes, Ecoclines, Acclimation, Plant adaptations Strategies.

UNIT-III: NUTRIENT CYCLING AND BIOGEOCHEMICAL CYCLING **15Hrs**

Nutrient cycling models, Nutrients inputs and outputs to ecosystem, Storage and Accumulation of nutrients in plants, Intersystem and Intrasystem nutrient cycling, Biogeochemical cycling - C, N, P and S cycle.

UNIT-IV: GLOBAL ENVIRONMENTAL CHANGE AND ENVIRONMENTAL POLLUTION **15 Hrs**

Green house gas effect, Global warming and its effects on environment, Tools to study global climate change and strategies of mitigation, Ozone layer depletion and means of Protection, Global and Indian initiatives to mitigate climate change. Air, water, soil

and noise pollution, Ecotoxicants: distribution and fate of toxic substance, Toxic effect from individuals to ecosystem.

Suggested Readings

1. Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publ., New Delhi. 688Pp.
2. Climate Change and Biodiversity; By Thomas E. Lovejoy, Lee Jay Hannah Published by Yale University Press, 2006 ISBN 0300119801, 80300119800 418 pages
3. William H. Schlesinger. 1997. Biogeochemistry: An Analysis of Global Change. Academic Press, San Diego, CA. 2nd edition. Available at the Bay Tree Bookstore.
4. Global Environmental Change: Research Pathways for the Next Decade, National Research Council, 1999
5. M. C. Jacobson, R. J. Charlson, H. Rodhe, and G. H. Orians. 2002. Earth System Science: From Biogeochemical Cycles to Global Change. Academic Press, San Diego, CA.
6. 5.Our Common Journey: A Transition Toward Sustainability, National Research Council, 1999

SEMESTER-IV (Theory): ELECTIVE PAPER-III BOTPG-ET-401-5: PLANT METABOLISM

Total Max. Marks-100 **Total Credit-04**

UNIT-I: CARBOHYDRATE METABOLISM **15Hrs**

Gluconeogenesis; Stoichiometry and energy balance of gluconeogenesis; Regulation of gluconeogenesis;; Glycogen biosynthesis; Catabolism of polysaccharides; Pentose phosphate pathway. Sucrose biosynthesis and degradation, role of Fructose 2,6-bisphosphate in carbohydrate metabolism, starch synthesis and degradation.

UNIT-II: LIPID METABOLISM **15Hrs**

Biosynthesis of fatty acids; Oxidation of lipids: â, á and ù oxidation of fatty acids; Stoichiometry of â-oxidation; Triacylglycerol synthesis; Metabolism of cholesterol and its regulation; Glycerolipid biosynthesis; Role of lipids in signaling and defence.

UNIT-III: AMINO ACID METABOLISM **15Hrs**

Classification of amino acids; General reactions of amino acid metabolism; Biosynthesis of aromatic amino acids; Amino acid proline and stress response; Glutathione: metabolism and function; Amino acid degradation; Urea cycle and its regulation; Catabolism of amino acids; Metabolic defects in amino acid metabolism.

Unit-IV: SECONDARY METABOLITES **15Hrs**

Secondary metabolites: introduction and functions; Basic metabolic pathway and the origin of secondary metabolites; Biosynthesis of to phenolics; Alkaloids: Nomenclature, classification and uses; Biosynthesis of alkaloids; biosynthesis of terpenoids; General account of flavonoids; Plant defenses against pathogens; Metabolic engineering in the production of pharmaceuticals; Bioprospecting for naturally derived anticancer agents, metabolomics

Suggested Reagings

1. Voet and Voet, 1992. **Biochemistry**, John Wiley & Sons, Inc., New York, USA.
2. Nelson DL and Cox MM. (2004) Lehninger Principles of Biochemistry, 4th Edition, W.H.Freeman and Company, New York, USA
3. Bowsher et al., 2008. Plant Biochemistry, Garland Science, New York
4. Mathews, Van Holde and Ahern. 2007,Biochemistry (3rd Ed), Pearson Edsucation, Delhi
5. Dey PM and Harborne JR. 2000, Plant Biochemistry, Harcourt Asia Pvt. Ltd., Singapore
6. Buchanan B, Gruissem G and Jones R. (2000) Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA.

SEMESTER-IV (Theory): ELECTIVE PAPER-III

BOTPG-ET-401-6: HERBAL MEDICINE AND EASTERN HIMALAYAN BIORESOURCES

Total Max. Marks-100 **Total Credit-04**

UNIT- I HERBAL MEDICINE **15 Hrs.**

Medicinal plant research scenario in India; Diagnostic features, bioactive molecules and therapeutic value of some common medicinal plants; Standardisation of herbal drugs; Commercial cultivation of medicinal plants; Conservation of medicinal plants; Neutraceuticals and medicinal food

UNIT- II CHEMISTRY AND PHARMACOLOGY OF HERBAL DRUGS **15 Hrs.**

Classification of active plant constituents with source and phytotherapeutic properties; Routes of drug administration; Absorption, metabolism and fate of drugs; Mechanism of drug action; Drug tolerance. Metabolic pathways of some important secondary metabolites.

UNIT- III EASTERN HIMALAYAN BIORESOURCES **15 Hrs.**

Definition and demarcation of the Eastern Himalayas. Geographical background of Eastern Himalayas. Biodiversity hotspot zones and sub classification Bio-resources of Eastern Himalayas: medicinal and aromatic plants, wild edible plants spices and condiments, beverages, masticatories, important timber yielding and fire wood plants, important Non-Timber Forest Products (NTFP's), ethno-veterinary plants, bamboos, raw material for paper, gum, resin, tannins and dyes.

UNIT- IV CONSERVATION BIOLOGY **15 Hrs.**

Current practice in conservation in India and abroad. Organisations involved in resource conservation; Phytogeography – Hotspots of India and world. Strategies for *in situ* and *ex-situ* conservation – Protected areas, Wildlife sanctuaries, National parks, Biosphere reserves.

Suggested Readings

1. Cotton, C.M. (1997). Ethnobotany – Principles and applications. John Wiley and Sons – Chichester.
2. Das, A.P. and Pandey, A.K. (2007). Advances in Ethnobotany. Bishen Singh and Mahendra Pal Singh, Dehradun.
3. Dhar, U. (1993). Himalayan Biodiversity: Conservation Strategies. Gyanodaya Prakashan.
4. Pusphanganthan *et al*. (1997).Conservation and Ecological Economics of Biodiversity.
5. Simpson, B.B. and Conner - Ogorzaly, M. (1986). Economic Botany: plants of our world. Mc Graw Hill.
6. Subba, T. B. and Ghosh , G. C. (2003). Antropology of North-East India. Orient Longman Limited, New Delhi.

SEMESTER-IV (Theory): ELECTIVE PAPER-IV

BOTPG-ET-402-1: BIODIVERSITY CONSERVATION AND RESTORATION ECOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT-I: BIODIVERSITY CONSERVATION **15 Hrs**

Introduction and levels of biodiversity; biodiversity hotspots; Biodiversity threats-habitat loss and over exploitation of resources, invasive species. Biodiversity conservation-*in-situ* and *ex-situ*, sacred grooves, JFM, Concept of Lead Botanical Gardens and Biodiversity Parks, role of Botanical Gardens in plant conservation; IUCN threat categorization, extinction of species; biodiversity –ecosystem services; Biodiversity Act 2002.

UNIT-II: ECOLOGICAL RESTORATION AND EIA **15 Hrs**

Ecosystem degradation, concept and strategies of ecorestoration; Biological and biotechnological tools of ecorestoration; restoration of degraded ecosystems. EIA-purpose, aims, principles, EIA process and community involvement.

UNIT-III: REMOTE SENSING AND GIS **15 Hrs**

Process of remote sensing; remote sensing satellites; microwave remote sensing; data analysis and image processing; application of remote sensing; basic of GIS, tools of GIS, GIS data management. Application of GIS in ecology

UNIT –IV: SUSTAINABLE DEVELOPMENT AND ECOLOGICAL ECONOMICS **15 Hrs**

Definition and dimensions of sustainability; ecological footprint and carrying capacity. Threat to sustainbale development; indicators of sustainability; environmental sustainability index; ecological footprints; ecological economics; characteristics and role of Government and NGOs in sustainable development.

Suggested Readings:

1. Cracknell AP, Hayes L (2009) Introduction to Remote Sensing. CRC Press, Boca Raton, USA (Special Indian Edition)
2. Raven PH, Begr LR, Hassenzahl DM (2008) Environment. 6th edition. John Wiley & Sons, Inc., New York.
3. Gliesmann, S.R. (2006). Agroecology: The Ecology of Sustainable Food Systems. Technology & Engineering.
4. Gliesmann, S.R. (2006). Field and Laboratory Investigations in Agroecology. Technology & Engineering.
5. Paul A. Wojtkowski, P.A. (2004). Landscape agroecology, Haworth Press, Inc., New York. 330 pp.
6. Environmental Biotechnology - Theory and Application – M. H. Fulekar: CRC Press and Science Publisher, USA
7. M. H. Fulekar (2005) Environmental Biotechnology Oxford IBH Publishing cooperation.
8. Environmental Biotechnology-Alan Scragg,Oxford University Press. 6. Environmental Biotechnology, A BiosystemsApproach, Author(s):Daniel A. Vallero, PhD, ISBN: 978-0-12- 375089-1,Copyright © 2010 Elsevier
9. Bruce Rittman, Perry L. McCarty (2000). Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000. Environmental Biotechnology: Basic Concepts and Applications. 2006, Indu Shekhar Thakur, I. K. International Pvt Ltd.
10. Ecosystem services: Charting a path to sustainability. National Academies Press (20 April 2012).

SEMESTER-IV (Theory): ELECTIVE PAPER-IV BOTPG-ET-402-2: CROP PROTECTION AND MANAGEMENT

Total Max. Marks-100 **Total Credit-04**

UNIT-I: PRINCIPLES OF DISEASE MANAGEMENT **15 Hrs.**

Disease avoidance, Pathogen exclusion, Eradication of pathogens, Resitance to pathogen, Plant protectants (Fungicides, bactericides, pesticides and herbicides). Biological pest control and diseases, Storage pest and diseases.

UNIT –II: PLANT DISEASE CONTROL **15 Hrs.**

Cultural, chemical, biological plant disease management, biopesticides, breeding for resistant varieties, Plant quarantine, integrated pest management.

UNIT-III: PLANT DISEASE MANAGEMENT **15 Hrs.**

Screening of genetic disease resistance germplasm. Exploitation of pre penetration and penetration events, enhancing plant tolerance, resistance mechanism. Fungicide resistance.

UNIT-IV: MODERN ASPECTS OF PHYTOPATHOLOGY **15 Hrs.**

Application of plant biotechnology in plant pathology. Uses of modern biotechnological tools in crop management. Testing for host resistance to diseases. Development of transgenic plants for disease resistance. Molecular breeding for disease resistance.

Suggested Readings

1. R.P. Singh, (2005) Plant Pathology. Kalyani Publishers Ludhiana.
2. Singh DP & Singh A. 2007. Disease and Insect Resistance in Plants. Oxford & IBH, New Delhi Biotechnology. Oxford & IBH, New Delhi.
3. Upadhyay RK & Mukherjee KG. 1997. Toxins in Plant Disease Development and Evolving
4. Fry WE. 1982. Principles of Plant Disease Management. Academic Press, New York
5. Hewitt HG. 1998. Fungicides in Crop Protection. CABI, Wallington.
6. Marsh RW. 1972. Systemic Fungicides. Longman, New York.
7. Nene YL & Thapliyal PN. 1993. Fungicides in Plant Disease Control. Oxford & IBH, New Delhi.
8. Palti J. 1981. Cultural Practices and Infectious Crop Diseases. Springer- Verlag, New York.
9. Vyas SC. 1993 Handbook of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

SEMESTER-IV (Theory): ELECTIVE PAPER-IV BOTPG-ET-402-3 PLANT TISSUE CULTURE: TECHNIQUES & APPLICATIONS

Total Max. Marks-100 **Total Credit-04**

UNIT-I: INTRODUCTION TO PLANT TISSUE CUTLURE **15 Hrs**

Introduction to Plant Tissue culture, Terms and definitions, Historical background, Laboratory organization, Tools and techniques, methods of sterilization. Laboratory contaminants- it's control and measures.

UNIT-II: MEDIA AND CULTURE PREPARATION **15 Hrs**

Role of Micro and macro nutrients, Vitamins and carbon source in tissue culture, Media preparation- pH, Temperature, Solidifying agents, Slant Preparations etc. Maintenance of cultures, Environmental Conditions, explants characteristics. Explants selection, sterilization and inoculation; Various media preparations; MS, B5, SH PC L-2.

UNIT III: MICROPROPAGATION METHODS **15 Hrs**

Induction and growth parameters; Culture initiation, Callus culture. Micropropagation through various explants (Leaf, Stem, Axillary bud, Tuber, Corms and Bulbills), Somatic embryogenesis, Applications of micropropagation. Haploid production through anther and ovary culture. Endosperm culture.

UNIT IV: PLANT TISSUE CUTLURE IN CROP IMPROVEMENT **15 Hrs**

Crop improvement by in vitro techniques. Techniques and significance of Androgensis and Gynogenesis (ovary, ovule, egg, synergids culture). Protoplast culture and applications. Somatic hybridization. Somaclonal variation. Production of disease resistant, stress resistant and other mutants for agronomic characters and for efficient nutrient utilization. Advantages and limitations. Molecular farming.

Suggested Readings

1. Butcher, D.n and D.S. Ingram,1982. Plant tissue culture. Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi.
2. Butenko, R.G, 1985. Plant cell culture. MIR Publishers, Moscow.
3. Dixon, R.A, 1985. Plant cell cultureA practical approach. IRL press Oxford, London. —
4. Dodds. J.H and L.N. Roberrtis (1985) Experiments in plant tissue culture, Cambridge University Press New York. –
5. Kalyan Kumar D.E.1992. Plant tissue culture, Agrobios, New Delhi.
6. Lindsley,K. 1992.Plant tissue culture manual. Kluwer Academic publishers.
7. Narayanaswamy, S. 1994. Plant cell and tissue culture. Tata McGraw Hill Publishing company,Ltd. New Delhi.
8. Purohit, S.S and S.K. Mathur, 1993. Fundamentals of Biotechnology. Agrobotanical publishers, India.

SEMESTER-IV (Theory): ELECTIVE PAPER

BOTPG-ET 402-4: BIODIVERSITY CONSERVATION AND RESTORATION ECOLOGY

Total marks-100 **Total credits-04**

UNIT-I: BIODIVERSITY CONSERVATION **15 Hrs**

Introduction and levels of biodiversity; biodiversity hotspots; Biodiversity threats-habitat loss and over exploitation of resources, invasive species. Biodiversity conservation-*in-situ* and *ex-situ*, sacred grooves, JFM, Concept of Lead Botanical Gardens and Biodiversity Parks, role of Botanical Gardens in plant conservation; IUCN threat categorization, extinction of species; biodiversity –ecosystem services; Biodiversity Act 2002.

UNIT-II: ECOLOGICAL RESTORATION AND EIA **15 Hrs**

Ecosystem degradation, concept and strategies of ecorestoration; Biological and biotechnological tools of ecorestoration; restoration of degraded ecosystems. EIA-purpose, aims, principles, EIA process and community involvement.

UNIT-III: REMOTE SENSING AND GIS

Process of remote sensing; remote sensing satellites; microwave remote sensing; data analysis and image processing; application of remote sensing; basic of GIS, tools of GIS, GIS data management. Application of GIS in ecology

UNIT –IV: SUSTAINABLE DEVELOPMENT AND ECOLOGICAL ECONOMICS **15Hrs**

Definition and dimensions of sustainability; ecological footprint and carrying capacity. Threat to sustainbale development; indicators of sustainability; environmental sustainability index; ecological footprints; ecological economics; characteristics and role of Government and NGOs in sustainable development.

Suggested Readings:

1. Cracknell AP, Hayes L (2009) Introduction to Remote Sensing. CRC Press, Boca Raton,
2. USA (Special Indian Edition)
3. Raven PH, Begr LR, Hassenzahl DM (2008) Environment. 6th edition. John Wiley & Sons, Inc., New York.
4. Gliesmann, S.R. (2006). Agroecology: The Ecology of Sustainable Food Systems. Technology & Engineering.
5. Gliesmann, S.R. (2006). Field and Laboratory Investigations in Agroecology. Technology & Engineering.
6. Paul A. Wojtkowski, P.A. (2004). Landscape agroecology, Haworth Press, Inc., New York. 330 pp.
7. Environmental Biotechnology - Theory and Application – M. H. Fulekar: CRC Press and Science Publisher, USA
8. M. H. Fulekar (2005) Environmental Biotechnology Oxford IBH Publishing cooperation.
9. Environmental Biotechnology-Alan Scragg,Oxford University Press. 6. Environmental Biotechnology, A BiosystemsApproach, Author(s):Daniel A. Vallero, PhD, ISBN: 978-0-12- 375089-1,Copyright © 2010 Elsevier
10. Bruce Rittman, Perry L. McCarty (2000). Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000. Environmental Biotechnology: Basic Concepts and Applications. 2006, Indu Shekhar Thakur, I. K. International Pvt Ltd.

SEMESTER-IV (Theory): ELECTIVE PAPER-IV

BOTPG-ET-402-5: BIOCHEMISTRY

Total Max. Marks-100 **Total Credit-04**

UNIT-I: PROTEIN BIOCHEMISTRY **15 Hrs.**

Protein sorting and vesicle traffic; Machinery for protein sorting; Protein targeting to different organelles; Protein-protein interactions, protein-DNA interactions; Protein degradation; Proteins in diseases: Alzheimer, Parkinson, BSE. Strategies for protein purification, Use of vectors for over- expression of proteins, Tagging for protein expression.

UNIT-II: SIGNAL TRANSDUCTION **15 Hrs.**

Overview, second messengers and G-proteins; Phospholipid signaling; Role of cyclic nucleotides. Cacium-Calmodulin cascade; Protein kinases and phosphtases; Two component sensor-regulator system in bacteria and plants, quorum sensing; Gibberellin and Auxin signal transduction in plants.

UNIT-III: IMMUNOLOGY **15 Hrs**

Introduction: immune system, organs, immune cells; Types of immunity: innate and adaptive; Antigens: types, properties, antigen-antibody interaction; Major histocompatibility complex: Class I and II MHC molecules; Cytokines: types, mechanism of action and therapeutic uses

Immunity in Health & Disease: Immune response to infectious diseases, Immunodeficiency and AIDS.

UNIT-IV – RECOMBINANT DNA TECHNOLOGY **12 Hrs.**

An overview, Gene cloning: tools and techniques; Vectors: Plasmids and bacteriophages; purification of plasmid, bacteriophage and cell DNA. DNA manipulative enzymes, Manipulation of DNA, transformation, selection, DNA libraries, PCR, DNA sequencing. RNA interference.

Suggested Readings

1. Alberts, B., Bray, D., Lewis, J. Raff, M., Roberts, K. and Watson, J.D. 1989. Molecular Biology of the cell, Garland Publishing Inc., New York.
2. Brown TA. (2002) Genomes, BIOS Scientific Publishers Ltd, Oxford, UK.
3. Brown TA. (2008) Gene cloning and DNA analysis (5th Edition),Blackwell Publishing, Oxford, UK.
4. Lodish H, Berk A, Kaiser CA and Krieger M. (2008) Molecular Cell Biology, 6th Edition, W.H. Freeman and Company, New York, USA.
5. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. 2004. Molecular Biology of th
6. Gene, Pearson Education, Singapore.
7. Nelson DL and Cox MM. (2004) Lehninger Principles of Biochemistry, 4th Edition, W.H., Freeman and Company, New York, USA.
8. Kuby, J. 2000. Immunology, 4th edition, W.H. Freeman and Company, New York, USA.
9. Roitt *et al*., 1998, Immunology 5th edition, Mosby International Ltd. London. UK.

SEMESTER-IV (Theory): ELECTIVE PAPER-IV

BOTPG-ET-402-6: PHARMACOGNOSY AND PHYTOCHEMISTRY

Total Max. Marks-100 **Total Credit-04**

UNIT-I FUNDAMENTALS OF PHARMACOGNOSY **15 Hrs**

Definition, scope and applications in herbal medicine. Classification and identification of drugs: Need for classification of drugs; classical (taxonomic, morphological, organoleptic, therapeutic); microscopy and modern (biogenetic) criteria for classification of powdered drugs, methods for documentation of raw drugs. Drug evaluation.

UNIT-II: DRUG ADULTERATION **15 Hrs**

Types, methods of evaluation - biological, anatomical, physical, Phytochemical investigation. Global trend in herbal market. Status of Indian medicinal plant trade, medicinal plants prohibited from export. WHO regulation of herbal medicine. CHMP/ CVMP guidelines of the European Medicines Agency Inspections

UNIT-III: PHYTOCHEMICAL EXTRACTION **15 Hrs.**

Introduction, definition, factors influencing the choice of extraction. Principles of extraction methods, types of extraction. Extraction of Plant drugs by Microwave assisted techniques and their merits and demerits. Selection of Solvents for extraction. Methods of isolation, purification and characterization of some natural products: Podophyllin, Ginsenosides, Curcumin, Cordycepin,Lemon grass oil, Emitine, Artimisinin, Quinine etc.

UNIT-IV: BIOACTIVE SECONDARY METABOLITES **15 Hrs.**

Steroids: Occurrence and distribution in plants, saponins, sapogenins and steroids; Isolation, and biosynthesis of bioactive steroids such as cholesterol, diosgenin, estrone, estrodiol, etc.; *Terpenoids*: Occurrence and distribution in plants, essential oils, aroma chemicals, mono and sesquiterpenoids, their use in flavour and perfumery industry, diterpenes, triterpenes, isolation and characterization of terpenes, their synthesis; *Alkaloids*: occurrence and distribution in plants, bioactive alkaloids-isolation and structure elucidation of alkaloids such as atropine, quinine, papaverine, thebaine, vincristine, etc.;

Suggested Readings

1. Dey. P.M. and J.B.Horborne: Plant Bio Chemistry Acadamic Press, London.
2. Sadasivam. S. and A. Manickam : Bio Chemical methods 2nd edition. New Age International Pvt. Ltd. New delhi.
3. Dennis D.T., Turpin, D.H. Lefebvre, Layzell D.D and D.B. (eds) 1997. Plant Metabolism (Second Edition) Longman, Essex, England.
4. Verma S.K. and Verma Mohit 2007. A.T.B of Plant Physiology, Biochemistry and Biotechnology, S.Chand Publications
5. Leninger A.C 1987. Principles of Biochmistry, CBS Publishers and Distributers (Indian Reprint).

SEMESTER-IV (Practical): ELECTIVE PAPER-V

BOTPG-ET-403-1: TAXONOMY LAB

Total Max. Marks-100 **Total Credit-04**

1. Specimens collection and handling
2. Taxonomic literatures – Check lists, Floras, Keys, Monographs and Laboratory identification manuals.
3. Preparation of artificial keys.
4. Understanding of phylogenetic classifications.
5. Chemotaxonomy – Flower pigment analysis of plants from Caryophyllales and Curvembryae.
6. Palynotaxonomy – Study of pollen characters of taxonomic significance.
7. Cytotaxonomy – Study of intergeneric / interspecific karyotypic differences.
8. Numerical taxonomy-study attributes, coding, statistical analysis
9. Molecular Taxonomy: Specimen collection, Isolation of DNA,
10. DNA-purification, quantification.
11. Gain a basic understanding of botanical vocabulary and terminology.
12. Learn about major themes and trends in plant evolution.

Suggested Readings

1. Angiosperm Phylogeny Group 2003. An update of the Angiosperm Phylogeny Group
2. Classification for the orders and families of flowering plants: APG II. Botanical Journal of the Linnaean Society 141: 399-436.
3. Crawford, D.J. 2003. Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
4. Cronquist, A. 1981. An integrated system of classification of flowering plants. Columbia University Press, New York.
5. Judd, W.S., C.S. Campbell, E.A. Kellogg, P.F.Stevens and M.J. Donoghue 2002. Plant Systematics: A phylogenetic Approach. Sinauer Associates, Inc., Massachusetts.
6. Maheshwari, J.K. 1963. The Flora of Delhi, CSIR, New Delhi.
7. Nei, M. and S. Kumar 2000. Molecular Evolution and Phylogenetics. Oxford University Press, New York.
8. Radford, A. E., W.C. Dickison, J.R. Massey and C.R. Bell 1974. Vascular Plant Systematics. Harper and Row, New York.
9. Semple, C. and M.A. Steel 2003. Phylogenetics. Oxford University Press, Oxford.
10. Michael,G. Simpson. Plant Systematics. 2006. Elsevier Academic Press, Burlington, MA.

SEMESTER - IV (Practical): ELECTIVE PAPER-V

BOTPG-ET-403-2: PLANT PATHOLOGY LAB

Total Max. Marks-100 **Total Credit-04**

1. Preparation of culture media.
2. Methods of sterilization.
3. Isolation of bacterial plant pathogen from diseased tissue.
4. Isolation of fungal plant pathogen.
5. Study of the Fungal diseases: Club root, Damping off, White rust, Early and late Blight, Downy mildew, Powdery mildew, Smut, Rust, leaf spot, Anthracnose, Rot, Wilt.
6. Bacterial Diseases: Citrus canker, Blight and Leaf Spot, Grassy shoot disease and Little leaf,
7. Viral disease: TMV,Yellow mosaic
8. Nematode disease: Root knot
9. Treatment methods for Seed/propagules disinfection for disease free planting
10. Treatment methods for soil disinfection
11. Diagnosis of plant diseases using molecular tools.
12. Symptomatology and histopathology of locally available disease-plants.

Suggested Readings

1. Agrios, G. N. 1978: Plant Pathology
2. Aneja, K. R. 1993. : Experiments in Microbiology, plant pathology and Tissue culture
3. Metcalf & Flint –Desructive & useful Insects.
4. J.B. Free – Insect pollination of field crops.
5. D.S. Bindra- Plant Protection and equipments.

SEMESTER-IV (Practical): ELECTIVE PAPER-V BOTPG-ET-403-3: PLANT TISSUE CULTURE LAB

Total Max. Marks-100 **Total Credit-04**

1. Requirement for Plant tissue culture works: Work station, equipments and culture conditions.
2. Preparation of MS media stock solution and hormones.
3. Media Preparation & Sterilization.
4. Preparation of explants & callus induction techniques.
5. Micropropagation through axillary bud culture.
6. Induction of Somatic embryogenesis.
7. Anther/ovary culture
8. Isolation of protoplasts.
9. Suspension culture.
10. Preparation of synthetic seeds.
11. Hardening and Acclimatization.
12. Transformation of callus through *A.tumefaciens.*

Suggested Readings

1) Krishnamurthy, K.V, 1988. Methods in plant histochemistry. Viswanathan printers and publishers, Chennai.
2) Lindsley,K. 1992.Plant tissue culture manual. Kluwer Academic publishers.
3) McClung, C.L, 1961. Hand book of Microscopic technique. MacGraw Hill, New Delhi.
4) Purvis, C.J., Collen, D and Walls, D. 1966. Laboratory technique in Botany. Orient Longman, Singapore.
5) Reinert .J and Yeoman, M.M 1983 Plant cell and Tissue culture- Laboratory manual, Narosa publishing house, New Delhi
6) Patki, L.R, 1992. An introduction to Mictotechnique. S. Chand & Co, New Delhi.
7) Prasad and Prasad, 2000. Outlines of Microtechnique. Emkay publ, New Delhi.
8) Thorpe, T.A. 1981. Plant tissue culture methods and application in agriculture, Elsevier, London

SEMESTER-IV (Practical): ELECTIVE PAPER-V

BOTPG-ET-403-4: ENVIRONMENTAL BIOLOGY LAB

Total Max. Marks-100 **Total Credit-04**

1. To estimate the biomass allocation pattern in grassland community.
2. Determination of Dissolved oxygen by Winkler method.
3. Study of phytoplankton in an aquatic ecosystem.
4. Determination of litter accumulation in forest stand.
5. Determination of pH of soil and water by using pH meter.
6. Study of root nodules of leguminous and non leguminous species.
7. Estimation of NO3 from water and waste water.
8. Estimation of phosphate from water and waste water.
9. Study of girth increment in tree species
10. Study of density of invasive species and native species.
11. Data collection using Global positioning system(GPS)
12. Land use/ land cover delineation from satellite imagery using visual interpretation technique.

Suggested Readings

1. Brewer, R. and McCann, M.T. (1982).Laboratory and field manual of ecology. Saunders College Publishing.
2. APHA, (2005). Standard methods for the examination of water and wastewater (21st edition). American Public Health Association (APHA), AWWA, WPCF, Washington, DC, USA. De, A K. (2006). Environmental chemistry. New Age International. Michael, P. (1984).
3. Ecological methods for field and laboratory investigations. Tata McGraw Hill, New Delhi.
4. Husch, B., Beers, T.W. and Kershaw, J.A. (2003). Forest mensuration. John Willey and Sons.

SEMESTER-IV (Practical): ELECTIVE PAPER-V

BOTPG-ET-403-5: BIOCHEMISTRY LAB

Total Max. Marks-100 **Total Credit-04**

1. Estimation of DNA (DPA Method)
2. Estimation of total proteins [Bradford's / Lowry's]
3. Effect of pH on enzyme activity.
4. Estimation of PPO oxidase from plant sample.
5. Estimation of Ascorbic acid [Calorimetric / volumetric]
6. Estimation of Riboflavin
7. Estimation of Phenolics [Folin – Ciocalteau]
8. Estimation of Tannins [Folin – Denis / Vanillin hydrochloride]
9. Separation of proteins by SDS-PAGE
10. Determination of Nitrate reductase activity
11. Estimation of ascorbate peroxidase enzyme from plants
12. Estimation of carbohydrate by Anthrone reagent

Suggested Readings

1. Wilson, E. & Goulding, K.H. 2000 A Biologists' Guide to Principles and Techniques of Practical Biochemistry ELBS.
2. Jayaraman, J. 1985. Laboratory Manual of Biochemistry, Wiley Eastern Limited. New Delhi.
3. Modern Experimental Biochemistry, (3rd Edn.) R.Boyer, Benjamin Cumming, 2000.
4. Practical Biochemistry, Principle and Technique (5th Edn.) K. Wilsen and J. Walker, Cambridge University press. 2000.
5. Plant Biochemistry, P.M dey and J.B. Harborne, Harcourt Asia Ltd. Academic press, 1997.

SEMESTER-IV (Practical): ELECTIVE PAPER-V

BOTPG-ET-403-6: NATURAL PRODUCTS LAB

Total Max. Marks-100 **Total Credit-04**

1. Determination of tannins.
2. Determination of flavonoids.
3. Pharmacological screening of Anti-diabetic Agents.
4. Determination of anti-oxidant activity from local plants.
5. Screening of Crude Drugs for Anti-microbial activity.
6. Phytochemical screening methods: Paper Chromatography, TLC, HPLC, Spectrometry.
7. Estimation of Alkaloids from local plants.
8. Identification of amino acids by Paper Chromatography.
9. Identification and Estimation of Lipids
10. Qualitative determination of Phenols from local plants.
11. Determination of adulteration in crude drugs.
12. Determination of extractive value of crude drugs.

Suggested Readings

1. Horborne. J.B. 1983. Phyto chemical methods. Chapman and Hall. London.
2. Trease. G.E. and Evanes W.C.Pharmacognosy. 12 Edition. Bailliere, Tindall, East Bourne, U.K. 1983.
3. Kokate. C.K.Purohit A.P. and S.B. Gokhale. Pharmacognosy Nivali Prakashan Publication.
4. Miller.L.P. Phyto chemistry. 1-3 volumes Van Nostrand, Reinhold Co. 1973.

SEMESTER-IV (DISSERTATION): ELECTIVE PAPER-VI

BOTPG-DV-404: DISSERTATION AND VIVA-VOCE)

Total Max. Marks-100 **Total Credit-04**

On any topic related to one of the following specialization assigned to the student:

1. Plant Taxonomy and Biodiversity
2. Microbiology and Plant Pathology
3. Plant Biotechnology
4. Plant Ecology
5. Plant Biochemistry
6. Ethnopharmacology and Herbal Medicine

DEPARTMENT OF BOTANY

Ph.D Course Work Syllabus

Code	Course	Credit	Marks
BOT-RS-C101	Research methodology in life sciences	04	100
BOT-RS-C102	Research Proposal	04	100
Any one of the following Elective (Advances in Plant Sciences) Courses:			
BOT-RS-C103	Trends in Plant Biochemistry	04	100
BOT-RS-C104	Trends in Microbiology and Plant Pathology	04	100
BOT-RS-C104	Trends in Taxonomy, Biodiversity & Conservation	04	100
BOT-RS-C106	Trends in Ecology	04	100
BOT-RS-C107	Trends in Biotechnology	04	100
BOT-RS-C108	Trends in Natural Products and Ethnopharmacology	04	100
Total		**12**	**300**

BOT-RS-C101: RESEARCH METHODOLOGY (Common for School of Life Sciences)

Total Marks – 100 **Total Credit – 04**

UNIT I- RESEARCH DESIGN AND DATA COLLECTION **15 Hrs**

Research methodology- definition, different types of research design. Basic principles of experimental designs. Sampling design- sample survey, steps in sample design, criteria of selecting a sampling procedure and different types of sample designs. Methods of Data Collection: Primary and secondary data.

Literature collection and citation, bibliography. Writing skills - Preparation of research report, presentations, and writing scientific paper. Impact factor, Citation factor, Plagiarism, ISBN, ISSN.

UNIT II- PROCESSING AND ANALYSIS OF DATA AND SAMPLING **15 Hrs**

Processing operations, elements/types of analysis, statistics in research, measures of central tendency, dispersion, asymmetry, relationships. Simple regression analysis, multiple correlation and regression, partial correlation, association in case of attributes and other measures.

UNIT III- TESTING OF HYPOTHESES **15 Hrs**

Basic concepts of testing of hypothesis, procedures for hypothesis testing. Hypothesis testing for differences between means, hypothesis testing for comparing two related samples, hypothesis testing of proportions. Testing the equality of variances of two normal populations, hypothesis testing of correlation coefficient. Chi square test

UNIT IV- ANALYSIS OF VARIANCE AND COVARIANCE **15 Hrs**

Analysis of Variance and Covariance (basic principles of one-way ANOVA, two-way ANOVA and ANCOVA). Multivariate analysis techniques (Characteristics and applications, classification of Multivariate analysis, important multivariate techniques, important method of factor analysis).

Ethics in research.

Suggested Readings:

1. Bernard Rosner, B. 2005. *Fundamentals of Biostatistics*, 6th edition Duxbury Press.
2. Gerry, Q. P and Keough, M. J. 2002. *Experimental Design and Data Analysis for Biologists*.Cambridge Univ. Press.
3. Kothari, C.R. 2004. *Research Methodology, Methods & Techniques*. 2nd Revised Edition. New Age International Publisher, India.
4. Norman, N. G. and Streiner, D. 2008. Biostatistics: *The Bare Essentials*. 3rd edition, BC Decker Inc.
5. Paulson, D. S. 2008. *Biostatistics and Microbiology*. Springer.
6. Sokal, R. R. and Rohlf, F. J. 2008. *Introduction to Biostatistics*. Dover Publication.
7. Laake, P., Benestat, H.B. and Olsen, B.R. 2007. *Research Methodology in the Medical and the Biological Sciences*. Academic Press, UK.

COURSE-II: ADVANCES IN PLANT SCIENCES (ELECTIVES)

BOT-RS-C102: TRENDS IN PLANT BIOCHEMISTRY

Total Marks – 100 **Total Credit – 04**

UNIT-I: ENZYMOLOGY 15 Hrs

Extraction and purification of enzymes; application of enzymes in food and drink industries; enzymes and in-born errors in metabolism; preparation and application of immobilized enzymes; enzymes and recombinant DNA technology.

UNIT- II: HORMONES & SIGNAL TRANSDUCTION 15 Hrs

Hormonal regulation of plant growth and development, signal Transduction, Role of PGR in agriculture and horticulture, Auxin signal transduction pathway; Gibberellin signaling and its significance; ABA signal transduction pathway.

UNIT- III: PLANT STRESS RESPONSES 15 Hrs

Biotic and Abiotic stress; Physiological and Biochemical responses of plants to environmental stress; Plant responses to salinity and chilling stress; Abiotic stress and secondary metabolite production. Development of transgenic plants for abiotic stress tolerance; Stress Proteins in plants; biochemistry of plant defense reactions; plant responses to herbivory, control of plant pathogen by genetic engineering.

UNIT-IV: INSTRUMENTATION IN PLANT BIOCHEMISTRY 15 Hrs

Construction and principles of light, electron and scanning probe microscopy. Centrifugation: differential, density. Principles of spectrophotometry and spectroscopy; biomolecules separation, detection and estimation methods methods; HPLC

Suggested Readings:

1. L. Taiz and E. Zeiger (2002) Plant Physiology (Second Edition) Simauer Associates Inc Publishers Sunderlands, Massachusetts
2. H.W. Heldt (1997) Plant Biochemistry and Molecular Biology Oxford University Press
3. W.G. Hopkins (1985) Introduction to Plant Physiology John Wiley and Sons, Inc. New York
4. Methods in Enzymology Colowick and Caplan Academic Press, New York
5. Coombs, Hall, Long and Scurlik (1985) Techniques in Bioproductivity and Photosynthesis, Pergmon Press, Oxford
6. Hall, Sccurlik, Bolhar, NordenKamf, Leagood and Long (1993) Photosynthesis and production in a Changing Environment. A Field and Laboratory Manual, Chapman and Hall Publication
7. Buchnan, B.B., Gruissem, W. and Jones, R.L.(2000) Biochemistry and Molecular Biology of Plants. I.K. International Pvt.Ltd., New Delhi, Mumbai, Bangalore

BOT-RS-C103: TRENDS IN MICROBIOLOGY AND PLANT PATHOLOGY

Total Marks - 100 **Total Credit – 04**

UNIT I: PLANT DISEASE MANAGEMENT 15 Hrs

Molecular techniques for Identification and classification of fungi. Recent concept of plant defence: Mechanism of sensing pathogenecity, Systemic Acquired Resistance (SAR), Biochemical defence, Biological control of plant diseases, chemicals in plant disease management. Uses of modern biotechnological tools in crop management. Testing for host resistance to diseases.

UNIT II: ADVANCES IN FOOD MICROBIOLOGY 15 Hrs

Genetically modified foods. Biosensors in food, Applications of microbial enzymes in dairy industry. Utilization and disposal of dairy by-product. Prebiotic and Probiotic. Functional foods- health claims and benefits, Development of functional foods; Food Safety and Molecular Detection.

UNIT III: FERMENTATION TECHNOLOGY 15 Hrs

Source of microbes, Isolation, selection and culture collection banks, Preservation of industrially important microbes; Sterilization techniques, Strain development (mutagenesis, metabolic engineering and recombinant DNA techniques). Types of fermentation processes: Solid state and submerged fermentation, Batch, fed-batch and continuous fermentation strategies and their application, Types of fermenters (airlift, stirred tank and bubble column fermenter) Isolation and genotypic identification of microorganisms associated with the foods.

UNIT IV: INSTRUMENTATION IN PLANT PATHOLOGY AND MICROBIOLOGY 15 Hrs

Laboratory practices: General safety measures, Chemical hazards, Physical hazards, Biological hazards, waste disposal. Chromatography techniques, Electrophoresis techniques, Centrifugation techniques. Microscopy: Principles and appplications of Light and Electron microscopy. Dark field, Bright Field, Phase contrast, fluorescence, scanning & transmission electron microscopy. Fermenter, spectrophotometer, HPLC, PCR machines.

Suggested Readings:

1. Dennis, E.S.et al, 1992 Plant Gene Research: Basic knowledge and Application. Springer- Verlag Wien Publ. New York.
2. Gengopadhyay, S 1984 Clinical plant pathology, Kalyani Publ. New Delhi
3. Nane Y.1 and Thapliyal 1979, Fungicides in plant disease control. Oxford IBH, Publ. New Delhi.
4. Smith, J.E and D.R. Berry. 1978. The filamentous fungi. Vol-I Industrial mycology. Vol-II Development Mycologym, Edward Arnold Publ. London
5. Taiz, 1, and E. Zeiger. 1998. Plant physiology, Sinquer Assoc Inc. Publ. New York.
6. Trehan. K.1994. Biotechnology, Wiley Eastern Ltd, New Delhi.
7. Vaidya, J.G 1995 Biology of the fungi, Satyajeet Prakashan, Pune.
8. Tamang, J.P. 2010. Himalayan Fermented Foods: Microbiology, Nutrition and Ethnic Values. CRC Press, Taylor and Francis Group, New York, USA.
9. Tamang, J.P. and Kailasapathy, K. 2010. Fermented Foods and Beverages of the World. CRC Press, Taylor and Francis Group, New York, USA.
10. Tamang, J.P. 2014. Health Benefits of Fermented Foods and Beverages. CRC Press, Taylor and Francis Group, New York, USA.

BOT-RS-C104: TRENDS IN TAXONOMYAND BIODIVERSITY CONSERVATION

Total Marks - 100 **Total Credit – 04**

UINIT-I: TAXONOMY AND BIODIVERSITY 15 Hrs

The principles and practices of Taxonomy. The role of Taxonomy. The Global biodiversity assessment, measures of biodiversity, diversity indices, biodiversity values, use and importance of biodiversity, threatened biodiversity, major causes of biodiversity loss. RET species.

UNIT-II: VARIATION, BIOSYSTEMATICS AND EVOLUTION 15 Hrs

Developmental, experimental and genetic variations; concepts of systematic botany; origin and early evolution of angiosperms, with reference to recent findings. Taxonomic literature, floras, taxonomic accounts, revisionary studies.

UNIT-III: PLANT CLASSIFICATIONS 15 Hrs

Phenetic methods, molecular systematics, cladastic methods, phylogenetic analysis, APG classification. Diagnostic features, systematic position and affinities of major groups of flowering plants recognized in APG classification: Basal angiosperms, Magnoliids, Monocots, Commelinids, Eudicots, Core Euasterids-II.

UNIT-IV: INSTRUMENTATION IN PLANT SYSTEMATICS 15 Hrs

Techniques in Botanical specimens preservation; Laboratory drawing; Basic of GPS and plant phenology; Microscopy and micrometry-light, electron, scanning probe; Centrifugation types; differential and density gradient; Principles of spectroscopy; different types of mass spectrometry methods. Principles of chromatography; Protein sequencing methods; DNA Bar coding and DNA fingerprinting, strategies for genome sequencing.

Suggested Readings:

1. Ray Samit and A. K. Ray (ed.) 2006. Biodiversity and Biotechnology. New Central Book Agenc(p.) Ltd. Kolkata; India.
2. Singh Gurucharan 2010. Plant systematic: An Integrated approach. Science publisher. USA.
3. Judd, W.S., Campbell, C.S., Kollogg, E.A., Stevens, P.F. and Donoghue M.J. 2008. Plant systematic: phylogenetic approach. Sircuier Associates, Inc.
4. Futuyma D.J. 2009. Evolution. Sinauer Associates, INC. Publishers, Sunderland. USA.
5. Groom, M.J., Meffe, G.K. and Carroll, C.R. 2006. Principles of conservation biology. Sircuier Associates, Inc.
6. Etelka leadlay and Stephen Jury (ed.). 2006. Taxonomy and plant conservation. Cambridge University press, UK.
7. David Briggs 2009. Plant microevolution and conservation in human influenced ecosystems. Cambridge University press, UK.John P. Bentley. (2004).
8. Principles of measurement systems (4th Edition). Pearson Education; 4th edition, ISBN-10: 0130430285.
9. H.W. Heldt (1997) Plant Biochemistry and Molecular Biology Oxford University Press

BOT-RS-C105: TRENDS IN PLANT ECOLOGY

Total Marks – 100 **Total Credit –04**

Unit-I: CURRENT SCENARIO OF ECOLOGY 15 Hrs

Globalization and ecology, Importance of ecology, Relationship between climate change and ecological studies, Effect of climate change and strategies of mitigation, CO2 fertilization effect on plants, Ecosystem services and payment for ecosystem services(PES), Carbon trading, Ecological footprint, Image of Ecology Economics.

Unit-II: METHODS AND TECHNIQUES FOR ECOLOGICAL STUDIES 15 Hrs

Different methods used for ecosystem analysis- Qualitative and quantitative approaches, Methods of estimation of plant productivity, Tools to study global climate change, Tools to restore degraded ecosystems, Modern techniques and tools for ecological studies- GPS,GIS and remote sensing, Computer simulated models, Data loggers, soft wares and sensors.

Unit-III: ECOLOGICAL RESEARCH AND ACTS AND POLICIES 15 Hrs

National Forest policy 1988, National Biodiversity Policy 1998, National Biodiversity Act 2002, National policy on wetlands 2005, REDD+, Kyoto protocol, Rio Earth summit, G- Summits, Durban agreement 2011,Paris convention 2015

Unit-IV: INSTRUMENTATION IN ECOLOGY 15 Hrs

Centrifugation- high speed and ultra; Principles of spectroscopy-UV, visible, IR, FTIR, Raman, MS, NMR; Principles of spectrophotometer; Principles of chromatography- ion exchange, gel filtration, hydrophobic interaction, Radiobiology and uses. Calibration and maintenance of instruments. Demonstration of relevant techniques used in ecological research.

Suggested Readings:

1. Comin F.A (Ed.)(2010). Ecological restoration - a global challenge. Cambridge University Press
2. De Blij, H.J. (2006). Human geography, sulture, society and space (7th edition). John Wiley and Sons
3. Akimasa Suni, Kensuke, F., and Ai, Hiramatsu.(2010). Adaptation and mitigation strategies for climate change. Springer. Burroughs
4. Mandal, F.B and Nandi, N.C. (2009). Biodiversity concept, conservation and bioculture. Asian Books Pvt. Ltd

JOURNALS:

1. Nature
2. Plant and soil
3. Ecology
4. International journal of Ecology and environmental sciences
5. Tropical Ecology
6. Plant Biology and Biochemistry

BOT-RS-C106: TRENDS IN PLANT BIOTECHNOLOGY

Total Marks - 100 **Total Credit – 04**

UNIT-I: THEORETICAL FRAMEWORK FOR PLANT BIOTECHNOLOGY 15 Hrs

Totipotency: Methods and applications; Transgenics: development, applications and ethical concerns; Molecular markers: development and analyses; DNA sequencing: Theory and applications; Functional genomics: Approach, analysis and applications, Genome editing: CRISPR etc., GLP; writing publications, grant proposals and reports.

UNIT-II: TOOLS & TECHNIQUES IN PLANT BIOTECHNOLOGY 15 Hrs

Plant Cell and Tissue culture: Laboratory organization, Laboratory contaminants- it's control measures, methods of sterilization, aseptic culture, culture of different explants; Isolation of nucleic acids, vectors and uses, PCR & RT-PCR, Genomic and cDNA library preparation, DNA and RNA hybridization, RNAi, Genome sequencing approaches, data collection preparation and analysis, softwares, experimental design, waste disposal.

UNIT-III: BIOINFORMATICS 15 Hrs

Major bioinformatic resources and search tools; Sequence and structure databases; Sequence analysis (file formats, scoring matrices, sequence alignment, phylogeny); Data mining and analytical tools for genomic and proteomic studies; Molecular dynamics and simulations (basic concepts including force fields, protein-protein, protein-nucleic acid, protein-ligand interaction).

UNIT-IV: INSTRUMENTATION IN BIOTECHNOLOGY 15 Hrs

Principles of microscopy-light, electron, fluorescent and confocal; Centrifugation- high speed and ultra; Principles of spectroscopy-UV, visible, IR, FTIR, Raman, MS, NMR; Principles of chromatography- ion exchange, gel filtration, hydrophobic interaction, Radiobiology and uses. Calibration and maintenance of instruments.

Suggested Readings:

1. Agarwal, S.K.(2007) Bioinformatics. APH Publishing Corporation, New Delhi. 240.p
2. Glick, B.R. and Pasternak, J.J. (1994) Molecular Biotechnology: Principles and Application of r- RNA Press, Washington.
3. Gupta, P.K. (2006) Cell and Molecular Biology, Third edition. Rastogi Publications, Meerut.
4. Kumar, S. and Flading M. (2005) Molecular Genetics and Breeding of Forest Trees. International Book Distributers, Lucknow. 436p.
5. Mandal, A.K. and Gibson, G.L. (2008) Forest Genetics and Tree Breeding. CBS Publishers and Distributers, New Delhi. 268p.

Journals:

1. Applied Microbiology & Biotechnology
2. Biotechnology Letters
3. Biotechnology Techniques
4. Indian Journal of Biotechnology
5. Biotechnology Journal

BOT-RS-C107: TRENDS IN NATURAL PRODUCTS STUDY AND ETHNOPHARMACOLOGY

Total Marks - 100 **Total Credit – 04**

UNIT-I: NATURAL PRODUCTS 15 Hrs

Approaches available for drug development, role of natural products in new drug development. Bioactive compounds from bacterial and fungal sources. Natural products as a guide (leads) for design of new drugs. Bioassay-directed fractionation of natural products. Recent developments in plant based natural products for their activity as adaptogens, immunomodulators, memory enhancers, anti- inflammatory agents, anti-parasitics alongwith screening methods, isolation of active principle, mode of action and future prospects.

UNIT-II: ETHNOPHARMACOLOGY 15 Hrs

Definition, scope and applications in herbal medicines; Importance of ethnopharmacological studies. Plant chemicals in modern pharmacology: Biochemistry and pharmacology of atropine, caffeine, ephedrine, opioids, taxol, Vinca alkaloids; drug improvement by structure modification and biotransformation **.** Bioavailability and pharmacokinetics aspects of herbal drugs with examples. Phytoequivalence, pharmaceutical equivalence. WHO guidelines for assessment of herbal drugs; authentication and standardization of herbal raw materials.

UNIT-III: HERBAL TECHNOLOGY 15 Hrs

Introduction, concepts and prospects. Phyto-technology- value addition to biodiversity through chemo prospection. Medicinal mushrooms for healthy life. Natural dyes for cotton and silk industry. Scope and uses of essential oil from plants as perfumes and cosmetics. Preparation of perfumes from aromatic plants with special reference to the following Lemon grass, Palm-rosa, Lavender, Rose, and Vetiver. Incorporating the herbal extracts in various cosmetic formulations like Skin care preparations, Sunscreens, Hair care preparations.

UNIT-IV: INSTRUMENTATION IN NATURAL PRODUCTS STUDY 15 Hrs

Principles of microscopy-light, electron, fluorescent and confocal; Centrifugation- high speed and ultra; Principles of spectroscopy-UV, visible, IR, FTIR, Raman, MS, NMR; Principles of chromatography- ion exchange, gel filtration, hydrophobic interaction, Radiobiology and uses. Calibration and maintenance of instruments.

Suggested Readings:

1. W.C.Evans & Trease, Pharmacognosy, 15th edn.2008, W.B. Saunders & Co.Ltd., London.
2. A.N. Kalia, Textbook of Industrial Pharmacognosy, 2005, CBS Publishers, New Delhi.
3. Dr.P.Mukherjee, Quality control herbal drugs, 2005, Business Horizons, New Delhi
4. Dillon, B.S., Tyagi, R.K., Lal, A. and Saxena, S. (Eds.). 2004. *Plant Genetic Resources Management*. Narosa Pub. House, New Delhi
5. Hurtmann, H.T., Kester, D.E., Davies, F.T. and Geneva, R.L. 2004. Plant Propagation: Principle and Practice. Prentice-Hall of India, New Delhi
6. Newman DJ, Cragg GM (2007) Natural products as sources of new drugs over the last 25 years. Journal of Natural Products 70, 461-477.
7. Dewick, P. M. (2009). Medicinal Natural Products: A Biosynthetic Approach. United Kingdom: John Wiley & Sons. 335-336.

BOT-RS-C108: RESEARCH PROPOSAL PREPARATION

Total Marks -100 **Total Credit – 04**

Objective: To understand the preparation of Research Proposal through survey of literature in the chosen field of research, identification of gaps in the knowledge and preparation of specific objectives to bridge the gaps with realistic budget requirement.

Activities:

- Sources of research material, literature survey, compiling records.
- Collection of source documents- research papers, review paper, book reviews, theses, and conference and project reports.
- Preparation of submission of proposal to funding agencies.
- Develop communication skills for presentation of proposal and justification of budget.
- To understand and follow ethical issues in research

INTRODUCTION

North East in general and Sikkim in particular is highly suitable for cultivation of horticultural crops. As the entire country was realizing the potential of the Information Technology (IT) and Biotechnology (BT) boom, North East region genuinely poised for Horticulture revolution. To fulful the rightful aspiration of this region an Integrated B.Sc-M.Sc course on Horticulture was introduced in 2009 under the Department of Horticulture.

B.Sc (Horticulture) is offered as a four year degree course and divided into eight semesters with a total credit of 160 (89 theory and 71 practical).In each semester maximum credit limt is kept at 22 so that burden in single semester can be reduced.

The course curriculum is designed based on the basic frame work given by the Indian Council of Agricultural Research (ICAR) with more impetus given to the regional and local needs. The course is truly interdisciplinary having subjects of agro forestry, agronomy, biochemistry, computer science, economics, environmental science, farm engineering,management, microbiology, rural sociology, statistics etc. along with horticulture as its core. To make the course more professional, experiential learning with 15 credits each has been introduced during the seventh and eighth semester.Major emphasis has been given for the local and regional needs keeping in view of organic production practices.

Courses are denoted by course code. Course code has two parts the alapahabets denotes the subject and numerals denotes the number of the course. All the courses are given four letter alphabet code followed by three digit numeral code i.e. HORT 214. HORT implies the couse is offered under horticulture subject and in numeral first digit (2) denotes year of study i.e second year, second digit denotes semester (1) i.e first semester and third digit (4) denotes number of course in that semester i.e. fourth course.

* Course code will be adopted as per University guidelines merging with ICAR coding

DEPARTMENT OF HORTICULTURE

Syllabus for B.Sc. Horticulture

Course Code	Course Name	Credits
	SEMESTER I	
HORT UG 101	Elementary Statistics & Computer Application	2+1
HORT UG 102	Fundamentals of Soil Science	1+1
HORT UG 103	Introduction to Major Field Crops	1+1
HORT UG 104	Elementary Plant Biochemistry & Elementary Biotechnology	2+1
HORT UG 105	Introductory Crop Physiology	1+1
HORT UG 106	Fundamentals of Horticulture	2+1
HORT UG 107	Introductory Economics	2+0
HORT UG 108	Fundamentals of Plant Protection	2+1
HORT UG 109	English/ Regional Language	1+0
	TOTAL	**14 + 7 (21)**
	SEMESTER II	
HORT UG 201	Tropical and Subtropical Fruits	2+1
HORT UG 202	Tropical and Subtropical Vegetables	2+1
HORT UG 203	Elementary Agro-meteorology	1+1
HORT UG 204	Water Management in Horticultural Crops	1+1
HORT UG 205	Plant Propagation and Nursery Management	1+2
HORT UG 206	Growth and Development of Horticultural Crops	2+1
HORT UG 207	Introductory Microbiology	1+1
HORT UG 208	Principles of Genetics and Plant Breeding	2+1
	TOTAL	**12+ 9 (21)**
	SEMESTER III	
HORT UG 301	Ornamental Horticulture	2+1
HORT UG 302	Temperate Vegetables and tuber crops	2+1
HORT UG 303	Fundamental of Extension Education & Rural Sociology	2+1
HORT UG 304	Genetic Resources Management & Intellectual Property Rights	2+1
HORT UG 305	Temperate Fruits	2+1
HORT UG 306	Commercial Floriculture	2+1
HORT UG 307	Environmental Science	2+1
HORT UG 308	North East Study Tour (Winter Vacation)	0+1
	TOTAL	**14+8 (22)**
	SEMESTER IV	
HORT UG 401	Spices and Condiments	2+1
HORT UG 402	Post Harvest Management of Horticultural Crops	2+1
HORT UG 403	Plantation Crops	2+1
HORT UG 404	Breeding of Fruits, Plantation &Medicinal Plants	2+1
HORT UG 405	Integrated Insect- Pest Management of Fruits, Plantation & Medicinal plants	2+1
HORT UG 406	Integrated Disease Management of Fruits, Plantation & Medicinal plants	2+1
HORT UG 407	Integrated Nutrient Management and Soil and Plant Tissue analysis	2+1
	TOTAL	**14+7 (21)**

	SEMESTER V	
HORT UG 501	Arid and Minor Fruits	1+1
HORT UG 502	Production and Post Harvest Management of Medicinal and Aromatic Crops	2+1
HORT UG 503	Integrated Insect- Pest Management of Vegetables, Flowers & Spices	2+1
HORT UG 504	Integrated Disease Management of Vegetables, Flowers & Spices	2+1
HORT UG 505	Breeding of Vegetables, Flowers & Spices	2+1
HORT UG 506	Farm Mechanization in Horticultural Crops	2+1
HORT UG 507	Principles of Landscaping	1+1
HORT UG 508	Weed Management in Horticultural Crops	1+1
	TOTAL	**13+8 (21)**
	SEMESTER VI	
HORT UG 601	Protected Cultivation of Horticultural Crops	2+1
HORT UG 602	Apiculture, Sericulture andMushroom Production	1+2
HORT UG 603	Processing and Value Addition of Horticultural Crops	1+2
HORT UG 604	Seed Production of Vegetable and Flowers	2+1
HORT UG 605	Horti-Business Management	2+1
HORT UG 606	Organic Farming	1+1
HORT UG 607	Introductory Agroforestry & Agri-Horti Tourism	2+1
HORT UG 608	Orchard Management	1+1
	TOTAL	**12+10 (22)**
	SEMESTER VII	
HORT UG 701	Experiential Learning (Professional Package & Industrial/Institutional Attachment)	5+10
HORT UG 702	All India Study Tour (Winter Vacation)	0+1
	TOTAL	**5+11 (16)**
	SEMESTER VIII	
HORT UG 801	Experiential Learning (Professional Package & Rural Horticultural work Expierence)	5+10
HORT UG 802	Physical Education/ NSS/NCC	0+1
	TOTAL	**5+11 (16)**
	GRAND TOTAL CREDITS	**89+71= 160**

Semester I

HORT UG 101. Elementary Statistics and Computer Application Credits: 2+1

Teaching Hours 40+40= 80

Unit 1: Basic concepts (8 lectures)

Variable statistics, types and sources of data, classification and tabulation of data, construction of frequency distribution, tables, graphic representation of data, simple, multiple component and percentage, bar diagram, pie diagram, histogram, frequency polygon and frequency curve average and measures of location, mean, mode, median, geometric mean, harmonic mean, percentiles and quadrilles, for raw and grouped data.

Unit 2: Dispersion (6 lectures)

Range, standard deviation, variance, coefficient of variation for raw and grouped data.

Unit 3: Probability (6 lectures)

Basic concept, additive and multiplicative laws. Theoretical distributions, binominal, poison and normal distributions, sampling, basic concepts, sampling vs. complete enumeration parameter and statistic, sampling methods, simple random sampling and stratified random sampling.

Unit 4: Tests of Significance (6 lectures)

Basic concepts, tests for equality of means, and independent and paired t-tests, chi-square test for application of attributes and test for goodness of fit of Mendelian ratios.

Unit 5: Correlation (6 lectures)

Scatter diagram, correlation co-efficient and its properties, regression, fitting of simple linear regression, test of significance of correlation and regression coefficient.

Unit 6: Computer application (8 lectures)

Introduction to computers and personal computers, basic concepts, operating system, DOS and Windows, introduction to programming languages and programming techniques, MS Office, introduction to Multi-Media and its application. VISUAL BASIC-concepts, basics and programming techniques, introduction to statistical packages.

Practicals:

Construction of frequency distribution table and its graphical representation, histogram, frequency polygon, frequency curve, bar chart, simple, multiple, component and percentage bar charts, pie chart, mean, mode for row and grouped data, percentiles, quadrille, and median for row and grouped data, coefficient of variation, 't' test for independent, will equal and unequal variants, paired 't' test, chi-square test for contingency tables and theoretical ratios, correlation and linear regression. Studies on computer components – VISUAL BASIC, programming techniques, MS Office.

HORTUG 102. Fundamentals of Soil Science Credits:1+1

Teaching Hours 20+40= 60

Unit 1: Concept of soil (3 lectures)

Composition of earth's crust, soil as a natural body – major components. Soil Forming Factors Eluviations and illuviation formation of various soils.

Unit 2: Physical properties of soil (4 lectures)

Physical parameters; texture – definition, methods of textural analysis, stock' s law, assumption, limitations, textural classes, use of textural triangle; absolute specific gravity, definition, apparent specific gravity/bulk density – factors influencing, field bulk density. Relation between BD (bulk density), PD – practical problems. Pore space – definition, factors affecting capillary and non-capillary porosity, soil structure, definition, classification, clay prism like structure, factors influencing genesis of soil structure.

Unit 3: Soil air, soil temperature and soil colour (3 lectures)

Soil air, air capacity, composition, factors influencing, amount of air space, soil air renewal. Soil temperature, sources and distribution of heat, factors influencing, measurement, chemical properties. Soil colour – definition, its significance, colour variable, value hue and chroma. Munsell colour chart, factors influencing, parent material, soil moisture, organic matter.

Unit 4: Soil water (3 lectures)

Soil water, forms, hygroscopic, capillary and gravitational, soil moisture constants, hygroscopic coefficient, wilting point, field capacity, moisture equivalent, maximum water holding capacity, energy concepts, PF scale, measurement, gravimetric – electric and tensiometer methods – pressure plate and pressure membrane apparatus – Neutron probe – soil water movement – classification.

Unit 5: Soil consistency and soil colloids (3 lectures)

Soil consistency, plasticity, Atterberg' s constants. Soil colloids, organic, humus, inorganic, secondary silicate, clay, hydrous oxides. Ion exchange, cation-anion importance, soil organic matter decomposition, pH and nutrient availability, soil buffering capacity.

Unit 6: Remote sensing , soil formation and land capability classification (4 lectures)

Aerial photography – satellite of soil features their interpretation; soil orders; land capability classification; soil of different eco-systems and their properties.

Practicals (40 Hrs.):

Basic laboratory techniques, handling of glasswares,estimation of soil - moisture, EC, ESP, pH and bulk density. Textural analysis of soil by Robinson's pipette method, cation exchange capacity. Ennumeration of soil microbes, Soil profile

HORTUG 103. Introduction to Major Field Crops **Credits: 1+1**

Teaching Hours 20+40= 60

Unit 1 : Basic concepts of Crop raising **(6 lectures)**

Classification and distribution of field crops, definitions and concept of multiple cropping, mixed cropping, intercropping, relay and alley cropping.

Unit 2 : Cultivation of major field crops **(14 lectures)**

Cultural practices for raising major cereals, millets, pulses, oilseeds and fodder crops, green manuring, crop rotation.

Practical 40 Hrs

Identification of crop plants, seeds and weeds. Preparation of cropping scheme- mono cropping, inter cropping, mixed cropping, relay cropping,alley cropping etc. Application of herbicides in field crops cultivation practices on rice, maize, mustard, grams, kodo, nursery raising in rice.

HORTUG 104. Elementary Plant Biochemistry & Elementary Biotechnology Credits:2+1

Teaching Hours 40+40= 80

Unit1: Carbohydrates (5 lectures)

Occurrence classification and structure, physical and chemical properties of carbohydrates, isomerism, optical activity, reducing property, reaction with acids and alkalis.

Unit2: Proteins (5 lectures)

Proteins: Classification, function and solubility, amino acids: classification and structure, essential amino acids, properties of amino acids, colour reactions, amphoteric nature and isomerism; structure of proteins – primary, secondary tertiary and quaternary properties and reaction of proteins.

Unit 3: Lipids (5 lectures)

Classification, important fatty acids and triglycerides, essential fattyacids. Physical and chemical control of oils, their rancidity, phospholipids, types and importance.

Unit 4: Enzymes and vitamins (5 lectures)

Enzymes: Classification and mechanism of action; factors affecting enzyme action, co-factors and coenzymes. Vitamins and minerals as co-enzymes/ co-factors.

Unit 5: Plant pigments (2 lectures)

Plant pigment structure and function of chlorophyll, anthocyanins, xanthophylls and carotenoids, sterols, basic structure.

Unit6: Biosynthesis and metabolism (7 lectures)

Carbohydrate metabolism – glycolysis and TCA-cycle; metabolism of lipids, fatty acid oxidation, biosynthesis of fatty acids, electron transport chain, bioenergetics of glucose and fatty acids, structure and function of nucleic acid replication, transcription and translation.

Unit 7: Biotechnology (8 lectures)

History of plant biotechnology. Fundamental principles, micro-propagation and scope for commercialization. Application of micro-grafting in horticultural crops, meristem culture, anther culture, pollen culture, embryo culture, callus culture, cell culture, somoclonal variation, protoplast isolation, culture, fusion and applications. Cryopreservation.

Unit 8: Genetic engineering (3 lectures)

Genetic engineering and transgenics. Future scope and present trends, Importance of biotechnology in horticulture, biosafety issues.

Practicals (40 Hrs.):

Laboratory safety measures and first aid. Preparation of standard solutions and reagents. Carbohydrates :qualitative reaction, estimation of starch, reducing and non-reducing sugars; estimation of proteins by Lowery's method. Estimation of free fatty acids; determination of iodine number of vegetable oils. Vitamins : estimation of ascorbic acid. Paper and thin layer chromatography. Sterilization techniques, extraction and quantification of DNA, basic techniques in TC.

HORTUG 105. Introductory Crop Physiology Credits: 1+1

Teaching Hours 20+40= 60

Unit 1: Water Relations in Plants (2 lectures)

Role of water in plant metabolism, osmosis inhibition, diffusion, water potential and its components, measurement of water potential in plants, absorption of water, mechanism of absorption and ascent of sap.

Unit 2: Guttation and Transpiration (3 lectures)

Stomata: Structure, distribution, classification, mechanism of opening and closing of stomata. Osmotic pressure, guttation, stem bleeding; transpiration methods and mechanism and factors affecting transpiration.

Unit 3: Drought and other stresses (2 lectures)

Drought, Different types of abiotic stresses; water,hea, cold, acid, salt, heavy metal, ozone stress and tolerance; mechanism of tolerance.

Unit 4: Plant Nutrition (4 lectures)

Essentiality of nutrients- criteria and classification, mechanism of absorption and its role in plant metabolism.

Unit 5: Photosynthesis and respiration (6 lectures)

Photosynthesis, structure and function of chloroplast, dark and light reactions, cyclic and non-cyclic electron transfer, CO_2 fixation – C_3, C_4 and CA metabolism, advantages of C4 pathway. Photorespiration and its implications, factors affecting photosynthesis.

Unit 6: Plant Hormones (3 lectures)

Phytohormones, physiological role in controlling plant processes.

Practicals (40 Hrs.):

Measurement of water potential, osmosis & root pressure. Structure of the stomata, distribution, opening and closing of the stomata, measurement, transpiration and calculation of transpirational pull. Importance of light and chlorophyll in photosynthesis in horticultural crops, estimation of phenols, studying plant movements, root initiation in cuttings.Estimation of plant pigments-chlorophyll, carotenoids, xanthophylls etc.

HORTUG 106. Fundamental of Horticulture **Credits: 2+1**

Teaching Hours 40+40= 80

Unit1: Horticultural crops: classification, status, exports and agro-climatic zones (5 lectures)

Classification of horticultural crops, economic importance and and their culture and nutritive value, area and production, fruit and vegetable zones of India and of different states, exports and imports.

Unit 2: Nursery and orchard management (10 lectures)

Nursery management practices, soil and climate, vegetable gardens, nutrition and kitchen garden and other types of gardens , principles and planning and layout, management of orchards, planting systems and planting densities.

Unit 3: Production technology (20 lectures)

Production practices for fruit, vegetable and floriculture crops, nursery techniques and their management. Principles and methods of pruning and training of fruit crops, types and use of growth regulators in horticulture, water management, weed management, fertility management, cropping systems, intercropping, multi-tier cropping, mulching, bearing habits in fruits, factors influencing the fruitfulness and unfruitfulness. Rejuvenation of old orchards, top working and frame working.

Practicals (40 Hrs.):

Features of orchard, planning and layout of orchard, tools and implements, layout of nutrition garden, preparation of nursery beds for sowing of vegetable seeds, digging of pits for fruit plants, digging of pits,planting systems, training and pruning of orchard trees, preparation of fertilizer mixtures and field application, preparation and application of growth regulators, layout of different irrigation systems, identification and management of nutritional disorder in fruits and vegetables, assessment of bearing habits, maturity standards and harvesting, grading, packaging and storage.

HORTUG 107. Introductory Economics **Credits: 2+0**

Teaching Hours: 40+0=40

Unit 1: **(2 lecture)**

Nature and scope of economics, definition and concepts, divisions of economics, economic systems, approaches to the study of economics.

Unit 2: **(4 lectures)**

Consumption – theory of consumer behaviour, laws of consumption, classification of goods.

Unit 3: **(6 lectures)**

Wants – their characteristics and classification, utility and its measurement, cardinal and ordinal, law of diminishing marginal utility, law of equi-marginal utility, indifference curve and its properties, consumer equilibrium.

Unit 4: **(6 lectures)**

Theory of demand, demand schedule and curve, market demand. Price, income and cross elasticity, Engil's law of family expenditure – consumer's surplus.

Unit 5: **(6 lectures)**

Theory of firm, factors of production – land and its characteristics, labour and division of labour, theories of population.

Unit 6: **(6 lectures)**

Capital and its characteristics – classification and capital formation. Enterprises – forms of business organization – merits and demerits.

Unit 7: **(4 lectures)**

Laws or return – law of diminishing marginal return – cost concepts. Law of supply – supply schedule and curve elasticities.

Unit 8: **(6 lectures)**

Market equilibrium, distribution – theories of rent, wage, interest and profit. Price determination and forecasting under various market structures.

HORT UG 108. Fundamentals of Plant Protection **Credits: 2+1**

Teaching Hours 40+40= 80

Unit 1:Introduction to phytopathology **(4 lectures)**

Introduction to the science of phytopathology, its objectives, scope and historical background. Classification of plant diseases, symptoms, signs, and related terminologies.

Unit 2: Parasitic and non-parasitic plant diseases **(10 lectures)**

Parasitic causes of plant diseases (fungi, bacteria, viruses, phytoplasma, protozoa, algae and pheneno gamic parasitic plants, their characteristics and classification. Non-parasitic causes of plant diseases. Infection process. Survival and dispersal of plant pathogens.

Unit 3: Plant disease and its management **(5 lectures)**

Plant disease epidemiology, forecasting and disease assessment. Principles and methods of plant disease management. Integrated plant disease management.

Unit 4: Introductory entomology **(8 lectures)**

Introduction to phylum arthropoda. Importance of class Insecta. Insect dominance. Definition, division and scope of entomology.

Unit 5: Insect morphology and anatomy **(10 lectures)**

Comparative account of external morphonology-types of mouth parts, antennae, legs, wings and genetalia. Anatomy of digestive, excretory, nervous and reproductive systems. Postembryonic development, Metamorphosis. Types of larvae and pupa. Classification of insects upto orders and families of economic importance and their distinguished characters.

Unit 6: Introduction to non insect pests **(3 lectures)**

Nemoteds, birds, bats, rodents,molluscs, mites etc,

Practicals (40 Hrs.):

Familiarity with general plant pathological laboratory and field equipments. Study of disease symptoms and signs and host parasite relationship. Identification and isolation of plant pathogens. Koch's postulates. Preparation of fungicidal solutions, slurries, pastes and their applications.Insect collection and preservation. Identification of important insects. General body organization of insects. Study on morphology of grasshopper. Preparation of permanent mounts of mouth parts, antennae, legs and wings. Dissection of grasshopper and caterpillar for study of internal morphology. Observations on metamorphosis of larvae and pupae.Study on insect traps

HORTUG 109. English/ Regional Language Credits:1+0

Teaching Hours: 20+0=20 Hrs.

Unit 1: Grammar (6 lectures)

Grammatical Focus- Grammatical & Structural aspects covering Parts of Speech, Tense, Voice, Clause, Preposition, Degrees of Comparison, Synonyms & Antonyms, etc; Identifying & Analysing Grammatical Errors including errors in Spelling & Punctuation.

Unit 2: Reading and writing (6 lectures)

Reading- Vocabulary Building; Comprehension; Interpretation; Summarising. Writing- Letter Writing – Formal, Informal; Accepting & Declining Invitations; Precise Writing, Effective Writing- Business Correspondences (Letter, Fax, e-mail) for- Making Enquiries, Placing Orders, Asking & Giving Information, Registering Complaints, Handling Complaints; Drafting notices; Drafting Advertisements; Job Applications.

Unit 3: Speaking, pronunciation and listening (8 lectures)

Speaking- Interactive Communication like Introducing Self, Greetings, Conversations, etc; Business Etiquettes; Impromptu Speech; Debate; Role Play; Presentations. Pronunciation- appropriate stress, intonation, clarity. Listening- Understanding – Spoken English, Formal English; Exercises.

Semester II

HORTUG 201. Tropical and Subtropical Fruits Credits: 2+1

Teaching Hours 40+40= 80

Unit 1: Classification (2 lectures)

Horticultural classification of fruits including genome classification. Horticultural zones of India, Charecteristics of Troipcal and sub tropical fruit

Unit 2: Production technology of tropical and subtropical fruits (20 lectures)

detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning. Management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards. Physiological disorders. Post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage of the following crops.

Mango, Banana, Grapes, Citrus, Papaya, Sapota, Guava, Pineapple, Jackfruit, Avocado, Mangosteen, Litchi, Carambola, Durian and Passion fruit.

Unit 3: Production problems and its management (8 lectures)

Bearing in Mango, guava and Citrus, causes and control measures of special production problems, alternate and irregular bearing. Seediness and kokkan disease in banana, citrus decline and pineapple flowering.

Unit 4: Crop specific special production techniques (10 lectures)

Bud forecasting in grapes, sex expression and seed production in papaya, latex extraction and crude papain production, pineapple flowering, economics of production.

Practicals (40 Hrs.):

Description and identification of varieties based on flower and fruit morphology in T&ST Fruits. Training and pruning of Grapes, Mango, Guava and Citrus. Selection of site and planting system, pre-treatment of banana suckers, desuckering in banana, sex forms in papaya. Use of plastics in fruit production. Visit to commercial orchards and diagnosis of maladies. Manure and fertilizer application including bio-fertilizer in fruit crops, preparation and application of growth regulators in banana, grapes and mango, latex extraction and preparation of crude papain. Ripening of fruits, grading and packaging, production economics for tropical and sub-tropical fruits.

HORT UG 202. Tropical and Subtropical Vegetables **Credits: 2+1**
Teaching Hours: 40+40=80 Hrs.

Unit 1: Introduction **(2 lectures)**

Area, production, economic importance and export potential of tropical and sub-tropical vegetable crops. Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, nursery practices; planting for directly sown/transplanted vegetable crops, Spacing, planting systems water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators. Cropping systems, harvestand yield. Economics of cultivation of tropical and sub-tropical vegetable crops; post-harvest handling and storage of following crops.

Unit 2: Tomato, Brinjal, Chillies **(6 lectures)**

Unit 3: Okra **(2 lectures)**

Unit 4: Amaranthus **(2 lectures)**

Unit 5: Cluster Beans, Cowpea, Lab-Lab, Snap Bean, **(6 lectures)**

Unit 6: Cucurbits, **(10 lectures)**

Unit 7: Moringa, Curry Leaf, Portulaca and Basella. **(8 lectures)**

Unit 8: Off season production technique **(4 lectures)**

Practicals (40 Hrs.):

Identification and description of tropical and sub-tropical vegetable crops and their seeds; nursery practices and transplanting, preparation of field and sowing/planting for direct sown and planted vegetable crops. Herbicide use in vegetable culture; top dressing of fertilizers and intercultural; use of growth regulators; identification of nutrient deficiencies. Physiological disorder. Harvest indices and maturity standards, post-harvest handling and storage, seed extraction cost of cultivation for tropical and sub-tropical vegetable crops. Pot raising of vegetables.

HORT UG 203. Elementary Agro-meteorology **Credits: 1+1**

Teaching Hours: 20+40=60 Hrs.

Unit 1: Atmosphere **(4 lectures)**

Structure of atmosphere; weather elements, solar radiations, temperature, atmospheric pressure, wind, humidity, evaporation, rainfall, clouds, hydrologic cycle, monsoon and season.

Unit 2: Abnormalities in weather **(8 lectures)**

Floods, droughts, cyclones, other abnormalities; weather forecasting organizations, essentials of weather forecasting, forecasting information, types of weather forecasting, methods of forecasting; weather modifications- artificial rain making, reduction in wind velocity and its losses, protection against frost damage, heat trapping.

Unit 3: Influence of climate on crops **(8 lectures)**

Agro-climatic zones of India,solar radiations-photosynthetic effect, photoperiodic effect, other effects, utilization of solar energy; cardinal temperatures, cool season crops, warm season crops, influence of temperature on growth, growing degree days, photo thermal units, extreme temperature chilling requirementsrainfall climatology, relative humidity-water relation, leaf growth, photosynthesis and pollination.

Practicals (40 Hours):

Measurement of maximum and minimum air temperatures, soil temperatures, rain fall, open pan evaporation and evapo-transpiration. Determination of vapour pressure relative humidity, atmospheric pressure, wind speed and wind direction. Processing, tabulation and presentation of weather data.

HORT UG 204. Water Management in Horticultural Crops Credits:1+1

Teaching Hours: 20+40=60 Hrs.

Unit 1: Water resources (3 lectures)

Importance of water, water resources in India. Area of different crops under irrigation, function of water for plant growth, effect of moisture stress on crop growth- Deficit & excess.

Unit 2: Soil water relation (3 lectures)

Available and unavailable soil moisture – distribution of soil moisture, water budgeting – rooting characteristics , moisture extraction pattern.

Unit 3: Water requirement of horticultural crops (4 lectures)

Lysimeter studies, Plant water potential climatological approach ,use of pan evaporimeter – factor for crop growth stages, critical stages of crop growth for irrigation.

Unit 4: Irrigation scheduling (4 lectures)

Irrigation scheduling – different approaches, methods of irrigation surface and sub-surface pressurized methods viz., sprinkler and drip irrigation, their suitability, merits and limitations, fertigation, economic use of irrigation water.

Unit 5: Irrigation management (4 lectures)

Water management problem, soils quality of irrigation water, irrigation management practices for different soils and crops. Layout of different irrigation systems, drip, sprinkler. Layout of under ground pipeline system and drainage.

Practicals (40 Hrs.):

Measurements of irrigation water by using water measuring devices, use of common formula in irrigation practices, practicing of land leveling and land shaping implements, layout for different methods of irrigation. Estimation of soil moisture constants and soil moisture by using different, methods and instruments, scheduling of irrigation, different approaches, practicing use of instruments, estimation of irrigation efficiency and water requirements of horticultural crops, irrigation planning and scheduling, soil moisture conservation practices. Models for watershed management lay out for irrigation systems.

HORT UG 205. Plant Propagation and Nursery Management Credits:1+2

Teaching Hours: 20+40=60 Hrs.

Unit1: Basics of Propagation (6 lectures)

Propagation: Need and potentialities for plant multiplication, sexual and asexual methods of propagation, advantages and disadvantages. Seed dormancy (scarification & stratification) internal and external factors, nursery techniques, apomixes – mono-embrony, polyembrony, chimera & bud sport.

Unit 2: Propagation Structures (3 lectures)

Mist chamber, humidifiers, greenhouses, glasshouses, cold frames, hot beds, poly-houses, nursery (tools and implements).

Unit 3: Propagation methods: Physiology and techniques (11 lectures)

Use of growth regulators in seed and vegetative propagation, methods and techniques of cutting, layering, grafting and budding physiological & bio chemical basis of rooting, factors influencing rooting of cuttings and layering, graft incompatibility scion-stock relationship and their influences . Anatomical studies of bud union, selection and maintenance of mother trees, collection of scion wood stick, bud wood certification, techniques of propagation through specialized organs, corm, runners, suckers etc. Micrografting, hardening of plants in nurseries. Nursery registration act. Insect/ pest/disease control in nursery. Off season nursery production of vegetables.

Practicals (40 Hrs.):

Media for propagation of plants in nursery beds, pot and mist chamber. Preparation of nursery beds and sowing of seeds. Raising of rootstock. Seed treatments for breaking dormancy and inducing vigorous seedling growth. Preparation of plant material for potting. Hardening plants in the nursery. Practicing different types of cuttings, layering, graftings and buddings etc. Use of mist chamber in propagation and hardening of plants. Preparation of plant growth regulators for seed germination and vegetative propagation. Visit to a tissue culture laboratory. Digging, labeling and packing of fruit plants. Maintenance of nursery records. Use of different types of nursery tools and implements for general nursery and bud wood certification. Cost of establishment of a mist chamber, greenhouse, glasshouse, polyhouse and their maintenance. Top grafting, bridge grafting and nursery management. Nutrient and plant protection applications during nursery.

HORT UG 206. Growth and Development of Horticultural Crops Credits: 2+1

Teaching Hours: 40+40=60 Hrs.

Unit 1: Growth and development (6 lectures)

Growth and development -definitions, components, photosynthetic productivity, leaf area index (LAI) - optimum LAI in horticultural crops, canopy development; different stages of growth, growth curves, growth analysis in horticultural crops.

Unit 2: Plant Growth regulators (15 lectures)

Plant bioregulators- auxin, gibberellin, cytokinin, ethylene inhibitors and retardants, basic functions, biosynthesis, role in crop growth and development, propagation, flowering, fruit setting, fruit thinning, fruit development, fruit drop, and fruit ripening.

Unit 3: Seed development and dormancy (4 lectures)

Physiology of seed development and maturation, seed dormancy and bud dormancy, causes and breaking methods in horticultural crops.

Unit 4: Training and Pruning (5 lectures)

Pruning and training physiological basis of training and pruning source and sink relationship, translocation of assimilates.

Unit 5: Flowering and its physiology (5 lectures)

Factors affecting flowering, physiology of flowering, light -photoperiodism-long day, short day and day neutral plants, vernalisation and chilling temperature and its application in horticulture.

Unit 6: Fruit growth and development (5 lectures)

Physiology of fruit growth and development, fruit setting, factors affecting fruit set and development, physiology of ripening of fruits-climacteric and non climacteric fruits.

Practicals (40 Hours):

Estimation of photosynthetic potential of horticultural crops, leaf area index, growth analysis parameters including harvest index, bioassay of plant hormones, preparations of hormonal solution and induction of rooting in cuttings, ripening of fruits and control of flower and fruit drop. Important physiological disorders and their remedial measures in fruits and vegetables, seed viability by tetrazolium test, seed germination and breaking seed dormancy with chemicals and growth regulators.

HORT UG 207. Introductory Microbiology **Credits: 1+1**

Teaching Hours 20+40=60

Unit 1: Introduction to microbiology **(7 lectures)**

History and Scope of Microbiology: The discovery of micro-organism, spontaneous generation conflict, germ theory of diseases, microbial effect on organic and inorganic matter. Development of microbiology in India and composition of microbial world.

Unit 2: Microscopy and Specimen Preparation **(3 lectures)**

The bright field microscope, fixation, dyes and simple staining, differential staining.

Unit 3: Prokaryotic organism **(10 lectures)**

Difference between prokaryotic and eucaryotic cells. Procaryotic cell structure and functions. Types of culture media and pre-culture techniques. Microbial growth in models of bacterial, yeast and mycelial growth curve. Measurement of bacterial growth. General properties of viruses and brief description of bacterophages. General principle of bacterial genetics, DNA as genetic material. Antibiosis, symbiosis, intramicrobial and extra-microbial association.

Practicals (40 Hrs)

Examination of stained cells by simple staining and Gram staining. Methods for sterilization and nutrient agar preparation. Broth culture, agar slopes, streak plates and pour plats, colony isolation and turbidometric estimation of microbial growth.

HORT UG 208. Principles of Genetics and Plant Breeding Credits: 2+1

Teaching Hours 40+40= 80

Unit 1: Introduction to genetics (5 lectures)

Historical background of genetics, theories and hypothesis. Physical basis of heredity, cell reproduction, mitosis, meiosis and its significance. Gametogenesis and syngamy in plants.

Unit 2: Mendelian genetics (8 lectures)

Mendel' s principles of heredity, deviation from Mendelian inheritance, pleiotropy, threshold characters, co-dominance, penetrance and expressivity. Chromosome theory of inheritance, gene interaction.

Unit 3: Pollination and reproduction (10 lectures)

Sexual reproduction (cross and self pollination), asexual reproduction, pollination control mechanism (incompatibility and sterility and implications of reproductive systems on population structure).

Unit 4: Introduction to plant breeding (5 lectures)

Plant breeding as a dynamic science, genetic basis of Plant Breeding – classical, quantitative and molecular, Plant Breeding in India – limitations, major achievements, future requirements.

Unit 5: Breeding strategies and techniques (12 lectures)

Genetic components of polygenic variation and breeding strategies and methods as a basis of crop breeding. Hybridization and selection – goals of hybridization, selection of plants; population developed by hybridization – simple crosses, bulk crosses and complex crosses. General and special breeding techniques. Heterosis – concepts, estimation and its genetic basis. Mutation and polyploidy breeding

Practicals (40 Hrs.):

Study of fixatives and stains. Squash and smear techniques. Demonstrations of permanent slides and cell division, illustration in plant cells, pollen fertility and viability, gametes, Solving problems of monohybrid, dihybrid, and test cross ratios using chi-square test.

Breeding objectives and techniques in major field crop plants. Floral biology – its measurement, emasculation, crossing and selfing techniques in major crops. Handling of breeding material and maintenance of experimental records in self and cross pollinated crops. Use of chemical mutagens.

Semester III

HORT UG 301. Ornamental Horticulture **Credits: 2+1**

Teaching Hours: 40+40 =80 Hrs.

Unit 1: Introduction to Gardening **(4 lectures)**

History, scope of gardening, aesthetic values. types of gardens, Gardens in India,. Landscaping, historical background.

Unit 2: Floriculture industry **(2 lectures)**

Importance, area and production, industrial importance in India.

Unit 3: Principles of gardening **(6 lectures)**

Principles of gardening, garden components, adornments, lawn making, methods of designing rockery, water garden, etc. Landscaping, basic principles and basic components.

Unit 4: Garden types, features and components **(10 lectures)**

Special types of gardens, their walk-paths, bridges, constructed features. Greenhouse. Special types of gardens, trees, their design, values in landscaping, propagation, planting shrubs and herbaceous perennials. Importance, design values, propagation, potting, climbers and creepers, palms, ferns, grasses and cacti succulents.

Unit 5: Floral arrangement and bonsai **(8 lectures)**

Importance, production details and cultural operations, constraints, post-harvest practices. Culture of bonsai, art of making bonsai.

Unit 6: Bio-aesthetic planning **(10 lectures)**

Bio-aesthetic planning, definition, need, round country planning, urban planning and planting avenues, schools, villages, beautifying railway stations, dam sites, planting material for play grounds. Vertical gardens, roof gardens. Parks and public gardens.

Practicals (40 Hrs):

Identification and description of annuals, herbaceous, perennials, climbers, creepers, foliage flowering shrubs, trees, palms, ferns, ornamental grasses; cacti succulents. Planning and designing gardens, layout of location of components of garden study, functional uses of plants in the landscape. Panning design of house garden, roadside planting, avenues for new colonies, traffic islands, preparation of land for lawn and planting. garden, and Japanese gardens, recreational and children' s corner. Layout of terrarium, bottle garden, dish garden. Flower arrangement, bonsai practicing and training. Visit to nearby gardens.

HORT UG 302. Temperate Vegetables and tuber crops **Credits: 2+1**

Teaching Hours: 40+40=80 Hrs.

Unit 1: Introduction

Importance of cool season vegetable crops in nutrition and national economy. **(2 lecture)**

Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, seed production, post-harvest technology and marketing of :

Unit 2: Cole crops **(9 lectures)**

Cabbage, cauliflower, knol-khol, sprouting broccoli, Brussels' sprout, Chinese cabbage.

Unit 3: Leafy vegetables **(4 lectures)**

Lettuce, palak, spinach.

Unit 4: Bulb crops **(3 lectures)**

Garlic, onion, leek

Unit 5: Root crops **(6 lectures)**

Radish, carrot, turnip, beet root.Squashroot

Unit 6: Peas, beans and perennials **(6 lectures)**

Peas, broad beans, rhubarb, asparagus, globe artichoke.

Unit 7: Tuber crops **(10 lectures)**

Potato, Taro, Cassava, Yams, Colocasia, Sweet potato

Practicals (40 Hrs.):

Identification and description of varieties/hybrids; propagation methods, nursery management, preparation of field, sowing/transplanting; identification of physiological disorders and nutritional disorders and their corrections; post harvest handling; cost of cultivation and field visit to commercial farm.

HORT UG 303. Fundamentals of Extension Education & Rural Sociology Credits:2+1

Teaching Hours: 40+40=80 Hrs.

Unit 1: Extension education (2 lectures)

History, definition, nature, scope, objectives, principles and approaches.

Unit 2: Horticulture extension (4 lectures)

Horticulture extension: process, principles and selected programmes of leading national and international forest institutes. People' s participation in forestry programmes. Motivation of women community, children, youth and voluntary organizations for horticulture extension work.

Unit 3: Rural Development (4 lectures)

Objectives and genesis. Transfer of technology programmes like lab to land programme (LLP) national demonstration (ND),front line demonstration (FLD) Krishi Vigyan Kendras (KVK), Technology Assessment and Refinement Programme (TARP) etc. of ICAR.

Unit 4: Communication (4 lectures)

Communication: meaning, definition, elements and selected models. Audio – visual aids: importance, classification and selection. Programming planning process – meaning, scope, principles and steps. Agrarian journalism

Unit 5: Evaluation (4 lectures)

Evaluation: meaning, importance and methods. Scope and importance of Participatory Rural Appraisal (PRA) & Rapid Rural Appraisal (RRA).

Unit 6: Management and administration (2 lectures)

Management and administration: meaning, definition, principles and functions. Concepts of human resource development (HRD), rural leadership. Definition of Jounalism.

Unit 7: Basics of rural sociology (5 lectures)

Concepts, methods, tools, characteristics of rural society and people, rural-urban continuum and differences,

Unit 8: Rural social structure and stratification (10 lectures)

Rural social structure: interaction, processes, institutions, groups; Rural social stratification: status, roles, class, castes, etc.

Unit 9 : Panchayat Raj and Land reforms (5 lectures)

Panchayat Raj, and Block Development, specific programmes for rural area upliftment/ employment, Land reforms, Council for advancement of Peoples Action and Rural Technology.

Practicals (40 Hrs.):

Preparation & use of NPVA like poster, chart, flash cards, folders etc. and AVA like OHP & 35 mm slide projector transparencies.Exercises on distortion of message, script writing for farm broadcasts and telecasts, planning. Visits to study structure and mode of functioning of voluntary organizations (NGO)/Mahila Mandal, Village Panchayat, State Deptt. of Agriculture/All India Radio (AIR). Identification of local leaders to study their role in extension work. Evaluation of some selected case studies of horticulture extension programmes. Preparation of Village horticultural productions plan. Visit to Kisan Call Centre and Plant Health Clinic.

HORT UG 304. Genetic Resource Management & Intellectual property Rights Credits: 2+1 Teaching

Hours: 40+40=80 Hrs.

Unit 1: Genetic resources (5 lectures)

Role of genetic resources, centers of origin and diversity of crop plants, law of homologous series, plant introduction and exchange of genetic resources.

Unit 2: Introduction, domestication and germplasm conservation (8 lectures)

Principles and concepts of plant quarantine, plant introduction in horticultural crops, germplasm collection and gene bank, gene sanctuary for conservation, gene erosion, germplasm exploration, germplasm conservation, in vitro conservation, cryopreservation, DNA finger printing.

Unit 3: Sources of crop resistance and quality characters (5 lectures)

Wild relatives and sources of resistance to biotic, abiotic stress and quality characters for fruit vegetable, flower and plantation crops, spices, medicinal and aromatic plants.

Unit 4: Intellectual property rights (5 lectures)

International Institutes and organization for germplasm – Trade Related Intellectual Property Rights (TRIPS) and Intellectual Property Rights (IPR) for Indian cultivars.

Unit 5: Copy right and trade mark (5 lectures)

Copy right, Trade marks, geographical indicators

Unit 6: Industrial design (3 lectures)

Industrial design, layout design

Unit 7: Trade secrets and patents (4 lectures)

Trade secrets, Patents (Plant, Utility and Design)

Unit 8: Protection of Plant variety and farmers Right (5 lectures)

Protection of Plant variety and farmers Right, DUS Testing, Plant Breeders Right

Practicals (40 Hrs.):

Morphological evaluation of germplasm, collection and identification of wild relatives for fruit crops, vegetable crops, flower crops, spices, plantation crops, medicinal and aromatic plants, preparation of herbariums. Photo album/ digital photo album preparation of important horticultural plants. Use of descriptors, monographs in hort crops. Visit to the nearest germplasm centre, herbal garden, biodiversity park and botanical gardens.

HORT UG 305. Temperate Fruits **Credits: 2+1**

Teaching Hours: 40+40=80 Hrs.

Unit 1: Production technology of temperate fruits **(25 lectures)**

Classification of temperate fruits, detailed study of areas, production, varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage of apple, pear, peach, plum, apricot, cherry, persimmon, strawberry, kiwi, Queens land nut (Macadamia nut), almond, walnut, pecan nut, hazel nut, chest nut and raspberry.

Unit 2: Production problems and its management **(15 lectures)**

Re- plant problem, rejuvenation and special production problems like pre-mature leaf fall, physiological disorders, important insect – pests and diseases and their control measures.

Practicals (40 hrs.):

Description and identification of varieties of temp crops,Nursery management practices, , manuring and fertilization, planting systems, preparation and use of growth regulators, training and pruning in apple, pear, plum, peach and nut crops. Visit to private orchards to diagnose maladies. Working out economics for apple, pear, plum and peach.

HORT UG 306. Commercial Floriculture Credits: 2+1

Teaching Hours: 40+40=80 Hrs.

Unit 1: Production technology of flowers (20 lectures)

Scope and importance of commercial floriculture in India, production techniques of ornamental plants like Rose, Marigold, Chrysanthemum, Anthurium, Jasmine, Dahlia, Bird of Paradise, China Aster, Orchid,

Bulbous crops, Astroemeria, Amaryllis, Begonia, Hyacinth, Zantedischia, Ornythogallum, Tulip

Unit 2: Cut foliage and pot plants (10 lectures)

Unit3: Post harvest technology of cut flowers (5 lectures)

Post harvest technology of cut flowers in respect of commercial flower crops

Unit 4: Oil extraction and dry flowers (5 lectures)

Essential oil/concrete extraction, dehydration techniques of flowers.

Practicals (40 Hrs.):

Identification of commercially important floricultural crops. Propagation practices in chrysanthemum, sowing of seeds and raising of seedlings of annuals. Propagation by cutting, layering, budding and grafting. Training and pruning of roses. Use of chemicals and other compounds for prolonging the vase life of cut flowers. Drying and preservation of flowers. Flower arrangement practices. Pigment extraction.

HORT UG 307. Environmental Science **Credits 2+1**

Teaching hours 40+40=80

Unit 1: Introduction **(1 lecture)**

Definitions, Scope and Importance of Environment

Unit 2: Ecology and ecosystems **(5 lectures)**

Definition of ecology. Concept of ecosystem.Structure and function of an ecosystem. Producers, consumers and decomposers. Energy flow in the ecosystem. Ecological succession. Food chains, food webs and ecological pyramids. Introduction, types, characteristic features, structure and function of the following ecosystem :- Mountain ecosystems (Forest ecosystem, Grassland ecosystem), Aquatic ecosystems (ponds, streams, lakes, rivers and other wetlands)

Unit 3: Natural resources **(5 lectures)**

Renewable and non-renewable resources: Natural resources and associated problems. Forest resources: Use and over-exploitation, deforestation, case studies. Timber and Minor Forest Produce, overgrazing, mining, dams and their effects on forest and tribal people. Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources . Agro-Horticultural resources, changes caused by agriculture, effects of modem agriculture, fertilizer pesticide problems, water logging, organic farming. Energy resources: energy needs, renewable and non renewable energy sources, use of alternate energy sources. Land resources.

Unit 4: Biodiversity and its Conservation **(5 lectures)**

Introduction -Definition: genetic, species and ecosystem diversity. Biogeographical classification of India. Medicinal, Aromatic and Wild edible plants, with especial reference to Sikkim . Agrobiodiversity,Value of biodiversity, consumptive use, productive use, social, ethical, aesthetic and option values . Biodiversity at global, national and local levels. India as a mega-diversity nation .Hot-spots of biodiversity. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India. Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Unit 5: Human Population and Environment **(5 lectures)**

Population growth, variation among nations. Population explosion Family Welfare Programme. Environment and Human health. Human Rights. HIV/AIDS. Women and Child Welfare.

Unit 6: Social Issues and the Environment **(5 lectures)**

Social problems related to energy . Water conservation, rain water harvesting, concept of watershed. Resettlement and rehabilitation of people; its problems and concerns. Public awareness and Environmental ethics (Issues and possible solutions). Consumerism and waste products. Tourism and eco-tourism. Environmental laws and policies: Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act .Biodiversity Act. Wildlife Protection Act.ForestConservationAct,etc.

Unit 7: Environmental Pollution **(4 lectures)**

Definition, Cause, Effects and Control Measures of: Air pollution , Water pollution: Water quality criteria, potable water and sewage (domestic and industrial effluent) treatment, fundamentals, primary, secondary and tertiary treatment.

Soil pollution , Noise pollution, Thermal pollution, Radioactive pollution . Role of an individual in prevention of pollution.

Unit 8: Environmental Management **(4 lectures)**

Concept of Sustainable development, Hazard and Disaster management, Solid waste Management -Causes, effects and control measures of rural, urban and industrial wastes, biomedical wastes. Watershed management. Land degradation. Wasteland reclamation and management. Environmental impact assessment (EIA): Concept of EIA, various methods of EIA and their relative advantages, EIA as a management tool. Environmental economics.

Unit 9: Climate change **(6 lectures)**

Definition of climate, Causes of climate change: anthropogenic and natural, Global warming, Impact of climate change, Acid rain, ozone depletion and related issues of climate change, Carbon trading and clean energy concept- carbon foot prints, carbon sequestration, carbon credit and audit, Global perspective of climate change- conferences.

Project Work (40hrs.)

Students should be given project work, covering any of the topics covered in the syllabus; however, the emphasis should be given on Sikkim aspects. Mechanism to involve other locally based research institutions need to be strengthened.

HORT UG 308. North East Study Tour (Winter vacation) **Credits: 0+1**

Visit to research institutes& production clusters, industries, botanical garden of horticultural importance located within NE region

Semester IV

HORT UG 401. Spices and Condiments **Credits: 2+1**

Teaching Hours: 40+40=80 Hrs.

Unit 1: Production technology **(38 lectures)**

History, scope and importance, area and production, uses, export potential and role in national economy. Classification, soil and climate, propagation-seed, vegetative and micropropagation systems and methods of planting. Nutritional management, irrigation practices, weed control, mulching and cover cropping, training and pruning practices, role of growth regulators, shade crops and shade regulation. Harvesting, post-harvest technology, packaging, storage, value added products, methods of extraction of essential oil and oleoresins. Economics of cultivation of Cardamom, pepper, ginger, turmeric, clove, nutmeg, cinnamon, all spice, curry leaf, coriander, fenugreek, fennel, cumin, dill, celery, bishops weed, saffron, vanilla, thyme, rosemary and Garcinia (Kokum)

Unit 2: Institutes and organization dealing with spices **(2 lectures)**

Role of Spice Board and Pepper Export Promotion Council, institutions and research centers in R&D.

Practicals (40 Hours.):

Identification of crops, propagation, seed treatment – sowing; planting; hoeing and earthing up; manuring and use of weedicides, training and pruning; maturity standards, harvesting, curing, processing, grading and extraction of essential oils and oleoresins. Visit to commercial plantations.

HORT UG 402. Post Harvest Management of Horticultural Crops Credits: 2+1

Teaching Hours: 40+40=80 Hrs.

Unit 1: Important of Post Harvest Technology (1 lecture)

Importance of post-harvest technology in horticultural crops. Principles and methods

Unit 2: Post-harvest physiology (7 lectures)

Structure of fruits, vegetables and cut flowers related to physiological changes after harvest.

Unit 3: Post harvest handling and Pre-harvest factors affecting quality (16 lectures)

Maturity indices, harvesting, handling, grading of fruits, vegetables, cut flowers, plantation crops, medicinal and aromatic plants. Pre-harvest factors affecting quality, factors responsible for deterioration of horticultural produce, physiological and bio-chemical changes, hardening and delaying ripening process. Pre-harvest treatment and precooling, pre-storage treatments.

Unit 4: Post-harvest treatments and quality parameters (6 lectures)

Post-harvest treatments of horticultural crops. Quality parameters and specification.

Unit 5: Storage, packaging and transport (10 lectures)

Methods of storage for local market and export. Different systems of storage, packaging methods and types of packages, recent advances in packaging. Types of containers and cushioning materials, vacuum packaging, cold storage, poly shrink packaging, grape guard packing treatments. Modes of transport.

Practicals (40 Hours):

Practice in judging the maturity index of various horticultural produce and organoleptic test, determination of physiological loss in weight and quality. Grading of horticultural produce, post-harvest treatment of horticultural crops, physical and chemical methods. Packaging studies in fruits, vegetables, plantation crops and cut flowers by using different packaging materials, methods of storage, post-harvest disorders in horticultural produce. Identification of storage pests and diseased in spices. Visit to markets, packaging houses and cold storage units.Vase life increase in cut flowers.

HORT UG 403. Plantation Crops **Credits:2+1**

Teaching Hours: 40+40=80 Hrs.

Unit 1: History and status of plantation crops **(9 lectures)**

History and development, scope and importance, area and production, export and import potential, role in national and state economy, uses, industrial importance, by products utilization.

Unit 2: Production technology of Plantation crops **(31 lectures)**

Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, cropping system, mulching, shade regulation, weed and water management, training, pruning and handling, nutrition, foliar feeding, role of growth regulators, soil management, liming practices, tipping practices, top working, physiological disorders, harvesting, post-harvest handling and processing, packaging and marketing, yield and economics and by product utilization of coconut, arecanut, oil palm, palmyrah palm, cacao, cashew nut, coffee, tea and rubber.

Practicals (40 Hours):

Description and identification of coconut varieties, selection of coconut and arecanut mother palm and seed nut, planting of seed nuts in nursery, layout and planting of coconut, arecanut, oil palm, cashew nut, cacao gardens. Description and identification of species and varieties in coffee, harvesting, grading, pulping, fermenting, washing, drying and packing of coffee, seed berry collection, seed extraction, treatment and sowing of coffee, epicotyl, softwood, grafting and. Mother plant selection, preparation of cuttings and rooting of tea under specialized structure, training, centering, pruning, tipping and harvesting of tea.

HORT UG 404. Breeding of Fruits, Plantation & Medicinal Plants Credits:2+1

Teaching Hours: 40+40=80 Hrs.

Unit 1: Introduction to breeding (6 lectures)

History, importance of breeding in horticultural crops production, distribution, domestication and adaptation and centres of origin, plant bio-diversity and its conservation,

Unit 2: Modes of reproduction (10 lectures)

Modes of reproduction, pollination systems and genetics of important of commercially important fruits, medicinal and aromatic plants and plantation crops

Unit 3: Breeding strategies and achievements (18 lectures)

Principles of breeding in self-and cross pollinated crops, pure line selection, mass selection, heterosis breeding, hybridization, pedigree method, mass pedigree method, bulk method, modified bulk method, single seed descent method and back cross method. Self incompatibility and male sterility, its classification and application in crop improvement. Variability for economic traits, breeding strategies, clonal selection, bud mutations, mutagenesis and its application in crop improvement –manipulations

Unit4: Biotechnology for crop improvement and resistance breeding (6 lectures)

Application of biotechnology in crop improvement. Breeding for disease resistance.

Practicals (40 Hrs.):

Exercises on floral biology, pollen viability; emasculation and pollination procedures for some model crops; use of mutagens to induce mutations and polyploidy.*Invitro* breeding methods. Embryo rescue.

HORT UG 405. Integrated Insect-Pest Management of Fruits, Plantation & Medicinal Plants Credits: 2+1

Teaching Hours: 40+40=80 Hrs.

Unit 1: Introduction to insect pest management (33 lectures)

Economic classification of insects; ecology and insect-pest management with reference to horticultural crops; pest surveillance. Distribution, host range, bio-ecology, damage, integrated management of important insect pests affecting important horticultural crops.

Unit 2: Storage pest and its management (5 lectures)

Storage insects – distribution, host range, bioecology, damage, integrated management of important insect pests attacking stored fruits, plantation, medicinal and aromatic crops and their processed products.

Unit 3: Toxicology (2 lectures)

Toxicology – insecticide residue problems in fruit, plantation, medicinal and aromatic crops and their tolerance limits.

Practicals (40 Hours) :

Study of symptoms, damage, collection, identification, preservation, assessment of damage/population of important insect-pests affecting fruits, plantation, medicinal and aromatic crops in field and during storage. Management practices for important pests.

HORT UG 406. Integrated Disease Management of Fruits, Plantation & Medicinal Plants Credits 2+1

Teaching Hours: 40+40=80 Hrs.

Unit1: Disease management of horticultural crops (30 lectures)

Etiology, symptoms, mode of spread epidemiology and integrated management of the diseases of important Fruits, Plantation and Medicial crops.

Unit2: Post Harvest Disease management (10 lectures)

Important post-harvest diseases of Fruits, Plantation and Medicial crops and their management.

Practicals (40 Hrs.):

Observations of disease symptoms, identification of casual organisms and host parasite relationship of important diseases. Examination of scrapings and cultures of important pathogens of horticultural crops. Bio control, management includingpost Harvest management.

HORT UG 407. Integrated Nutrient Management and Soil and Plant Tissue Analysis Credits: 2+1

Teaching Hours: 40+40=60 Hrs.

Unit1: Plant nutrient elements (5 lectures)

Essential plant nutrient elements- functions, deficiency systems, transformations and availability.

Unit 2: Micro-organism and plant nutrition (4 lectures)

Role of microorganisms in organic matter- decomposition – humus formation. Importance of C:N ratio and pH in plant nutrition.

Unit 3: Fertility evaluation and INM: (3 lectures)

Soil fertility evaluation methods, critical limits of plant nutrient elements, deficiency symptoms, visual diagnosis and hunger signs.

Unit 4: Manure and fertilizers (4 lectures)

Manures, fertilizers: micronutrients composition and application methodology, luxury consumption, nutrient interactions.

Unit: 5: Different INM practices in Horticultural crops (6 lectures)

Components of INMand their integration in horticultural crops

Unit 6: Sampling methods (2 lectures)

Methods of soil and plant sampling and processing for analysis.

Unit 7: Soil structural analysis and mineral quantification (2 lectures)

Quantification of minerals and their abundance. Soil structure and aggregate analysis.

Unit 8: Soil moisture (2 lectures)

Theories and concepts of soil moisture estimation – gravimetric, tensiometric, gypsum block, neutron probe and pressure methods. Characterization of hydraulic mobility – diffusion and mass flow.

Unit 9: Leaf tissue analysis (6 lectures)

Chemical and mineral composition of horticultural crops. Leaf analysis standards, index tissue, interpretation of leaf analysis values.

Unit 10: Analytical instruments and its principles (3 lectures)

Principles of working of pH meter, electrical conductivity meter, spectrophotometer, flame photometer and atomic absorption spectrophotometer.

Unit: 11: Quality of irrigation water (3 lectures)

Irrigation water quality, determination of quality parameters, empirical equation management of irrigation water.

Practicals (40 Hrs.):

Collection and preparation of soil and plant samples for analysis. Determination of water holding capacity and hydraulic conductivity of soil. Estimation of moisture content in soils and plants. Estimation of available macro and micronutrient elements in plants. Irrigation water quality analysis. Analysis of soil for organic matter, available N,P,K and Micronutrients and interpretations. Gypsum requirement of saline and alkali soils. Lime requirement of acid soils. Hoagland solution, Soil less culture, identification of different fertilizers, numerical calculations on fertilizers, nutrient deficiency identification, amendment measures.

Semester V

HORT UG 501. Arid and Minor Fruits **Credits: 1+1**

Teaching Hours: 20+40 =60 Hrs

Unit 1: **(4 lectures)**

Arid zones of India. Plant adaptations for arid conditions.

Unit 2: **(16 lectures)**

Production, nutritive value and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning. Management of water, nutrient and weeds, special horticultural techniques including plant growth regulators. Physiological disorders. Post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage of the following crops.

Ber, Aonla, Annona, Jamun, Wood Apple, Bael, Pomegranate, Carissa, Date Palm, Phalsa, Fig, West Indian Cherry, Tamarind and indigenous fruits of Sikkim.

Practical (40 Hrs)

Mapping of arid and semi-arid zones of India. Botanical description and identification of Ber, Fig, Jamun, Pomegranate, Carissa, Phalsa, Wood Apple, West Indian Cherry, Tamarind, Aonla, Bael and Annona.Nursery preparation, growth regulator application, anti transpirants application, Pruning in ber, multi stem training and bahar treatment in pomegranate, post harvest management,calculation of cost economics and packaging studies.

HORT UG 502. Production and Post Harvest Management of Medicinal and Aromatic crops Credits: 2+1

Teaching Hours: 40+40= 80Hrs.

Unit1: Introduction to medicinal and aromatic crops (2 lectures)

History, scope, opportunities and constraints in the cultivation and maintenance of medicinal and aromatic plants in India.

Unit 2: Outline of production technology (14 lectures)

Importance, origin, species and varieties, distribution, area, production, climatic and soil requirements, propagation and nursery techniques, planting and after care, cultural practices, training and pruning, nutritional and water requirements, plant protection, harvesting and processing of under mentioned important medicinal and aromatic plants, study of chemical composition of a few important medicinal and aromatic plants, extraction, use and economics of drugs and essential oils in medicinal and aromatic plants. Therapeutic and pharmaceutical uses for the following crops.

Unit 3: Medicinal crops (12 lectures)

Medicinal Plants: Betelvine, periwinkle, Rauvolfia, Dioscorea, Isabgol, *Ammi majus*, Belladonna, Cinchona, Pyrethrum and other species relevant to local conditions. *Aloevera*.

Unit 4: Aromatic plants (12 lectures)

Aromatic Plants: Citronella grass, khus grass, flag (baje), lavender, geranium, patchouli, bursera, Mentha, musk, Ocimum and other species relevant to the local conditions.

Practicals (40 Hrs.):

Collection and identification of medicinal and aromatic plants from their natural habitat and study their morphological description, herbarium preparation, nursery techniques, harvesting, curing and processing techniques and extraction essential oils.

HORT UG 503. Integrated Insect-Pest Management of Vegetables, Flowers & Spices Credits: 2+1

Teaching Hours: 40+40=80 Hrs.

Unit 1: Insect pest management (28 lectures)

Economic importance of insects in vegetable, ornamental and spice crops -ecology and pest management with reference to these crops. Pest surveillance in important vegetable, ornamental and spice crops. Distribution, host range, bio-ecology, damage, integrated management of important insect-pests affecting vegetable, ornamental and spice crops (selected crops).

Unit 2: Storage pest and its management (10 lectures)

Storage insects – distribution, host range, bioecology, damage, integrated management of important insect pests attacking stored vegetable, flower and spice crops and their processed products.

Unit 3: Toxicology (2 lectures)

Toxicology – insecticide residue problems in vegetable, flower and spice crops and their tolerance limits.

Practicals (40 Hours) :

Study of symptoms, damage, collection, identification, preservation, assessment of damage/population of important insect-pests affecting vegetable, flower and spice crops in field and during storage. Management practices for important pests.

HORT UG 504. Integrated Disease Management of Vegetables, Flowers & Spices Credits 2+1

Teaching Hours: 40+40=80 Hrs.

Unit1: Disease management of Vegetables, Flowers & Spice crops (30 lectures)

Etiology, symptoms, mode of spread epidemiology and integrated management of the diseases and management of important Vegetables, Flowers & Spices crops (selected crops).

Unit2: Post Harvest Disease management (10 lectures)

Important post-harvest diseases of Vegetables, Flowers & Spices crops and their management.

Practicals (40 Hrs.):

Observations of disease symptoms, identification of casual organisms and host parasite relationship of important diseases. Examination of scrapings and cultures of important pathogens of vegetable, flower and spice crops.

HORT UG 505. Breeding of Vegetables, Flowers and Spices Credits:2+1

Teaching Hours: 40+40=80 Hrs.

Unit 1: Introduction to breeding of Vegetables, Flowers & Spices crops (5 lectures)

History, importance of breeding in Vegetables, Flowers & Spices crops production, distribution, domestication and adaptation and centres of origin, plant bio-diversity and its conservation,

Unit 2: Modes of reproduction in Vegetables, Flowers & Spices crops (10 lectures)

Modes of reproduction, pollination systems and genetics of important of commercially important Vegetables, Flowers & Spices crops.

Unit 3: Breeding strategies and achievements (20 lectures)

Variability for economic traits, breeding strategies, clonal selection, bud mutations, mutagenesis and its application in crop improvement – polidy manipulations. Breeding techniques employed in Vegetables, Flowers & Spices .Principles of breeding in self-and cross pollinated crops, pure line selection, mass selection, heterosis breeding, hybridization, pedigree method, mass pedigree method, bulk method, modified bulk method, single seed descent method and back cross method. Self incompatibility and male sterility, its classification and application in crop improvement.

Unit4: Biotechnology for crop improvement and resistance breeding (5 lectures)

Application of biotechnology in crop improvement. Breeding for disease resistance. MAS, QTL

Practicals (40 Hrs.):

Exercises on floral biology, pollen viability and germination; emasculation and pollination procedures; hybrid seed germination; raising and evaluation of segregating populations; use of mutagens to induce mutations and polyploidy.

HORT UG 506. Farm Mechanization in Horticultural Crops Credits: 2+1

Teaching Hours: 40+40=80 Hrs.

Unit 1: Farm mechanization (6 lectures)

Farm mechanization: benefits and constraints, role of power and energy in mechanization, different sources of power and energy. Ergonomics in design of farm tools, safety aspects of agricultural machinery.

Unit 2: Implements for land preparation and sowing etc. (10 lectures)

Horticultural land preparation implements: Tillage, methods of ploughing, field capacity and working out problems. Primary tillage implements: function of indigenous ploughs, mould board ploughs, disc and rotary ploughs, chisel plough, hole-diggers, and augers. Secondary tillage implements: function of tillers, harrows, levelers, ridgers, bund formers, channel formers, and trencher. Nursery raising machinery: planters, under cutters, compost and soil shredders, rotary sieves - functions of components. Sowing machines: seed drills, planters, and plant replacer.

Unit 3: Implements for interculture and mowing etc. (9 lectures)

Intercultural equipments: sweep, junior hoe, weeders, power rotary weeder - types and their uses. Mowing machines: types and uses. Harvesting tools, turf aerators, rakes, edge trimmers, turf cutters, chain saws, hedge cutters, pruner. Plant protection equipment: types and uses of sprayers, dusters, orchard sprayers.

Unit 4: Harvesting equipment (9 lectures)

Equipment for root crops and fruits harvesting – turmeric digger, onion digger, potato digger, cassava digger, fruit crop harvesting – manual fruit plucker, and tree shakers. Cost analysis of Farm Machinery and equipment. Selection of systems of equipment for horticultural crops.

Unit 5: Cost and maintenance of farm equipments (6 lectures)

Cost analysis of Farm Machinery and equipment. Selection of systems of equipment for horticultural crops. Repair and maintenance of farm equipment.

Practicals (40 Hours) :

IC engines – showing the components of dismantled engines. Identification of functional components of tractors and power tillers. Tractor and power tiller operation. Primary & secondary tillage implements: hitching, adjustments, and operations. Plant protection equipment: calculation of dilution ratio, calibration and operation. Weeding & harvesting equipment: adjustment and operations of weeders, mowers, fruit harvester, plucker, tapioca puller, ladders & hoists, multi-utility elevated platform. Local implements.

HORT UG 507. Principles of Landscaping Credits: 1+1

Teaching Hours: 20+40= 60 Hrs.

Unit 1: Introduction to landscaping (4 lectures)

Basic principles and components of landscaping. Principles of landscape design, Principles of gardening, land scaping, garden components, adornments, lawn making, methods of designing rockery, water garden etc.

Unit 2: Garden layouts (6 lectures)

Layout of formal garden: layout of informal gardens, Drawing tool for designing of landscape garden, graphic language for design preparation,. Preparation of landscape design: Criteria for landscape design, Different types of design maps/ formats, Ccomputer Aid Designing (CAD) Special types of gardens, their designs, their walk paths, bridges, trees, constructed features, values in landscaping. Planting climbers and creepers, annuals, flowering plants, palms, ferns, grasses and cacti succulents. Different types of gardens, vertical gardens, roof gardens, park and public gardens.

Unit 3: Landscape gardening of different places I (4 lectures)

Consoderation for landscaping for home dardens educational institute, official sites, market place, hospital.

Unit 4: Landscape gardening of public places II (6 lectures)

Landscaping in place of public importance like town, railway station/bus terminus, educational institutes, industrial sites, place of historical importance and worship, home gardens, roadside avenue plantation, colonies, river banks, planting materials for play grounds, CAD.

Practicals (40 Hours):

Selection of ornamental plants, practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens, burlapping, lawn making, planting herbaceous and shrubbery borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, Application of CAD

HORT UG 508. Weed Management in Horticultural Crops **Credits: 1+1**

Teaching Hours: 20+40=60 Hrs.

Unit1: Introduction **(5 lectures)**

Introduction, harmful and beneficial effects, classification, propagation and dissemination; Weed biology and ecology, crop weed association, crop - weed competition and allelopathy. Seasonal weeds.

Unit2: Weed control **(5 lectures)**

Concepts of weed prevention, control and eradication; Methods of weed control: physical, cultural, chemical and biological methods. Integrated weed management.

Unit 3: Herbicides **(10 lectures)**

Herbicide classification, formulations, methods of application; Introduction to Adjuvants and their use in herbicides; Introduction to selectivity of herbicides; Compatibility of herbicides with other agro chemicals; Weed management in major field and horticultural crops, shift of weed flora in cropping systems, aquatic and problematic weeds and their control.Advantages and limitation of herbicide usage in India.

Practicals (40 Hrs.):

Identification of weeds; Survey of weeds in crop fields and other habitats; Preparation of herbarium of weeds; Calculations on weed control efficiency and weed index; Herbicide label information; Computation of herbicide doses; Study of herbicide application equipment and calibration; Demonstration of methods of herbicide application; Preparation of list of commonly available herbicides; Study of phytotoxicity symptoms of herbicides in different crops; Biology of nut sedge, bermuda grass, parthenium and celosia; Economics of weed control practices.

Semester VI

HORT UG 601. Protected Cultivation of Horticultural Crops Credits:2+1

Teaching Hours: 40+40=80 Hrs.

Unit 1: Basic principles (3 lectures)

Importance, scope and basic principles of protected cultivation of horticultural crops.

Unit 2: Protected structures and components (12 lectures)

Greenhouse designs, use of portable tunnel. types of protected structures, greenhouses, polyhouses, shade houses, rain shelters etc., designing and erection of protected structures. Low cost/Medium cost/High cost structures, economics of cultivation; location specific designs; structural components;

Unit 3: Environmental control and management (7 lectures)

Environment control, management and manipulation of temperature, light, humidity, air and CO2; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooling , light regulation.

Unit 4: Protected cultivation techniques (18 lectures)

Containers and substrates, media decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, IPM and IDM, Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); staking and netting. Harvest indices, harvesting techniques, post-harvest handling techniques, Precooling, sorting, grading, packing, storage, quality standards, Green house cultivation of important horticultural crops- Tomato, Cucumber, Capsicum, Bell Pepper, Gerbera, Rose, Carnation and Strawberry,Orchid.

Practicals (32 Hrs.):

Study of various protected structures, soil decontamination techniques, practices in environmental control systems, practices in drip and fertigation techniques, special horticultural practices, harvesting methods, post harvest handling, packing methods, project preparation, visit to commercial Green houses. Spray of PP chemicals.

HORT UG 602. Apiculture, Sericultureand Mushroom Cultivation Credits: 1+2

Teaching Hours: 20+80=100 Hrs.

Unit 1: (4 lectures)

Importance and history of apiculture, different species of bees, morphology, anatomy, colony organization and life cycle, bee-keeping equipment, social behaviour, reproduction, queen rearing, bee pasturage, seasonal management, economics of beekeeping.

Unit 2: (4 lectures)

Bee enemies, diseases of bees, role of bees in increasing the productivity of horticultural crops in India economy, bee products and their uses. Recent trends in apiculture. Acquaintance with honey bee species, morphology, structural adaptation, biology-castes-bee-keeping equipment, bee forage plants.

Unit 3: (4 lectures)

Collection and preservation of bee flora, enemies and diseases of bees. Handling of bee colonies and manipulation for honey production.

Unit 4 (4 Lectures)

Introduction to sericulture, identification of silk moth, basic life cycle of silk moth, enemies of silk moth

Unit 5 (4 Lectures)

Manual and industrial level silk production, equipments required for silk production and scientific procedure

Practicals (80 Hrs.):

Handling of bee colonies (on and off season); extraction of honey from the honey comb; visit to apiculture centre. Identification of silk moth, study of basic life cycle, visit to commercial silk rearing centre, cultivation of silk rearing plant species. Introduction to mushrooms fungi – nutritional value, edible and poisonous types, edible mushrooms, Pleurotus, Volvariella and Agaricus, medicinal value of mushrooms, genetic improvement of mushroom, preparation of culture, mother spawn production, multiplication of spawn, cultivation techniques, harvesting, packing and storage; problems in cultivation – diseases, pest and nematodes – weed moulds and their management strategies. Economics of cultivation, post harvest technologies. Equipment and sterilization techniques for culture media, isolation of mother culture, and span preparation and maintenance of mushroom beds of oyster mushroom, Volvariella and Agaricus. Processing and preservations of mushrooms, economics of spawn and mushroom production and mushroom recipes

HORT UG 603. Processing and Value addition of Horticultural Crops Credits: 1+2

Teaching Hours: 20+80=100 Hrs.

Unit1: (4 lectures)

Importance and scope of fruit and vegetable preservation industry in India, food pipe line, losses in post-harvest operations, unit operations in food processing.

Unit 2: (1 lecture)

Principles and guidelines for the location of processing units.

Unit 3: (5 lectures)

Principles and methods of preservation by heat pasteurization, canning, bottling. Methods of preparation of juices, squashes, syrups, cordials and fermented beverages. Jam, jelly and marmalade. Preservation by sugar and chemicals, candies, crystallized fruits, preserves chemical preservatives, preservation with salt and vinegar, pickling, chutneys and sauces, tomato and mushrooms, freezing preservation.

Unit 4: (6 lectures)

Processing and value addition of plantation crops, products, spoilage in processed foods, quality control of processed products, Govt. policy on import and export of processed fruits.

Unit 5: (4 lectures)

Food laws.Product development from flowers and ornamental crops.

Practicals (80 Hours):

Equipment used in food processing units. Physico-chemical analysis of fruits and vegetables. Canning of fruits and vegetables, preparation of squash, RTS, cordial, syrup, jam, jelly, marmalade, candies, preserves, chutneys, sauces, pickles. Dehydration of fruits and vegetables – tomato product dehydration, refrigeration and freezing, cut out analysis of processed foods. Processing of flower and plantation crops. Visit to processing units.

HORT UG 604. Seed Production of Vegetable and Flowers Credits: 2+1

Teaching Hours: 40+40= 80 Hrs.

Unit I Introduction (3 lectures)

Seed ,definition ,importance ,quality characteristics ,history of seed industry classes of seed, difference between Orthodox and recalcitrant seeds, generation system , multiplication ratio, seed replacement rate, varietal deterioration ,causes ,maintenance.

Unit 2 Principles of seed production (5 lectures)

Methods and tools of seed production in variety and hybrid, seed crop management, land requirement, isolation, pre-sowing seed treatment, dormancy, spacing,nutrient-irrigation, contaminants, rouging, plant protection, physiological maturation, pre-harvest sanitation spray, harvest and postharvest techniques, extraction, methods, drying, processing, seed treatment, pre-storage, packing ,storage, mid-storage treatment.

Unit 3 Seed quality control and seed certification (5 lectures)

Seed certification, phases, procedures, general and specific standards, field inspection, field counts, contaminants, post harvest inspection, seed standards, bagging, tagging, blending of seed lots, grow out test.

Unit 4 Seed testing (3 lectures)

Seed testing, importance, seed lot, seed sample, sampling methods, purity analysis, moisture estimation, germination tests, viability test, seed vigour tests, seed health test.

Unit 5 Seed legislation (5 lectures)

Seed Act and Rules, Central Seed Committee, Central Seed Certification Board, State Seed Certification Agency, Central and State Seed Testing Laboratories, Seed Inspector duties and responsibilities, offences and penalties , Seed Control Order 1983, New policy on seed development / New Seed Policy 1988, National Seed Policy 2002, Seed Bill 2004.

Unit 6 Introduction to horticultural crops seed production (2 lectures)

Variety and hybrid seed production, factors influencing seed production, seed production planning.

Unit 7 Seed production in tropical vegetables (8 lectures)

Seed production in tomato, brinjal and chilli (solanaceae), bhendi (malvaceae) and cowpea, lablab and (fabaceae), bitter gourd, riuge gourd and bottle gourd (cucurbitaceae) -onion (alliaceae), amaranthus (amaranthaceae)and yam (Dioscoreaceae)

Unit 8 Seed production in temperate vegetables (6 lectures)

Seed production in cabbage, cauliflower (cruciferae), carrot(umbelliferae)and beetroot (chenopodiaceae), peas and french beans (fabaceae) -potato (solanaceae).

Unit 9 Seed production in flowers (3 lectures)

Seed production -flower crops –marigold, chrysanthemum and annuals

Practicals (40 Hours):

Study of seed structure, colour size, shape and texture. Field inspection of seed crops. Practices in rouging. Harvesting and seed extraction. Germination and purity analysis. Methods of seed production in self and cross pollinated crops. Seed processing machines. Visit to seed production units.

HORT UG 605. Horti-Business Management **Credits: 2+1**

Teaching Hours: 40+40=80 Hrs.

Unit 1: **(2 lectures)**

Farm management - definition, nature, characteristics and scope. Farm management principles and decision making, production function, technical relationships.

Unit 2: **(8 lectures)**

Cost concepts, curves and functions – factors, product, relationship – factors relationship, product relationship, optimum conditions, principles of opportunity cost-equi-marginal returns and comparative advantages, time value of money, economic of scale, returns to scale, cost of cultivation and production, break even analysis, decision making under risk and uncertainty. Farming systems and types.

Unit 3: **(6 lectures)**

Planning – meaning, steps and methods of planning, types of plan, characteristics of effective plans. Organizations – forms of business organizations, organizational principles, division of labour. Unity of command, scalar pattern, job design, span of control responsibility, power authority and accountability.

Unit 4: **(6 lectures)**

Direction – guiding, leading, motivating, supervising, coordination – meaning, types and methods of controlling – evaluation, control systems and devices.

Unit 5: **(6 lectures)**

Budgeting as a tool for planning and control. Record keeping as a tool of control. Functional areas of management – operations management – physical facilities, implementing the plan, scheduling the work, controlling production in terms of quantity and quality.

Unit 6: **(6 lectures)**

Materials management – types of inventories, inventory costs, managing the inventories, economic order quantity (EOQ). Personnel management – recruitment, selection and training, job specialization.

Unit 7: **(6 lectures)**

Marketing management – definitions, planning the marketing programmes, marketing mix and four P' s. Financial management – financial statements and rations, capital budgeting. Project management – project preparation evaluation measures.

Practicals (40 hrs.):

Visit to the office of agricultural produces trading house, commercial farming units, processing units, markets Project preparation, interaction with market personnel.

HORT UG 606. Organic Farming **Credits: 1+1**

Teaching Hours: 20+40=60 Hrs.

Unit 1: Introduction **(2 lectures)**

Introduction, concept, relevance in present context; Organic production requirements.

Unit 2: Biological intensive nutrient management **(4 lectures)**

Biological intensive nutrient management-organic manures, vermicomposting, green manuring, recycling of organic residues.

Unit 3: Biofertilizers **(4 lectures)**

Biofertilizers; Soil improvement and amendments.

Unit 4: Organic disease, pest and weed management **(6 lectures)**

Use of biocontrol agents, biopesticides pheromones, trap crops, bird perches; Weed management;

Unit 5: Organic certification **(4 lectures)**

Certification,Quality considerations, labeling and accreditation processors, marketing, exports.

Practicals (40 Hrs.):

Raising of vegetable crops organically through nutrient, diseases and pest management; vermicomposting; vegetable and ornamental nursery raising; macro quality analysis, grading, packaging, post harvest management.

Visit to an organic certified village and interaction with the members of small farm holder group regarding quality standard, inspection, certification, labeling and accreditation for farm produce. Bio fertilizer, Bio control agents, Botanicals

HORT UG 607. Introductory Agroforestry & Agri-Horti-Tourism Credits:2+1
Teaching Hours: 40+40=80 Hrs.

Unit 1: (3 lectures)

Agroforestry – definition, objectives and potential. Distinction between agroforestry and social forestry. Status of Indian forests and role in India farming systems.

Unit 2: (9 lectures)

Agroforestry system, sub-system and practice: agri-silviculture, silvipastoral, horti-silviculture, hortisilvipastoral, shifting cultivation, taungya, home gardens, alley cropping, intercropping, wind breaks, shelterbelts and energy plantations.

Unit 3: (4 lectures)

Planning for agroforestry – constraints, diagnosis and design methodology, selection of tree crop species for agro-forestry.

Unit 4: (5 lectures)

Agroforestry projects – national, overseas, MPTS – their management practices, economics of cultivation – nursery and planting (*Acacia catechu, Dalbergia sissoo,, Tectona, Populus, Morus, Grewia, Eucalyptus, Quercus* spp. and bamboo, tamarind, neem etc.)

Unit 5: (6 lectures)

Introduction, rural and green tourism, community-based tourism, home stay villages, types of attributes and their corresponding levels, Peri urban cultivation.

Unit 6: (8 lectures)

Research related to tourism, seasonality, experiences, and events; mass tourism, type of accommodations, log cabins and CONDO to motels; farm inns, experiences, events and meals, the cost factors.

Unit 7: (6 lectures)

History of Green Tourism, promotion policies and its potential success, Horti tourism in Sikkim.

Practicals:

Identification and seeds and seedlings of multipurpose tree species. Nursery practices for poplar, *Grewia optiva, Morus alba, Acacia catechu, Dalbergia sissoo,* robinia, leucaena, *Alnus*, Teak etc. Visit to agro-forestry fields to study the compatibility of MPTS with agricultural crops: silvipastoral, alley cropping, horti-silviculture, agro-silvipasture, fuel and fodder blocks. Visit to social forestry plantations – roadside plantations, industrial plantations and shelterbelts. Rapid assessment of farmers needs for green manure, fodder, fuel wood in selected villages. Economics and marketing of products raised in agro-forestry systems.

HORT UG 608. Orchard Management **Credits: 1+1**

Teaching Hours: 20+40=60 Hrs.

Unit 1: Introduction **(2 lectures)**

Orchard management, importance, objectives, merits and demerits

Unit 2: Floor Management **(3 lectures)**

Clean cultivation, sod culture, Sod mulch, herbicides and inorganic and organic mulches.

Unit 3: Cropping system **(8 lectures)**

Tropical, sub-tropical and temperate horticultural systems, competitive and complimentary effect of root and shoot systems. Biological efficiency of cropping systems in horticulture, Crop model and crop regulation in relation to cropping systems.

Unit 4: Irrigation, nutrition pest management **(7 lectures)**

Systems of irrigation. Soil management in relation to nutrient and water uptake and their effect on soil environment, moisture, organisms and soil properties. Integrated nutrient and pest management. Utilization of resources constraints in existing systems.

Practicals (40 Hours):

Layout of different systems of orchard soil management, clean, inter, cover and mixed cropping, fillers. Use of mulch materials, organic and inorganic, moisture conservation, weed control. Layout of various irrigation systems.

SEMESTER VII

HORT UG 701. EXPERIENTIAL LEARNING (Rural Horticulture Work experience (RHWE) & Industrial/ Institutional attachment) **Credits: 5+10**

To inculcate professional attitude one full semester the students will be attached with village/industry/institutes connected with horticulture activities.

Orientation	– 3 weeks
RHWE	- 7 weeks
Industrial attachment	- 3 weeks
Institutional attachment	- 3 weeks
Report writing & Evaluation	- 2 weeks

HORT UG 702. All India Study Tour (winter vacation) **Credits: 0+1**

Visit to the research institutes of various agro climatic regions and horticulture zones of India. Report writing & viva voce.

SEMESTER VIII

HORT UG 801. EXPERIENTIAL LEARNING (Professional Package) Credits: 5+10

To inculcate entrepreneurship skill and confidence among the students studying horticulture as a major subject, it was felt that the graduates coming out must have adequate hands on experience on different aspects of horticulture for which provision for one semesterof professional pachage with a total course credit of 15 has been made in the eighth semester. The following four areas have been identified and detailed as a model with different activities for learning and evaluation. The students would be required to prepare a work plan in the area selected with end-to-end approach *i.e* from purchasing the input to producing a product and marketing. It should have components of project development, monitoring and accounting. Students at the end of completion of project will submit report for evaluation. An advisor/ faculty member will guide the students and supervise their work and a committee appointed by the Dean of the Faculty/Academic Executive will evaluate the project. The evaluation will entail skills developed/learnt, proficiency in project execution, project report preparation followed by viva-voce.

Final year B.Sc (Hort.) students have to select any one area from the following to undergo specialized training.

I. Nursery Production and Orchard Management-

1. Project proposal preparation
2. Nursery registration, methodology and processing of certification
3. Establishment and management of plant propagating structures
4. Plant tissue culture practices
5. Establishment of progeny blocks, identification of mother plants and maintenance of bud wood bank
6. Procurement of inputs (pots, polythene, FYM etc.)
7. Techniques and environment management for large scale production
8. Packaging and selling of plant material
9. Working out economics
10. Project report preparation
11. Viva -voce

II. Floriculture

1. Project proposal preparation
2. Soil and water analysis, preparation of land and layout
3. Visit to flower growing areas and export house
4. Specialized lectures by the experts
5. Production and management of commercial flowers

6. Harvesting and post harvest handling of produces
7. Marketing of produces
8. Cost analysis
9. Institutional management
10. Attachment with private landscape agencies
11. Planning and designing, site analysis, selection and use of plant material for landscaping
12. Formal and informal garden, features, styles, principles and elements of landscaping
13. Preparation of landscape plans of home gardens, farm complexes, public parks, institutions, highways, dams and avenues
14. Making of lawns, use of software in landscape
15. Making of bouquets, button hole, wreath, *veni* and *gajras*, car and marriage palaces
16. Dry flower technology (identification of suitable species, drying, packaging and forwarding techniques)
17. Project report preparation
18. Viva-voce

III. Protected Cultivation of High Value Horticultural Crops

1. Project proposal preparation
2. Specialized lectures by the commercial flower experts
3. Study of designs of green house structures for cultivation of crops
4. Land preparation and soil treatment
5. Visit to commercial poly houses
6. Planting and production:

v Cultural management including soil/media management in poly house

v Fertigation and irrigation management

v Integrated Pest Management

v Harvesting and Post harvest management, certification and distribution; cost of production

7. Visit to export houses
8. Market intelligence/survey
9. Marketing of produce
10. Cost analysis

11. Institutional management
12. Project report preparation
13. viva-voce

IV. Post Harvest Technology and value Addition

1. Project proposal preparation
2. Design and layout of pilot plant, cold store, grading-packing line cool-chain
3. Pre-harvest practices to extend shelf life
4. Quality standards of fruits and vegetable for processing
5. Procurement of raw material, inventory control
6. Post harvest handling; grading; packaging; cool chain transportation and storage of fresh produce
7. Processing (juice/pulp extraction, concentration, product preparation; dehydration, waste management; input quality control)
8. Packaging (bottling, corking, sealing, labeling, aseptic packaging, storage)
9. Quality laboratory exercises, quality assurance, analytical tools, hygiene, machinery maintenance, HACCP, International standards, FPO License, PFA standards, Codex law
10. Sales promotion, certification, distribution and marketing, banking, finance and institutional managements
11. Work experience in food processing unit.
12. Project report preparation
13. Viva-voce

HORT UG 802. Physical Education/NCC/NSS Credits: 0+1

NSS: Orientation of students in national problems, study of philosophy of NSS, fundamentals rights, directive principles of state policy, socio-economic structure of Indian society, population problems, brief of five year plan. Functional literacy, non-formal education of rural youths, eradication of of social evils, awareness programmes, consumer awareness, highlights of consumer act. Environment enrichment and conservation, health, family welfare and nutrition.

NCC: Introduction to NCC, defence services, system of NCC training, foot drill, sizing, forming up in three ranks, open and close order match, dressing, getting on parade, dismissing and falling out, saluting, marching, arms drill, shoulder arm, order arm, present arm, guard of honour, ceremonial drill, weapon training-rifle bayonet, light machine gun, sten machine carbine, introduction and characteristic stripping, assembling and cleaning, loading, unloading and firing. Field craft, visual training, targets, judging distance, fire discipline and firecontrol orders, battle craft, field signals, description of ground, section formation, section battle drill, scouts and patrols, ambush, field engineering, map reading, conventional signs, grid systems, use of service protractor, prismatic compass and its use, self defence, general principles, precaution and training, attacks and counter attacks, marching and searching, first aid, hygiene and sanitation, civil defence, leadership and NCC song.

Physical Education: Introduction to physical education. Posture, exercise for goodposture, physical fitness exercises for agility, strength, coordination, endurance and speed. Rules are regulations of important games, skill development in any of the games-football, hockey, volleyball, badminton, throw ball, tennikoit. Participation in of the indoor games- shuttle badminton, chess and table tennis. Rules and regulations of athletic events, participation in any one of the athletic events- broad jump, high jump, triple jump, javelin throw, discuss throw, shot put, short and long distance running. Safety education, movement education, effective way of doing day-to-day activities. First-aid training, coaching for major games and indoor games. Asans and indigenous ways for physical fitness and curative exercises. Exercises and games for leisure time, use and experience.

Grand Total 89+71= 160

ORGANIZATION OF COURSE CONTENTS & CREDIT EQUIREMENTS FOR MASTER IN HORTICULTURE

Credit Requirements

Subject	Master's programme
Major	24
Minor	09
Supporting	05
Seminar	01
Research	25
Total Credits	**64**
Compulsory Non Credit	06

Major subject: The subject in which the students want specialization.

Minor subject: The subject closely related to students major subject.

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Non-Credit Compulsory Courses: The courses are relevant supporting major subjects.

Course Structure

CODE	COURSE TITLE	CREDITS
Fruit Science		
HORT PG 101	TROPICAL AND DRY LAND FRUIT PRODUCTION	2+1
HORT PG 102	SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION	2+1
HORT PG 103	BIODIVERSITY AND CONSERVATION OF FRUIT CROPS	2+1
HORT PG 104	BREEDING OF FRUIT CROPS	2+1
HORT PG 105	POST HARVEST TECHNOLOGY FOR FRUIT CROPS	2+1
Floriculture & Landscaping		
HORT PG 111	BREEDING OF FLOWER CROPS AND ORNAMENTAL PLANTS	2+1
HORT PG 112	PRODUCTION TECHNOLOGY OF CUT FLOWERS	2+1
HORT PG 113	PRODUCTION TECHNOLOGY OF LOOSE FLOWERS	2+1
HORT PG 114	LANDSCAPING AND ORNAMENTAL GARDENING	2+1
HORT PG 115	TURFING AND TURF MANAGEMENT	2+1
Vegetable Science		
HORT PG 121	PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS	2+1

HORT PG 122	PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS	2+1
HORT PG 123	BREEDING OF VEGETABLE CROPS	2+1
HORT PG 124	SEED PRODUCTION TECHNOLOGY OF VEGETABLE CROPS	2+1
HORT PG 125	PRODUCTION TECHNOLOGY OF UNDER EXPLOITED VEGETALE CROPS	2+1
Plantation, Spices, Medicinal & Aromatic Plants		
HORT PG 131	PRODUCTION OF PLANTATION CROPS	2+1
HORT PG 132	PRODUCTION TECHNOLOGY OF SPICE CROPS	2+1
HORT PG 133	PRODUCTION TECHNOLOGY OF MEDICINAL AND AROMATIC CROPS	2+1
HORT PG 134	BREEDING OF PLANTATION CROPS AND SPICES	2+1
HORT PG 135	BREEDING OF MEDICINAL AND AROMATIC CROPS	2+1
Common Compulsory major courses for all students		
HORT PG 141	POST HARVEST TECHNOLOGY FOR HORTICULTURAL CROPS	2+1
HORT PG 142	GROWTH REGULATION OF HORTICULTURAL CROPS	2+1
HORT PG 143	PROTECTED CULTIVATION OF HORTICULTURE CROPS	2+1
Compulsory supportive courses for all students		
GP PG 101	BIOTECHNOLOGY FOR CROP IMPROVEMENT	2+1
STAT PG 101	EXPERIMENTAL DESIGNS	2+1
HORT PG 161	MASTER'S SEMINAR	1+0
HORT PG 191	MASTER'S RESEARCH	25
Compulsory Non-Credit Courses		
HORT PG 171	LIBRARY AND INFORMATION SERVICES	0+1
HORT PG 172	TECHNICAL WRITING AND COMMUNICATIONS SKILLS	0+1
HORT PG 173	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN	1+0
HORT PG 174	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
HORT PG 175	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
HORT PG 176	DISASTER MANAGEMENT	1+0

A student majoring in Horticulture has to select any one specialization i.e. Fruits Science/ Floriculture & Landscaping/ Vegetable Science/ Plantation, Spices, Medicinal & Aromatic Plants and all the courses of concerned specialization is compulsory. He/ She can opt for any other specialization courses as minor. All the students should take compulsory supportive courses.

FRUIT SCIENCE

Course Contents

HORT PG 101: TROPICAL AND DRYLAND FRUIT PRODUCTION (2+1)

Theory

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, root stock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bio-regulators, abiotic factors limiting fruit production, physiology of flowering, pollination fruit set and development, honeybees in cross pollination, physiological disorders- causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones(AEZ) and industrial support of the following crops.

UNIT I: Mango and Banana

UNIT II: Citrus and Papaya

UNIT III: Guava, Sapota and Jackfruit

UNIT IV: Pineapple, Annonas and Avocado

UNIT V: Aonla, Pomegranate, Phalsa, Ber and minor fruits of tropics

Practical

Identification of importantcultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical and arid zone orchards, Project preparation for establishing commercial orchards.

Suggested Readings

- Bose TK, Mitra SK& Rathore DS. (Eds.). 1988. *Temperate Fruits- Horticulture*. Allied Publ Bose TK, Mitra SK & Sanyal D. 2001. (Eds.). *Fruits -Tropical and Subtropical*. Naya Udyog.
- ChadhaKL&PareekOP.1996.(Eds.).*Advancesin Horticulture*.Vols.II- IV. Malhotra Publ. House.NakasoneHY& Paul RE. 1998. *Tropical Fruits.* CABI.
- Peter KV. 2008. (Ed.) .*Basics of Horticulture*. New India Publ. Agency. Pradeep Kumar T, Suma B, Jyothibhaskar & Satheesan KN 2008. *Management of Horticultural Crops*. PartsI,II. New India Publ. Agency, New Delhi.
- Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency, New Delhi.
- Singh HP, Negi JP & Samuel JC. (Eds.). 2002. *Approaches for Sustainable Development of Horticulture*. National Horticultural Board.
- Singh HP, Singh G, Samuel JC & Pathak RK. (Eds.). 2003. *Precision Farmingin Horticulture*. NCPAH, DAC/PFDC, CISH, Lucknow.

HORT PG 102: SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION (2+1)

Theory

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, bio-regulation, abiotic factors limiting fruit production, physiology of flowering, fruitset and development, abiotic factors limiting production, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, pre-cooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones(AEZ) and industrial support of the following crops.

UNIT I: Apple, pear, quince, grapes

UNIT II: Plums, peach, apricot, cherries, hazelnut

UNIT III: Litchi, loquat, persimmon, kiwifruit, strawberry

UNIT IV: Nuts- walnut, almond, pistachio, pecan

UNIT V: Minor fruits- mango, steen, carambola, bael, wood apple, fig, jamun, rambutan, pomegranate

Practical

Identification of important cultivars, observations ongrowth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical, subtropical, humid tropical and temperate orchards, Project preparation for establishing commercial orchards.

Suggested Readings

- Bose TK, Mitra SK & Sanyol D. (Ed.). 2002. *Fruits of India – Tropical and Sub-tropical*.3rdEd.Vols.I, II. Naya Udyog.
- Chadha, KL&PareekOP.1996.(Eds.). *Advancesin Horticulture*. Vol. I. Malhotra Publ. House.
- Chadha, KL & Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House.
- Janick J& Moore JN. 1996. *Fruit Breeding*. Vols. I-III. John Wiley & Sons. Nijjar GS. 1977. (Eds.). *Fruit Breeding in India*. Oxford & IBH.
- Radha T& Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.
- Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.).2004.*Advances in Citriculture*. Jagmander Book Agency.

HORT PG 103: BIODIVERSITYAND CONSERVATION OF FRUIT CROPS (2+1)

Theory

UNIT I

Biodiversity and conservation; issues and goals, centers of origin of cultivated fruits; primary and secondary centers of genetic diversity.

UNIT II

Present status of gene centers; exploration and collection of germplasm;

Conservation of genetic resources – conservation *insitu* and *ex situ.*

UNIT III

Germplasm conservation-problem of recalcitrancy- colds storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine.

UNIT IV

Intellectual property rights, regulatory horticulture.. Detection of genetic constitution of germplasm and maintenance of core group.

UNIT V

GIS and documentation of local biodiversity, Geographical indication.

Crops

Mango,sapota,citrus,guava,banana,papaya,grapes,jackfruit,custard, apple,ber,aonla,malus,*Prunus* sp,litchi,nuts,coffee,tea,rubber,cashew, coconut, cocoa, palmyrah, areca nut, oil palm and betel vine.

Practical

Documentation of germplasm – maintenance of passport data and other records of accessions; field exploration trips, exercise on *ex situ* conservation–colds torage, pollen/ seed storage, cryopreservation, visits to National Gene Bank and other centers of PGR activities. Detection of genetic constitution of germplasm, core sampling, germplasm characterization using molecular techniques.

Suggested Readings

- Frankel OH & Hawkes JG. 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press.
- Peter KV & Abraham Z. 2007. *Biodiversity in Horticultural Crops*.Vol. I. Daya Publ. House.
- Peter KV. 2008. *Biodiversity of Horticultural Crops*.Vol.II. Daya Publ. House.

HORT PG 104: BREEDING OF FRUIT CROPS (2+1)

Theory

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, ideo -types, approaches for crop improvement - introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops.

UNIT I : Mango, banana and pineapple

UNIT II: Citrus, grapes, guava and sapota

UNIT III: Jackfruit, papaya, custard apple, aonla, avocado and ber

UNIT IV: Mangosteen, litchi, jamun, phalsa, mulberry, raspberry, kokum nuts

UNIT V: Apple, pear, plums, peach, apricot, cherries and strawberry

Practical

Characterization of germplasm, blossom biology, study of anthesis, estimating fertility status, practices in hybridization, ploidybreeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for resistance, developing breeding programme for specific traits, visit to research stations working on tropical, subtropical and temperate fruit improvement

Suggested Readings

- Bose TK, Mitra SK & Sanyo lD. (Eds.).2002.*FruitsofIndia–Tropical and Sub-tropical*. 3rdEd. Vols. I, II. Naya Udyog.
- Chadha KL & Pareek OP.1996. (Eds.).*Advancesin Horticulture*. Vol.I. Malhotra Publ. House.
- Chadha KL & Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management.* Malhotra Publ. House.
- Janick J & Moore JN. 1996. *Fruit Breeding*. Vols.I-III. John Wiley & Sons. Nijjar GS. 1977. (Eds.). *Fruit Breeding in India*. Oxford & IBH.
- Radha T& Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.
- Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004.*Advances in Citriculture*. Jagmander Book Agency.

HORT PG 105: POST HARVEST TECHNOLOGY FOR FRUIT CROPS (2+1)

Theory

UNIT I

Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration.

UNIT II

Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling.

UNIT III

Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage-ventilated, refrigerated, MAS, CA storage, physical injuries and disorders.

UNIT IV

Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies.

UNIT V

Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

Practical

Analyzing maturity stages of commercially important horticultural crops, improved packing and storage of important horticultural commodities, physiological loss in weight of fruits and vegetables, estimation of transpiration, respiration rate, ethylene release and study of vase life extension in cut flower using chemicals, estimation of quality characteristics in stored fruits and vegetables, cold chain management -visit to cold storage and CA storage units, visit to fruit and vegetable processing units, project preparation, evaluation of processed horticultural products.

Suggested Readings

- Bhutani RC. 2003. Fruit and Vegetable Preservation. Biotech Books.
- Chadha KL &Pareek OP. (Eds.). 1996 Advances in Horticulture. Vol. IV. Malhotra Publ. House.
- Haid NF &Salunkhe SK. 1997. Post Harvest Physiology and Handling of Fruits and Vegetables. Grenada Publ.
- Mitra SK. 1997. Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruits. CABI.
- Ranganna S. 1997. Hand Book of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill.
- Sudheer KP & Indira V. 2007. Post Harvest Technology of Hor
- Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals. CABI.

FLORICULTURE& LANDSCAPING

Course Contents

HORT PG 111: BREEDING OF FLOWER CROPS AND ORNAMENTAL PLANTS (2+1)

Theory

UNIT I

Importance of breeding in flower crops & ornamental plants , Board objectives of breeding. Principles—Evolution of varieties, origin, distribution, genetic resources, genetic divergence - Patents and Plant Variety Protection in India. Genetic inheritance of flower colour, doubleness, flower size, fragrance, post harvest life.

UNIT II

Breeding methods suitable fo rsexually and asexually propagated flower crops and ornamental plants— introduction, selection, domestication, polyploidy and mutation breeding for varietal development, Role of heterosis, Productio no fhybrids, Malesterility, incompatibility problems, seed production of flower crops.

UNIT III

Breeding constraints and achievements made in commercial flowers - rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster, heliconia, liliums, nerium.

UNIT IV

Breeding constraints and achievements made in ornamental plants – petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snapdragon, pansy) and ornamental foliages–Introduction and selection of plants for water scaping and xeriscaping.

Practical

Description of flower morphology of importance flower crops & ornamental plants Cataloging of cultivars, varieties and species in flowers, floral biology, selfing and crossing, evaluation of hybrid progenies, seed production-Induction of mutants through physical and chemical mutagens, induction of polyploidy, screening of plants for biotic, abiotic stresses and environmental pollution, *in vitro* breeding in flower crops and ornamental plants.

Suggested Readings

- Bhattacharjee SK.2006 .*Advancesin Ornamenta lHorticulture*. Vols.I-VI. Pointer Publ.
- Bose TK & Yadav LP. 1989. *Commercial Flowers.*NayaProkash.
- Chadha KL & Choudhury B.1992. *Ornamental Horticulture in India*. ICAR.
- ChadhaKL.1995.*Advancesin Horticulture.*Vol.XII. Malhotra Publ. House.
- Chaudhary RC. 1993. *Introduction to Plant Breeding.* Oxford & IBH. Singh BD. 1990. *Plant Breeding*. Kalyani.

HORT PG 112: PRODUCTION TECHNOLOGY OF CUT FLOWERS (2+1)

Theory

UNIT I

Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India.

Growing environment, open cultivation, protected cultivation, soil and artificial growing media, soiled contamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO_2 on growth and flowering.

UNIT II

Flower production – climatic requirement, water and nutrient management, fertigation, weed management, rationing, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM: .

UNIT III

Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation.

UNIT IV

Cut flowerst and ardsandgrades, harvestindices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, Storage &transportation, marketing, export potential, institutional support. Flower Agri Export Zones.

Production of Crops: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, liliums, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliages and fillers.

Practical

Botanical description of varieties, propagation techniques, mistchamber operation, training and pruning techniques, practices inmanuring, dripand fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, cold chain, project preparation for regionally important cut flowers, visit to commercial cut flower units and case study.

Suggested Readings

- Arora JS. 2006. *Introductory Ornamental horticulture*. Kalyani. Bhattacharjee SK.2006. *AdvancesinOrnamentalHorticulture*.Vols.I-VI., PointerPubl.
- Bose TK & Yadav LP. 1989.*Commercial Flowers.* NayaProkash.
- Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.
- Chadha KL & Chaudhury B. 1992. *Ornamental Horticulturein India*. ICAR.

- ChadhaKL.1995.*Advancesin Horticulture.*Vol.XII.Malhotra Publ. House.
- LauriaA&RiesVH.2001.*Floriculture–FundamentalsandPractices.*Agrobios.
- PrasadS& Kumar U. 2003. *Commercial Floriculture.*Agrobios.
- RandhawaGS&MukhopadhyayA.1986.*FloricultureinIndia*.Allied Publ.
- ReddyS,JanakiramB,BalajiT,KulkarniS&MisraRL.2007.*Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

HORT PG 113: PRODUCTION TECHNOLOGY FOR LOOSE FLOWERS (2+1)

Theory

UNIT I

Scope of loose flower trade, Significance in the domestic market/ export, Varietal wealth and diversity, propagation, propagation in mist chambers, nursery management, pro-tray nursery under shade nets, transplanting techniques.

UNIT II

Soil and climate requirements, field preparation, systems of planting, precision farming techniques.

Water and nutrient management, weed management, rationing, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM.

UNIT III

Flower for cing an dye around flowering, production for special occasions through physiological interventions, chemical regulation.

UNIT IV

Harvest indices, harvesting techniques, post-harvest handling and grading, pre-cooling, packing and storage, value addition, concrete and essential oil extraction, transportation and marketing, export potential, institutional support, Agri Export Zones for loose flower crops.

Crops: Jasmine, Scented rose, Chrysanthemum, Marigold, Tuberose, Crossandra, Nerium, Hibiscus, Barleria, Celosia, Gomphrena, Non-traditional flowers: Nyctanthes, Tabernaemontana, Ixora, Lotus, Lilies, Tecoma, Champaka, Pandanus.

Practical

Botanical description of species and varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, storage and coldchain, project preparation for regionally important commercial loose flowers, visits to fields, essential oil extraction units and markets.

Suggested Readings

- Arora JS. 2006. *Introductory Ornamental Horticulture*. Kalyani. Bhattacharjee SK. 2006. *Advancesin Ornamental Horticulture*.Vols.I-VI. Pointer Publ.
- Bose TK & Yadav LP. 1989. *Commercial Flowers.* NayaProkash.
- Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.
- Chadha KL & Chaudhury B. 1992. *Ornamental Horticulturein India*. ICAR.
- Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.
- Lauria A & Ries VH. 2001. *Floriculture–Fundamentalsand Practices.* Agrobios.
- Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios.
- Randhawa GS & Mukhopadhyay A.1986. *Floriculturein India.* Allied Publ.
- Sheela VL. 2007. *Flowers in Trade*. New India Publ. Agency.
- Valsalakumari PK, Rajeevan PK, Sudhadevi PK & Geetha CK. 2008. *Flowering Trees*. New India Publ. Agency.

HORT PG 114: LANDSCAPING AND ORNAMENTALGARDENING (2+1)

Theory

UNIT I

Terminology, Garden planting components: arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Production technology for selected ornamental plants.

UNIT II

Study of formal, informal & special types of garden:-layout important features & planting material. Design components & different types of design or map used in landscaping. Auto –CAD.

UNIT III

Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, trafficislands, damsites, ITparks, corporates.

UNIT IV

Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

Practical

Selection of ornamental plants**,** practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens, burlapping, lawn making, planting herbaceous and shrubbery borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

Suggested Readings

- Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.
- Lauria A & Victor HR. 2001.*Floriculture–Fundamentals and Practices* Agrobios.
- Nambisan KMP. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH.
- Randhawa GS & Mukhopadhyay A. 1986. *Floriculturein India*. Allied Publ.
- Sabina GT & Peter KV. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency.
- Valsalakumari et al. 2008. *Flowering Trees*. New India Publ. Agency. Woodrow MG.1999. *Gardening in India*. Biotech Books.

HORT PG 115: TURFING AND TURF MANAGEMENT (2+1)

Theory

UNIT I

Turf industry introduction, importance and scope. Basic requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment.

UNIT II

Visual and functional properties of turf grasses. Turf-grasses-Types, species, varieties, hybrids; Selection of grasses for different locations; Grouping according to climatic requirement- Adaptation.

UNIT III

Preparatory operations; Growing media used for turf grasses - Turf establishment methods, seeding, sprigging / dibbling, plugging, sodding/ turfing, turf plastering, hydro-seeding, astro-turfing.

UNIT IV

Turf management–Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing—mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs.

UNIT V

Establishment and maintenance of turfs for play grounds, viz. golf, football, hockey, cricket, tennis, rugby, etc.

Practical

Identification of turf grasses, Preparatory operations in turf making, Practices in turf establishment, Layout of macro and micro irrigation systems, Water and nutrient management; Special practices – mowing, raking, rolling, soiltop dressing, weed management; Biotic and abiotic stress management; Project preparation for turf establishment, visit to IT parks, model cricket and golf grounds, airports, co-orporates, Govt. organizations; Renovation of lawns; Turf economics.

Suggested Readings

- Nick-Christians 2004. *Fundamentals of Turf grass Management*.

VEGETABLE SCIENCE

Course Contents

HORT PG 121: PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS (2+1)

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/ hybrids, sowing/ planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production of:

UNIT I

Potato

UNIT II

Cole crops: cabbage, cauliflower, knollkohl, sprouting broccoli, Brussels sprout

UNIT III

Root crops: carrot, radish, turnip and beetroot

UNIT IV

Bulb crops: onion and garlic

UNIT V

Peas and broad bean, green leafy cool season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of winter vegetable crops and their economics; Experiments to demonstrate the role of mineral elements, plant growth substances and herbicides; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial greenhouse/ poly house.

Suggested Readings

- Bose TK & Som MG. (Eds.). 1986. *Vegetable Cropsin India*. Naya Prokash.
- Bose TK, Som G & Kabir J. (Eds.). 2002. *Vegetable Crops*. Naya Prokash. Bose TK, Som MG & Kabir J. (Eds.). 1993. *Vegetable Crops*. Naya Prokash.
- Bose TK, Kabir J,Maity TK, ParthasarathyVA & Som MG. 2003.
- *Vegetable Crops*. Vols. I-III. Naya Udyog.
- Chadha KL & Kalloo G. (Eds.).1993-94.*Advances in Horticulture* Vols. V-X. Malhotra Publ. House.
- Chadha KL. (Ed.). 2002. *Hand Book of Horticulture*. ICAR.

- Chauhan DVS.(Ed.).1986.*VegetableProduction in India*. Ram Prasad& Sons.
- Decoteau DR. 2000. *Vegetable Crops*. Prentice Hall.
- Edmond JB, Musser AM &Andrews FS. 1951. *Fundamentals of Horticulture*. Blakiston Co.
- Fageria MS, Choudhary BR & Dhaka RS. 2000. *Vegetable Crops: Production Technology*. Vol. II. Kalyani.
- Gopalakrishanan TR. 2007. *Vegetable Crops*. New India Publ. Agency. Hazra P & Som MG. (Eds.). 1999. *Technology for Vegetable Production and Improvement*. Naya Prokash.
- Rana MK. 2008. *Olericulture in India*. Kalyani Publ.
- Rana MK. 2008. *Scientific Cultivation of Vegetables*. Kalyani Publ. Rubatzky VE & Yamaguchi M. (Eds.). 1997. *World Vegetables:*
- *Principles, Production and Nutritive Values*. Chapman & Hall.
- Saini GS.2001. *A Text Book of Oleri and Flori Culture*. Aman Publ. House.
- Salunkhe D.K & Kadam S.S. (Ed.). 1998. *Hand Book of Vegetable Science and Technology: Production, Composition, Storage and Processing*. Marcel Dekker.
- Shanmugavelu KG. 1989. *Production Technology of Vegetable Crops* Oxford & IBH.
- Singh DK. 2007. *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co.
- Singh S.P.(Ed.). 1989. *Production Technology of Vegetable Crops*. Agril. Comm. Res. Centre.
- Thamburaj S. & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.
- Thompson HC & Kelly WC. (Eds.). 1978. *Vegetable Crops*. Tata McGraw- Hill.

HORT PG 122: PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS (2+1)

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/ hybrids, sowing/ planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures, economics of crop production and seed production of:

UNIT I

Tomato, eggplant, hot and sweet peppers

UNIT II

Okra, beans, cowpea and cluster bean

UNIT III

Cucurbitaceous crops

UNIT IV

Tapioca and sweet potato

UNIT V

Green leafy warm season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of summer vegetable crops and their economics; study of physiological disorders and deficiency of mineral elements, preparation of cropping schemes for commercial farms; experiments to demonstrate the role of mineral elements, physiological disorders; plant growth substances and herbicides; seed extraction techniques; identification of important pests and diseases and their control; maturity standards; economics of warm season vegetable crops.

Suggested Readings

- Bose TK & Som MG. (Eds.). 1986. *Vegetable Cropsin India*. Naya Prokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. *Vegetable Crops*. Vols. I-III. Naya Udyog.
- Bose TK, Som MG & Kabir J. (Eds.). 2002. *Vegetable Crops*. Naya Prokash.
- Brown HD & Hutchison CS. *Vegetable Science*. JB Lippincott Co.
- Chadha K.L & Kalloo G. (Eds.).1993-94.*Advances in Horticulture*.Vols. V-X. Malhotra Publ. House.
- Chadha KL. (Ed.). 2002. *Hand Book of Horticulture*. ICAR.
- Chauhan DVS.(Ed.).1986. *Vegetable Production in India*. Ram Prasad& Sons.

- Decoteau DR. 2000. *Vegetable Crops*. Prentice Hall.
- Edmond JB, Musser AM &Andrews FS. 1964. *Fundamentals of Horticulture*. Blakiston Co
- Fageria MS, Choudhary BR & Dhaka RS. 2000. *Vegetable Crops: Production Technology*. Vol. II. Kalyani.
- Gopalakrishanan TR. 2007. *Vegetable Crops*. New India Publ. Agency. Hazra P & Som MG. (Eds.). 1999. *Technology for Vegetable Production and Improvement*. Naya Prokash.
- Kalloo G & Singh K (Ed.). 2000. *Emerging Scenarioin Vegetable Research and Development*. Research Periodicals & Book Publ. House.
- Nayer NM & More TA 1998. *Cucurbits*. Oxford & IBH Publ.
- Palaniswamy & Peter KV. 2007. *Tuber Crops*. New India Publ. Agency. Pandey AK & MudranalayV. (Eds.). *Vegetable Production in India: ImportantVarieties and Development Techniques.*
- Rana MK. 2008. *Olericulture in India*. Kalyani Publication.
- Rana MK. 2008. *Scientific Cultivation of Vegetables*. Kalyani Publication.
- Rubatzky VE & Yamaguchi M. (Eds.). 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall.
- Saini GS. 2001. *A Text Book of Oleri and Flori Culture*. Aman Publ. House.
- Salunkhe DK & Kadam SS. (Ed.). 1998. *Hand Book of Vegetable Science and Technology: Production, Composition, Storage and Processing*. Marcel Dekker.
- Shanmugavelu KG. 1989. *Production Technology of Vegetable Crops*. Oxford & IBH.
- Singh DK. 2007. *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co.
- Singh NP, Bharadwaj AK, Kumar A & Singh KM. 2004. *Modern Technology on Vegetable Production*. International Book Distributing Co.
- Singh SP. (Ed.). 1989. *Production Technology of Vegetable Crops*. Agril. Comm. Res. Centre.
- Thamburaj S & Singh N. 2004. *Vegetables, TuberCrops and Spices*., ICAR.
- Thompson HC & Kelly WC. (Eds.). 1978. *Vegetable Crops*. Tata McGraw Hill.

HORT PG 123: BREEDING OF VEGETABLE CROPS (2+1)

Theory

Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, molecularmarker, genomics, markerassisted breeding and QTLs, biotechnology and their use in breeding in vegetable crops-Issue of patenting, PPVFR act.

UNIT I

Potato and tomato

UNIT II

Eggplant, hot pepper, sweet pepper and okra

UNIT III

Peas and beans, amaranth, chenopods and lettuce

UNIT IV

Gourds, melons, pumpkins and squashes

UNIT V

Cabbage, cauliflower, carrot, beetroot, radish, sweet potato and tapioca

Practical

Selection of desirable plants from breeding population observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations; induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops; hybrid seed production of vegetable crops in bulk. Screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops, demonstration of sib-mating and mixed population; molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques. Visit to breeding blocks.

Suggested Readings

- Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons. Basset MJ. (Ed.). 1986. *Breeding Vegetable Crops*. AVI Publ.
- Dhillon BS, Tyagi RK, Saxena S. & Randhawa GJ. 2005. *Plant Genetic Resources: Horticultural Crops*. Narosa Publ. House.
- Fageria MS, Arya PS & Choudhary AK. 2000. *Vegetable Crops: Breeding and Seed Production*. Vol. I. Kalyani.
- Gardner EJ. 1975. *Principles of Genetics*. John Wiley & Sons.
- Hayes HK, Immer FR & Smith DC.1955. *Methods of Plant Breeding*. McGraw-Hill.

- Hayward MD, Bosemark NO & RomagosaI. (Eds.). 1993. *Plant Breeding-Principles and Prospects*. Chapman& Hall.
- Kalloo G. 1988. *Vegetable Breeding*. Vols. I-III. CRC Press.
- Kalloo G.1998.*Vegetable Breeding*. Vols. I-III (Combined Ed.).Panima Edu. Book Agency.
- Kumar JC & Dhaliwal MS. 1990. *Techniques of Developing Hybrids in Vegetable Crops*. Agro Botanical Publ.
- Paroda RS & Kalloo G.(Eds.). 1995. *Vegetable Research with Special Reference to Hybrid Technology in Asia-Pacific Regio*n.FAO.
- Peter KV & Pradeepkumar T. 2008. *Genetics and Breeding of Vegetables.* Revised, ICAR.
- Rai N & Rai M. 2006. *Heteros is Breeding in Vegetable Crops*. NewIndia Publ. Agency.
- Ram HH. 1998. *Vegetable Breeding: Principles and Practices*. Kalyani
- Simmonds NW. 1978. *Principles of Crop Improvement*. Longman. Singh BD. 1983. *Plant Breeding*. Kalyani.
- Singh PK, Dasgupta SK & Tripathi SK. 2004. *Hybrid Vegetable Development*. International Book Distributing Co.
- Swarup V. 1976. *Breeding Procedure for Cross-pollinated Vegetable Crops*. ICAR.

HORT PG 124: SEED PRODUCTION TECHNOLOGY OF VEGETABLE CROPS (2+1)

Theory

UNIT I

Definition of seed and its quality, new seed policies; DUS test, scope of vegetable seed industry in India.

UNIT II

Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behaviour, seed development and maturation; methods of hybrid seed production.

UNIT III

Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control.

UNIT VI

Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/ packets), storage and cryopreservation of seeds, synthetic seed technology.

UNIT V

Agro-techniques for seed production in solanaceous vegetables, cucurbits, leguminous vegetables, cole crops, bulb crops, leafy vegetables, okra, vegetatively propagated vegetables.

Practical

Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, physical purity) and seed health testing; testing, releasing and notification procedures of varieties; floral biology; rouging of off-type; methods of hybrid seed production in important vegetable and spice crops; seed extraction techniques; handling of seed processing and seed testing equipments; seed sampling; testing of vegetable seeds for seed purity, germination,vigour and health; visit to seed processing units seed testing laboratory and seed production farms.

Suggested Readings

- Agrawal PK & Dadlani M. (Eds.). 1992. *Techniques in Seed Science and Technology*. South Asian Publ.
- Agrawal RL. (Ed.). 1997. *Seed Technology*. Oxford & IBH.
- Bendell PE.(Ed.). 1998. *Seed Science and Technology: Indian Forestry Species*. Allied Publ.
- Fageria MS, Arya PS & Choudhary AK. 2000. *Vegetable Crops: Breeding and Seed Production*. Vol. I. Kalyani.
- George RAT. 1999. *Vegetable Seed Production*.2ndEd. CABI.
- Kumar JC & Dhaliwal MS.1990 .*Techniques of Developing Hybrids in Vegetable Crops*. Agro Botanical Publ.
- More TA, Kale PB & Khule BW. 1996. *Vegetable Seed production Technology*. Maharashtra State Seed Corp.
- Rajan S & Baby L Markose. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency.
- Singh NP, Singh DK, Singh YK &Kumar V. 2006. *Vegetable Seed Production Technology*. International Book Distributing Co.
- SinghSP.2001. *Seed Production of Commercial Vegetables*. Agrotech Publ. Academy.

HORT PG 125: PRODUCTION TECHNOLOGY OF UNDEREXPLOITED VEGETABLE CROPS (2+1)

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial Varieties/ hybrids, sowing/ planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural perations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed production of:

UNIT I

Asparagus, artichoke and leek

UNIT II

Brussels's sprout, Chinese cabbage, broccoli, kale and artichoke.

UNIT III

Amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathu

(chenopods) and chekurmanis.

UNIT IV

Elephant foot yam, lima bean, winged bean, vegetable pigeon pea, jack bean and sword bean.

UNIT V

Sweet gourd, spine gourd, pointed gourd, Oriental pickling melon and little gourd (kundru).

Practical

Identification of seeds; botanical description of plants; layout and planting; cultural practices; short-term experiments of underexploited vegetables.

Suggested Readings

- Bhat KL. 2001. Minor Vegetables - Untapped Potential. Kalyani.
- lndira P & Peter KV. 1984. Unexploited Tropical Vegetables. Kerala Agricultural University, Kerala.
- Peter KV. (Ed.). 2007-08. Underutilized and Underexploited Horticultural Crops. Vols. I-IV. New India Publ. Agency.
- Rubatzky VE & Yamaguchi M. (Eds.). 1997. World Vegetables:
- Principles, Production and Nutritive Values. Chapman & Hall
- Srivastava U, Mahajan RK, Gangopadyay KK, Singh M &Dhillon BS. 2001. Minimal Descriptors of Agri-Horticultural Crops. Part-II:
- Vegetable Crops. NBPGR, New Delhi.

PLANTATION, SPICES, MEDICINAL & AROMATIC CROPS

Course Contents

HORT PG 131: PRODUCTION OF PLANTATION CROPS (2+1)

Theory

Role of plantation crops in national economy, export potential, IPR issues, clean development mechanism, classification and varietal wealth. Plant multiplication including *in vitro* multiplication, systems of cultivation, multitier cropping, photosynthetic efficiencies of crops at different tiers, rainfall, humidity, temperature, light and soil pH on crop growth and productivity, high density planting, nutritional requirements, physiological disorders, role of growth regulators and macro and micronutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management, training and pruning, crop regulation, maturity indices, harvesting. Cost benefit analysis, organic farming, management of drought, precision farming.

UNIT I: Coffee and tea

UNIT II: Cashew and cocoa

UNIT III: Rubber, palmyrah and oil palm

UNIT IV: Coconut and arecanut

UNIT V: Wattle and betel vine

Practical

Description of botanical and varietal features, selection of motherpalms and seedlings in coconut and areca nut, soil test crop response studies and manuring practices, pruning and training, maturity standards, harvesting, Project preparation for establishing plantations, Visit to plantations.

Suggested Readings

- Anonymous, 1985. *Rubber and its Cultivation*.The Rubber Board of India. Chopra VL & Peter KV. 2005.*Handbook of Industrial Crops*. Panima. Harler CR. 1963. *The Culture and Marketing of Tea*. Oxford Univ. Press. Kurian A &Peter KV. 2007. *Commercial Crops Technology*. New India Publ. Agency.
- Nair MK, Bhaskara Rao EVV, Nambiar KKN & Nambiar MC. 1979. *Cashew*. CPCRI, Kasaragod.
- Peter KV. 2002. *Plantation Crops*. National Book Trust.
- Pradeep Kumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops*. PartI, II. New India Publ. Agency.
- Rai PS & Vidyachandram B.1981. *Review of Work Doneon Cashew*. UAS, Research Series No.6, Bangalore.
- Ranganathan V.1979. *Hand Book of Tea Cultivation*.UPASI,TeaRes. Stn. Cinchona
- Srivastava HC, Vatsaya B & Menon KKG. 1986. *Plantation Crops– Opportunities and Constraints*. Oxford & IBH.
- Thampan PK. 1981. *Hand Book of Coconut Palm*. Oxford & IBH.

HORTPG 132: PRODUCTION TECHNOLOGY OF SPICE CROPS (2+1)

Theory

Introduction, importance of spice crops – historical accent, present status- national and international, future prospects, botany and taxonomy, climatic and soil requirements, commercial varieties/ hybrids, site selection, layout, sowing/ planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, inter cropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, postharvest management, plant protection measures and seed planting material and micro-propagation, precision farming, organic resource management, organic certification, quality control, pharmaceutical significance and protected cultivation of.

UNIT I

Blackpepper, cardamom

UNIT II

Clove, cinnamon and nutmeg, allspice

UNIT III

Turmeric, ginger and garlic

UNIT IV

Coriander, fenugreek, cumin, fennel, ajowain, dill, celery

UNIT V

Tamarind, garcinia and vanilla

Practical

Identification of seeds and plants, botanical description of plant; preparation of herbarium, propagation, nursery raising, field layout and method of planting, cultural practices, harvesting, drying, storage, packaging and processing, value-addition; short term experiments on spice crops.

Suggested Readings

- Agarwal S, Sastry EVD & Sharma RK. 2001. *Seed Spices: Production, Quality, Export*. Pointer Publ.
- Arya PS. 2003. *Spice Crops of India*. Kalyani.
- Bhattacharjee SK. 2000. *Hand Book of Aromatic Plants*. Pointer Publ.
- Bose TK, Mitra SK, Farooqi SK & Sadhu MK (Eds.). 1999. *Tropical Horticulture*. Vol.I. Naya Prokash.
- Chadha KL & Rethinam P.(Eds.). 1993. *Advances in Horticulture*. Vols. IX-X. *Plantation Crops and Spices*.Malhotra Publ. House.
- Gupta S. (Ed.). *Hand Book of Spices and Packaging with Formulae*. Engineers India Research Institute, NewDelhi.

- Kumar NA, Khader P, Rangaswami & IrulappanI. 2000. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Oxford &IBH.
- Nybe EV, Miniraj N & Peter KV. 2007. *Spices*. New India Publ. Agency. ParthasarthyVA, KandiannanV & Srinivasan V. 2008. *Organic Spices*. New India Publ. Agency.
- Peter KV.2001. *Hand Book of Herbs and Spices*. Vols.I-III.Woodhead Publ. Co. UK and CRC USA
- Pruthi JS. (Ed.). 1998. *Spices and Condiments*. National Book Trust
- Pruthi JS.2001. *Minor Spices and Condiments- Crop Management and Post Harvest Technology*. ICAR.
- Purseglove JW, Brown EG, Green CL &Robbins SRJ. (Eds.). 1981. *Spices*. Vols.I, II.Longman.
- Shanmugavelu KG, Kumar N & Peter KV. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.
- Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.
- Tiwari RS & Agarwal A. 2004. *Production Technology of Spices*. International Book Distr. Co.
- Varmudy V.2001. *Marketing of Spices*. Daya Publ. House.

HORT PG 133: PRODUCTION TECHNOLOGY FOR MEDICINAL AND AROMATIC CROPS (2+1)

Theory

UNIT I

Herbal industry, WTO scenario, Export and importstatus, Indian system of medicine, Indigenous Traditional Knowledge, IPR issues, Classification of medicinal crops, Systems of cultivation, Organic production, Role of institutions and NGO's in production, GAP in medicinal crop production.

UNIT II

Production technology for Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Sarpagandha, *Dioscorea* sp., *Aloe vera*, *Phyllanthus amarus*, *Andrographis paniculata.*

UNIT III

Production technology for Medicinal solanum, Isabgol, Poppy, Safedmusli, *Stevia rebaudiana*, *Mucunapruriens*, *Ocimum sp.*

UNIT IV

Post harvest handling–Drying, Processing, Grading, Packing and Storage, processing and value addition; GMP and Quality standards in herbal products.

UNIT V

Influence of biotic and abiotic factors on the production of secondary metabolites, Regulations for herbal raw materials, Phytochemical extraction techniques.

UNIT VI

Aromatic industry, WTO scenario, Export and import status, Indian perfumery industry, History, Advancements in perfume industry.

UNIT VII

Production technology for palmarosa, lemongrass, citronella, **v**ettiver, geranium, artemisia, mentha, ocimum, eucalyptus, rosemary, thyme, patchouli, lavender, marjoram, oreganum.

UNIT VIII

Post-harvest handling, Distillation methods, advanced methods, Solvent extraction process, steam distillation, Perfumes from non-traditional plants, Quality analysis, Value addition, Aroma chemicals, quality standards and regulations.

UNIT IX

Institutional support and international promotion of essential oil and perfumery products.

Practical

Botanical description, Propagation techniques, Maturity standards, Digital documentation, Extraction of secondary metabolites, Project preparation for commercially important medicinal crops, Visit to medicinal crop fields, Visit to herbal extraction units. Extraction of Essential oils, Project preparation for commercially important Aromatic crops, Visit to distillation and value addition units–Visit to CIMAP.

Suggested Readings

- Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Aromatic Plants*. RRL, CSIR, Jammu.
- Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.
- Farooqi AA & Sriram AH. 2000. *Cultivation Practices for Medicinal and*
- *Aromatic Crops*. Orient Longman Publ.
- Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops*. Natural Remedies Pvt. Ltd. Hota D. 2007. *Bio Active Medicinal Plants*. Gene Tech Books.
- Jain SK. 2000. *Medicinal Plants*. National Book Trust.
- Khan IA & Khanum A. *Role of Bio Technology in Medicinal and Aromatic Plants*. Vol. IX. Vkaaz Publ.
- Kurian A & Asha Sankar M. 2007. *Medicinal Plants*. Horticulture Science Series, New India Publ. Agency.
- Panda H.2002. *Medicinal Plants Cultivation and their Uses*. Asia Pacific Business Press.
- Prajapati SS, Paero H, Sharma AK & Kumar T. 2006. *A Handbook of Medicinal Plants*. AgroBios.
- Ramawat KG & Merillon JM. 2003. *Biotechnology-Secondary Metabolites*. Oxford & IBH.
- Skaria P Baby, Samuel Mathew, Gracy Mathew, Ancy Joseph, Ragina Joseph.2007. *Aromatic Plants*. New India Publ. Agency.

HORT PG 134: BREEDING OF PLANTATION CROPS AND SPICES (2+1)

Theory

Species and cultivars, cytogenetics, survey, collection, conservation and evaluation, blossom biology, breeding objectives, approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, molecular aided breeding and biotechnological approaches, marker-assisted selection, bioinformatics, IPR issues, achievements and future thrusts.

Crops

UNIT I: Coffee and tea

UNIT II: Cashew and cocoa

UNIT III: Rubber, palmyrah and oil palm

UNIT IV: Coconut and arecanut

UNIT V: Black pepper and cardamom

UNIT VI: Ginger and turmeric

UNIT VII: Fenugreek, coriander, fennel, celery and ajwoain

UNIT VIII: Nutmeg, cinnamon, clove and allspice

Practical

Characterization and evaluation of germplasm accessions, Blossom biology, studies on pollen behaviour, practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for biotic and abioticstresses, haploid culture, protoplast culture and fusion-induction of somaclonal variation and screening the variants. Identification and familiarization of spices; floral biology anthesis; fruitset; selfing and crossing techniques; description of varieties. Salient features of improvedvarieties and cultivars from public and private sector, bioinformatics, visit to radiotracer laboratory, national institutes for plantation crops and plant-genetic resource centers, genetic transformation in plantation crops for resistance to biotic stress/quality improvement etc.

Suggested Readings

- Anonymous1985. *Rubber and its Cultivation*. The Rubber Board of India. Chadha KL & Rethinam P. (Eds.). 1993. *Advances in Horticulture*. Vol. IX. *Plantation Crops and Spices*. Part-I. Malhotra Publ. House.
- Chadha KL, Ravindran PN & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops.* Malhotra Publ. House.
- Chadha KL. 1998. *Advances in Horticulture*. Vol. IX. *Plantation and Spices Crops*. Malhotra Publishing House, New Delhi.
- Chopra VL & Peter KV. *Handbook of Industrial Crops*. Haworth Press.
- Panama International Publishers, New Delhi (Indian Ed.). Damodaran VK,Vilaschandran T&.Valsalakumari PK.1979. *Researchon Cashewin India*. KAU, Trichur.
- Ferwerden FP & WitF. (Ed.).1969.*Outlines of PerennialCropBreeding in the Tropics*. H. Veenman & Zonen.
- Harver AE. 1962. *Modern Coffee Production*. Leonard Hoff.
- Raj PS & Vidyachandra B. 1981. *Review of Work Done on Cashew*. UAS Research Series No.6, Bangalore.
- Thampan PK 1981. *Hand Book of Coconut Palm*. Oxford & IBH.

HORT PG 135: BREEDING OF MEDICINAL AND AROMATIC CROPS (2+1)

Theory

UNIT I

Plant bio-diversity, conservation of germplasm, IPR issues, Major objectives of breeding of Medicinal and Aromatic Crops, Scope for introduction; cytogenetic background of important Medicinal and Aromatic Crops; Scope for improvement of Medicinal and Aromatic Crops through selection, intra and interspecific hybridization, induced autotetraploidy, mutation breeding and biotechnological approaches.

UNIT II

Breeding for yield and quality improvement in medicinal plants, Breeding for high herbage yield, essential oil and quality components, secondary metabolites in medicinal and aromatic crops; Genetics of active principles and assay techniques useful in evaluation of breeder's material. Breeding problems in seed and vegetatively propagated medicinal and aromatic crops.

UNIT III

Achievements and prospects in breeding of medicinal crops, *viz*. *Cassiaa ngustifolia*, *Catharanthus roseus*, *Gloriosa superba*, *Coleus forskohlii*, Stevia, *Withania somnifera*, *Papaver somniferum*, *Planta goovata*, *Dioscorea* sp.

UNIT IV

Prospects in breeding of medicinal crops, *viz. Chlorophytum* sp, *Rauvo lfiaserpentina*, *Aloevera*, *Ocimum* sp, *Phyllanthus amarus, Solanum* sp.

UNIT V

Prospects in breeding of aromatic crops viz., Geranium, vettiver, Lemon grass, Palmarosa, citronella, Rosemary, Patchouli, Eucalyptus, Artemisia and Mint.

Practical

Description of Botanical features, Cataloguing of cultivars, varieties and species in medicinal and aromatic crops, Floral Biology, Selfing and crossing, Evaluation of hybrid progenies, Induction of economic mutants, High alkaloid and high essential oil mutants, evolution of mutants through physical and chemical mutagens, Introduction of polyploidy, Screening of plants for biotic and abiotic stress and environmental pollution, *in-vitro* breeding in medicinal and aromatic crops.

Suggested Readings

- Atal CK & Kapur BM.1982.*CultivationandUtilization of Medicinal Plants*. RRL, CSIR, Jammu.
- Chadha KL & Gupta R.1995.*Advances in Horticulture*. Vol.XI. Malhotra Publ. House.
- Farooqi AA, Khan MM & VasundharaM. 2001. *Production Technology of*
- *Medicinal and Aromatic Crops*. Natural Remedies Pvt. Ltd. Jain SK. 2000. *Medicinal Plants*. National Book Trust.
- Julia F & Charters MC. 1997. *Major Medicinal Plants – Botany, Cultures and Uses*. Thomas Publ.
- Kurian A & Asha Sankar,M. 2007. *Medicinal Plants*. Horticulture Science Series, New India Publ. Agency.
- Prajapati ND, Paerohit SS, Sharma AK, Kumar T. 2006. *A Handbook of Medicinal Plants*. Agro Bios (India).
- Skaria P Babu. 2007. *Aromatic Plants*. New India Publ. Agency.
- Thakur RS, Pauri HS & Hussain A. 1989.*Major Medicinal Plants of India*. CSIR.

COMMON COMPULSORY MAJOR COURSES FOR ALL STUDENTS

HORT PG 141: POST HARVEST TECHNOLOGY FOR HORTICULTURE CROPS (2+1)

Theory

UNIT I

Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration.

UNIT II

Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling.

UNIT III

Treatments priorto shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage- ventilated, refrigerated, MAS, CA storage, physical injuries and disorders.

UNIT IV

Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies.

UNIT V

Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

Practical

Analyzing maturity stages of commercially important horticultural crops, improved packing and storage of important horticultural commodities, physiological loss in weight of fruits and vegetables, estimation of transpiration, respiration rate, ethylene release and study of vase life extension in cut flower using chemicals, estimation of quality characteristics in stored fruits and vegetables, cold chain management- visit to cold storage and CA storage units, visit to fruit and vegetable processing units, project preparation, evaluation of processed horticultural products.

Suggested Readings

- Bhutani RC. 2003. *Fruit and Vegetable Preservation*. Biotech Books. Chadha KL & Pareek OP. (Eds.). 1996 *Advancesin Horticulture*. Vol. IV. Malhotra Publ. House.
- Haid NF & Salunkhe SK. 1997. *Post Harvest Physiology and Handling of Fruits and Vegetables*. Grenada Publ.
- Mitra SK.1997.*Post Harvest Physiology and Storage Sub-tropical Fruits*. CABI.
- Ranganna S. 1997. *Hand Book of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw-Hill.
- Sudheer KP & IndiraV. 2007. *Post Harvest Technology of Horticultural Crops*. New India Publ. Agency.
- Willis R, McGlassen WB, Graham D & Joyce D. 1998. *Post Harvest. An Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals*. CABI.

HORT PG 142: GROWTH REGULATION OF HORTICULTURAL CROPS (2+1)

Theory

UNIT I

Growth and development- definition, parameters of growth and development, growth dynamics, morphogenesis.

UNIT II

Annual, semi-perennial and perennial horticultural crops, environmental impact on growth and development, effect of light, photosynthesis and photoperiodism vernalisation, effect of temperature, heat units, thermo-periodism.

UNIT III

Assimilate partitioning during growth and development, influence of water and mineral nutrition during growth and development, bio-synthesis of auxins, gibberellins, cytokinins, abscissic acid, ethylene, brasssinosteroids, growth inhibitors, morphactins, role of plant growth promoters and inhibitors.

UNIT IV

Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruitset, fruit drop, fruit growth, ripening and seed development.

UNIT V

Growth and developmental process during stress-manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth development.

Practical

Understanding dormancy mechanisms in seeds, tubers and bulbs and stratification of seeds, tubers and bulbs, visit to arid, subtropical and temperate horticultural zones to identify growth and development patterns, techniques of growth analysis, evaluation of photosynthetic efficiency under different environments, study of growth regulator functions, hormone assays, understanding ripening phenomenon in fruits and vegetables, study of impact of physical manipulations on growth and development, study of chemical manipulations on growth and development, understanding stress impact on growth and development.

Suggested Readings

- Buchanan B, Gruiessam W & Jones R. 2002. *Biochemistry & Molecular Biology of Plants*. John Wiley & Sons.
- Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. Wiley.
- Fosket DE. 1994. *Plant Growth and Development: a Molecular Approach*. Academic Press.
- Leoplod AC & Kriedermann PE. 1985.*Plant Growth and Development*. 3rdEd.McGraw-Hill.
- Peter KV. 2008. (Ed.) *Basics of Horticulture*. New India Publ. Agency. Roberts J, Downs S & Parker P. 2002. Plant Growth Development. In: *Plants* (I. Ridge, Ed.), pp. 221-274, Oxford University Press. Salisbury FB & Ross CW. 1992. *Plant Physiology*. 4thEd.Wadsworth Publ.

HORT PG 143: PROTECTED CULTIVATION OF HORTICULTURE CROPS (2+1)

Theory

UNIT I

Greenhouse – World scenario, Indian situation: present and future, Different agro-climatic zones in India, Environmental factors and their effects on plant growth.

UNIT II

Basics of greenhouse design, different types of structures–glasshouse, shadenet, poly-tunnels- Design and development of low cost greenhouse structures.

UNIT III

Interaction of light, temperature, humidity, CO2, water on crop regulation- Green house heating, cooling, ventilation and shading.

UNIT IV

Types of ventilation-Forced cooling techniques- Glazing materials -Micro irrigation and Fertigation.

UNIT V

Automated greenhouses, microcontrollers, waste water recycling, Management of pest and diseases – IPM.

Practical

Designs of greenhouse, lowcost poly-tunnels, nethouse – Regulation of light, temperature, humidity in greenhouses, media, greenhouse cooling systems, ventilation systems, fertigation systems, special management practices, project preparation for greenhouses, visit to greenhouses.

Suggested Readings

- Aldrich RA & Bartok JW. 1994. *Green House Engineering*. NRAES, Riley, Robb Hall, Cornell University, Ithaca, New York.
- Bhatcharjee BS. 1959. *Rose Growing in Tropics*. Thackars pink & Co.
- Laurie A, Kiplingr DD & Nelson KS.1968.*CommercialFlowerForcing*. McGraw-Hill.
- Mears DR, Kim MK & Roberts WJ. 1971. *Structural Analysisat an Experimental Cable-supported Air Inflated Green Houses.* Trans. ASAE.
- PantVNelson.1991. *Green House Operation and Management*. Bali Publ.
- Pradeep kumar T, Suma B, Jyothibhaskar & Satheesan KN. 2007. *Management of Horticultural Crops.* PartsI, II.New India Publ. Agency.

COMPULSORY SUPPORTIVE COURSES FOR ALL STUDENTS

HORT PG 101: BIOTECHNOLOGY FOR CROP IMPROVEMENT (2+1)

Theory

UNIT I

Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding.

UNIT II

Tissue culture- History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.

UNIT III

Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.), mapping populations (F2s, back crosses, RILs, NILs and DH).

UNIT IV

Molecular mapping and tagging of agronomically important traits.Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding.

UNIT V

Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/ economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression, Generation of EDVs.

UNIT VI

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer. Production of transgenic plants in various horticultural crops and Commercial releases.

UNIT VII

Biotechnology applications in male sterility/hybrid breeding, molecular farming.

UNIT VIII

MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights.

UNIT IX

Bioinformatics & Bioinformatics tools.

UNIT X

Nanotechnology and its applications in crop improvement programmes.

Practical

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants ; observations on the contaminants occurring in media – interpretations - Inoculation of explants; Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial micropropagation unit. Transformation using Agrobacterium strains, GUS assay in transformed cells / tissues. DNA isolation, DNA purity and quantification tests, gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship, construction of genetic linkage maps using computer software.

Suggested Readings

- Chopra VL &Nasim A. 1990. Genetic Engineering and Biotechnology: Concepts, Methods and Applications. Oxford & IBH.
- Gupta PK. 1997. Elements of Biotechnology. Rastogi Publ.
- Hackett PB, Fuchs JA & Messing JW. 1988. An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation. 2nd Ed. Benjamin Publ. Co.
- Sambrook J &Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.
- Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani.

HORT PG 101: EXPERIMENTAL DESIGNS **(2+1)**

Theory

UNIT I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

UNIT II

Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV

Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ Lattice design, alpha design - concepts, randomisation procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

UNIT V

Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation.

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Analysis of resolvable designs; Fitting of response surfaces.

Suggested Readings

- Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
- Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.
- Federer WT. 1985. Experimental Designs. MacMillan.
- Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
- Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.
- Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice.
- Design Resources Server: www.iasri.res.in/design.

HORT PG 161: MASTER'S SEMINAR (1+0)

The students will deliver a one credit compulsory seminar related to his or her major course.

HORT PG 191: MASTER'S RESEARCH (25)

The Master's student will have to submit synopsis of the research work to be done in the first semester and it will be approved by Departmental Research Committee. The student will have to submit thesis maximum at the end of fourth semester.

NON-CREDIT COMPULSORY COURSES

Course Contents

HORT PG 171 LIBRARY AND INFORMATION SERVICES (0+1)

Theory

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate in formation search strategies, and to use modern tools (Internet, OPAC, searching nets etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

HORT PG 172: TECHNICALWRITING AND COMMUNICATIONS SKILLS (0+1)

Theory

To equip the students/ scholars with skills to write dissertations, research papers, etc.

To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

- *Chicago Manual of Style*. 14thEd.1996. Prentice Hall of India.
- *Collins'Cobuild English Dictionary*. 1995. Harper Collins.
- Gordon HM & Walter JA.1970. *Technical Writing*. 3rdEd.Holt,Rinehart & Winston.
- Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of*
- *Current English*. 6thEd. Oxford University Press.
- James HS. 1994. *Handbook for Technical Writing*. NTC Business Books. JosephG.2000. *MLA Handbook for Writers of Research Papers*. 5thEd.
- Affiliated East-West Press.
- Mohan K. 2005. *Speaking English Effectively*. MacMillan, India. Richard WS. 1969. *Technical Writing*. Barnes & Noble.
- Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek. Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English.* 2nd Ed. Prentice Hall of India.
- Wren PC & Martin H. 2006. *High School English Grammar and Composition.* S. Chand & Co.

HORT PG 173: INTELLECTUAL PROPERTY AND ITS MANAGEMENT INAGRICULTURE MENT (e-course) (1+0)

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundament also of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio- diversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protectioninitiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research

Collaboration, Agreement, License Agreement

Suggested Readings

- Erbisch FH & Maredia K. 1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
- Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
- *Intellectual Property Rights: Keyto New Wealth Generation. 2001*. NRDC & Aesthetic Technologies.
- Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol.V. *Technology Generation and IPR Issues*. Academic Foundation.
- Rothschild M & Scott N. Ed.).2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
- Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.
- *The Indian Acts-Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act,1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.*

HORT PG 174: BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/ chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralization of acid and bases; Preparation of buffers of different strengths and pHvalues. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath, water bath, oil bath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Readings

- Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
- Gabb MH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

HORT PG 175: (e-Course) AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partnerinthe global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group– Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

- Bhalla GS & Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.
- Punia MS. *Manual on International Research and Research Ethics*. CCS, Haryana Agricultural University, Hisar.
- Rao BSV. 2007. *Rural Development Strategies and Role of Institutions- Issues, Innovations and Initiatives*. Mittal Publ.
- Singh K..1998. *Rural Development-Principles, Policies and Management.* Sage Publ.

HORT PG 176 DISASTER MANAGEMENT (e-Course) (1+0)

Theory

UNIT I

Natural Disasters Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion

UNIT II

Man Made Disasters - Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial waste water pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III

Disaster Management – Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management frame work; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

Suggested Readings

- Gupta HK. 2003. *Disaster Management*. Indian National Science Academy. Orient Blackswan.
- Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: A Handbook of Disaster Management*. Routledge.
- Sharma VK. 2001. *Disaster Management*. National Centre for Disaster Management, India.

Ph.D HORTICULTURE SYLLABUS

Subject	PhD programme
Major	15
Minor	06
Supporting	06
Seminar	02
Research	46
Total Credits	**75**

Major subject: The subject in which the students want specialization.

Minor subject: The subject closely related to students major subject.

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work

Code	Title of the Course	Credit
	Fruit Science	
HORT RS 101	ADVANCES IN BREEDING OF FRUIT CROPS	2+1
HORT RS 102	ADVANCES IN PRODUCTION OF FRUIT CROPS	2+1
HORT RS 103	ADVANCES IN GROWTH REGULATION OF FRUIT CROPS	2+1
HORT RS 104	GENOMICS AND BIOINFORMATICS IN HORTICULTURE	2+1
HORT RS 105	BIOTIC AND ABIOTIC STRESS MANAGEMENT IN HORTICULTURAL CROPS	2+1
	Floriculture	
HORT RS 111	ADVANCES IN BREEDING OF FLOWER CROPS	2+1
HORT RS 112	ADVANCES IN FLOWER PRODUCTION TECHNOLOGY	2+1
HORT RS 113	ADVANCES IN PROTECTED AND PRECISION FLORICULTURE	2+1
HORT RS 114	ADVANCES IN LANDSCAPE ARCHITECTURE	1+2
HORT RS 115	ADVANCES IN BIOCHEMISTRY AND BIOTECHNOLOGY OF FLOWERS	2+1
	Vegetable Science	
HORT RS 121	ADVANCES IN VEGETABLE PRODUCTION	2+1
HORT RS 122	ADVANCES IN BREEDING OF VEGETABLE CROPS	2+1
HORT RS 123	PROTECTED CULTIVATION OF VEGETABLE CROPS	1+1
HORT RS 124	BIOTECHNOLOGY OF VEGETABLE CROPS	2+1
HORT RS 125	SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE CROPS	1+1
HORT RS 126	ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS	2+1
	Spices, Plantation and Medicinal Crops	
HORT RS 131	ADVANCES IN PRODUCTION OF PLANTATION AND MEDICINAL CROPS	2+1
HORT RS 132	ADVANCES IN SPICE PRODUCTION	2+1
HORT RS 133	ADVANCES IN BREEDING OF PLANTATION, MEDICINAL AND SPICE CROPS	2+1
HORT RS 134	BIOTECHNOLOGY IN PLANATION CROPS, SPICES AND MEDICINAL CROPS	2+1
HORT RS 135	POST HARVEST PROCESSING & EXTRACTION IN MEDICINAL & AROMATIC CROPS	2+1
	Supporting Courses	
PPAT RS 101	MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION	2+1
SSAC RS 101	SOIL BIOLOGY AND BIOCHEMISTRY	2+1
	Compulsory for all the Students	
HORT RS 161	DOCTORAL SEMINAR I	1+0
HORT RS 162	DOCTORAL SEMINAR II	1+0
HORT RS 191	DOCTORAL RESEARCH	46

Fruit Science

HORT RS 101 ADVANCES IN BREEDING OF FRUIT CROPS **2+1**

Objective

To update knowledge on the recent research trends in the field of breeding of fruit crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

Evolutionary mechanisms, adaptation and domestication, Genetic resources, cytogenetics, cytomorphology, chemotaxonomy, genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits , recent

advances in crop improvement efforts- introduction and selection, chimeras, apomixis, clonal selections, intergeneric, interspecific and intervarietal hybridization, mutation and polyploid breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, molecular and transgenic approaches in improvement of selected fruit crops.

Crops

UNIT I :

Mango and banana

UNIT II:

Papaya, grapes and citrus

UNIT III:

Guava and sapota

UNIT IV:

Pineapple and avocado

UNIT V:

Apple, pear, plums, peaches, apricot, cherries and strawberry

Practical

Description and cataloguing of germplasm, pollen viability tests, pollen germination-isozyme techniques-survey and clonal selection, observations on pest, disease and stress reactions in inbreds and hybrids, use of mutagenes and colchicine for inducing mutation and ploidy changes, practices in different methods of breeding fruit crops and in-vitro breeding techniques.

Suggested Readings

1. Bose TK, Mitra SK & Sanyol D. (Ed.). 2002. *Fruits of India – Tropical and Sub-tropical*. 3rd Ed. Vols. I, II. Naya Udyog.

2. Chadha KL & Pareek OP. (Eds.). 1996. *Advances in Horticulture*. Vol. I. Malhotra Publ. House.

3. Chadha KL & Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House.

4. Gowen S. 1996. *Banana and Plantains.* Chapman & Hall.

5. Janick J & Moore JN. 1996. *Fruit Breeding*. Vols.I-III. John Wiley & Sons.

6. Nijjar GS. (Ed.). 1977. *Fruit Breeding in India*. Oxford & IBH.

7. Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

8. Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. *Advances in Citriculture*. Jagmander Book Agency.

9. Stover RH & Simmonds NW. 1991. *Bananas*. Longman.

HORT RS 102 ADVANCES IN PRODUCTION OF FRUIT CROPS **2+1**

Objective

To keep abreast with latest developments and trends in production technology of fruit crops.

Theory

National and International scenario in fruit production, Recent advances in propagation - root stock influence, planting systems, High density planting, crop modeling , Precision farming, decision support systems - aspects of crop regulation-physical and chemical regulation effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, , Total quality management(TQM) - Current topics.

Crops

UNIT I :

Mango and banana

UNIT II:

Papaya, grapes and citrus

UNIT III:

Guava, sapota, pomegranate and aonla

UNIT IV:

Pineapple, avocado, jack fruit and fig

UNIT V:

Apple, pear, plums, strawberry, peach, apricot, cherries and nut crops

Practical

Survey of existing fruit cropping systems and development of a model cropping system, estimating nutrient deficiency-estimation of water use efficiency, soil test-crop response correlations, practices in plant growth regulation, studying physiological and biochemical responses, quality analysis.

Suggested Readings

1. Bose TK, Mitra SK & Rathore DS. (Eds.). 1988. *Temperate Fruits – Horticulture*. Allied Publ.
2. Bose TK, Mitra SK & Sanyal D. (Eds.). 2001. *Fruits -Tropical and Subtropical*. Naya Udyog.
3. Bose TK, Mitra SK, Farooqi AA & Sadhu MK. 1999. *Tropical Horticulture.* Vol. I. Naya prokash.
4. Chadha KL & Pareek OP. (Eds.).1996. *Advances in Horticulture*. Vols. IIIV. Malhotra Publishing House.
5. Chadha KL. 2001. *Handbook of Horticulture*. ICAR.
6. Nakasone HY & Paull RE. 1998. *Tropical Fruits*. CABI.
7. Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

HORT RS 103 ADVANCES IN GROWTH REGULATION OF FRUIT CROPS 2+1

Objective

Appraisal on the advances in growth regulation of fruit crops.

Theory

UNIT I

Ecophysiological influences on growth and development of fruit crops flowering, fruit set- Crop load and assimilate partitioning and distribution.

UNIT II

Root and canopy regulation, study of plant growth regulators in fruit culture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants.

UNIT III

Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards.

UNIT IV

Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production.

UNIT V

Flower drop and thinning, fruitset and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, molecular approaches in crop growth regulation- current topics.

Practical

Root- shoot studies, quantifying the physiological and biochemical effects of physical and chemical growth regulation, bioassay and isolation through chromatographic analysis for auxins, gibberellins, experiments on growth regulation during propagation, dormancy, flowering, fruit set and fruit development stages.

Suggested Readings

1. Buchanan B, Gruiessam W & Jones R. 2002. *Biochemistry & Molecular Biology of Plants*. John Wiley & Sons.
2. Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. Wiley.
3. Fosket DE. 1994. *Plant Growth and Development: A Molecular Approach*. Academic Press.
4. Leoplod AC & Kriedermann PE. 1985. *Plant Growth and Development*. 3rd Ed. McGraw-Hill.
5. Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.
6. Roberts J, Downs S & Parker P. 2002. Plant Growth Development. In: *Plants* (I. Ridge, Ed.), pp. 221-274, Oxford University Press.
7. Salisbury FB & Ross CW. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.

HORT RS 104 GENOMICS AND BIOINFORMATICS IN HORTICULTURE 2+1

Objective

Studies on the fundamentals and application of genomics and bioinformatics in horticulture.

Theory

UNIT I

Primer on bioinformatics and computational genomics, database fundamentals – biological databases, horticultural genome and protein databases, functional genomics.

UNIT II

Dynamic Programming Sequence Alignment, BLAST search engine, FASTA search engine, Microarrays- Microarray Clustering and Classification, Terminologies and Ontologies - EcoCYC knowledge base of E. Coli metabolism - Description of UMLS Semantic Network.

UNIT III

Multiple Sequence Alignment, MSA algorithm descriptions, ClustalW, 1D Motifs, Algorithms and Databases, methods for sequence weighting, BLOCKS database, Making BLOCK motifs, PROSITE database, 3D structure alignment, SCOP, DALI, LOCK, MUSTA algorithm for geometric hashing and multiple alignment.

UNIT IV

Hidden Markov models , Molecular energetics and dynamics , Protein structure prediction, genetic networks - Modeling and Simulation of Genetic Regulatory Systems- KEGG database of genes and gene pathways/networks - EcoCYC database of metabolic pathways in E. Coli - EGF-signal pathway modeling, Gene finding algorithms – Genome Annotation Assessment Project for Arabidopsis, Comparative genomics algorithms, Genome Alignment.

UNIT V

3D structure computations, NMR, Xtallography, NMR Structure Determination , X-ray crystallography Structure Determination, Distance Geometry Description, RNA secondary structure, Molecular Modeling and Drug discovery programs.

UNIT VI

Phylogenetic algorithms - Treebase database of phylogenetic information for plants mostly, Tree of Life Page, Samples from the Tree of Life, Ribosomal Database Project, Natural Language Processing , Proteomics, 3D Motifs, Applications and Integration with Horticulture, Final Thoughts.

Practical

Computers, Operating systems and Programming languages, Internet Resources, Horticultural Genome and Protein Databases, BLAST/RNA Structure, Sequence Alignment, Microarray Data Analysis, Ontology, MSA, HMMs, Identification of Functional Sites in Structures, Protein Structure Prediction - Phylogenetics - Gene Finding - Molecular Modeling and Drug Discovery Software – Assignments.

Suggested Readings

1. Attwood TK & Parry Smith DJ. 2006. *Introduction to Bioinformatics*. Pearson Edu.
2. Baxevanis AD. 2005. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. 3rd Ed. Wiley.
3. Bourne PE & Weissig H. (Eds.). 2004. *Structural Bioinformatics*. John Wiley & Sons.
4. Durbin R, Eddy SR, Krogh A & Mitchison G. 1999. *Biological Sequence Analysis: Probabilistic Model of Proteins and Nucleic Acids*. Cambridge Univ. Press.
5. Keshavachandran R, Nazeem PA, Girija D, John PS & Peter KV. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. Vols. I, II. New India Publ. Agency.
6. Kohane IS, Kho A & Butte AJ. 2002. *Microarrays for an Integrative Genomics*. M1T Press.
7. Mount DW. 2001. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbour Laboratory Press.

HORT RS 105 BIOTIC AND ABIOTIC STRESS MANAGEMENT IN HORTICULTURAL CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of biotic and abiotic stress management in horticultural crops.

Theory

UNIT I

Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.).

UNIT II

Pollution - increased level of CO2, industrial wastes, impact of stress in horticultural crop production, stress indices, physiological and biochemical factors associated with stress, horticultural crops suitable for different stress situations.

UNIT III

Crop modeling for stress situations, cropping system, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stress and their impact on crop growth and productivity.

UNIT IV

Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers.

UNIT V

Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, cropping systems, stability and sustainability indices.

Practical

Seed treatment /hardening practices, container seedling production, analysis of soil moisture estimates (FC, ASM, PWP), analysis of plant stress factors, RWC, chlorophyll flurosence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate etc. under varied stress situations, influence of stress on growth and development of seedlings and roots, biological efficiencies, WUE, solar energy conversion and efficiency, crop growth sustainability indices, economics of stress management, visit to orchards and water shed locations.

Suggested Readings

1. Blumm A. 1988. *Plant Breeding for Stress Environments*. CRC.
2. Christiansen MN & Lewis CF. 1982. *Breeding Plants for Less Favourable Environments*. Wiley Inter. Science.

3. Gupta US. 1990. *Physiological Aspects of Dry Farming*.

4. Hsiao TC. 1973. Plant Responses to Water Stress. *Ann. Rev. Plant Physiology* 24: 519-570.

5. Kramer PJ. 1980. Drought Stress and the Origin of Adaptation. In: *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons.

6. Levitt J. 1972. *Response of Plants to Environmental Stresses*. Academic Press.

7. Maloo SR. 2003. *Abiotic Stress and Crop Productivity*. Agrotech Publ. Academy.

8. Mussell H & Staples R. 1979. *Stress Physiology in Crop Plants*. Wiley Inter. Science.

9. Nickell LG. 1983. *Plant Growth Regulating Chemicals*. CRC.

10. Peter KV. (Ed.). 2008. *Basics of Horticulture*. New India Publ. Agency.

11. Turener NC & Kramer PJ. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons.

FLORICULTURE

HORT RS 111 ADVANCES IN BREEDING OF FLOWER CROPS **2+1**

Objective

To update knowledge on the recent research trends in the field of breeding of flower crops with special emphasis on crops grown in India.

Theory

UNIT I

Origin and evolution of varieties, distribution, Genetic resources, genetic divergence, Plant introduction, selection and domestication, Inheritance of important characters, Genetic mechanisms associated with flower colour and flower size, doubleness, fragrance and post-harvest life, Plant Variety Protection Act.

UNIT II

Specific objectives of breeding in flower crops, Methods of breeding suited to seed and vegetatively propagated flower crops, Introduction, selection, polyploidy and mutation breeding in the evolution of new varieties, Exploitation of heterosis, utilization of male sterility- incompatibility problems, *In Vtro* breeding.

UNIT III

Breeding for resistance to pests, diseases, nematodes and other biotic and abiotic stresses in flower crops.

UNIT IV

Specific breeding problems and achievements made in rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, gerbera, gladioli, orchids and anthurium.

UNIT V

Specific breeding problems and achievements made in aster, petunia, liliums, heliconia, bird of paradise, hibiscus and bougainvillea.

Practical

Description of crops and cultivars; Cataloguing of species and cultivars, floral biology, selfing and crossing, evaluation of hybrid progenies; Induction of mutants; Physical and chemical mutagens; Induction of polyploidy; Screening of plants for biotic and abiotic stresses and environmental pollution; *in-vitro* breeding in flower crops.

Suggested Readings

1. Arora JS. 2006. *Introductory Ornamental Horticulture*. Kalyani.
2. Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.
3. Choudhary RC.1993. *Introduction to Plant Breeding.* Oxford & IBH.
4. Singh BD.1990. *Plant Breeding*. Kalyani.

HORT RS 112 ADVANCES IN FLOWER PRODUCTION TECHNOLOGY 2+1

Objective

To keep abreast with latest developments and trends in production technology of flower crops.

Theory

UNIT I

Commercial flower production; Scope and importance; Global Scenario in cut flower production and trade, varietal wealth and diversity; Soil and Environment; Special characteristics and requirements; cut flower, loose flowers, dry flowers and floral oil trade.

UNIT II

Propagation and multiplication; IPR issues related to propagation of materials; Greenhouse management; Soil/media decontamination techniques; Microirrigation; nutrition and fertigation; slow release fertilizers and biofertilizers; influence of environmental parameters, light, temperature, moisture, humidity and CO2 on growth and flowering; regulation for quality flowers.

UNIT III

Flower forcing and year-round flowering through physiological interventions; Chemical regulation; Environmental manipulation; Harvest indices; Harvesting techniques; Post-harvest handling; Precooling, pulsing, packing, marketing; Export potential; Agri Export Zones.

UNIT IV

Crop specific practices – rose, anthurium, orchids, carnation, gladioli, gerbera, liliums, heliconia, bird of paradise, *Jasminum* sp., marigold, tuberose, crossandra.

UNIT V

Floral oil industry, floral concrete production, extraction methods, recent advances.

Practical

Varietal wealth in flower crops; Greenhouse management; Soil decontamination techniques; Microirrigation; Nutrition and fertigation. Special practices- Pinching, netting, disbudding, defoliation and chemical pruning; Photoperiodic and chemical induction of flowering; Assessing

harvest indices; Post-harvest handling; Tissue analysis; Preparation of floral decoratives; Extraction of floral concrete and oils; case studies; visit to commercial cut flower units.

Suggested Readings

1. Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.
2. Chadha KL & Choudhury B. 1992. *Ornamental Horticulture in India*. ICAR.
3. George S & Peter KV. 2008. *Plants in a Garden*. New India Publ. Agency.
4. Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices.* Agrobios.
5. Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.
6. Reddy S, Janakiram B, Balaji T, Kulkarni. S & Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

HORT RS 113 ADVANCES IN PROTECTED AND PRECISION FLORICULTURE 2+1

Objective

Appraisal on the advances in protected and precision farming of flower crops.

Theory

UNIT I

Prospects of protected floriculture in India, growing structures, basic considerations in establishment and operation of green houses, functioning and maintenance.

UNIT II

Environmental control systems in greenhouse, containers, substrate culture, soil decontamination techniques.

UNIT III

Water and nutrient management, crop regulation, special horticultural practices under protected cultivation of rose, chrysanthemum, carnation, orchids, anthurium, gerbera, liliums, cut foliage; Harvest indices – harvesting, PH handling, marketing, export.

UNIT IV

Precision floriculture, Principles and concepts, crop modeling, enabling technologies of precision farming, GPS, GIS, Remote sensing, sensors.

UNIT V

Variability management in precision farming, mapping, variable rate technology, precision equipments, computers and robotics in precision farming, post-harvest process management in floriculture using precision farming.

Practical

Growing structures, basic considerations in establishment and operation of greenhouses, environmental control systems in greenhouse, containers, substrate culture, soil decontamination techniques, Crop regulation, special horticultural practices under protected cultivation, precision equipments, computers and robotics in precision farming, post-harvest process management in floriculture using precision farming.

Suggested Readings

1. Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.
2. Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.
3. Reddy S, Janakiram B, Balaji T, Kulkarni S, & Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

HORT RS 114 ADVANCES IN LANDSCAPE ARCHITECTURE 1+2

Objective

To update knowledge on the recent trends in the field of landscape architecture and developing practical skills.

Theory

UNIT I

Commercial landscape gardening- History, Plant identification and ecology, Materials of garden design, Design making by different garden styles and types.

UNIT II

Expenses to model landscaping units of all category, Creativity and communication skills for landscape architect, Way of designing a commercial landscape project.

UNIT III

Assessing site and plants adaptability for different locations, Landscape engineering (Topographical) survey and designing concept), special techniques in garden landscaping (Burlaping, waterscaping, hardscaping, lawn making, topiary styles specializing, bioaesthetic planning).

UNIT IV

Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing.

UNIT V

Contemporary landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Case study with the successful landscapist, Budget / Project cost estimating, Execution strategies, Assessing a successful design in site.

Practical

Commercial landscaping, Plant identification, Materials of garden design, Design making by different garden styles and types. Way of designing a commercial landscape project, visit to model ornamental nursery. Assessing site and plants adaptability for different locations, Landscape engineering (Topographical survey and designing concept), special techniques in garden landscaping (Burlaping, waterscaping, hardscaping, lawn making, topiary styles specializing, bioaesthetic planning). Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing. Contemporary landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Case study with the successful landscapist, Budget/Project cost estimating, Execution.

Suggested Readings

1. Bose TK, Maiti RG, Dhua RS & Das, P. 1999. *Floriculture and Landscaping.* Naya Prokash.
2. Nambisan KMP. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH.

HORT RS 115 ADVANCES IN BIOCHEMISTRY AND BIOTECHNOLOGY OF LOWERS 2+1

Objective

Appraisal on the advances in biochemistry of flowers and application of biotechnology in flower crops.

Theory

UNIT I

Biochemistry of flowers: Principle involved in the formation of pigments – chlorophyll, xanthophyll, carotenoids, flavonoids and anthocyanins. Chemistry and importance of secondary metabolites in rose, jasmine,marigold, tuberose, carnation, orchids, liliums and bougainvillea.

Biochemistry and utilization commercial products (select items).

UNIT II

Recent trends- Extraction of biocolours and their value addition, uses in food and textile industries. Biochemistry of post harvest management of cut flowers.

UNIT III

Biotechnology – tools techniques and role in floriculture industry, physical factors and chemical factors influencing the growth and development of plant cell, tissue and organs, cytodifferentiation, organogenesis, somatic embryogenesis.

UNIT IV

In vitro lines for biotic and abiotic stress – Meristem culture for disease elimination, production of haploids through anther and pollen culture – embryo and ovule culture, micrografting, wide hybridization and embryo rescue techniques, construction of somatic hybrids and cybrids, regeneration and characterization of hybrids and cybrids, *in vitro* pollination and fertilization, hardening media, techniques and establishment of tissue culture plants in the primary and secondary nursery.

UNIT V

Somoclonal variation and its applications – variability induction through *in vitro* mutation, development of cell suspension cultures, types and techniques, *in vitro* production of secondary metabolites, role of bioreactors in production of secondary metabolites, quantification and quality analysis of secondary metabolites using HPLC, *in vitro* conservation and cryo- preservation techniques.

UNIT VI

Gene cloning, genetic engineering: vectors and methods of transformation – electroporation, particle bombardment, *Agrobacterium* mediated, transgenic plants in flower crops, medicinal and aromatic crops, isolation of DNA, RNA, quantification, Polymerase Chain Reaction for amplification; AGE & PAGE techniques; identification of molecular markers.

UNIT VII

Construction of c- DNA library, DNA fingerprinting technique in economic flower crop varieties, molecular approaches to control ethylene response, improving shelf life, improving resistance for environmental stress, approaches to improve

flower development, pigment production, secondary metabolite production, post harvest biotechnology of flowers, ornamental plants, achievements of bio-technology in flower crops.

Practical

Extraction of flower pigments – xanthophylls, carotenoids and anthocyanins. Plant nutrient stock- growth regulators- media preparation and sterilization- *In vitro* seed germination- callus culture and organ culture- Cell suspension culture – cell plating and regeneration- clonal propagation through Meristem culture, induction of multiple shoots- Anther- Pollen- Ovule and Embryo culture- Synthetic seed production, *in vitro* mutation induction, *in vitro* rooting – hardening at primary and secondary nurseries, Project preparation for establishment of low, medium and high cost tissue culture laboratories, DNA isolation from economic flower crop varieties – Quantification and amplification, DNA and Protein profiling – molecular markers for economic flower crops, restriction enzymes, vectors for cloning and particle bombardment, DNA fingerprinting of flower crop varieties .

Suggested Readings

1. Chopra VL & Nasim. 1990. *Genetic Engineering and Biotechnology – Concepts, Methods and Applications.* Oxford & IBH.
2. Debnath M. 2005. *Tools and Techniques of Biotechnology*. Pointer Publ.
3. Dey PM & Harborne JB. 1997. *Plant Biochemistry*. 2nd Ed. Academic Press.
4. Glover MD. 1984. *Gene Cloning: The Mechanics of DNA Manipulation.* Chapman & Hall.
5. Goodwin TW & Mercer EI. 2003. *Introduction to Plant Biochemistry*. CBS.
6. Gorden H & Rubsell S. 1960. *Hormones and Cell Culture*. AB Book Publ.
7. Keshavachandran R & Peter KV. 2008. *Plant Biotechnology: Methods in*
8. *Tissue Culture and Gene Transfer*. Orient & Longman (Universal Press).
9. Keshavachandran R, Nazeem PA, Girija D, John PS & Peter KV. (Eds.).
10. 2007. Recent Trends in Horticultural Biotechnology. Vols. I, II. New India Publishing Agency.
11. Panopoulas NJ. (Ed.). 1981. *Genetic Engineering in Plant Sciences*. Praeger Publ.
12. Pierik RLM. 1987. *In vitro Culture of Higher Plants*. Martinus Nijhoff Publ.
13. Prasad S. 1999. *Impact of Plant Biotechnology on Horticulture*. 2nd Ed. Agro Botanica.
14. Sharma R. 2000. *Plant Tissue Culture*. Campus Books International.
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17. Vasil TK, Vasi M, While DNR & Bery HR. 1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture*. Planum Press.
18. Williamson R. 1981-86. *Genetic Engineering*. Vols. I-V.
19. www.amazon.com

Vegetable Science

HORT RS 121 ADVANCES IN VEGETABLE PRODUCTION 2+1

Objective

To keep abreast with latest developments and trends in production technology of vegetable crops.

Theory

Present status and prospects of vegetable cultivation; nutritional and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies, disorders and correction methods; different cropping systems; mulching; containerized culture for year round vegetable production; low cost polyhouse; net house production; crop modeling, organic gardening; vegetable production for pigments, export and processing of:

UNIT I

Tomato, brinjal, chilli, sweet pepper and potato

UNIT II

Cucurbits, cabbage, cauliflower and knol-khol

UNIT III

Bhendi, onion, peas and beans, amaranthus and drumstick

UNIT IV

Carrot, beet root and radish

UNIT V

Sweet potato, tapioca, elephant foot yam and taro.

Practical

Seed hardening treatments; practices in indeterminate and determinate vegetable growing and organic gardening; portrays and ball culture; diagnosis of nutritional and physiological disorders; analysis of physiological factors like anatomy; photosynthesis; light intensity in different cropping situation; assessing nutrient status, use of plant growth regulators; practices in herbicide application; estimating water requirements in relation to crop growth stages, maturity indices; dryland techniques for rainfed vegetable production; production constraints; analysis of different cropping system in various situation like cold and hot set; vegetable waste recycling management; quality analysis ;marketing survey of the above crops; visit to vegetable and fruit mals and packing houses.

Suggested Readings

1. Bose TK & Som NG. 1986. *Vegetable Crops of India*. Naya Prokash.
2. Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. *Vegetable Crops*. Vols. I-III. Naya Udyog.
3. Brewster JL. 1994. *Onions and other Vegetable Alliums*. CABI.
4. FFTC. *Improved Vegetable Production in Asia*. Book Series No. 36.
5. Ghosh SP, Ramanujam T, Jos JS, Moorthy SN & Nair RG. 1988. *Tuber Crops*. Oxford & IBH.
6. Gopalakrishnan TR. 2007. *Vegetable Crops*. New India Publishing Agency.
7. Kallo G & Singh K. (Ed.). 2001. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals & Book Publ. House.
8. Kurup GT, Palanisami MS, Potty VP, Padmaja G, Kabeerathuma S & Pallai SV. 1996. *Tropical Tuber Crops, Problems, Prospects and Future Strategies*. Oxford & IBH.
9. Sin MT & Onwueme IC. 1978. *The Tropical Tuber Crops*. John Wiley & Sons.
10. Singh NP, Bhardwaj AK, Kumar A & Singh KM. 2004. *Modern Technology on Vegetable production*. International Book Distr. Co.
11. Singh PK, Dasgupta SK & Tripathi SK. 2006. *Hybrid Vegetable Development*. International Book Distr. Co.

HORT RS 122 ADVANCES IN BREEDING OF VEGETABLE CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of vegetable crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

Evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, *in vitro* breeding; breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of

resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance of:

UNIT I

Tomato, brinjal, chilli, sweet pepper and potato

UNIT II

Cucurbits, Cabbage, cauliflower and knol-khol

UNIT III

Bhendi, onion, peas and beans, amaranthus and drumstick

UNIT IV

Carrot, beet root and radish

UNIT V

Sweetpotato, tapioca, elephant foot yam and taro.

Practical

Designing of breeding experiments, screening techniques for abiotic stresses, screening and rating for pest, disease and nematode resistance, estimation of quality and processing characters, screening for-quality improvement, estimation of heterosis and combining ability, induction and identification of mutants and polyploids, distant hybridization and embryo rescue techniques.

Suggested Readings

1. *Acta Horticulture*. Conference on Recent Advance in Vegetable Crops. Vol. 127.
2. Chadha KL, Ravindran PN & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.

3. Chadha KL. 2001. *Hand Book of Horticulture*. ICAR.

4. Dhillon BS, Tyagi RK, Saxena S & Randhawa GJ. 2005. *Plant GeneticResources: Horticultural Crops*. Narosa Publ. House.

5. Janick JJ. 1986. *Horticultural Science*. 4th Ed. WH Freeman & Co.

6. Kaloo G & Singh K. 2001. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals and Book Publ. House.

7. Kaloo G. 1994. *Vegetable Breeding*. Vols. I-III. Vedams eBooks.

8. Peter KV & Pradeep Kumar T. 2008. *Genetics and Breeding of Vegetables*. (Revised Ed.). ICAR.

9. Ram HH. 2001. *Vegetable Breeding*. Kalyani.

HORT RS 123 PROTECTED CULTIVATION OF VEGETABLE CROPS 1+1

Objective

To impart latest knowledge in growing of vegetable crops under protected environmental condition.

Theory

Crops: Tomato, capsicum, cucumber, melons and lettuce

UNIT I

Importance and scope of protected cultivation of vegetable crops; principles used in protected cultivation, energy management, low cost structures; training methods; engineering aspects.

UNIT II

Regulatory structures used in protected structures; types of greenhouse/polyhouse/nethouse, hot beds, cold frames, effect of environmental factors, *viz.* temperature, light, CO2 and humidity on growth of different vegetables, manipulation of CO2, light and temperature for vegetable production, fertigation.

UNIT III

Nursery raising in protected structures like poly-tunnels, types of benches and containers, different media for growing nursery under cover.

UNIT IV

Regulation of flowering and fruiting in vegetable crops, technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, training and staking in protected crops, varieties and hybrids for growing vegetables in protected structures.

UNIT V

Problem of growing vegetables in protected structures and their remedies, insect and disease management in protected structures; soil-less culture, use of protected structures for seed production.

Practical

Study of various types of structures, methods to control temperature, CO2 light, media, training and pruning, maintenance of parental lines and hybrid seed production of vegetables, fertigation and nutrient management, control of insect-pests and disease in greenhouse; economics of protected cultivation, visit to established green/polyhouse/ net house/shade house in the region.

Suggested Readings

1. Anonymous 2003. *Proc. All India Seminar on Potential and Prospects for Protective Cultivation*. Organised by Institute of Engineers, Ahmednagar. Dec.12-13, 2003.
2. Chandra S & SomV. 2000. *Cultivating Vegetables in Green House*. *Indian Horticulture* 45: 17-18.
3. Prasad S & Kumar U. 2005. *Greenhouse Management for Horticultural Crops*. 2nd Ed. Agrobios.
4. Tiwari GN. 2003. *Green House Technology for Controlled Environment*. Narosa Publ. House.

HORT RS 124 BIOTECHNOLOGY IN VEGETABLE CROPS 2+1

Objective

To teach advances in biotechnology for improvement of vegetable crops.

Theory

Crops: Tomato, eggplant, hot and sweet pepper, potato, cabbage, cauliflower, tapioca, onion, cucurbits.

UNIT I

In vitro culture methods and molecular approaches for crop improvement in vegetables, production of haploids, disease elimination in horticultural crops, micro grafting, somoclones and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, *in vitro* production of secondary metabolites.

UNIT II

Protoplast culture and fusion; construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in vitro* conservation.

UNIT III

In vitro mutation for biotic and abiotic stresses, recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology.

UNIT IV

Quality improvement, improvement for biotic and abiotic stresses, transgenic plants.

UNIT V

Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements, problems and future thrusts in horticultural biotechnology.

Practical

Establishment of axenic explants, callus initiation and multiplication, production of suspension culture, cell and protoplast culture, fusion, regeneration and identification of somatic hybrids and cybrids; Identification of embryonic and non-embryonic calli, development of cell lines; *in vitro* mutant selection for biotic and abiotic stresses, *In vitro* production and characterization of secondary metabolites, isolated microspore culture, isolation and amplification of DNA, gene transfer methods, molecular characterization of transgenic plants.

Suggested Readings

1. Bajaj YPS. (Ed.). 1987. *Biotechnology in Agriculture and Forestry*. Vol.XIX. *Hitech and Micropropagation*. Springer.
2. Chadha KL, Ravindran PN & Sahijram L. (Eds.). 2000. *Biotechnology of Horticulture and Plantation Crops*. Malhotra Publ. House.
3. Debnath M. 2005. *Tools and Techniques of Biotechnology*. Pointer Publ.

4. Glover MD. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall.

5. Gorden H & Rubsell S. 1960. *Hormones and Cell Culture*. AB Book Publ.

6. Keshavachandran R & Peter KV. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer.* Orient & Longman (Universal Press).

7. Keshavachandran R et al. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. New India Publ. Agency.

8. Panopoulas NJ. (Ed.). 1981. *Genetic Engineering in Plant Sciences*. Praeger Publ.

9. Pierik RLM. 1987. *In vitro Culture of Higher Plants*. Martinus Nijhoff Publ.

10. Prasad S. 1999. *Impact of Plant Biotechnology on Horticulture*. 2nd Ed. Agro Botanica.

11. Sharma R. 2000. *Plant Tissue Culture*. Campus Books. Singh BD.2001. *Biotechnology*. Kalyani.

12. Skoog Y & Miller CO. 1957. *Chemical Regulation of Growth and Formation in Plant Tissue Cultured in vitro*. Attidel. II Symp. On Biotechnology Action of Growth Substance.

13. Vasil TK, Vasi M, While DNR & Bery HR. 1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture.* Planum Press.

14. Williamson R. 1981-86. *Genetic Engineering*. Vols. I-V.

HORT RS 125 SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE CROPS 1+1

Objective

To educate the recent trends in the certification, processing and storage of vegetable crops.

Theory

UNIT I

Seed certification, objectives, organization of seed certification, minimum seed certification standards of vegetable crops, field inspection, specification for certification.

UNIT II

Seed processing, study of seed processing equipments seed cleaning and upgrading, Seed packing and handling, equipment used for packaging of seeds, procedures for allocating lot number.

UNIT III

Pre-conditioning, seed treatment, benefits, types and products, general principles of seed storage, advances in methods of storage, quality control in storage, storage containers, seed longevity and deterioration, sanitation, temperature and relative humidity control.

UNIT IV

Seed testing; ISTA rules for testing, moisture, purity germination, vigor test, seed sampling, determination of genuineness of varieties, seed viability, seed health testing; seed dormancy and types of dormancy, factors responsible for dormancy.

UNIT V

Seed marketing, demand forecast, marketing organization, economics of seed production; farmers' rights, seed law enforcement, seed act and seed policy.

Practical

Seed sampling, purity, moisture testing, seed viability, seed vigor tests, seed health testing, seed cleaning, grading and packaging; handling of seed testing equipment and processing machines; seed treatment methods, seed priming and pelleting; field and seed inspection, practices in rouging, seed storage, isolation distances, biochemical tests, visit to seed testing laboratories and processing plants, mixing and dividing instruments, visit to seed processing unit and warehouse visit and know about sanitation standards.

Suggested Readings

1. Agrawal PK & Dadlani M. 1992. *Tecniques in Seed Science and Technology*. South Asian Publ.
2. Singh N, Singh DK, Singh YK & Kumar V. 2006. *Vegetable Seed Production Technology*. International Book Distr. Co.
3. Singh SP. 2001. *Seed Production of Commercial Vegetables*. Agrotech Publ. Academy.
4. Tanwar NS & Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, GOI, New Delhi.
5. Rajan S & Baby L Markose 2007. *Propagation of Horticultural Crops*. New India Publ. Agency.

HORT RS 126 ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of vegetable crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

UNIT I

Environmental stress and its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress; root stock, use of wild species, use of antitranspirants.

UNIT II

Mechanism and measurements of tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

UNIT III

Soil-plant-water relations under different stress conditions in vegetable crops production and their management practices.

UNIT IV

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

UNIT V

Techniques of vegetable growing under high and low temperature conditions, use of chemicals in alleviation of different stresses.

Practical

Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops, measurement of tolerance to various stresses in vegetable crops, short term experiments on growing vegetable under water deficit, water-logging, salinity and sodicity, high and low temperature conditions, and use of chemicals for alleviation of different stresses.

Suggested Readings

1. Dwivedi P & Dwivedi RS. 2005. *Physiology of Abiotic stress in Plants*. Agrobios.
2. Lerner HR (Ed.). 1999. *Plant Responses to Environmental Stresses*. Marcel Decker.
3. Maloo SR. 2003. *Abiotic Stresses and Crop Productivity*. Agrotech Publ. Academy.

Spices, Plantation and Medicinal Crops

HORT RS 131 ADVANCES IN PRODUCTION OF PLANTATION AND MEDICINAL CROPS 2+1

Objective

To keep abreast with latest developments and trends in production technology of plantation and Medicinal crops.

Theory

UNIT I

Plantation crops – area and production, export potential - varietal wealth and appraisal on the crop improvement in plantation crops. Mass multiplication techniques, High density planting, systems of cultivation, multitier cropping, companion cropping, studies of on canopy and root management, photosynthetic efficiencies of crops at different tiers, Biotic and abiotic factors on growth and productivity, nutritional requirements, role of macro and micro nutrients, Nutrient deficiency symptoms, growth regulators, water requirement, fertigation, soil and moisture conservation practices, Drought management, permanent vegetation management, Basin management, training and pruning, maturity indices, harvesting, curing, processing and value addition, grading, packing and storage, role of commodity boards in plantation crop development, Production of plantation crops through GAP, GMP, HACCP.

Crops

Coffee, tea, Cashew and cocoa, Rubber, palmyrah, oil palm, Coconut and arecanut, Wattle and betelvine

UNIT II

Production technology for Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Sarpagandha, Dioscorea sp., Aloe vera, Phyllanthus amarus, Andrographis paniculata, Medicinal solanum, Isabgol, Poppy, Safed musli, Stevia rebaudiana, Mucuna pruriens, Ocimum sp.

UNIT III

Influence of biotic and abiotic factors on the production of secondary metabolites, Regulations for herbal raw materials, Phytochemical extraction techniques.

Practical

Plantation Crops

Description of botanical and varietal features-selection of mother palms and elite clones, Clonal fidelity testing, nursery techniques and propagation methods, High density planting, training and pruning practices, fertigation and foliar nutrition, shade regulation, maturity standards, harvesting, curing, processing and grading, project preparation for establishing new plantations, visit to plantation gardens, commodity boards and plantation based industries.

Medicinal Plants

Propagation techniques, Maturity standards, Digital documentation, Extraction of secondary metabolites.

Suggested Readings

1. Atal CK & Kapur BM. 1982. Cultivation and Utilization of Medicinal Plants. RRL, CSIR, Jammu.
2. Farooqi AA & Sriram AH. 2000. Cultivation Practices for Medicinal and Aromatic Crops. Orient Longman Publ.
3. Farooqi AA, Khan MM & Vasundhara M. 2001. Production Technology of Medicinal and Aromatic Crops. Natural Remedies Pvt. Ltd.
4. Hota D. 2007. Bio Active Medicinal Plants. Gene Tech Books.
5. Jain SK. 2000. Medicinal Plants. National Book Trust.
6. Khan IA & Khanum A. Role of Bio Technology in Medicinal and Aromatic Plants. Vol. IX. Vkaaz Publ.
7. Kurian A & Asha Sankar M. 2007. Medicinal Plants. Horticulture Science Series, New India Publ. Agency.
8. Panda H. 2002. Medicinal Plants Cultivation and their Uses. Asia Pacific Business Press.
9. Prajapati SS, Paero H, Sharma AK & Kumar T. 2006. A Hand book of Medicinal Plants. Agro Bios.
10. Ramawat KG & Merillon JM. 2003. BioTechnology-Secondary Metabolites. Oxford & IBH.
11. Skaria P Baby, Samuel Mathew, Gracy Mathew, Ancy Joseph, Ragin
12. Anonymous 1985. *Rubber and its Cultivation*. The Rubber Board of India.
13. Grimwood BE. 1975. *Coconut Palm Products*. FAO.
14. Kurian A & Peter KV. 2007. *Commercial Crops Technology*. New India Publ. Agency.
15. Nair MK, Bhaskara Rao EVV, Nambiar KKN & Nambiar MC. 1979. *Cashew*. CPCRI, Kasaragod.
16. Patel JS. 1938. *The Coconut – A Monograph*. Govt. Press, Madras.
17. Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2007. *Management of Horticultural Crops*. Parts I, II. New India Publ. Agency.
18. Rai PS & Vidyachandram B. 1981. *Review of Work Done on Cashew*. UAS Research Series No.6, Bangalore.
19. Ranganathan V. 1979. *Hand Book of Tea Cultivation*. UPASI, Tea Res Stn. Cinchona.
20. Srivastava HC, Vatsaya B & Menon KKG. 1986. *Plantation Crops – Opportunities and Constraints*. Oxford & IBH.
21. Thampan PK. 1981. *Hand Book of Coconut Palm*. Oxford & IBH.

HORT RS 132 ADVANCES IN SPICE PRODUCTION 2+1

Objective

To educate advances in production technology of spice crops.

Theory

Spices- current status on area and production, state, national and global scenario of spices, global trade, problems encountered in spices productivity, systems of cultivation, varieties, soil and climate, propagation techniques and nursery management, planting systems and methods,

cropping pattern, permanent floor management concepts in mulching and weed management, canopy and root studies under different spice-based cropping systems, shade and basin management, INM practices, irrigation and fertigation techniques, chemical regulation of crop productivity, IPM, clean cultivation strategies, harvesting, Post-harvest and quality management for value added spices, quality standards, GAP and GMP for spices production, quality control and certification. Protected cultivation of high value spice crops. Value addition and byproduct utilization. Pricision farming and organic farming in spice crops. Commodity Boards in spices development

UNIT I: Pepper and cardamom

UNIT II: Nutmeg, clove, cinnamon and allspice

UNIT III: Turmeric, ginger, garcinia, tamarind and garlic

UNIT IV: Coriander, fenugreek, fennel, cumin and vanilla

UNIT V: Paprika and important herbal spices

Suggested Readings

1. Chadha KL. 2001. *Hand book of Horticulture*. ICAR
2. George CK. (Ed.). 1989. *Proceedings of First National Seminar on Seed Spices*. Spices Board, Ministry of Commerce, Govt. of India, Kochi.
3. Marsh AC, Moss MK & Murphy EW. 1977. *Composition of Food Spices and Herbs, Raw, Processed and Prepared*. Agric. Res. Serv. Hand Book 8-2. Washinton DC.
4. Parry JW. 1969. *Spices and Condiments*. Pitman.
5. Peter KV. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ. Co., UK & CRC, USA.
6. Purseglove JW. 1968. *Tropical Crops – Dicotyledons*. Longman.
7. Purseglove JW, Brown EG, Green CL & Robbins SRJ. 1984. *Spices*. Vols. I, II. Longman.
8. Ridley HM. 1972. *Spices*. Mac Millan.
9. Rosengarten F Jr. 1969. *The Book of Spices*. Wynnewood; Livingston Publ. Co.
10. Ravindran PN. 2001. *Monograph on Black Pepper*. CRC Press.

11. Ravindran PN & Madhusoodanan KJ. 2002. *Cardamom, The Genus Elettaria*. Series - *Medicinal and Aromatic Plants – Industrial Profiles*. Routledge, UK.

12. Agarwal S, Divkara Sastry EV & Sharma RK. 2001. Seed Spices, Production, Quality and Export. Pointer Publ.

13. Shanmugavelu KG, Kumar N & Peter KV. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.

14. Winton AL & Winton KB. 1931. The Structure and Composition of Food. John Wiley & Sons.

15. Yagna Narayan Ayer AK. 1960. *Cultivation of Cloves in India*. ICAR.

16. Nybe EV, Mini Raj N & Peter KV. 2007. *Spices*. New India Publ. Agency.

17. Varmudy V. 2001. *Marketing of Spices*. Daya Publ. House.

HORT RS 133 ADVANCES IN BREEDING OF PLANTATION CROPS AND SPICES 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of plantation crops and spices.

Theory

Evolutionary mechanisms, adaptation and domestication, genetic resources, genetic divergence, cytogenetics, variations and natural selection, types of pollination and fertilization mechanisms, sterility and incompatibility system, recent advances in crop improvement efforts, introduction and selection, chimeras, clonal selections, intergeneric, interspecific and intervarietal hybridization, heterosis breeding, mutation and polyploidy breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, genetics of important traits and their inheritance pattern, molecular and transgenic approaches and other biotechnological tools in improvement of selected spice and plantation crops.

Crops

UNIT I: Coffee and tea

UNIT II: Cashew and cocoa

UNIT III: Rubber, palmyrah and oil palm

UNIT IV: Coconut and arecanut

UNIT V: Pepper and cardamom

UNIT VI: Nutmeg, clove, cinnamon and allspice

UNIT VII: Turmeric, ginger, garcinia, tamarind and garlic

UNIT VIII: Coriander, fenugreek, fennel, cumin and vanilla

Practical

Description and cataloguing of germplasm, pollen viability tests, pollen germination, survey and clonal selection, screening techniques for abiotic stresses, screening and rating for pest, disease and stress resistance in inbreds and hybrids, estimation of quality and processing characters for quality improvement, use of mutagenes and colchicine for inducing mutation and ploidy hanges, practices in different methods of breeding and *in vitro* breeding techniques.

Suggested Readings

1. Chadha KL. 1998. *Advances in Horticulture*. Vol. IX, X. *Plantation and Spices Crops*. Malhotra Publ. House.
2. Chadha KL, Ravindran PN & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.
3. Chadha KL. 2001. *Hand book of Horticulture*. ICAR.
4. Chopra VL & Peter KV. 2002. *Handbook of Industrial Crops*. Haworth Press, USA &. Panama International Publ. (Indian Ed.).

5. Damodaran VK, Vilaschandran T & Valsalakumari PK.1979. *Research on Cashew in India*. KAU, Trichur.

6. George CK. (Ed.). 1989. *Proceedings of First National Seminar on Seed Spices*. Spices Board, Ministry of Commerce, Govt. of India, Kochi.

7. Harver AE. 1962. *Modern Coffee Production*. Leonard Hoff (Book) Ltd.

8. Purseglove JW. 1968. *Tropical Crops – Dictyledons*. Longman.

9. Purseglove JW, Brown EG, Green CL & Robbins SRJ. 1984. *Spices*. Vols. I, II. Longman.

10. Peter KV. 2001-04. *Handbook of Herbs and Spices*. Vols.I-III.Woodhead Publ. Co., UK & CRC, USA.

11. Raj PS & Vidyachandra B. 1981. *Review of Work Done on Cashew*. UAS Research Series No.6, Bangalore.

12. Ravindran PN. 2001. *Monograph on Black Pepper*. CRC Press.

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14. Rosengarten F Jr. 1969. *The Book of Spices*. Wynnewood; Livingston Publ. Co.

15. Shanmugavelu KG, Kumar N & Peter KV. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.

HORT RS 134 BIOTECHNOLOGY IN PLANTATION CROPS, SPICES AND MEDICINAL CROPS 2+1

Objective

To teach advances in biotechnology for improvement of plantation crops, medicinal crops and spices.

Theory

Crops: Coconut, oil palm, coffee, tea, cocoa, pepper, cardamom, turmeric, ginger, vanilla Senna, Periwinkle, Coleus, Aswagandha

UNIT I

In vitro culture methods and molecular approaches for crop improvement in plantation crops and spices, production of haploids, disease elimination in horticultural crops, micro grafting; somoclones and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, *in vitro* production of secondary metabolites.

UNIT II

Protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in vitro* conservation of spices and plantation crops.

UNIT III

In vitro mutation for biotic and abiotic stresses, recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology.

UNIT IV

Quality improvement; improvement for biotic and abiotic stresses; transgenic plants.

UNIT V

Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements, problems and future thrusts in horticultural biotechnology.

UNIT VI

Metabolomics in spices and medicinal crops

Practical

Establishment of axenic explants, callus initiation and multiplication; production of suspension culture, cell and protoplast culture, fusion, regeneration and identification of somatic hybrids and cybrids, Identification of embryonic and non-embryonic calli, development of cell lines; *in vitro* mutant selection for biotic and abiotic stresses, *In vitro* production and characterization of secondary metabolites, isolated microspore culture, isolation and amplification of DNA, gene transfer methods; molecular characterization of transgenic plants.

Suggested Readings

1. Bajaj YPS. (Ed.). 1987. *Biotechnology in Agriculture and Forestry*. Springer.
2. Chadha KL, Ravindran PN & Sahijram L. (Eds.). 2000. *Biotechnology of Horticulture and Plantation Crops*. Malhotra Publ. House.

3. Debnath M. 2005. *Tools and Techniques of Biotechnology*. Pointer Publ.

4. Glover MD. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall.

5. Gorden H & Rubsell S. 1960. *Harmones and Cell Culture*. AB Book Publ.

6. Keshavachandran R & Peter KV. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer*. Orient & Longman (Universal Press).

7. Keshavachandran R, Nazim PA, Girija D. & Peter KV 2007. *Recent Trends in Biotechnology of Horticultural Crops*. New India Publ. Agency.

8. Panopoulas NJ. (Ed.). 1981. *Genetic Engineering in Plant Sciences*. Praeger Publ.

9. Pierik RLM. 1987. *In vitro Culture of Higher Plants*. Martinus Nijhoff Publ.

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11. Sharma R. 2000. *Plant Tissue Culture*. Campus Books, International.

12. Singh BD. 2001. Biotechnology. Kalyani.

13. Skoog F & Miller CO. 1957. *Chemical Regulation of Growth and Formation in Plant Tissue Culture in vitro.* Symp. Soc. Exp. Biol. 11: 118-131.

14. Vasil TK, Vasi M, While DNR & Bery HR. 1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture*. Plenum Press.

15. Williamson R. 1981-86. *Genetic Engineering*. Vols. I-V. Academic Press.

HORT RS 135 POST-HARVEST PROCESSING AND EXTRACTION IN MEDICINAL AND AROMATIC PLANTS 2+1

Objective

To teach advances in post harvest processing and extraction of economically important medicinal and aromatic crops.

Theory

UNIT I

Post-harvest handling of plant material, preparation of plant material for packaging and extraction. Methods of extraction of secondary metabolites from medicinal crops like sarpagandha, steroid-bearing solanums, ashwagandha, henbane, periwinkle, senna, costus, coleus, etc.

UNIT II

Procedures and equipments used for extraction of active principles. Principles and practices of different types of chromatographs - paper, thinlayer, column, gas and high performance liquid chromatography and mass spectroscopy. Preservation of plant extracts and their trade mechanisms.

UNIT III

Harvesting, drying, handling and preparation of different aromatic crops - jasmine, tuberose, oil-bearing rose, scented geranium, patchouli, davana, mints, basils, etc., for essential oil extraction.

UNIT IV

Principles and practices of different types of extraction - distillation, solvent extraction, supercritical fluid extraction, etc. Fine flavour and perfume extraction. Qualitative determination of essential oils. *In vitro* production of biomass and organic extraction of oils. Quality analysis and characterization through chromatographs.

UNIT V

Commercial uses of essential oils, aromatherapy, etc. Commercial utilization of spent material. Storage of essential oils.

Practical

Identification of different economic parts of medicinal and aromatic crops. Preparation of plant material for extraction. Study of different extraction methods. Study of solvents used in extraction of concrete and absolutes. Extraction of crude drugs and essential oils from different medicinal and aromatic crops respectively. Handling of different chromatographs. Quality analysis of essential oils - both physical and chemical, determination of phenol values, acid values, alcohol values, etc. Sensory evaluation of essential oils. Storage studies in essential oils. Visit to commercial extraction and product development units.

Suggested Readings

1. Bhattacharjee SK. *Amenity Horticulture, Biotechnology and Post-harvest Technology*. Vol. V. International Book Periodicals Supply Services.
2. Chadha KL (Ed.). 1993-95. *Advances in Horticulture*. Vols. I-XIII. Malhotra Publ. House.

3. Kumar N, Abdul Khader ML, Rangaswamy P & Ikrulappan I. 1994. *Spices, Plantation Crops, Medicinal and Aromatic Plants.* Rajalakshmi Publ.

4. Leo ML Nollet. 1995. *Food Analysis by HPLC*. Marcel Dekker.

5. Masada Y.1986. *Analysis of Essential Oil by Gas Chromatograph and Mass Spectrometry.* John Wiley & Sons.

6. Sadasivam S & Manickam A. 1996. *Biochemical Methods*. 2nd Ed. New Age International Pvt. Ltd., Bangalore and TNAU; Scientific Publishers (India), Jodhpur.

7. Teranishi R, Hornstein I, Issenberg P &. Wick EL. 1971. *Flavour Research: Principles and Techniques.* Marcel Dekker.

8. WHO. 1998. *Quality Control Methods for Medicinal Plants Materials*. WHO. 83

MICROBIOLOGY

M.Sc. Syllabus

Paper	Paper Code	Paper Name	Credits	Full Marks
First Semester				
Paper - 1	MIC-PG-C101	Microbial Diversity	4 Credits	100 Marks
Paper - 2	MIC-PG-C102	Microbial Biochemistry	4 Credits	100 Marks
Paper - 3	MIC-PG-C103	Microbial Physiology	4 Credits	100 Marks
Paper - 4	MIC-PG-C104	Laboratory Course-I	4 Credits	100 Marks
		National Service*	Non-credit	
Second Semester				
Paper - 5	MIC-PG-O201	Instrumentation and Bioinformatics	4 Credits	100 Marks
Paper - 6	MIC-PG-C202	Microbial genetics and Molecular Biology	4 Credits	100 Marks
Paper - 7	MIC-PG-C203	Clinical Microbiology	4 Credits	100 Marks
Paper - 8	MIC-PG-C204	Laboratory Course-II	4 Credits	100 Marks
Third Semester				
Paper - 9	MIC-PG-C301	Agricultural and Industrial Microbiology	4 Credits	100 Marks
Paper - 10	MIC-PG-C302	Environmental Microbiology	4 Credits	100 Marks
Paper - 11	MIC-PG-O303	Immunology	4 Credits	100 Marks
Paper - 12	MIC-PG-C304	Laboratory Course –III	4 Credits	100 Marks
Fourth Semester				
Paper – 13	MIC-PG-C401	Molecular Virology	4 Credits	100 Marks
Paper - 14	MIC-PG-C402	Food Microbiology	4 Credits	100 Marks
Paper - 15	MIC-PG-C403	Laboratory Course –IV	4 Credits	100 Marks
Paper - 16	MIC-PG-C404	Dissertation	4 Credits	100 Marks

***** One compulsory audit paper is called “National Service”. The National Service shall be compulsory for all Master students of our Department. It is exempted only for NSS volunteers who have completed 120 hours of service. The students shall complete the requirements of “National Service” by doing some service in their own villages, towns, etc. for a period of 30 days during the winter vacation between I and II semesters. The reports of such service shall be evaluated by the Department and adjudged “Satisfactory” or “Not Satisfactory”. If the report is “Not Satisfactory” the student will not be eligible for the degree.

FIRST SEMESTER

Paper -1: MIC-PG-C101: Microbial Diversity **4 Credits**

Unit I: Introduction to Microbiology

History and scope of Microbiology: Discovery of Microorganism, Conflict over spontaneous generation. General introduction and overview of Microbial Evolution and Diversity. Microbial Taxonomy: General introduction and overview of Taxonomic ranks, Classification system Structural and functional differences between prokaryotic and eukaryotic cells.

Unit II: Bacteria

General characteristics of Proteobacteria. General characteristics of Gram Positive. Actinobacteria. Cyanobacteria, Prochlorophytes, *Chlamydia. Planctomyces*. The Verrucomicrobia. The Flavobacteria. The Cytophaga Group. Green sulfur bacteria. The Spirochaetes. *Deinococci*. The green non-sulfur bacteria. Hyperthermophilic bacteria. *Nitrospira* and *Deferribacter.*

Unit III: Archaea, Fungi and Protozoa

Archaea: General account of habitat and physiology of Euryarchaeota (Halophilic, Methanogen, *Thermoplasmatales, Thermococcales* and *Methanopyrus, Archaeoglobales, Nanoarchaeum and Aciduliprofundum)* and Crenarchaeota (Hyperthermophiles and Non-Hyperthermophiles). Mycology: Brief about classification, morphology, reproduction and economic importance of Fungi. Overview of Protozoa

Unit IV: Viruses

General characteristics and classification system of viruses. Isolation and cultivation of viruses. Viral multiplication and replication strategies for bacteriophages, DNA viruses (Herpesviruses, Poxviruses, Adenoviruses) RNA Viruses (Poliovirus, coronavirus, influenza, rabies and Reoviruses), Viruses that employ reverse transcriptase (Retroviruses, Hepadnavirus). Introduction to Giant Viruses, disease caused by them and the implication of their discovery on evolutionary tree.

Reading List

1. Carter, J. and Saunders, V. 2007. *Virology*: *Principles and Applications.* 1st edition. Wiley.
2. Garrett, R. A. and Hans-Peter Klenk, H-P.2007. *Archaea: Evolution, Physiology, and Molecular Biology*. 1st edition, Wiley-Blackwell.
3. Garrity, G.M. et al. 2005. *Bergey's Manual of Systematic Bacteriology.* 2nd edition, Springer.
4. Kavanagh, K. 2005. *Fungi: Biology and Applications,* 1st edition, Wiley.
5. Madigan, M. T., Martinko, J. M., Dunlap, P. V. Clark, D. P. 2009. *Brock Biology of Microorganisms*. Twelfth edition, Pearson Education Inc, Pearson Benjamin Cummings, San Francisco.
6. Mehrotra, R.S. and Aneja, K. R. 1990. *An introduction to Mycology*. New Age International Publishers.
7. Willey, J. M., Sherwood, L. M. and Woolverton, C.J. 2008. *Prescott, Harley and Klein's Microbiology*. 7th edition. Mc-Graw Hill Companies Inc. New Jersey.

Paper - 2: MIC-PG-C102: Microbial Biochemistry **4 Credits**

Unit I: Biomolecules I

Buffers and pH, Henderson Hasselbach equations; covalent and weak bonds (Hydrogen bond; van der Waals forces; hydrophobic interactions). Carbohydrate chemistry: classification and biochemistry of carbohydrates. Lipid Chemistry: Classification, properties and structure of lipids with emphasis on membrane lipids of archaebacterial and mycobacterium; Brief account of application of membrane lipids in classification of bacteria

Unit II: Biomolecules II

Proteins**:** Introduction to Amino acids chemistry and Classification and properties; Brief account of Peptide bond, Protein structure; Protein characterization and functional analysis. Protein degradation, Protein sequencing.

Unit III: Enzymology

Introduction, classification of enzymes, kinetics, enzyme inhibition and inhibitors. Allosteric enzymes and their regulation; Specific mechanisms of enzyme catalysis – serine proteases, ribonucleases, triose phosphate isomerase, lysozyme, lactate and alcohol dehydrogenases.

Unit IV: DNA replication, recombination and repair

Nucleic acids: Structural features and chemistry of nucleic acid. DNA replication. Homologous and site- specific recombination, DNA damage and repair.

Reading List

1. Benfield, Rosalie. 2009. *Biochemistry*. 1st ed. Chandni Chowk, Delhi: Global Media.
2. Nelson, D. L. and Cox, M.M. 2008. *Lenhinger's Principles of Biochemistry*. 5th edition. W.H. Freeman.
3. Pelley, John W., and Edward F. Goljan 2007. *Biochemistry*. Philadelphia, PA: Mosby Elsevier.
4. Powar, C. B, and G. R Chatwal. 2008. *Biochemistry*. New Delhi: Himalaya Pub. House.
5. Stryer, L. 1988. *Biochemistry*. 3rd edition, W. H. Freeman & Co.
6. Voet, D. and Voet, J.G. 1995. *Biochemistry*. Wiley.
7. Wilson, K. and Walker, J. 2010. *Principles and Techniques of Biochemistry and Molecular Biology*. 7th edition, Cambridge University Press.

Paper - 3: MIC-PG-C103: Microbial Physiology **4 Credit**

Unit I: Bioenergetics and membrane biology

Introduction to the Principles of bioenergetics, entropy, enthalpy, redox reactions in biological systems and redox potentials. Plasma Membrane: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active and passive transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.

Unit II: Metabolism of carbon compounds

Embden-Meyerhof pathway, Krebs cycle and reverse TCA cycle, glyoxylate pathway, gluconeogenesis; fermentation of carbohydrates- lactic, alcoholic, acetic acid fermentations; Methylotrophy and methanotrophy, Degradation and utilization of cellulose and starch. Lipid metabolism – biosynthesis and oxidation of fatty acid oxidation. Introduction to Metabolomics.

Unit III: Phosphorylation and metabolism of inorganic compounds

Oxidative phosphorylation: Electron carrier molecules, Electron transport chain; coupling of ADP and Pi; Photosynthesis: Brief account of photosynthetic and accessory pigments: chlorophyll, bacteriochlorophyll, carotenoids, and phycobiliproteins. Oxygenic and anoxygenic photosynthesis, autotrophic generation of ATP; Bacteriorhodopsin; Fixation of CO2 (Calvin cycle). Chemosynthesis and anaerobic respiration.

Unit IV: Microbial development

Peptidoglycan synthesis, bacterial cell division, sporulation, differentiation, stress response.

Reading List

1. Chaudhary, Vikas. 2008. *Microbial Physiology and Metabolism*. New Delhi, India: Navyug Publishers & Distributors.
2. Madigan, T. M., Martinko, J.M. and Parker, J. 2008. *Brock's Biology of Microorganisms*. 12th edition, Prentice Hall College Div.
3. Moat, A.G. and Foster, J.W. 2002. *Microbial Physiology.* 4th edition, Wiley-Liss.
4. Nelson, D. L. and Cox, M.M. 2008. *Lehninger's Principles of Biochemistry*. 5th edition. W.H. Freeman.
5. Poole, Robert K. 2012. *Advances in Microbial Physiology*. Amsterdam: Elsevier/Academic Press.
6. Voet, D. and Voet, J.G. 1995. *Biochemistry*. Wiley.
7. Wilson, K. and Walker, J. 2008. *Practical Biochemistry - Principles and Techniques*. 5th edition, Cambridge Low Price Edition.

Paper - 4: MIC-PG-104: Laboratory Course I **4 Credits**

1. Good Microbiology Laboratory Practices and Laboratory discipline.
2. Demonstration of different instruments commonly used in microbiology laboratory.
3. Handling and care of microscopes.
4. Calibration of microscope and measurement of microscopic objects (Bacteria, yeast and fungal filaments).
5. Staining: Preparation of stains, simple staining techniques, Differential staining techniques, Special staining techniques [smear preparation, Gram's staining, Acid fast staining (Demonstration), staining for metachromatic granules, Negative staining and spore staining].
6. Motility test by wet mount (hanging drop) and in solid media.
7. Sterilization and disinfection methods with special reference to hot air oven, autoclave, ultrafiltration.
8. Preparation of culture media and biochemical reagents.
9. Isolation of pure culture of bacteria by streak plate method.
10. Serial dilution and enumeration of bacteria by pour plate and spread plate methods.
11. Isolation of pure culture of fungi from the given sample by pour plate.
12. Identification of bacteria using standard biochemical tests– Carbohydrate fermentation tests (Glucose, lactose, Fructose, Sucrose, Mannitol, Arabinose) for detection of acid and gas production.
13. Identification of bacteria using standard biochemical tests– SIM, IMViC, TSI.
14. Estimation of Carbohydrate.
15. Isolation and estimation of Protein.
16. Assay of enzymes: Amylase.
17. Enzyme kinetics.
18. Factor influencing enzyme activity: pH, Temperature.
19. Separation of lipids and amino acids by Paper chromatography and Thin layer Chromatography.
20. Electrophoresis (Agarose and SDS-PAGE).
21. Demonstration of gas chromatography.
22. Demonstration HPTLC, Biolog, PCR.
23. Microbial growth curve.
24. Enumeration of microbial population.

Reading List

1. Baxevanis, A. D. and Ouellette, B. F. F. 2004. Bioinformatics: A Practical Guide to the Analysis of Genes“and Proteins. 3rd edition, Wiley-Inter Science, USA.
2. Goldman, E. and Green, L. H. 2008. Practical Handbook of Microbiology. 2nd edition, Francis and Taylor“Group, USA.
3. Krane, D. E. and Raymer, M. L. 2002. *Fundamental Concepts of Bioinformatics.* Benjamin Cummings, USA.
4. Krawetz, Stephen A. 2009. *Introduction to Bioinformatics*. New Delhi: Springer, India.
5. Plummer, D. T. 2004. *Introduction to Practical Biochemistry*. 3rd edition, Tata McGraw Hill Publishing Company Limited. India
6. White, D. and Hegeman G. D 1998. *Microbial Physiology and Biochemistry Laboratory: A Quantitative Approach.* Oxford University Press: New York, USA.
7. Wilson, K. and Walker, J. 2008. Practical Biochemistry - Principles and Techniques. 5th edition, Cambridge“Low Price Edition, UK.

Compulsory Non-Credit Paper: National Service

The students shall complete the requirements of “National Service” by doing some service in their own villages, towns, etc. for a period of 30 days during the winter vacation between I and II semesters. The reports of such service shall be evaluated by the departments concerned and adjudged “Satisfactory” or “Not Satisfactory”. If the report is “Not Satisfactory” they will not be eligible for the degree.

SECOND SEMESTER

Paper - 5: MIC-PG-O201: Instrumentation and Bioinformatics **4 Credits**

Unit I: Microscopy, Spectroscopy and Centrifugation

Principle and application: Light microscopy (Brightfield, Darkfield, Phase contrast, fluorescence microscopy and confocal microscopy), electron microscopy (Scanning and transmission microscopy), Atomic force Microscopy.

Spectrometric techniques: Principles of spectrophotometry (Beer-Lambert law, scatterings), Ultraviolet and visible light spectroscopy, Fluorescence spectroscopy, Atomic spectroscopy, Infrared and Raman spectroscopy. Mass spectroscopy and MALDI – TOF, ICP-MS, NMR, XRD. Centrifugation techniques: Preparative centrifugation and Analytical centrifugation, Care and safety aspects of centrifuges.

Unit II: Chromatography and Electrophoresis

Principles and application of Chromatography. Types: Paper and thin layer chromatography, Column chromatography, gel filtration, ion exchange, affinity, high-pressure liquid, Gas-liquid, HPTLC. Electrophoresis of proteins and nucleic acids.

Unit III: Molecular Techniques

Radio-isotopic and Fluorescence techniques. PCR, Real Time PCR, Blotting techniques. Molecular Markers (RAPD, RFLP, AFLP & Microsatellite); DNA Barcoding. Sequencing techniques: Sanger sequencing, Pyrosequencing, Illumina sequencing.

Unit IV Bioinformatics

Types, properties and application of biological databases with suitable examples (Gene Bank at NCBI, PDB, Swiss-Prot at EBI). Working with protein (predicting secondary structure, 3-D structures, RNA), building phylogenetic trees using DNA and protein sequences. General principles involved, global /local, tools available alike BLAST, CLUSTAL-W, Similarity Searches on sequence databases, comparing two sequences, building a multiple sequence alignment, editing and publishing alignments.

Reading lists

1. Davis, L. G., Dibner, M. D. and Battey, J. F. 1986. *Basic Methods in Molecular Biology*. Appleton and Lange, USA
2. Field, K. G. and Ream, W. 1999. *Molecular Biology Techniques: An Intensive Laboratory Course.* Academic Press.
3. Sambrook, J. and Russell David, W. R. 2001. *Molecular cloning A Laboratory Manual,* Three volumes, CSHL N.Y, USA.
4. Plummer, D. T. 2004. *Introduction to Practical Biochemistry*. 3rd edition, Tata Mcgraw Hill Publishing Company Limited, India.
5. Sambrook, J. M., Fritsch, E. F. and Maniatis, T. 1989. *Molecular Cloning: A Laboratory Manual* 3rd edition, Cold Spring Harbor Laboratory Press, USA.
6. Sharma, K. R. 2009. Bioinformatics. New York: McGraw-Hill, USA.
7. Sur, S. 2006. Bioinformatics. A P H Pub. Corp. New Delhi, India.
8. Wilson, K. and Walker, J. 2010. *Principles and Techniques of Biochemistry and Molecular Biology*. 7th edition, Cambridge University Press, UK.

Paper - 6: MIC-PG-C202: Microbial Genetics and Molecular Biology **4 Credits**

Unit I: Microbial Genetics

Introduction to the Gene transfer mechanisms: transformation, transduction, conjugation. Genetic mapping with the help of conjugation and transduction; Phage genetics: Fine structure analysis of T4 rII locus; Plasmid: Introduction, classification, incompatibility, copy number control.

Unit II: Transcription, translation and gene regulation

RNA polymerase structure and function, prokaryotic promoter sequence; transcription initiation, elongation and termination; anti-termination. Major differences between prokaryotic and eukaryotic transcription. Concept of genetic code, translation process in prokaryotes, translational proof-reading, translational inhibitors. Major differences between prokaryotic and eukaryotic translation. Operon – Positive and Negative regulation of *lac* operon; attenuation of *trp* operon.

Unit III: Transposons, RNA Molecules, Mutation

Transposable elements (DNA transposons, viral like retrotransposons, polyA retrotransposons), mechanism of transposition; RNA interference; Mutation – mutagens, types, causes and detection of mutation. In vitro mutagenesis and deletion techniques.

Unit IV: Recombinant DNA technology, Genomics and Proteomics

Phenomenon of Restriction Modification systems; molecular cloning, expression of recombinant proteins in prokaryotic and eukaryotic vectors; Preparation of cDNA libraries in plasmid, phagemid, cosmid, BAC and YAC vectors. Gene knockout in bacteria, Fluorescence *in situ* hybridization, sequence tagged site mapping; genome – structure and function, annotation, transcriptome – microarray or chip analysis; Introductory Proteomics. Introduction to unculturable microorganisms – metagenomics and microbiome.

Reading List

1. Karp, G., Iwasa, J., Marshall, W., 2015. *Karp's Cell and Molecular Biology*, 8th Edition, John Wiley and Sons.
2. Krebs, J.E., Goldstein, E.S. Kilpatrick, S.T. 2017. "Lewin's Genes XII. Jones and Bartlett Publishers, Inc; 12th revised edition.
3. Watson, J.D., Baker, T.A., Bell, S. P., Gann, A., Levine, M., Losick, R. 2013. *Molecular Biology of the Gene*, **7**th edition, Pearson.
4. Brown, T.A. 2006. *Genomes* 3rd edition, Garland Science.
5. Primrose, S.B. and Twyman, R.M., 2014, Principles of Gene Manipulation and Genomics 7th"edition, Wiley, India.
6. Maloy, S., Cronan, J.E., Freifelder, D. 2004. *Microbial Genetics* 2nd edition, Jones and Bartlett Publishers, Inc.
7. Streips, U. N. and Yasbin, R. E. 2002. *Modern Microbial Genetics*. 2nd edition, Wiley-Liss, USA.

Paper - 7: MIC-PG-C203: Clinical Microbiology **4 Credits**

Unit I: Principles of Clinical Microbiology

Koch's Postulates. Classification of medically important microorganisms. Normal microbial flora of human body and their role. Host pathogen interaction. Infection: Sources and vehicles of infection: waterborne, airborne, STDs, insect-borne, nosocomial. Establishment of infection: Mechanism of infection. Antimicrobials and their mode of action.

Unit II: Bacterial pathogens

Brief account of morphology, cultural characteristics, pathogenesis, clinical features, laboratory diagnosis, prevention and control of following: *Staphylococcus, Streptococcus, Pneumococcus, Neisseria, Corynebacterium, Clostridium,* organisms belonging to Enterobacteriaceae, *Vibrios, Haemophilus, Brucella, Mycobacteria, Spirochaetes, Actinomycetes, Acinetobacter.*

Unit III: Viral Pathogens

Brief account of morphology, cultural characteristics, pathogenesis, clinical features, laboratory diagnosis, prevention and control of important viral diseases like Influenza, Polio, Hepatitis, Herpes, AIDS.

Unit IV: Fungal and parasitic pathogens

Brief account of morphology, cultural characteristics, pathogenesis, clinical features, laboratory diagnosis, prevention and control of human fungal diseases. Dermatophytes, Dimorphic fungi, opportunistic fungal pathogens. Brief account of morphology, life cycle, pathogenesis, clinical features, laboratory diagnosis, prevention and control of important human parasitic diseases.

Reading List

1. Ananthanarayan and Paniker., 2013. *Ananthanarayan and Paniker's Textbook of Microbiology*.

C. K. Jayaram Paniker, 9th edition, Orient Blackswan, India

2. Brooks, G., Carroll, K. C., Butel, J. and Morse, S. 2007. *(Jawetz, Melnick, and Adelberg's Medical Microbiology* 24th edition McGraw-Hill Medical, USA.

3. Collee, J.G., Fraser, A. G., Marmion, B. P. Simmons. 2011. *Mackie & McCartney Practical Medical Microbiology* 14th edition, Churchill Livingstone, USA.

4. Forbes, B. A., Sahm, D. F. and Weissfeld, A. S. 2007, *Bailey and Scott's Diagnostic Microbiology*. 12th edition, Mosby, USA.

5. Mims, C. A. 2004. Medical Microbiology. 3rd edition C.V. Mosby, USA

6. Murray, P. R., Baron, E. J., Jorgensen, J. H. and Landry, M. J.: 2007 *Manual of Clinical* 9th edition, ASM Press, USA.

7. Chakraborty, P. 2013. A Textbook "of Microbiology. 3rd edition. New Central Book Agency (P) Limited, India.

Paper - 8: MIC-PG-C204: Laboratory Course II **4 Credits**

1. Biosafety and Good Microbiology Laboratory Practices.
2. Isolation of Genomic DNA from bacteria.
3. Isolation of plasmid DNA from bacteria.
4. Agarose gel Electrophoresis of the isolated genomic and plasmid DNA.
5. PCR Amplification of target DNA.
6. Purification of PCR amplified DNA from agarose gel.
7. Quantification of DNA by UV-Visual spectroscopy.
8. Bacterial transformation.
9. Bacterial conjugation.
10. Electrophoresis SDS-PAGE and native page.
11. Demonstration of Real-Time PCR.
12. Demonstration of DNA Sequencing techniques.
13. Isolation and Identification of medically important bacteria from human skin, and some clinical samples like pus, urine & stool.
14. Antibiotic susceptibility testing by disc diffusion method and MIC.
15. Demonstration of Acid Fast Bacilli (AFB) by ZN staining.
16. Demonstration of BIOLOG for phenotypic identification of bacteria.
17. Hands on Bioinformatics I: Introduction to Bioinformatics databases.
18. Hands on Bioinformatics II: Nucleotide sequence searches and alignments
19. Hands on Bioinformatics III: Building Phylogenetic trees.
20. Hands on Bioinformatics IV. Working with proteins.
21. Hands on Bioinformatics V. Primer designing.

Reading List

1. Arora, D.K., Surajit D., Mesapogu S., (Eds.) 2013. *Analyzing Microbes: Manual of Molecular Biology Techniques*, Springer-Verlag Berlin Heidelberg, USA.
2. Carson, HB. Miller and D. S Witherow. 2012. *Molecular Biology Techniques*. Amsterdam: Elsevier /Academic Press. USA
3. Collee, J.G., Fraser, A. G., Marmion, Simmons B. P.. 2011. *Mackie & McCartney Practical Medical Microbiology*. 14th edition, Churchill Livingstone, USA.

4. Cappucino, J. and Shuman, P. 2008. *Microbiology*: A Laboratory Manual. Benjamin Cummings, USA.

5. McPherson MJ and Moller SG. 2006. *PCR*. Taylor and Francis, Madison Avenue, NY.

6. Sambrook, J. and Russell , W. R. 2001. *Molecular cloning A Laboratory Manual*, Three volumes, CSHL N.Y, Ed., USA.

7. Wilson K. and Walker, J 2010. *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge: Cambridge Univ. Press. UK

THIRD SEMESTER

Paper - 9: MIC-PG-C301: Agricultural and Industrial Microbiology **4 Credits**

Unit I: Rhizosphere, Nitrogen Fixation, Biofertilizers

Microorganisms of soil, rhizospheres and Phylloplane, Microbial ecology of soil with respect to biotic and abiotic factors. Endophytic microorganisms and Mycorrhiza: PGPR. Nitrogen cycle and Biological Nitrogen Fixation in Symbiotic and Free living microorganisms. Phosphorus cycle and Phosphate solubilizing bacteria. Biofertilizers – Types and Application. Antibiosis and Biological control. Bio- pesticides. Humus Formation.

Unit II: Genetic Engineering in Agriculture

Significance of *Agrobacterium tumefaciens* and viral vectors in development of transgenic plants. Antisense RNA technology. Brief discussion of Bt cotton, Beta-Carotene Maize, Golden Rice, Rainbow Papaya, Flavr-Savr. Concept of edible vaccine as biopharmaceuticals (ZMAPP). Genetically Modified Microorganisms: *Pseudomonas syringe* (Ice-minus), *P. putida*. Regulatory issues in using genetically modified organisms.

Unit III: Introduction to Industrial Microbiology and Fermentation Principles

Bioprocess Technology. Types of Fermenters. Fermentation in batch culture: Media formulation, Microbial growth kinetics (Batch and Continuous kinetics), Effect of growth and nutrient, Condition on product formation. Industrial application of enzymes. Solid-Sate and submerged fermentation; mechanically & non-mechanically agitated fermenters.

Unit IV: Typical fermentations, Industrial strains and Immobilization technique

Fermentation processes: optimization, screening, strain improvement and factors affecting downstream processing and recovery. Fermentative production of antibiotics (Penicillin), Solvents (Ethanol), Biopolymer (PHAs) and Recombinant DNA products e.g. Insulin and amylase. Immobilized Enzyme and Cell based biotransformation. Biosensors. Biofuels.

Reading List

1. Biswas, P. K. 2008. *Agricultural Microbiology*: Dominant Publishers and Distributors. New Delhi, India
2. Boland, G. J. and Kuykendall, L. D. 1998. *Plant-Microbe Interactions and Biological Control*. Marcel Dekker Inc., New York.
3. Casida, L.E.J.R. 2019. Industrial Microbiology. 2nd edition. New Age International Publishers.
4. Crueger, W. Crueger, A. and Aneja, K.R. 2017. Biotechnology: A textbook of Industrial Microbiology, 3rd edition.
5. Stanbury, P. F., Stephen, J.H. and Whitaker, A. Principles of Fermentation Technology. 3rd edition, Butterworth-Heinemann. Elsevier Science & Technology.
6. Subba Rao, N. S. 2016. *Advances in Agricultural Microbiology*. Elsevier Science.

Paper 10: MIC-PG-C302 : MIC Environmental Microbiology **4 Credits**

Unit I: Aquatic, Atmospheric and Extreme Environments

Microbial habitats in the aquatic environment- Planktonic, Benthic, Microbial Mats, Biofilms. Freshwater environments, brackish water, marine water, subterranean water. Aeromicrobiological Pathway (Launching, Transport and Deposition); Extramural and Intramural aeromicrobiology. Bioaerosol control. General characteristics and mechanisms of adaptation of extremophiles. General stress signaling pathways in microorganisms.

Unit II: Microbial Communication

Quorum sensing in Gram-negative bacteria –Role of N acyl homoserine lactones. The *Agrobacterium tumefaciens* Tra I/Tra R virulence system and the *Vibrio fischeri* Lux I/Lux R bioluminescence system. Peptide mediated quorum sensing in Gram-positive bacteria. The *Staphylococcus aureus* Agr C/ Agr A virulence system.

Unit III: Microbial Biodegradation and Bioremediation

Concept of biotransformation and biodegradation of organic pollutants (Aliphatic, alicyclic, aromatic) and factors affecting biodegradation. Biodegradation of xenobiotics - pesticide catabolism, reductive and aerobic dechlorination. Microbial leaching of ores and metal recovery.

Unit IV: Solid and Liquid Waste Management

Types and sources of solid waste; methods of treatment of solid wastes. Wastewater treatment (Primary, secondary and tertiary) processes. Indicator microorganisms for fecal contamination. Drinking water purification (Physical and Chemical purification, Disinfection).

Reading List

1. Anitori, R. P. 2012. Extremophiles: Microbiology and Biotechnology, Caister Academic Press.
2. Bitton, G. 2010. Wastewater Microbiology. Fourth Edition, Wiley –Blackwell.
3. Madigan, M.T. Martinko, J.M., Stahl, D.A. and Clark, D.P. 2010. Brock Biology of Microorganisms, 13th edition, Pearson Benjamin-Cummings, San Francisco.
4. Nag, A. and Vizayakumar, K. 2005. Environmental Education and Solid Waste Management. New Age International (P) Ltd. Publishers, New Delhi.
5. Pepper, I.L, Gerba, C.P. and Gentry, T J. (Eds) 2014. Environmental Microbiology, 3rd edition, Academic Press.

Paper - 11: MIC-PG-O303: Immunology **4 Credits**

Unit I: Introduction to Immune system

Innate immune response and its components; adaptive immune response, Organs, cells and molecules involved in immune system, antigen and structure of antibody.

Unit II: Structure and Development of Immune system

B and T cell receptor, Development of B and T cells, Antigen presentation, Hypersensitivity, Cytokines and Complement system.

Unit III: Diseases due to innate and adaptive immunity and Immune evasion

Polymorphs, mast cells, phagocytosis, NK cells, dendritic cells and cytokine network. Hypersensitivity, autoimmune disease.

Bacterial and Viral immune evasion.

Unit IV: Vaccine and Immunological techniques

Different types of vaccines, Monoclonal and polyclonal antibodies, Immuno-techniques including ELISA, Immunofluorescence, Immunoprecipitation.

Reading List

1. Banerjee, A. K. and Banerjee, N. 2006. *Fundamentals of Microbiology and Immunology,* New Central Book Agency (Pvt.) Ltd., Kolkata.
2. Hall A, and Christine Y. 2010. *Immunology*. Oxford University Press.
3. Kindt TJ, Osborne, B. A. and Goldsby, R. A. 2006. *Kuby Immunology* 6th edition, W. H. Freeman.
4. Paut, J. Stramford, S. Jones, P. Owen, J. A. Kuby Immunology 8th edition W. H. Freeman.
5. Paul, W. E. 2003. Fundamental Immunology. 5th edition, Lippincott Williams and Wilkins Publishers, USA.
6. Pier, G. B., Lyczak, J. B. and Wetzler, L. M. 2004. *Immunology, Infection, and Immunity*. 1st edition, ASM Press.
7. Playfair, J. Bancroft, G. 2008. *Infection and Immunity*. 3rd edition, Oxford University Press. New York.

Paper - 12: MIC-PG-C304: Laboratory Course III **4 Credits**

1. Isolation and identification of microbes from environmental samples.
2. Microbial testing of water.
3. Assessment of air microbial quality.
4. Estimation of BOD from sewage samples.
5. Isolation, characterization and identification of thermophilic and psychrophilic bacteria.
6. Preparation of plant extracts by solvent extraction (methanol/ethanol).
7. Antibacterial activity of plant extracts by well diffusion method.
8. Demonstration of Immuno-techniques like Agglutination, Precipitation Immuno-precipitation.
9. Demonstration of western blot and ELISA.
10. Separation of different blood cells by ficoll method.
11. Demonstration of BIOLOG for phenotypic identification.
12. Ethanol production from any starchy materials.
13. Estimation of Ethanol.
14. Fermentation for the production of amylase and penicillin.
15. Enumeration of total bacterial, fungal and Actinomycetes counts from rhizospheric soils by pour & spread plate method.
16. Isolation of endophytic bacteria.
17. Isolation of symbiotic nitrogen fixers from leguminous/non-leguminous root nodules.
18. Determination of Biocontrol activity of endophytic bacteria.
19. Qualitative and quantitative evaluation of phosphate solubilization activity by soil isolates.
20. Qualitative evaluation of siderophore production by soil isolates.
21. Demonstration of bio-fertilizer preparation.

Reading List

1. Aga, Diana S. 1997. *Immunochemical Technology for Environmental Applications*. Washington, DC: American Chemical Society.
2. Cappuccino, J. G. and Sherman, N. 2007. *Microbiology- A Laboratory Manual*, 7th Edition, Pearson Education, Inc. and Dorling Kindersley Pvt. Ltd, Delhi, India.
3. Hay, F.C. and Westwood, O.M.R. 2002. *Practical Immunology.* 4th Edition, Blackwell Science.

4. Hurst, C. J., Crawford, R. L., Knudsen, G. R., McInerey, M. J. and Stetzenbach, L. D. 2002) *Manual of Environmental Microbiology*, 2nd edition. ASM Press, Washington DC.

5. Malik, Vedpal S, and Lillehoj E.P. 2013. *Antibody Techniques.* Burlington: Elsevier Science.

6. Harborne, J. B. Phytochemical Methods: *A Guide to Modern Techniques of Plant Analysis*. 2012. Springer Science & Business Media.

7. Alexander, M. 1977. *Soil Microbiology*. John Wiley.

8. Ilao, Rodolfo O, Patricio S Faylon, William D Dar, William D Batchelor, Riyaz Sayyed, Hari K Sudini, K. Vijay Krishna Kumar, Adoracian B Armanda, S Gopalakrishnan, and M. S Reddy. 2014. *Recent Advances In Biofertilizers And Biofungicides (PGPR) For Sustainable Agriculture*. Newcastle upon Tyne: Cambridge Scholars Publishing.

FOURTH SEMESTER

Paper – 13: MIC-PG-C401: Food Microbiology **4 Credits Unit**

I: Taxonomy and Microorganisms associated with the food

Taxonomic Tools and Approaches to study microorganisms associated with the foods. Food preservation: Principle of food preservation, asepsis, preservation by temperature, radiations, chemicals; bio- preservation, Hurdle concept in food preservation.

Unit II: Microbiology of food, Foodborne illness

Characteristics and clinical features of foodborne diseases caused by *Salmonella* and *Shigella, Escherichia coli, Staphylococcus aureus, Clostridium botulinum, Bacillus cereus Listeria monocytogenes,* viruses, prions. Food poisoning due to algal toxins, bacterial toxins and mycotoxins, viruses; predictive microbiology**.**

Unit III Fermented foods and beverages

Methods of production, mode of consumption, microbiology and nutrition: Himalayan fermented foods (*any two*): *gundruk, kinema, chhurpi, soibum, ngari.* Indian fermented foods (*any one*): *dahi, idli, dosa, rabdi, wari.* Oriental fermented foods (*any one*): *natto, kimchi, tempeh, soysauce, miso.* European fermented foods (*any one*): cheese, sausage, *sauerkraut, yogurt, sourdough.* African fermented foods (*any one*): *dawadawa, gari, kenkey, mageu, ogi.* Alcoholic beverages (*any two*): *kodo ko jaanr, sake,* wine, beer.

Unit IV: Food Safety, Probiotics

Food Safety Management: Codex Alimentarius, Hazard Analysis and Critical Control Point (HACCP) System-definition, application; Indicators of food quality- microbial indicator and microbial metabolites. Probiotics: Definition, characteristic and criteria of probiotic microorganisms, beneficial effects of probiotic bacteria; prebiotics and synbiotics.

Reading List

1. Adams, M. R. and Nout, M. J. R. 2001. *Fermentation and Food Safety.* Aspen Publishers Inc., Maryland.
2. Hutkins, R.W. 2006. *Microbiology and Technology of Fermented Foods*. Blackwell Publishing.
3. Jay, J. M., Loessner, M. J. and Golden, D. A. 2005. *Modern Food Microbiology*. 7th Edition, Springer, NY.
4. Omaye, S.T. 2004. *Food and Nutritional Toxicology*. CRC Press, London
5. Steinkraus, K. H. 1996. *Handbook of Indigenous Fermented Food*. 2nd edition, Marcel Dekker, Inc., New York.
6. Tamang, J.P. 2009. *Himalayan Fermented Foods: Microbiology, Nutrition and Ethnic Values*. Taylor and Francis Group, USA.
7. Tamang, J.P. and Kailasapathy, K. 2009. *Fermented Foods and Beverages of the World*. Taylor and Francis Group, USA.
8. Wood, B.J.B. 1998. *Microbiology of Fermented Foods*, 2nd edition, Elsevier Applied Science Publications.

Paper - 14: MIC-PG-C402: Molecular Virology **4 Credits**

Unit I: Nature of viruses

Modern classification of viruses. Concept of viroid's, satellite viruses, virusoids and prions. Structure of viruses and their cultivation. Capsid symmetry and virus architecture. Protein nucleic acid interaction.

Unit II: Techniques in virology and viral vaccines

Virus cultivation, Detection of viruses: (Complement fixation tests (CFT), Single Radial Haemolysis, Recombinant immunoblot assay (RIBA)). Quantification of viruses: Physical methods (TEM, PCR, qPCR, ELISA), Biological methods (Plaque assay, hemagglutination assay, Endpoint assay). Viral vaccines: Interferons and antiviral drugs.

Unit III: Bacterial and Plant Viruses

Bacterial Viruses: Viral multiplication and replication strategies of T4, T7, FX174. Plant Viruses: Viral multiplication and replication strategies of Tobacco Mosaic Virus, Cauliflower Mosaic Virus.

Unit IV: Animal Viruses

Epidemiology, molecular pathogenesis, diagnosis, prevention and treatment of RNA viruses, Picorna, Corona, Orthomyxo, Paramyxo, Toga, Flavi and other arthropod viruses, Rhabdo, Rota, HIV and other Oncogenic viruses; DNA viruses: Pox, Herpes, Adeno, Papilloma; Hepatitis viruses.

Reading List:

1. Cann, Alan J. 2016. *Principles of Molecular Virology*. London: Elsevier.
2. Carter, J. and Saunders, V. 2007. Virology: *Principles and Applications.* 1st edition Wiley.
3. Dimmock, N.J., Primrose, S.B. 1994. *Introduction to Modern Virology, 4th* edition, Blackwell Scientific Publications, Oxford.
4. Fields, B.N. et al. 2001. *Fields-Virology, Vol I and II,* 4th edition. Lippincott Williams & Wilkins Publishers.
5. Harper, D.R. 1993. *Virology Labfax*. Oxford: BIOS Scientific Publishers.
6. Modrow, Susanne. 2013. "Molecular Virology. Heidelberg: Springer.
7. Tiwari, V. N. 2012. *Virology*. Jodhpur: Agrobios, India.

Paper - 15: MIC-PG-C403: "Laboratory Course IV **4 Credits**

1. Isolation of bacteriophages.
2. Aseptic handling and cultivation of animal cell culture.
3. Cell counting by Hemocytometer.
4. Isolation of animal viruses.
5. Quantification of viruses by plaque assay/Real Time PCR.
6. Microbiology and quality assessment of any fermented.
7. Microbiology and quality assessment of non-fermented food samples.
8. Isolation of dominant microorganisms from fermented food – cereal and vegetable products (any local product): *Bacillus*/Lactic acid bacteria/ yeasts/coliforms.
9. Identification of dominant microorganisms from food samples by phenotypic characteristics.
10. Microbiological analysis of milk, meat, eggs.
11. Estimation of carbohydrates and proteins in fresh/fermented food samples.
12. Estimation of lipids from food samples.

Reading List

1. Harrigan, W.F. 1998. *Laboratory Methods in Food Microbiology.* 3rd edition. Academic Press, London.
2. Roberts, D. and Greenwood, M. 2002. *Practical Food Microbiology.* 3rd edition, Wiley-Blackwell.
3. Cappucino, J. and Shuman, P. 2008. *Microbiology: A Laboratory Manual.* Benjamin Cummings.
4. Nielsen, Suzane S. 2010. *Food Analysis Laboratory Manual*. Springer, NY
5. Fields, B.N. et al. 2001. *Fields-Virology, Vol I and II,* 4th edition. Lippincott Williams & Wilkins Publishers.
6. Desselberger, U. 1998. *Medical Virology: A Practical Approach.* Oxford University Press, UK.

Paper -16: MIC-PG-C404: Dissertation **4 Credits**

The students shall submit dissertations and defend their methodologies and findings before the entire faculty plus one external examiner at the end of the IV semester. The average of marks given by internal faculty members shall be counted out of 50% and the external examiner shall mark out of the remaining 50%.

Sl. No	Details	Internal Examiner	External Examiner	(Total Marks=100)
1.	# Dissertation findings #Further advancement (Future scope) of Assigned dissertation topic followed by a brief review of literature on the same.	25	25	50
2.	Thesis Evaluation and Viva-voce.	25	25	50
Total Marks				100

Evaluation shall be done by all the Faculty members of the Department and one external examiner.

DEPARTMENT OF MICROBIOLOGY

M.Phil Course Work Syllabus

CONTENTS

Paper No.	Paper Code	Paper Number and Name	Number of Lectures	Credits	Full Marks
Paper - 1		Research Methodology (School of Life Sciences Level Paper) – **To be prepared at the School Level**	48 Lectures	4 Credits	100 Marks
Paper– 2	MIC-RS-E-102	Preparation of Research Proposal	48 Lectures	4 Credits	100 Marks
Paper – 3*	MIC-RS-E-103	Emerging areas of research in Medical Microbiology	48 Lectures	4 Credits	100 Marks
Paper – 4*	MIC-RS-E-104	Emerging areas of research in Food Microbiology	48 Lectures	4 Credits	100 Marks
Paper – 5*	MIC-RS-C105	Emerging areas of research in Environmental Microbiology	48 Lectures	4 Credits	100 Marks
Paper – 6*	MIC-RS-E-106	Emerging areas of research in Industrial Microbiology	48 Lectures	4 Credits	100 Marks
		Dissertation for M. Phil		12 Credits	

(*) – Candidate have to opt any one paper depending on their choice of specialization.

Paper- 1: Research Methodology

To be prepared at the School Level

Paper - 2: MIC-RS-C-102: Preparation of Research Proposal **4 Credit**

Preparation of Research Proposal through review and survey of literature in the topic of research.

Identification of gaps in the knowledge and preparation of specific objectives and rationale to bridge the gaps. Preparation of a real time budget and infrastructure requirements.

(**To be evaluated by all faculty members**)

Paper -3: MIC-RS-E-103: Emerging areas of research in Medical Microbiology **4 Credit**

Unit I: Microbiological Techniques

Aseptic techniques: (Physical and chemical methods of Sterilization and Disinfection), Isolation and pure culture Techniques, Staining (Simple staining, Grams staining, Capsule, Spore and Acid fast staining), Sample selection, sample collection and sample transport. Preservation Techniques. Antibiotic susceptibility techniques: disc diffusion and Minimum Inhibitory Concentration. Brief overview of Biosafety, Institutional Biosafety Committee, Institutional Ethical Committee. Biodiversity Act.

Unit II: Study of Important Human Pathogens

Infection and disease process in humans. Pathogenesis, clinical feature and Laboratory diagnosis of important bacterial, viral, fungal and parasitic diseases. Important molecular methods of identification and typing of pathogenic microorganisms. Vaccines.

Unit III: Advanced Techniques in Microbiology: I

Polymerase Chain Reaction (PCR), Denaturing Gradient Gel Electrophoresis (DGGE),

Restriction Fragment Length Polymorphism (RFLP), Amplified Ribosomal DNA

and Restriction Analysis (ARDRA), PFGE.

Unit IV: Advanced Techniques in Microbiology: II

Phenotypic Identification of bacteria and fungi including automated method by Biolog and other methods. Sequencing including next generation sequencing techniques. Techniques of metagenomics.

Reading List:

1. Ananthanarayan and Paniker. 2013. *Ananthanarayan and Paniker's Textbook of Microbiology*. C. K. Jayaram Paniker,9th edition, Orient Blackswan, India
2. Bottone, E. J. 2006. *Atlas of the Clinical Microbiology of Infectious Diseases, Volume 2: Viral, Fungal and Parasitic Agents.* 1st edition, Informa Health Care Publishing.
3. Brooks, G., Carroll, K. C., Butel, J. and Morse, S. 2007. *Medical Microbiology(Jawetz, Melnick, and Adelberg's Medical Microbiology)*. 24th edition McGraw-Hill Medical, USA
4. Cappuccino, J. G. and Sherman, N. 2007. *Microbiology- A Laboratory Manual.* Seventh Edition, Pearson Education, Inc. and Dorling Kindersley (India) Pvt Ltd, Delhi, India.
5. Collee, J.G., Fraser, A. G., Marmion, B. P. Simmons. 2011. *Mackie & McCartney Practical Medical Microbiology*. 14th edition, Churchill Livingstone, UK.
6. Goldman, E and Green, L.H. 2008.Practical Handbook of Microbiology. 2nd Edition, CRC Press.
7. Murray, P. R., Baron, E. J., Jorgensen, J. H. and Landry, M. J. 2014. *Manual of Clinical Microbiology* (2 Volume Set). 10th edition, ASM Press, USA.

Paper - 4: MIC-RS-E-104: Emerging areas of research in Food Microbiology **4 Credit**

Unit I: Microbiological Techniques

Aseptic techniques: (Physical and chemical methods of Sterilization and disinfection), Isolation and pure culture Techniques, Staining (Simple staining, Grams staining, Capsule, Spore and Acid fast staining), Sample selection, sample collection and sample transport. Preservation Techniques. Antibiotic susceptibility techniques: disc diffusion and Minimum Inhibitory Concentration. Brief overview of Biosafety, Institutional Biosafety Committee, Institutional Ethical Committee.

Unit II: Microorganisms in foods and their study

Factors affecting growth and survival of microorganisms in foods; Classification, physiology and Genotypic identification of microorganisms associated with the foods: Lactic acid bacteria, *Bifidobacteria, Propionibacteria*, *Bacillus*, yeasts and molds; techniques to study of un-culturable microorganisms in foods.

Unit III: Prebiotics, Probiotics and Functional foods

Brief overview of gut microbiome; Prebiotic and Probiotic: Prebiotics – criteria of prebiotics, effects of prebiotics on metabolism and or absorption of nutrients; prebiotics in infant formulas; Probiotics: Criteria for probiotics, Development of Probiotics for animal and human use; Functional foods- health claims and benefits, Development of functional foods.

Unit IV: Food safety management

Indicators of food safety, Microbiological quality and microbiological criteria, sampling plans; quality control using microbiological criteria, control at source; Good Manufacturing Practices; Rapid detection of pathogenic bacteria and viruses in the foods by various methods.

Reading List:

1. Salle, A.J. 2007. *The Fundamentals and Principles of Bacteriology*. Tata McGraw Hill Company.
2. Vos, P., Garrity, G., Jones, D., Krieg, N.R., Ludwig, W., Rainey, F.A., Schleifer, K.-H., Whitman, W. (Eds.), M. 2009. *Bergey's Manual of Systematic Bacteriology*, The Firmicutes, Volume 3, Springer-Verlag New York
3. Gibson, G.R. and Christine M. Williams. 2001. *Functional foods: Concept to product*. CRC Press, Boca Raton, Boston.
4. Gibson, GR and Roberfroid (2008) Handbook of Prebiotics, CRC Press, Taylor & Francis Group, Boca Raton, FL
5. Goktepe, I., Juneja, V.K. and Ahmedna M. 2006. *Probiotics in Food Safety and Human Health*. CRC Press, Taylor & Francis Group, Boca Raton, FL
6. Adams, M.R. and Nout, M.J.R. 2001. *Fermentations and Food Safety. Aspen Publication.* Aspen Publishers, Inc., Gaithersburg, Maryland.
7. Salminen, S. and Wright, A.V. 1998. Lactic *acid bacteria Microbiology and Functional Aspects.* 2nd Ed., Marcel Dekker, New York.
8. Wood, B.J.B. and Holzalpfel, W.H. 1995. The genera of Lactic acid bacteria. Vol 1 and 2. Springer, US.

Paper - 4: MIC-RS-E-105: Emerging areas of research in Environmental Microbiology **4 Credit**

Unit I: Microbiological Techniques

Aseptic techniques: (Physical and chemical methods of Sterilization and disinfection), Isolation and pure culture Techniques, Staining (Simple staining, Grams staining, Capsule, Spore and Acid fast staining), Sample selection, sample collection and sample transport. Preservation Techniques. Antibiotic susceptibility techniques: disc diffusion and Minimum Inhibitory Concentration. Brief overview of Biosafety, Institutional Biosafety Committee, Institutional Ethical Committee.

Unit II: Instrumentation Techniques

Polymerase Chain Reaction (PCR), Recombinant DNA techniques,

Restriction Fragment Length Polymorphism (RFLP), Denaturing/ Temperature Gradient Gel Electrophoresis (DGGE/ TGGE), Sanger Sequencing, Pyrosequencing, HPLC, HPTLC, GC-MS, LC-MS.

Unit III: Bacterial response to antimicrobials

Effects of various phytochemicals and antibiotics on microorganisms. Methods of phytochemical extraction. Cellular defense strategy of microorganisms against phytochemicals, cellular oxyradicals and antioxidative strategies in bacteria. New perspectives on the use of phytochemicals as antimicrobial and antioxidant agents.

Unit IV: Extreme Environments

Extremophiles: Introduction, Diversity, Habitat, Physiology and applications of Acidophilic, Alkaliphilic. Thermophilic, Psychrophilic, Barophilic, Halophilic microorganism and Microorganism resistant to radiations.

Reading List:

1. Patra, A.K. (Ed.). 2012. Dietary "Phytochemicals and Microbes. Springer.
2. Anitori, R. P. 2012. *Extremophiles: Microbiology and Biotechnology*. Caister Academic Press.
3. Field, K. G. and Ream, W. 1999. *Molecular Biology Techniques: An Intensive Laboratory Course*. Academic Press.
4. Gerday, C., Glansdorff, N. (Eds) 2007. *Physiology and Biochemistry of Extremophiles*, first edition, ASM Press.
5. Harborne, J. B. 2012. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. Springer"Science & Business Media.
6. Robb, F. Antranikian, G., Gorgan, D. Driessen, A. 2012. *Thermophiles: Biology and Technology at High Temperature*, CRC Press.
7. Wilson, K. and Walker, J. 2008. *Practical Biochemistry - Principles and Techniques*. 5th edition, Cambridge Low Price Edition.

Paper – 6: MIC-RS-E-106: Emerging areas of research in Industrial Microbiology

Unit I: Introduction to Industrial Microbiology

An introduction to fermentation process. Screening of industrial microbes – Detection and assay of fermentation products. Classification of fermentation types. Metabolic engineering. Strain selection and improvement, mutation - protoplast fusion and recombinant DNA technique for strain development. Preservation methods of cultures.

Unit II: Microbial growth and Fermentation kinetics:

Batch kinetics –single substrate, dual substrates – sequential utilization, multiple substrates – simultaneous utilization, substrate inhibition, product synthesis (primary and secondary metabolite), toxic inhibition, death constant.

Fed-batch kinetics – fixed volume, variable volume and cyclic fed-batch, applications and examples of fed-batch systems.

Continuous cultivation system –applications and examples of continuous cultivation system; comparison between various cultivation systems.

Unit III: Bioprocess System:

Bioprocess Technology. Types of Fermenters. Fermentation in batch culture: Media formulation, Solid-Sate and submerged fermentation; mechanically & non-mechanically agitated fermenters.

Fermentation processes: optimization, and factors affecting downstream processing and recovery.

Unit IV: Fermentation technology for microbial products

Fermentative production of antibiotics (Penicillin), Solvents (Ethanol), Biopolymer (PHAs) and Recombinant DNA products e.g. Insulin and amylase. Mixed Acid Fermentation

Industrial application of enzymes, Microbial leaching and Biodegradation.

Enzyme immobilization and different techniques used for immobilizationand cell based biotransformation.

Reading List:

1. Casida, L.E.J.R. 2019. Industrial Microbiology. 2nd edition. New Age International Publishers.
2. Crueger, W. Crueger, A. and Aneja, K.R. 2017. Biotechnology: A textbook of Industrial Microbiology, 3rd edition.
3. Stanbury, P. F., Stephen, J.H. and Whitaker, A. Principles of Fermentation Technology. 3rd edition, Butterworth-Heinemann. Elsevier Science & Technology.
4. Flickinger, M. C. and Drew S. W., The Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation, Volumes 1 - 5, Wiley-Interscience.

DEPARTMENT OF MICROBIOLOGY

Ph.D. Course Work Syllabus

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MIC-RS-E-103	Emerging areas of research in Medical Microbiology	4 Credits	100 Marks
MIC-RS-E-104	Emerging areas of research in Food Microbiology	4 Credits	100 Marks
MIC-RS-E-105	Emerging areas of research in Environmental Microbiology	4 Credits	100 Marks
MIC-RS-E-106	Emerging areas of research in Industrial Microbiology	4 Credits	100 Marks
	Dissertation for M. Phil	12 Credits	

Candidate have to opt any one Elective (E) paper depending on their choice of specialization.

Paper- 1: MIC-RS-C-102: Research Methodology **4 Credit**

 # School Level

Paper - 2: MIC-RS-C-102: Preparation of Research Proposal **4 Credit**

Preparation of Research Proposal through review and survey of literature in the topic of research. Identification of gaps in the knowledge and preparation of specific objectives and rationale to bridge the gaps. Preparation of a real time budget and infrastructure requirements.

(**To be evaluated by all faculty members**)

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4. Gerday, C., Glansdorff, N. (Eds) 2007. *Physiology and Biochemistry of Extremophiles*, first edition, ASM Press.
5. Harborne, J. B. 2012. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. Springer"Science & Business Media.
6. Robb, F. Antranikian, G., Gorgan, D. Driessen, A. 2012. *Thermophiles: Biology and Technology at High Temperature*, CRC Press.
7. Wilson, K. and Walker, J. 2008. *Practical Biochemistry - Principles and Techniques*. 5th edition, Cambridge Low Price Edition.

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Bioprocess Technology. Types of Fermenters. Fermentation in batch culture: Media formulation, Solid-Sate and submerged fermentation; mechanically & non-mechanically agitated fermenters.

Fermentation processes: optimization, and factors affecting downstream processing and recovery.

Unit IV: Fermentation technology for microbial products

Fermentative production of antibiotics (Penicillin), Solvents (Ethanol), Biopolymer (PHAs) and Recombinant DNA products e.g. Insulin and amylase. Mixed Acid Fermentation

Industrial application of enzymes, Microbial leaching and Biodegradation.

Enzyme immobilization and different techniques used for immobilizationand cell based biotransformation.

Reading List:

1. Casida, L.E.J.R. 2019. Industrial Microbiology. 2nd edition. New Age International Publishers.
2. Crueger, W. Crueger, A. and Aneja, K.R. 2017. Biotechnology: A textbook of Industrial Microbiology, 3rd edition.
3. Stanbury, P. F., Stephen, J.H. and Whitaker, A. Principles of Fermentation Technology. 3rd edition, Butterworth-Heinemann. Elsevier Science & Technology.
4. Flickinger, M. C. and Drew S. W., The Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation, Volumes 1 - 5, Wiley-Interscience.

DEPARTMENT OF ZOOLOGY, SIKKIM UNIVERSITY

M.Sc. SYLLABUS

Paper No.	Title	*Total Credits*
SEMESTER-I		
ZOOPG-CT-101	Functional biology of Non-Chordates, Chordates	4
ZOOPG-CT-102	Biosystematics, Ecology, Biostatistics	4
ZOOPG-CT-103	Biochemistry, Endocrinology	4
ZOOPG-CP-104	Practicals - Non-Chordates, Chordates, Ecology, Biochemistry, Endocrinology	4
Total Credits		**16**
SEMESTER-II		
ZOOPG-OT-201	Molecular Biology, Biotechnology, Immunology	4
ZOOPG-CT-202	Genetics, Evolutionary Biology	4
ZOOPG-CT-203	Developmental Biology, Parasitology	4
ZOOPG-CP-204	Practicals - Immunology, Genetics, Developmental Biology, Parasitology	4
Total Credits		**16**
SEMESTER-III		
ZOOPG-OT-301	Cell Biology, Techniques in Biology, Bioinformatics	4
ZOOPG-CT-302	Animal Physiology	4
Elective Theory (Any One from Theory)		
ZOOPG-ET-303	Applied Ecology, Climate Change Biology	4
ZOOPG-ET-304	Immunobiology and Parasitology-I	
ZOOPG-ET-306	Comparative Animal Physiology and Biochemistry-I	
ZOOPG-CP-305	Practicals – Cell Biology, Techniques in Biology, Animal Physiology	4
Total Credits		**16**
SEMESTER-IV		
Elective Theory and Practical (Any Two from Theory & One from Practical groups)		
ZOOPG-ET-401	Biodiversity, Conservation Biology	4
ZOOPG-ET-402	Immunobiology and Parasitology-II	
ZOOPG-ET-403	Wildlife Biology, Animal Behaviour	4
ZOOPG-ET-404	Immunobiology and Parasitology-III	
ZOOPG-ET-408	Comparative Animal Physiology and Biochemistry-II	4
ZOOPG-ET-409	Comparative Animal Physiology and Biochemistry-III	
ZOOPG-EP-405	Practicals – Biodiversity, Wildlife Biology, Animal Behaviour	4
ZOOPG-EP-406	Practical – Immunobiology and Parasitology	
ZOOPG-EP-410	Practical-Animal Physiology and Biochemistry	
ZOOPG-DV-407	Dissertation and Viva-Voce	4
Total Credits		**16**

Abbreviations:

CT – Core Theory; CP- Core Practical; OT-Open Theory; ET-Elective Theory; EP-Elective Practical; DV- Dissertation and Viva Voce

SEMESTER - I

ZOOPG-CT-101: FUNCTIONAL BIOLOGY OF NON-CHORDATES, CHORDATES

Total Max. Marks-100 **Total Credit-04**

UNIT I – FUNCTIONAL BIOLOGY OF NON-CHORDATES

Hydrostatic movements in Cnidaria, Annelida and Echinodermata; Significance of segmentation with reference to locomotion in Annelids.

Excretory organs in mollusks and echinoderms.

Reproductive organs and life history of major crustaceans, decapods and echinoderms.

Origin of multicellularity, cephalization, trend of neural evolution in non-chordates.

Defence mechanism in Cnidaria and Mollusca.

UNIT II – ENTOMOLOGY

Insect classification upto orders with characters and examples.

Adaptive radiations in insects with reference to trophic relation.

Insect developmental hormones in cockroach and silkworm: sources, biosynthesis, transport, mode of action and regulation of their titers.

Life cycle strategies in social insects and aphids.

Communications in insects.

UNIT III – FUNCTIONAL BIOLOGY OF CHORDATES-I

Skull in vertebrates: structural and evolutionary approach.

Anatomical features of desert animals [Camels (*Camelus*), Horned lizards (*Phyrnosoma*)].

Central Nervous System (CNS): cranial nerves, functional associations, information processing.

Sensory organs in mammals: Auditory system and its evolutionary changes.

Stomach in ruminants.

UNIT IV – FUNCTIONAL BIOLOGY OF CHORDATES-II

Aquatic adaptations in birds and mammals, cave adaptation, deep sea adaptation.

Aerodynamics in birds.

Echo location in bats.

Integuments in reptiles and mammals.

Circadian rhythm.

Suggested Reading

1. Anderson, D.T. (2001) *Invertebrate Zoology*. Oxford University Press.
2. Ruppert, E. E., Fox, R. S. & Barnes, R. D. (2004) *Invertebrate zoology: a functional evolutionary approach* (7th edition). Belmont, CA: Thomas-Brooks.
3. Chapman, R. F. (2012) The Insects: Structure and Function. Cambridge University Press.
4. Gullan, P. J & Crasnston, P. S. (2010) The Insects: An Outline of Entomology. Wiley Blackwell Publisher
5. Klowden, M. J. (2013) Physiological system in Insects. Academic Press.
6. Price, P. W. (1997) Insect Ecology. Wiley Blackwell Publisher.
7. Pugh, Heifer & McFarland (1999) Vertebrate life. 4th End. Prentice-Hall of India, New Delhi.
8. R.F. Schmidt & Thaws (1989) Human Physiology, (Eds.), 2nd End. Springer-Vela, Berlin.
9. K. Kardong (2011) Vertebrates: Comparative Anatomy, Functions, Evolution, 6th Ed. McGraw-Hill Science.
10. Thangamani et al (2013) A Text Book of Chordates. Saras Publication

ZOOPG-CT-102: BIOSYSTEMATICS, ECOLOGY, BIOSTATISTICS

Total Max. Marks-100 **Total Credit-04**

UNIT I - BIOSYSTEMATICS

Procedures of taxonomy: alpha, beta and gamma taxonomy.

Classification: species and supra and infra species categories, cryptic, polytypic and sibling species, apomictic and panmictic populations.

Rules of zoological nomenclature: nomenclature at species and higher categories, types, homonyms and synonyms.

Phenetics and cladistics classification.

Molecular taxonomy: DNA barcoding, use of genetic markers, determination of genetic distance.

UNIT II – ECOLOGY

Population ecology: population regulation - extrinsic and intrinsic mechanisms, oscillation, dispersal, competitive exclusion principle.

Concept of metapopulations: theories and applications.

Life history strategy: r-selection, k-selection.

Construction of life table, survivorship curves.

Plant-animal interactions, evolution of plant-pollinator relationships.

UNIT III – BIODIVERSITY AND WILDLIFE

Types of biodiversity: species, genetic and ecosystem.

Geographical level biodiversity: local and regional diversity, â-diversity.

Measurements of biodiversity: dominance indices, diversity indices (Shannon-Weiner, Brillouin index), similarity index.

Macroecological patterns: vertical zonation of vegetation with special reference to the Himalayas.

Faunal diversity patterns: altitudinal and latitudinal gradients.

Major threats to biodiversity of the world.

Introduction to biodiversity hotspot.

Importance of wildlife and rationale for their conservation.

In situ and *Ex situ* conservation: prospects and limitations.

UNIT IV – BIOSTATISTICS

Probability distribution: concept, normal, bionomial and Poisson’s distribution.

Hypothesis testing.

Statistical tests: correlation and regression analyses (linear and non-linear, meanings of intercept, slope and intercept values), student's "t" test (paired and unpaired), Mann-Whiteny 'U' Test, ANOVA.

Models: types of models, empirical, mechanistic, stochastic, deterministic.

Suggested Reading

1. Odum, E.P. (1983). Basic Ecology. Saunders, Philadelphia.
2. Smith, R.L. and T.M. Smith (2002) Ecology and Field Biology. Addison – Wesley Educational Publishers Inc.
3. Ricklefs, R.E. and G.L. Miller. (1999) Ecology. W.H. Freeman & Company.
4. M. Kato. (2000) The Biology of Biodiversity. Springer.
5. Kothari, A.S. & Chapgar. (2005) Treasure of Indian Wildlife, BNHS, Mumbai.
6. B. B. Hosetti. (2005) Concepts in Wildlife Management. 2nd Revised & Enlarged Edn, 2005. Daya Publishing House, Delhi.
7. Sharma, A.K. (2005). Text Book of Biostatistics. Vol. I. Discovery Publishing House.
8. Sokal, R.R. & Rohlf, F.J. (1994). Biometry: The Principles and Practices of Statistics in Biological Research. W. H. Freeman.
9. Slater, P.J.B and Milinski, M. (1996) Parental Care: Evolution, Mechanisms, And Adaptive Significance. Academic Press.
10. Wells, K.D. (2007) Ecology and Behaviour of Amphibians. The University of Chicago Press.

ZOOPG-CT-103: BIOCHEMISTRY, ENDOCRINOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I – BIOCHEMISTRY-I

Bioenergetics and metabolism: principles of glycolysis with regulation, citric acid cycle with regulation, glycogenolysis, gluconeogenesis, HMP-shunt pathway.

Amino acids: transamination and deamination reactions, oxidative phosphorylation in mitochondria, â-oxidation of fatty acids.

Protein structure: Ramachandran plot.

UNIT II – BIOCHEMISTRY-II

Enzymology: introduction to enzymes, classification, structure and properties, energetics of enzyme-catalyzed reaction, effects of different physico-chemical factors on enzyme activity. Enzyme kinetics: Michaelis-Menten equation and its derivation, Lineweaver-Burk plot, significance of Km, simple calculation on enzyme kinetics; Inhibition of enzyme, allosteric enzyme, isoenzyme, ribozyme.

UNIT III – ENDOCRINOLOGY-I

Vertebrate endocrine system: concept of neurosecretion, neurosecretory centres; Hypothalamus, pineal and thymus and their hormones.

Hypophysis: neurohypophysis and adenohypophysis - structure, function and hormones.

Molecular mechanism of steroid and peptide hormone actions.

Chemistry and biosynthesis of steroid hormones, thyroid hormones and melatonin.

UNIT IV– ENDOCRINOLOGY-II

Hormone receptors: characteristics and types of receptors, membrane-bound and intra-cellular receptors, receptor recycling.

Hormone-receptor complex and signal transduction mechanism.

Regulation of estrous and menstrual cycles by hormones.

Suggested Reading

1. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2002) Biochemistry. W.H.Freeman & Company.
2. Murray, R.K. et al (2012) Harpers Illustrated Biochemistry. McGraw-Hill Medical.
3. Nelson, D.L & Cox, M.M. (2008) Lehninger Principles of Biochemistry. W.H. Freeman & Company.
4. Zubay, G. (1999) Biochemistry. William C Brown Publishers.
5. Mathews, C.K., van Holde, K.E., Appling, D.R. & Anthony-Cahill, S.J. (2012) Biochemistry. Prentice Hall Publisher.
6. Murray et al. (2003) Harper's Illustrated Biochemistry (26th ed), Appleton and Lange.
7. Hadley, M. & Levine, J.E. (2006) Endocrinology. Benjamin Cummings.
8. Nussay, S.S. & Whitehead, S.A. (2001) Endocrinology: An Integrated Approach. CRC Press.
9. Bentley, P. J. (1998) Comparative Vertebrate Endocrinology, Cambridge University Press.
10. Brook, C.G.D. & Marshall, N.J. (2001) Essential Endocrinology, 4th edn. Wiley.

ZOOPG-CP-104: PRACTICAL

NON-CHORDATES, CHORDATES, ECOLOGY, BIOCHEMISTRY, ENDOCRINOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I – NON-CHORDATES AND CHORDATES

Preparation of identification keys of insects.

Mounting of mouthparts of mosquitoes and houseflies.

Isolation and identification of soil nematodes.

Demonstration of endocrine glands in vertebrates.

Demonstration of cranial nerves in vertebrates.

UNIT II – ECOLOGY

Water Analysis: estimation of total hardness, salinity, chloride, calcium, magnesium, phosphate, TDS.

Demonstration of limnological apparatus: Secchi disk, Jacksons candle turbidometer, Ekman dredge.

UNIT III – BIOCHEMISTRY AND ENDOCRINOLOGY

Estimation of protein using Folin's/Bradford reagent.

Estimation of sugar by anthrone reagent.

Estimation of DNA using diphenylamine reagent.

Estimation of RNA using orcinol reagent.

Assay of urease enzyme by tritimetric method.

Display of endocrine glands in laboratory bred animals.

Histological study of endocrine glands (Thyroid, Adrenal, Testis and Ovary).

UNIT IV – ECOLOGICAL EXCURSION, FIELD REPORTS AND SEMINAR

Students have to participate in ecological excursion organized by the department and prepare a field report based on observation in the field.

Students have to prepare a term paper on any topic related to the subject in consultation with faculty members. Every student has to present a 10 minutes duration seminar on the chosen topic.

SEMESTER - II

ZOOPG-OT-201: MOLECULAR BIOLOGY, BIOTECHNOLOGY, IMMUNOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I – MOLECULAR BIOLOGY-I

Structure and properties of DNA and RNA.

DNA replication: semi-conservative, structural properties of DNA polymerases, mechanism of DNA replication.

Transcription: mechanism of transcription - initiation, elongation and termination, sense and antisense strands, structural properties of RNA polymerases, RNA processing.

UNIT II – MOLECULAR BIOLOGY-II

Protein synthesis: initiation, elongation and termination.

Genetic code: triplet codon concept, features of genetic code.

Prokaryotic gene expression: positive and negative control, lac operon in *E. coli*, tryptophan operon in *E. coli*, repression and attenuation.

UNIT III - BIOTECHNOLOGY

Genomic and cDNA libraries: construction and screening; expression of vectors and expression of fusion proteins; Transgenic animals: production, prospects, advantages and disadvantages; Site directed mutagenesis: strategies and prospects.

Recombinant DNA technology and its application in human gene therapy, vaccine development, environmental bioremediation and protein engineering; Reverse transcriptase.

Microbial synthesis of commercial products: restriction endonucleases, antibiotics and vitamins.

UNIT IV – GENERAL IMMUNOLOGY

Overview of the immune system: components of the immune system, innate and adaptive immune system.

Barriers of immune system: mechanical barriers, chemical barriers.

Cells of immune system: lymphoid and myeloid lineages.

Concept of antigen: physical and chemical nature, general properties of antigens, superantigens, haptens, adjuvants.

Immunoglobulin structure: CDR/hypervariable region, framework region, biological and physical properties, antibody subclass, isotype, allotype, idiotype, antibody engineering.

Antibody-mediated effector functions: complement activation, cell mediated cytotoxicity, opsonisation.

Suggested Reading

1. Cooper, G.M. (2009) The Cell: A Molecular Approach. Sinauer Associates, Inc.
2. Karp, G. (2009) Cell & Molecular Biology Concepts and Experiment. Willey Blackwell Publisher.
3. Lewin, B. (2007) Genes IX. Jones & Bartlett Publishers.
4. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010) Molecular Biotechnology: principles and applications of recombinant DNA. 4th Edition. ASM Press.
5. Balasubramanian, D, Dharmalingam, K., Bryce, C. F. A., Green, J. & Jayaraman, K. Concepts in Biotechnology. Revised edition. University Press (India).
6. Abbas, A.K. (2011). Cellular and Molecular Immunology (7th Ed). Saunders.
7. Chakravarty, A.K. (2003) Immnology II. N.L. Publishers.
8. Kindt, T.J et. al. (2006) Kuby: Immunology, 6 Th Ed. W.H. Freeman & Company.
9. Roitt. I. (2001) Immunology. Mosby Publ. London.
10. Tizard I.R. (1995). Immunology: an introduction , 4th edn. Saunders College Publishing.

ZOOPG-CT-202: GENETICS, EVOLUTIONARY BIOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I – GENETICS-I

Extra chromosomal inheritance: inheritance of mitochondrial and chloroplast genes,

maternal inheritance.

Microbial Genetics: methods of gene transfers - transformation, transduction, conjugation, sexduction.

Transposable genetic elements in prokaryotes and eukaryotes: IS element, composite transposons, Tn3 element, mechanism of transposition, P element and hybrid dysgenesis in *Drosophila*, retrotransposons.

Somatic cell genetics: concept and applications, transfection of cells - principles and methods, cell fusion, hybridoma, applications of embryonic stem cells.

UNIT II – GENETICS-II

Destabilizing forces influencing allele frequencies: mutation and estimation of mutation rates. Natural Selection: gametic selection, selection against recessive and recessive lethal, selection against dominant, heterozyote advantage.

Genetic structure of population: optimum phenotype, selection pressure, Fisher's theorem of natural selection, canalization, genetic homeostasis, genetic load and genetic death.

Inbreeding: measure of inbreeding, inbreeding depression, heterosis.

UNIT III - EVOLUTIONARY BIOLOGY-I

Isolation mechanisms and their role in evolution, Implication of geographical distribution for modes of speciation.

Concept of molecular evolution: molecular clock and molecular drive, human evolution.

Macro evolution: concept, phylogenetic gradualism, punctuated equilibrium, major trends in the origin of higher categories.

UNIT IV - EVOLUTIONARY BIOLOGY-II

Genome evolution: evolution of multigene family, acquisition of new genes - mechanisms and exon theory.

Concerted evolution.

Emergence of Non-Darwinism: neutral hypothesis.

Genetic variations, genetic polymorphism, determination of average heterozygosity.

Founder principle, bottleneck effect and genetic drift as factors in speciation.

Suggested readings

1. Karp, G. (2009) Cell & Molecular Biology Concepts and Experiment. Willey Blackwell Publisher.
2. Pierce, B.A. (2010) Genetics: A Conceptual Approach. W. H. Freeman Publisher.

3. Griffths, A.J.F. et al. (2010) Introduction to Genetic Analysis. W. H. Freeman Publisher.
4. Hartwell, L. et al. (2010) Genetics: From Genes to Genomes. McGraw-Hill Science/Engineering/Math.
5. Cooper, G.M. (2009) The Cell: A Molecular Approach. Sinauer Associates, Inc.
6. Gardner, E.J., Simmons, M.J. & Snustad, D.P. (2000) Principles of Genetics. John Wiley & Sons.
7. Futuyama, D.J. (2005) Evolutionary Biology, Sinauer Associates INC Publishers, Dunderland.
8. Strikberger, M.W. Evolution. Jones and Bartlett Publishers, Boston London
9. Rastogi, V.B. (2014) Organic Evolution. Medtec.
10. Graur, D. & Li,W-H., Fundamentals of Molecular Evolution, 2nd Ed., Sinauer Associates.

ZOOPG-CT-203: DEVELOPMENTAL BIOLOGY, PARASITOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I - DEVELOPMENTAL BIOLOGY- I

Gametogenesis: spermatogenesis, formation of spermatids and spermeiogenesis, sperm function, composition of semen.

Oogenesis: oocyte growth, maturation, vitellogenesis, types of eggs.

Hormonal control of gametogenesis.

Fertilization: fertilization in sea urchin, recognition of sperm and egg, polyspermy, activation of egg metabolism, fusion of genetic material.

UNIT II - DEVELOPMENTAL BIOLOGY - II

Cleavage: characteristics, plane and patterns of cleavage; Mechanism and products of cleavage; types of blastula; Axis pattern in *Drosophila.*

Gastrulation and formation of germinal layers, gastrulation in amphibians, concept of organizer, induction and competence.

Nuclear transplantation experiments and genomic equivalence.

UNIT III – PROTOZOAN PARASITOLOGY

Host-parasite interactions.

General characters and classification of parasitic protozoans.

Distribution, life cycle and pathogenecity of *Acanthamoeba*, *Naegleria, Giardia*, *Toxoplasma*, *Cryptosporidium.*

Mechanism of strain formation in *Plasmodium.*

UNIT IV – HELMINTH PARASITOLOGY

Parasitic adaptations in helminthes.

Distribution, life cycle and pathogenecity of medically important helminth parasites of man: Trematodes – *Paragonimus, Clonorchis*; Cestodes – *Diphyllobothrium*; Nematodes – soil-transmitted helminthes, filarial worms; Plant parasitic nematodes: diversity and host-parasite relationship.

Suggested readings

1. Balinsky, B.I. (1970) An Introduction to Embryology, Saunders, New York.
2. Berrill, N.J. (1974) Developmental Biology. Tata McGraw-Hill.
3. Gilbert, S.F. (2013) Developmental Biology, 10th edn. Sinauer Associates Inc.
4. Wolpert, L. (2011) Principles of Development. Oxford University Press.
5. Subramoniam, T. (2011) Molecular Developmental Biology. Alpha Science International.
6. Roberts, L.S., Janovy, J. & Nadler, S. (2013) Foundations of Parasitology, 9th edn. McGraw-Hill.
7. Cox, F. E. G. (2009) Modern Parasitology: A Text Book of Parasitology, 2nd edn. John Wiley & Sons.
8. Cheng, T.C. (2012). General Parasitology, 2nd edn. Elsevier.
9. Smyth, J.D. and Wakelin, D. (1994) Introduction to Animal Parasitology, 3rd edn. Cambridge University Press, London.
10. Soulsby, E.J.L. (2004) Helminths, Arthopods and Protozoa of Domesticated Animals, 7th edn. Elsevier.

ZOOPG-CP-204: PRACTICAL

IMMUNOLOGY, GENETICS, DEVELOPMENTAL BIOLOGY, PARASITOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I – IMMUNOLOGY

Collection of plasma and serum, separation and preparation of lymphocytes from the whole blood sample by ammonium chloride method, viability test of separated lymphocytes.

UNIT II – GENETICS

Determination of allelic frequency and genotype frequency of ABO blood group.

Meiotic cell division from grasshopper testis and calculation of chiasma frequency and coefficient of terminalisation.

Preparation of human karyotypes: normal male and female; analysis of some come common chromosomal aberrations.

Drosophila genetics: preparation of culture medium, study of wild type and mutants.

UNIT III – DEVELOPMENTAL BIOLOGY AND PARASITOLOGY

Preparation of developmental stages of chick embryo.

Study of regeneration in Hydra/ Planaria.

Identification: spot and with reasons of permanent mounts of protozoans, trematodes and cestodes viz. *Plasmodium, Leishmania, Polystoma, Paramphistomum, Gastrothylax, Fasciola, Fasciolopsis, Schistosoma, Clonorchis, Paragonimus, Taenia, Railletina, Cotugnia, Echinococcus, Diphyllobothrium, Dipylidium, Hymenoplepis, Gyrocotyle.*

UNIT IV – TERM PAPER PREPARATION AND PRESENTATION

Students have to prepare a term paper on any topic related to the subject in consultation with faculty members. Every student has to present a 10 minutes duration seminar on the chosen topic.

SEMESTER – III

ZOOPG-OT-301: CELL BIOLOGY, TECHNIQUES IN BIOLOGY, BIOINFORMATICS

Total Max. Marks-100 **Total Credit-04**

UNIT I – CELL BIOLOGY

Chromatin: types, chemical compositions, histones, molecular organization of nucleosomes, nucleoplasmin, chromatin to chromosomes, histone modifications, chromatin remodeling complex.

Cell cycle: features and phases, cyclins and cyclin dependent kinases, cell cycle checkpoints.

Targeting and sorting of proteins.

Cancer biology: oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis.

Cancer therapeutics: surgery, radiation and chemotherapy.

UNIT II – TECHNIQUES IN BIOLOGY-I

Microscopy: General concept, fluorescent and electron microscopy.

Chromatography: principles and applications of adsorption, ion exchange, gel filtration, affinity, gas liquid chromatography (GLC), high performance liquid chromatography (HPLC)

Spectroscopy: colorimeter, spectrophotometer, spectrofluorometer, nuclear magnetic resonance (NMR) spectroscopy, mass spectrometry.

UNIT III – TECHNIQUES IN BIOLOGY-II

Electrophoresis: basic principles, polyacrylamide gel electrophoresis, isoelectric focusing, agarose gel electrophoresis.

Crystallography and X-ray diffraction.

Nucleic acid amplication: polymerase chain reaction (PCR), real-time PCR (RT PCR).

Radioisotope techniques: radioactivity and half life, radioisotopes, units of radioactivity, G-M counter, solid and liquid scintillation counter, applications of radioisotopes.

UNIT IV – BIOINFORMATICS

Introduction to Bioinformatics resources and databases: tools and databases.

Sequence Analysis: basic concepts of sequence similarity, identity and homology, homologues, orthologues, paralogues.

Sequence-based Database Searches: BLAST and FASTA.

Pairwise and multiple sequence alignments: basic concepts of sequence alignment.

Phylogeny: phylogenetic analysis, definition, description and method of construction of phylogenetic trees.

Current Advancements in Bioinformatics.

Suggested Reading

1. Cooper, G.M. (2009) The Cell: A Molecular Approach. Sinauer Associates, Inc.
2. De Robertis, E.D.P. (2006) Cell & Molecular Biology. Lippincott Williams and Wilkins.
3. Narayanan, P. (2007) Essentials of Biophysics. New Age International Publishers,
4. Boyer, R.F. (2001) Modern Experimental Biochemistry, 3rd Edition. Pearson Education
5. Primrose, S. B. &. Twyman, R. M. (2006) Principles of Gene Manipulation and Genomics. Seventh Edition. Blackwell Publishing.
6. Pranav Kumar (2016) Fundamentals and Techniques of Biophysics and Molecular Biology. Pathfinder Publication.
7. Moganty R. Rejeswari (2013) An Introduction to Biophysics. Rastogai Publications.
8. Xiong, J. (2006) Essential Bioinformatics. Cambridge University Press.
9. Attwood, T.K. (1999) Introduction to Bioinformatics. Pearson Education.
10. Higgs, P.G. & Attwood, T.K. (2013) Bioinformatics and Molecular Evolution. John Wiley & Sons.

ZOOPG-CT-302: ANIMAL PHYSIOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I – PHYSIOLOGY-I

Physiology of digestion: digestive enzymes in vertebrates, secretion and regulation in mammals, mechanism of digestion and absorption of different components of food materials.

Circulation: circulatory system in invertebrates and vertebrates, types of hearts, cardiac cycle and its regulation, functions of blood and its components, haemopoiesis, blood pressure and its regulation, blood group types.

UNIT II – PHYSIOLOGY-II

Nervous system: ultrastructure of neuron, resting and action potential, neuronal conduction through an axon, nernst equation, simple calculation for RP and AP, neurotransmitters and synaptic transmission.

Musculature: types of muscles, chemical composition of skeletal muscles, molecular mechanism of skeletal muscle contraction.

UNIT III – PHYSIOLOGY-III

Respiration: respiratory organs in vertebrates, mechanism of respiration through gills in fish and through lungs in mammals.

Respiratory pigments: types, chemistry and functions.

Mechanism of transport of O_2 and CO_2, oxygen dissociation curve, Bohr effect and Root effect.

UNIT IV – PHYSIOLOGY-IV

Excretion: mechanism of urine formation through counter current mechanism in higher vertebrates, acid-base balance.

Osmoregulation: control of osmoregulation via ADH; Osmoregulation in aquatic and terrestrial animals.

Stress physiology: basic concepts of stress and strain, stress avoidance, stress tolerance, stress resistance.

Adaptation to cold and heat stress.

Physiological response to oxygen deficient stress, physiological response to body exercise, meditation, yoga and their effects.

Suggested readings

1. Hughes, G. M. Comparative Physiology of Vertebrate Respiration (1963) Cambridge, Mass., Harvard University Press.
2. Barrett, K.E. et al (2012). Ganong: Review of Medical Physiology (24th Ed.), McGraw-Hill Medical.
3. Guyton and Hall (2001) Text Book of Medical Physiology (10th Ed.), W.B. Saunders.
4. Keel et al (1989) Samson Wright's Applied Physiology (13th Ed.), Oxford Press.
5. West, J B (Ed) (1985) Best and Taylor's Physiological Basis of Medical Practice (11th Ed), Williams and Wilkins.
6. Webster, R. (2001) Neurotransmitters, Drugs and Brain Function (Ist Ed). Wiley.
7. Hill, R. W., Wyse, G. A. and Anderson, M. (2012). Animal Physiology, 3rd Edition, Sinauer Associates Inc.
8. Schmidt-Nielsen, K. (2002). Animal Physiology: Adaptation and Environment. Cambridge University Press.

ZOOPG-ET-303: APPLIED ECOLOGY, CLIMATE CHANGE BIOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I – ECOLOGICAL NICHE, RESTORATION ECOLOGY, BIOLOGICAL INVASION

Development of niche concept, niche width, niche overlap, diffuse competition, niche dynamics, ecological equivalents, character displacement, sympatry and allopatry; Concept of ecological niche modelling.

Restoration ecology: historical perpectives, strategies; Plan and rehabilitation measures; Successes and effectiveness.

Biological invasion: nature and status; Invasion process and hypothesis, characteristics of invasive species; Impact, prevention and mitigation of invasion.

UNIT II – SYSTEMS ECOLOGY AND SUSTAINABLE DEVELOPMENT

Energy in ecological systems; Measuring ecosystem productivity, patterns in primary production.

Ecosystem services: overview, valuation, laws and policies.

Millennium Ecosystem Assessment: framework and synthesis.

Role of geographical information system (GIS) and remote sensing in ecology.

Sustainable Development: principles, sustainability indicators, sustainable development. Goals: Millennium development goals; Green economy; Environmental performance index.

UNIT III – CLIMATE CHANGE: CAUSES AND INITIATIVES

Greenhouse gases and green house effect, ozone layer depletion.

Global patterns of temperature and precipitation, carbon trading, carbon foot print, concept of REDD (reducing emission through destruction and deforestation); Introduction to UNFCCC and its protocols.

Introduction to Intergovernmental Panel on Climate Change (IPCC) and their reports.

Vulnerability assessment, resilience and adaptation of species.

El niño, La niña, southern oscillation and their ecological impact.

UNIT IV – IMPACT OF CLIMATE CHANGE

Impact on the physical environment: glacial melt including glacial retreat in the Himalayas, sea level rise, glacial lake outburst flood (GLOF), changes in rainfall patterns, snow fall events, coral reef bleaching, etc.

Impact on the faunal characteristics: species range shift, species migration, species extinction, changes in phenology and altered breeding pattern of animals (herpetofauna, birds and mammals), changes in insect emergence pattern and effect on food chain, infestations of diseases and crop pests.

ZOOPG-ET-304: IMMUNOBIOLOGY AND PARASITOLOGY-I

Total Max. Marks-100 **Total Credit-04**

UNIT I – ANTIBODY DIVERSITY, CYTOKINES

Generation of antibody diversity: genetic organization of immunoglobulin genes, rearrangement of genes, allelic exclusion.

Antibody diversity: junctional diversity, gene conversion, somatic hypermutation, association of light and heavy chain; Membrane bound and secreted immunoglobulins, assembly and secretion of immunoglobulins, antibody class switching.

Binding forces of antigen and antibody: hydrogen bond, ionic bond, hydrophobic interaction, Van der Waals interaction.

Cytokines: classification of cytokines, properties of cytokine, cytokine receptors, cytokine secretion by TH1 and TH2 subsets, mechanism of cytokine action, cytokine-related diseases, therapeutic uses of cytokines and their receptors.

UNIT II – COMPLEMENT HYPERSENSITIVITY, INFLAMMATION

Complement: characteristic features, methods of complement activation - classical, alternative and MBL pathways.

Hypersensitivity: Gell and Coombs classification, process of immediate hypersensitivity, cytotoxic hypersensitivity, immune-complex and delayed hypersensitivity.

Inflammation: chemical mediators of inflammation, cell surface adhesion molecules, chemotaxis during inflammation, process of inflammation - localized and systemic inflammation, anti-inflammatory agents.

UNIT III - GENERAL PARASITOLOGY

Emerging infectious diseases, re-emerging infectious diseases, neglected tropical diseases, zoonoses: general concept.

Host-parasite interactions: molecular, cellular and physiological basis.

Epidemiology and control: principles and concepts; parasite control strategies.

Impact of climate change on parasitic diseases.

UNIT IV - VECTOR BIOLOGY

Vectors and its importance in transmission of parasites; Vector biology: special reference to

blackflies, sandflies, tsetse flies and mollusks.

Major malaria vectors of India: distribution, bioecology, potentiality and present sustainability status, form and function.

Symbiotic association of microbes with vectors; Role of microbes as controlling agents of vectors.

ZOOPG-CP-305: PRACTICAL

CELL BIOLOGY, TECHNIQUES IN BIOLOGY, ANIMAL PHYSIOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I – CELL BIOLOGY

Preparation and staining of polytene chromosomes from Chironomous larva.

Barr body preparation from human buccal swab.

UNIT II –TECHNIQUES IN BIOLOGY

Demonstration of polyacrylamide gel electrophoresis (PAGE) and polymerase chain reaction (PCR).

Demonstration of ELISA.

UNIT III – ANIMAL PHYSIOLOGY

Estimation of O_2 consumption by fish.

Absorption of glucose by chicken gut.

Estimation of ascorbic acid in an unknown solution.

Estimation of casein content in milk.

Estimation of Amino-N by Sorenson's Formol Titration method.

Estimation of ESR.

Enumeration of blood platelets using haemocytometer.

Estimation of blood glucose during fasting and PP.

UNIT IV – TERM PAPER PREPARATION AND PRESENTATION

Students have to prepare a term paper on any topic related to the subject in consultation with faculty members. Every student has to present a 10 minutes duration seminar on the chosen topic.

ZOO-PG-ET306: COMPARATIVE ANIMAL PHYSIOLOGY AND BIOCHEMISTRY-I

Total Max. Marks-100 **Total Credit-04**

UNIT – I: **Circulation:** Chemistry of blood components and their functional significance; origin, formation, molecular regulation and maturation of RBCs and WBCs; biochemical interconversions during blood coagulation and homeostasis. Cardiac cycle and its regulatory mechanisms. Cardiac output and the factors that effect cardiac output, blood pressure, factors influencing blood pressure and its regulation.

Unit-II: Respiration: Concept of respiration, mechanism of breathing; biochemistry of respiratory exchange; Transport of respiratory gases; Regulatory mechanisms (humoral and neural) of respiration. Respiratory acidosis, alkalosis and regulation of pH.

Unit-III: **Introduction:** Carbohydrates: Carbohydrates: General structure, classification and chemical properties of carbohydrates. Homo and heteropolysaccharide: Structure of glycogen and cellulose. Biological functions of important ploysaccharides. Lipids: Simple lipids, general structure and chemical properties of simple lipids. Compound lipids: Structure of phospholipids like glycolipids and cerebrosides properties and functions of phospholipids.

Unit-IV: Derived lipids: Cholesterol and steroid hormones (chemistry), biological functions of lipids. Proteins: Amino acids as monomers of proteins and their properties, types of proteins and their classification, the conformation and subcellular assemblies of protein. Conjugated proteins: Lipoproteins and metalloproteins biological functions of proteins.

SEMESTER - IV

ZOOPG-ET-401: BIODIVERSITY AND CONSERVATION BIOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I – BIODIVERSITY: CONCEPTS, COMPONENTS AND PATTERNS

Conceptual framework of biodiversity; Patterns and process of local and regional biodiversity: niche assembly theories, Unified Neutral theory, island biogeography model. Global hotspots of biodiversity; Biodiversity with reference to Eastern Himalayas; Biogeography of India, restricted range species and endemism, key stone species, flagship species, indicator species, surrogate species; Plate tectonics and continental drift.

UNIT II – THREATS TO BIODIVERSITY

Biodiversity losses: past and present, natural and human induced threats and vulnerability of species to extinctions; Mass extinction, zero extinction, extinction vortex; Problem of genetic diversity loss over time: bottlenecks, genetic drifts, inbreeding depression.

UNIT III – CONSERVATION OF BIODIVERSITY

Identification and prioritization of ecologically sensitive area (ESA); Coarse filter and fine filter approaches of biodiversity conservation; Population viability analysis-conceptual foundation; Minimum viable populations and recovery strategies for threatened species.

Conservation genetics: genetic variation and its significance, measure of genetic variability.

Traditional knowledge and biodiversity conservation: world heritage convention, Satoyama concept, Tani cultural landscape, Demazong sacred landscape.

UNIT IV – LEGAL FRAMEWORK OF BIODIVERSITY CONSERVATION

Introduction to laws and policies for biodiversity conservation: convention on biological diversity and important protocols; Aichi targets; Indian Biodiversity laws and rules, national biodiversity authority, State biodiversity boards, Sikkim state biodiversity rules; Biodiversity management committees and peoples biodiversity register.

Ramsar convention on conservation of wetlands, Forest (Conservation) Act of India 1980, Environment (Protection) Act of India 1986.

ZOOPG-ET-402: IMMUNOBIOLOGY AND PARASITOLOGY-II

Total Max. Marks-100 **Total Credit-04**

UNIT I - MAJOR HISTOCOMPATIBILITY COMPLEX (MHC)

MHC: genetic organization, classical and non classical HLA (Human Leukocyte Antigen) genes; Molecular organization of HLA molecule; Polymorphism of HLA; Haplotype and Linkage disequilibrium, antigen presentation and MHC restriction; HLA and disease association; HLA typing: microlymphocytotoxicity assay, molecular HLA typing; HLA-G and reproductive immunology.

UNIT II - CYTOTOXIC RESPONSE, TOLERANCE AND AUTOIMMUNITY

Cell mediated cytotoxic responses: effector mechanisms, leukocyte activation and migration.

Tolerance: factors causing tolerance, types of tolerance, mechanism of tolerance.

Autoimmunity: characteristics, causes of autoimmune disease, pathogenesis, classification, common autoimmune disorder, therapeutic approaches to autoimmune disease.

UNIT III – TLR, TUMOUR IMMUNOLOGY, VACCINES, IMMUNODEFICIENCY DISEASES

Toll-like receptors: structure, ligands, mechanism of action.

Tumour immunology: tumours of the immune system, immune response to tumours, evasion of immune response by tumours, immunotherapy for cancer.

Vaccines: requirements and aims of a successful vaccine, types of vaccines, advantages and disadvantages, new vaccine strategies, concept of immunization.

Immunodeficiency diseases: combined immunodeficiency, acquired immunodeficiency syndrome (AIDS).

UNIT IV – IMMUNOLOGICAL TECHNIQUES

Techniques and technologies for quantitation of immunologically relevant molecules, substances and the cells and their uses for diagnostic purposes.

Agglutination reaction, precipitation reaction, immunodiffusion, immunoelectrophoresis, radioimmunoassay, hybridoma technology and monoclonal antibody synthesis and usage,

flow cytometry and flourescence-activated cell sorting (FACS), **immunohistochemistry.**

ZOOPG-ET-403: WILDLIFE BIOLOGY, ANIMAL BEHAVIOUR

Total Max. Marks-100 **Total Credit-04**

UNIT I – WILDLIFE AND THEIR MANAGEMENT

Wildlife wealth of India and threatened wildlife; Management of rare and endangered species; Control and management of over abundant wildlife populations.

Ecology and conservation of Red panda, Musk deer, Great Indian bustard, Olive ridley turtle.

Conservation approaches of important wildlife of India: project tiger, elephant and snow leopard.

Applications of cloning in wildlife conservation and management.

UNIT II - WILDLIFE MONITORING, TRADE AND LEGISLATION

Wildlife census technique: objectives, direct and indirect methods with reference to herpetofauna, birds and mammals.

Wildlife conservation approaches and limitations.

Human animal conflict: type and nature of conflict, causes of conflict, measures of conflict mitigation.

Assessment, documentation, and prevention of wildlife trade; Concept of wildlife forensics. Wildlife laws and ethics: wildlife protection act of India and its schedules.

Introduction to organizations: International Union for Conservation of Nature and Natural Resources (IUCN), Convention on International Trade on Endangered Species of Flora and Fauna (CITES), Indian Board for Wildlife (IBWL).

UNIT III – ANIMAL BEHAVIOUR- I

Four propositions of Tinbergen.

Innate and learned behaviour; Classical conditioning; Instrumental learning, habituation and extinction.

Optimal foraging theory: patch choice, diet choice, pre-selectivity, group and solitary feeding.

Conflict: Male-male competition; Sexual selection: contribution of Darwin, the Healthy Male theory, the Good Gene theory.

Elaborate ornaments: Fisher's hypothesis (runaway selection), Handicap hypothesis of Zahavi.

Survival value of behaviour: experimental studies, Darwinian and inclusive fitness.

Altruism: Kin-selection, reciprocal altruism, parental care, cooperation.

UNIT IV – ANIMAL BEHAVIOUR-II

Communications and signaling: Territoriality, home range and courtship display.

Mating systems: monogamy, polyandry and polygyny.

Social systems of mammals: primates; Contemporary theories in insect socio-biology.

Human behaviour: genetic differences and human behaviour, IQ differences.

Behavioural genetics: single and multiple gene effect.

ZOOPG-ET-404: IMMUNOBIOLOGY AND PARASITOLOGY-III

Total Max. Marks-100 **Total Credit-04**

UNIT I - PROTOZOOLOGY

Parasitic protozoa: origin and evolution; energy metabolism.

Plasmodium: immunopathology, treatment (drug targets, mechanism of drug resistance) and vaccine strategies.

Leishmania: immunopathology, treatment (drug targets, drug resistance) and vaccine strategies.

Trypanosoma (Human African Trypanosomiasis): immunopathology, evasion of host immune system, treatment.

UNIT II - HELMINTHOLOGY

Origin and evolution of parasitic helminthes; Larval form of helminthes; Ultra structure of important helminthes tegument/cuticle; Structure of scolex in cestodes.

Energy metabolism in parasitic helminthes.

Immunopathology, treatment and control of *Schistosoma, Echinococcus, Wuchereria.*

UNIT III – PARASITOLOGY TECHNIQUES-I

Laboratory diagnosis of parasitic infections: blood and stool examination and examination of biopsy material for parasitic infection; Identification and diagnostics: morphological, serological, DNA-based and *in silico* methods.

In vitro cultivation of parasites: *Plasmodium*, *Leishmania*, *Schistosoma.*

UNIT IV – PARASITOLOGY TECHNIQUES-II

Isolation of DNA and RNA, polymerase chain reaction, primer designing, DNA sequencing

nucleic acid hybridization, blotting techniques, ELISA.

Proteomics: 2D-Gel electrophoresis, liquid chromatography, mass spectrometry.

Introduction to drug designing.

ZOOPG-EP-405: PRACTICAL

ECOLOGY, PAEDOLOGY AND ANIMAL BEHAVIOUR

Total Max. Marks-100 **Total Credit-04**

UNIT I – COMMUNITY ECOLOGY

Ecological sampling and census techniques: butterflies, amphibians, reptiles, birds and mammals.

Study of vegetation using quadrat method.

Calculation of species richness, diversity, equitability, similarity and generation of species accumulation curves based on study of any animal community.

Inter-specific association.

UNIT II – APPLICATION OF ECOLOGICAL TOOLS

Preparation of GIS Maps using Q-GIS/Map Info/Arc GIS.

Estimation of species using appropriate statistical package.

Study of the traditional knowledge of biodiversity conservation of any local communities.

UNIT III – PEDOLOGY AND PRIMARY PRODUCTIVITY

Pedology: estimation of phosphorus, zinc and magnesium from soil samples; Estimation of percentage of calcium carbonate in soil by rapid titration method; Estimation of Organic-carbon in soil by wet oxidation method; Analysis of pH, specific conductivity and moisture content of soil samples; Qualitative analysis of soil micro-arthropods.

Estimation of Primary productivity of water bodies.

UNIT IV – ANIMAL BEHAVIOUR

Field study of behaviour of any one species of mammal/birds.

Flocking behaviour in pigeons.

Foraging behaviour in ants: orientation and cues.

Aggressive and predatory behaviour in fish.

Behavioral comments: a) Imprinting in Greylag Goose, b) Flank marking by golden Hamster, c) Mobbing behaviour of colonial ground squirrel, d) Cooperation among Scrub Jay relatives, e) Alarm call of Belding's Ground Squirrel, f) Sibling aggression in Great Egret, g) Parental care in male stickleback, h) Resource defense polygyny in African Chiclid fish, i) Female defense polygyny in marine amphipod, j) Resource defense polyandry in Spotted Sandpiper, k) Polyandry without polygyny in Red Phalarope, l) Egg shell removing behaviour in Black-headed Gull.

Film shows on Animal behaviour.

ZOOPG-EP-406: PRACTICAL

IMMUNOBIOLOGY AND PARASITOLOGY

Total Max. Marks-100 **Total Credit-04**

UNIT I – IMMUNOBIOLOGY-I

Haemagglutinin Assay.

Precipitation and quantitation of immunoglobulins from the immunized mouse serum by ammonium sulphate preparation; Characterization of purified immunoglobulin by SDS-PAGE.

Agglutination test for antigen and antibody.

UNIT II – IMMUNOBIOLOGY-II

Raising of antiserum (ALS) and test of specificity of the serum in lysis of target; Immunodiffusion and immunoelectrophoresis.

Plaque forming cell (PFC) Assay and rosette forming cell (RFC) assay.

Peritoneal lavage / Macrophage activity.

FITC conjugation of antibody.

HLA typing demonstration.

UNIT III – PARASITOLOGY-I

Preparation of stains: haematoxylin, acetocarmine, borax caramine, bouins fluid.

Collection, fixation, mounting of different helminth parasites from vertebrates (nematode, trematode and cestode).

Preparation, staining and identification (with reasons) of blood parasites from *Clarias batrachus*.

Submission of prepared slides.

UNIT IV – PARASITOLOGY-II

Faecal examination: qualitative analysis - simple flotation and sedimentation methods; Quantitative analysis: McMaster counting technique.

Studying the infection of tomato plant by root knot nematode.

Histochemical demonstration of alkaline phosphatase activity in tissues of parasitic helminthes.

Suggested readings

Ecology

1. Odum, E.P. Fundamentals of Ecology. W.B. Saunders Co. Philadelphia.
2. Clarke, G.L. Elements of Ecology. John Wiley & Sons, Inc. New York.

3. Giller, P.S. Community Structure and the Niche. Chapman & Hall.
4. Mc Naughton, S.J. & L.L. Wolf. General Ecology. Holt, Rinehartx, Winston New York.
5. Saunders, D.S. An Introduction to Biological Rhythms. Blackie, Glasgow & London.
6. Miller, R.W. & R. L. Donahue. Soils in our environment. Prentice Hall India Pvt. Ltd., New Delhi.
7. Bailey, J.A. Principles of Wild Life Management. John Wiley & Sons, New York.
8. Smith, R.L. Ecology and Field Biology. Addison – Wesley Educational Publishers. Inc.
9. Ricklefs, R.E. and G.L. Miller. Ecology W.H. Freeman & Company
10. Truk and Turk: Environmental Science (W.B. Saunders).
11. Chapman Jr., W.B. Natural Ecosystems. Macmilan Pub. Co. Inc.
12. Alcock, J. Animal Behaviour: An evolutionary approach. Sinauer Assoc., Sunderland, Mass. USA.
13. Bradbury, J, W., and S.L. Vehrencamp. Principles of animal communication. Sinauer Assoc., Sunderland, Mass, USA.
14. Clutton-Brock T.H. The evolution of parental care. Princeton Univ. Press, Princeton, NJ USA.
15. Eibl- Eibesfeldt, I. Ethology; The biology of behavior. Holt, Rinehart & Winston, New York.
16. Drickamer, L.C., S.H. Vessey and E.M. Jakob. Animal Behavior, McGraw Hill.
17. Dewsbur, D.A. Comparative animal behavior McGraw Hill Book Company.
18. Hunting ford, F. The Study of Animal Behavior, Chapman and Hall.
19. Mc Farland, D. Animal Behavior: Psychobiology, Ethology and Evolution.
20. Krebs, J.R. and N.B. Davies. Behavioral Ecology: An Evolutionary Approach.
21. IPCC (2007) Fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, United Kingdom.
22. Wormworth, J. and Sekercioðlu, Ç.H. (2011) Winged Sentinels: Birds and Climate Change. Cambridge University Press.
23. Ramasamy, B. (2013) General Issues on Environmental Ecology, Bio diversity and Climate change. Pragun Publication.
24. Hussain, M. (2013) Environment and Ecology: Biodiversity, Climate Change and Disaster Management. Access Publishing House.
25. The Little Data Book on Climate Change (2011) World Bank Publications.
26. Negi, S. S. (2010) Hand Book of Climate Change Science. Bishen Singh Mahendra Pal Singh.
27. Henson, R. (2011) The Rough Guide to Climate Change. Rough Guides Publisher.

28. Kaur, R. (2014) General Issues on Environment, Biodiversity and Climate Change. New Vishal Publication.

29. Kondratyev, K.Y. and Krapivin, V. F. (2014) Global Carbon Cycle and Climate Change. Springer publications.

30. Seidel, K. and Martinec, J. (2014) Remote Sensing in Snow Hydrology: Runoff Modelling, Effect of Climate Change. Springer publications.

31. Mastrandrea, M.D. and Schneider, S.H. (2010) Preparing for Climate Change. MIT Press.

32. Novacek, M.J. (2010) The Biodiversity Crisis: Losing What Counts. The New Press.

33. Biodiversity: Convention on Biological Diversity, Abiotic Stress, International Treaty on Plant Genetic Resources for Food and Agriculture Books LLC, Wiki Series (2011).

34. Wilson, E. O. (1988) Biodiversity. National Academy Press

35. Krihhnamurthy (2008) An Advanced Textbook On Biodiversity: Princilpes And Practice. Oxford & Ibh Pub. Co. Pvt. Ltd.

36. Pyers, G. (2010) Biodiversity of Rain Forests. Benchmark Books.

37. Anderson, A.B. (2006) Applying Nature's Design - Corridors as a Strategy for Biodiversity Conservation (Issues, Cases, and Methods in Biodiversity Conservation). Columbia University Press.

38. de Boef et al. ed (2013) Community Biodiversity Management: Promoting resilience and the conservation of plant genetic resources (Issues in Agricultural Biodiversity). Routledge.

39. Lanzerath, D. and Friele, M. (2014) Concepts and Values in Biodiversity (Routledge Studies in Biodiversity Politics and Management). Routledge

Immunology and Parasitology

1. Kuby Immunology, Richard, Thomas, Barbara, Janis, (5th Ed., 2003), W. H. Freeman and company, New York, USA.

2. Immuno Biology- The immune system in health and disease, Janeway, Travers, Walport and Shlomchik, (6th Ed., 2005), Garland Science Publishing, New York, USA.

3. Immunology, David, Brostoff and Roitt, (7th Ed., 2006), Mosby & Elsevier Publishing,

4. Canada,USA.

5. Abbas, A. K., Lichtman, A. H. & Pillai, S. (2006). Cellular and molecular Immunology. 6th ed. Saunders.

6. Abbas, A. K. & Lichtman, A. H. (2006). Basic Immunology.2nd ed. Elsevier.

7. Coico R, Sunshine, G., Benjamini, E. (2003). Immunology: A short Course. 5th ed. Wiley- Liss: New Jersey.

8. English, L. S. (1994). Technological Applications of Immunochemicals (BIOTOL).

9. Butterworth- Heinemann, Oxford Freeman & Co.

10. Goldsby, R. A., Kindt, T. J., Kuby, J. & Osborne, B. A. (2003). Immunology. 5th ed. W. H. Freeman & Co.
11. Khan F. H. (2009) The Elements of Immunology. Pearson.
12. Kindt, T., Goldsby, R. Osborne, B. (2007). Kuby Immunology. 6th ed. W.H. Freeman & Co.
13. Male, D., Brostaff, J., Roth, D. & Roitt, I. (2006). Immunology. 7th ed. Mosby.
14. Rao, C. V. (2002). Immunology. Narosa Publishing House, New Delhi.
15. Roitt, I. M. & Delves, P. J. (2001). Roitt's Essential Immunology. 10th ed. Blackwell
16. Science. Ltd.
17. Chandler, A. C. & Read. C. P. (1961). Introduction to Parasitology, 10th ed. John Wiley & Sons Inc.
18. Chandra, G. (2000). Mosquito. Sree Bhumi Publication Co. Kolkata.
19. Bogitsch, B.J. & Cheng , T.C. (2000) Human Parasitology, 2nd edn. Academic Press.
20. Hati, A. K. (2001) Medical Entomology. Allied Book Agency, Kolkata.
21. Hati, A. K. (2001) Medical Parasitology. Allied Book Agency, Kolkata.
22. Noble, E. R. & Noble G. A. (1982) Parasitology. The Biology of animal Parasites, 6th ed. Lippincott Williams and Wilkins.
23. Roberts, L.S., Janovy, J. & Nadler, S. (2013) Foundations of Parasitology, 9th edn. McGraw-Hill.
24. Cox, F. E. G. (2009) Modern Parasitology: A Text Book of Parasitology, 2nd edn. John Wiley & Sons.
25. Cheng, T.C. (2012). General Parasitology, 2nd edn. Elsevier.
26. Smyth, J.D. and Wakelin, D. (1994) Introduction to Animal Parasitology, 3rd edn. Cambridge University Press, London.
27. Soulsby, E.J.L. (2004) Helminths, Arthopods and Protozoa of Domesticated Animals, 7th edn. Elsevier.

ZOOPG-DV-407: DISSERTATION AND VIVA-VOCE

Total Max. Marks-100 **Total Credit-04**

Students have to undertake short term research work in the field of their special paper (elective subject). Topics are to be decided in consultation with the course teacher(s). Dissertation should be prepared following standard format i.e. Introduction, Materials and Methods, Results, Discussion and Conclusions. Every student has to present a seminar on their research in the presence of faculty members of Zoology and external examiner(s) appointed by the University followed by viva-voce.

SEMESTER-IV

ZOO-PG-ET408: COMPARATIVE ANIMAL PHYSIOLOGY AND BIOCHEMISTRY-II

Total Max. Marks-100 **Total Credit-04**

UNIT – I: Excretion: Concept of excretion and nitrogenous wastes; functional anatomy of renal unit; biophysical and chemical mechanisms of ultrafiltration, reabsorption and secretion, transport mechanisms, urine formation & regulatory control of sugar, urea, Na^+ K^+ and H^+. Role of kidneys in regulation of acid-base balance and osmoregulation.

Unit-II: Nervous system and sense organs: Neuron as the basic unit of nerve physiology; Methylaccepting chemotaxis proteins and chemotactic signals of the plasma membrane; Na^+ and K^+ permeability and action potentials, structure of Na^+ and K^+ channels. Neurotransmitters: Molecular mechanism of acetylcholine, catecholamine, serotinin - amino butyric and glycine

UNIT – III: **Nucleic acids:** Molecular structure and biological functions of DNA & RNA molecules, Z-DNA and its biological significance, physical properties of nucleic acid - denaturation of DNA, hydrolysis of nucleic acids, nucleic acids and protein interaction.

Unit-IV: Enzymes: Enzyme kinetics, mode of action of enzymes and biochemical role of coenzymes and isoenzymes, effect of enzyme concentration, substrate concentration and pH on enzyme activity, feedback inhibition - various mechanisms, covalent modifications Irreversible and Reversible.

SEMESTER-IV

ZOO-PG-ET409: COMPARATIVE ANIMAL PHYSIOLOGY AND BIOCHEMISTRY-III

Total Max. Marks-100 **Total Credit-04**

UNIT – I: Reproductive Physiology: Structure and functions of vertebrate testis; spermatogenesis and its hormonal control; structure and functions of leydig cells; role of accessory reproductive secretions; structure and functions of vertebrate ovary; folliculogenesis and ovogenesis and their hormonal control; ovulation and luteinization and their regulatory mechanisms.

UNIT-II: Environmental Physiology: Endothermy and physiological mechanism of regulation of body temperature. Physiological adaptations in response to high and low ambient temperature. Physiological adoptions in response to stenohaline, euryhaline and terrestrial environment, physiological adaptation at high altitude and deep sea environment.

Unit: III: **Metabolism:** ATP - cycle, energy rich phosphate compounds, major pathways of catabolism of carbohydrates, glycolysis, tricarboxylic acid cycle, phosphogluconate pathway, glycogenolysis.

Unit: IV: **Oxidation of fatty acids:** Oxidation, biosynthesis of saturated and unsaturated fatty acids. Mitochondrial-electron transport chain, mechanism of mitochondrial oxidative phosphorylation, inhibitors of electron transport chain, inhibitors and uncouplers of mitochondrial oxidative phosphorylation.

ZOOPG-EP-410: PRACTICAL: ANIMAL PHYSIOLOGY AND BIOCHEMISTRY

Total Max. Marks-100 **Total Credit-04**

UNIT I – ANIMAL PHYSIOLOGY-I

1. To demonstrate that the optimum activity of salivary amylase is pH dependent.
2. To study the effect of exercise on cardiovascular and respiratory system.
3. To perform the tuning fork tests of hearing.
4. To find out the physiological blind spot of human eye.

UNIT II – ANIMAL PHYSIOLOGY-II

1. To estimate the glucose level in blood of rat.
2. To prepare the vaginal smears of mice and identify the stage of estrous cycle.
3. To locate the endocrine glands in rat.
4. To study the histology of endocrine glands

UNIT III – BIOCHEMISTRY-I

1. Qualitative estimation of Carbohydrates.
2. Quantitative estimation of Glycogen in tissues.
3. Qualitative estimation of proteins
4. Quantitative estimation of proteins by Lowry's Method.

UNIT IV – BIOCHEMISTRY-II

1. Quantitative estimation of cholesterol in serum.
2. Quantitative estimation of DNA.
3. Quantitative estimation of RNA.
4. Effect of different substrate concentration on enzyme activity.

Books Recommended:

1. Hall, J.E., Guyton and Hall Text Book of Medical Physiology, 12th edition, saunders Company (2010).
2. Rhoades, R.a., Tanner, G.A., Medical Physiology, 2nd edition, Lippincott Williams and Wilkins (2003).
3. Richards, W. Hill, Comparative Physiology of animals: An Environmental approach (Harper and Row) Pub. New York (1986).
4. F. Read Hausworth, Animal Physiology: Adaption and Function (Addision Wesley Pub. Co.California) (1981).

5. Knut Schmidt Nielsen, Animal Physiology: Adaption and Environmental (Cambridge Univ.Press, London) (1985).

6. A.C. Guyton, Textbook of Medical Physiology 7th ed. Saunders Publication (1984).

7. Turner, C.D. & Bagnara, W.D: General Endocrinology W.B. Saunders Co. Philadelphia, U.S.A. (1976).

8. Text Book of Biochemistry and Human Biology by Talwar, O.P. Prentice Hall of India Pvt. Ltd., New Delhi.

9. B.I. Balinsky, An Introduction to Embryology Saunders Company (1981).

10. Balian and Glasser, Reproductive Biology by Excerpta Media Amsterdam (1984).

11. Knobil and Jimmy D. Neill (eds). The Physiology of Reproduction Vol.I & II, Ernst Raven Press.

12. Robert, H. Williams, Text Book of Endocrinology Saunder Company (1981).

Books Recommended for Biochemistry:

1. Conn, E. E. and Stump, P.K., Outline of Biochemistry, John Wiley and Sons, New York, (2009).

2. Murrary, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W., Harper's Illustrated Biochemistry, 26th ed. M.Graw-Hill Companies, Inc. (2003).

3. Berg J. M., Tymoczko, J.L., Stryer, L. and Gatto G.J., Biochemistry, 7th ed., W.H. Freeman and Company, New York (2012).

4. Nelson, D.L. and Cox, M.M., Lehninger Principles of Biochemistry, 5th ed., W.H. Freeman and Company, New York (2008).

5. Satyanarayana, U. and Chakrapani, U. Biochemistry, 3rd ed. Books and Allied Pvt. Ltd. (2009).

DEPARTMENT OF ZOOLOGY

M Phil/PhD Course Work

Code	Title	Credits
ZOO-RS-C101	Research Methodology (School Level)	4
ZOO-RS-C102	Preparation of Research Proposal and review of literature	4
ZOO-RS-E103	Recent advances in biodiversity and conservation biology	4
ZOO-RS-E104	Recent advances in Immunobiology and Parasitology	

MIC-RS-C101: Research Methodology (Common for School of Life Sciences)

Credits: 4 **Full Marks: 100**

Unit I- Research Design and Data Collection

Research methodology- definition, different types of research design. Basic principles of experimental designs. Sampling design- sample survey, steps in sample design, criteria of selecting a sampling procedure and different types of sample designs. Methods of Data Collection: Primary and secondary data.

Literature collection and citation, bibliography. Writing skills - Preparation of research report, presentations, and writing scientific paper. Impact factor, Citation factor, Plagiarism, ISBN, ISSN.

Unit II- Processing and Analysis of Data and Sampling

Processing operations, elements/types of analysis, statistics in research, measures of central tendency, dispersion, asymmetry, relationships. Simple regression analysis, multiple correlation and regression, partial correlation, association in case of attributes and other measures.

Unit III- Testing of Hypotheses

Basic concepts of testing of hypothesis, procedures for hypothesis testing. Hypothesis testing for differences between means, hypothesis testing for comparing two related samples, hypothesis testing of proportions. Testing the equality of variances of two normal populations, hypothesis testing of correlation coefficient. Chi square test.

Unit IV- Analysis of Variance and Covariance

Analysis of Variance and Covariance (basic principles of one-way ANOVA, two-way ANOVA and ANCOVA). Multivariate analysis techniques (Characteristics and applications, classification of Multivariate analysis, important multivariate techniques, important method of factor analysis). Ethics in research.

Reading List:

1. Bernard Rosner, B. 2005. *Fundamentals of Biostatistics*, 6th edition Duxbury Press.
2. Gerry, Q. P and Keough, M. J. 2002. *Experimental Design and Data Analysis for Biologists.* Cambridge Univ. Press.
3. Kothari, C.R. 2004. *Research Methodology, Methods & Techniques*. 2nd Revised Edition. New Age International Publisher, India.
4. Norman, N. G. and Streiner, D. 2008.Biostatistics: *The Bare Essentials*. 3rd edition, BC Decker Inc.
5. Paulson, D. S. 2008. *Biostatistics and Microbiology*. Springer.
6. Sokal, R. R. and Rohlf, F. J. 2008. *Introduction to Biostatistics*. Dover Publication.
7. Laake, P., Benestat, H.B. and Olsen, B.R. 2007. *Research Methodology in the Medical and the Biological Sciences*. Academic Press, UK.

ZOO-RS-C102: PREPARATION OF RESEARCH PROPOSAL AND REVIEW OF LITERATURE

Preparation of research proposal

Students have to prepare Research Proposal in any standard format (UGC, DBT, DST, etc) in the chosen field of research. The proposal should have clear objectives with identification of gaps in the knowledge, review of literatures, expected outcome, potential application, real time budget and time line.

Review of Literature

An extensive review work is to be undertaken in the proposed area of research. It should have appropriate citation and well formatted references using any of the standard journal formats approved by UGC.

ZOO-RS-E103: RECENT ADVANCES IN BIODIVERSITY AND CONSERVATION BIOLOGY

Unit I: Sampling techniques

Sampling technique of fauna: aquatic and terrestrial; Population estimation: distance sampling, occupancy studies, enumeration of morphometry; Enumeration of habitat and micro-habitat parameters; Reproductive ecology: nest characteristics, estimation of nesting and reproductive success; Feeding ecology: feeding guild, feeding rate, manoeuvre

Unit II: Taxonomy and biodiversity

Taxonomy: principles of taxonomy; Type specimens: holotype, lectotype, paratype, neotype. Description of new species, cataloguing and submission to museums; Role of taxonomy in biodiversity conservation; Introduction to species 2000: catalogue of life

Unit III: **Biodiversity management approach**

Management of protected areas; Conservation Zones, Important Bird Areas, Man and Biosphere reserve, Conservation programs of rare, endangered and threatened species, Conservation outside protected areas, management of urban biodiversity; Citizen Science: roles of community in conservation; Funding mechanism for promoting conservation

Unit IV: Application of Molecular Techniques in biodiversity

DNA and RNA extraction, designing of primers, Gene amplification and PCR, DNA and protein sequencing, Molecular markers: RAPD, PCR-RFLP, VNTR; DNA barcoding: process, application, barcode of life data systems; Phylogenetic analysis: construction of phylogenetic trees

Suggested Readings

1. Allendorf, F.W., Luikart, G.H. and Aitken, S.N. (2012 Conservation and the Genetics of Populations 2e. Willey-Blackwell.
2. Bibby, C.J., Burgess, N.D., Hill, D.A. and Mustoe, S.H. (2000) Bird census techniques. Academic Press, London.
3. Frankham, R., Ballou, J.D. and Briscoe, D.A. (2010) Introduction to Conservation Genetics. Cambridge University press.
4. Heyer, W.R., Donnelly, M.A., Mcdiarmid, R.W., Hayek, L.C. and Foster, M.S. (1994) Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press. Washington.
5. Magurran, A.E. and McGill, B.J. (2011) Biological Diversity: frontiers in measurement and assessment. Oxford University Press.
6. Primack, P.B. (2014) Essentials of Conservation Biology. Sinauer Associates Inc.
7. Southwood, T.R.E. and Henderson, P.A. (2000) Ecological methods. Blackwell Science, London.
8. Watson, M.F., Lyal, C. and Collin, P. (2015) Descriptive Taxonomy: The foundation for biodiversity Research. Cambridge University Press

ZOO-RS-E104: IMMUNOBIOLOGY AND PARASITOLOGY

Unit I: Immunogenetics and transplantation immunology

Evolution of MHC; Determination of HLA allele frequency, haplotype estimation, linkage disequilibrium, Relative Risk, P-value; Role of MHC; Transplantation immunology: Types of graft rejections- hyper acute rejection, acute rejection, chronic rejection; Types of cell-mediated immune responses in transplantation, prevention of graft rejection in transplantation

Unit II: Immunological methods

Experimental animal models, inbred strains of mice and its uses; Cell culture systems: types and forms of cell culture, methods and strategies for cell culture, examination of cells of suspension cultures, application of cell culture; Flow cytometry and fluorescence, DNA isolation: phenol chloroform method, salting out method, ARMS-PCR SSP typing, SSOP, SBT typing of HLA, RFLP.

Unit III: Parasitic protozoa and helminthes

Emerging and re-emerging parasitic diseases; problems and prospects of control; Neglected tropical diseases; molecular biology and immunopathology of important parasites: protozoan (*Entamoeba*), trematode (*Opisthorchis*), cestode (*Echinococcus*) and nematode (*Wuchereria*); parasite control strategies: drugs and vaccines

Unit IV: Parasitology techniques

Laboratory diagnosis of parasitism: old and new approaches; in vitro cultivation of parasites; Proteomics; Transcriptomics with reference to parasitic infections; Application of NGS technology in identification of drug targets and vaccine candidates; Biological databases (nucleotide, protein and natural products)

Suggested Readings

1. Abbas, A. K., Lichtman, A. H. And Pillai, S. (2006). Cellular and molecular Immunology. W.B. Saunders.
2. Boothroyd, J. C. and Komuniecki, R. (1995) Molecular approaches to Parasitology. Wiley-Liss, New York.
3. David, Brostoff and Roitt (2006) Immunology. Elsevier Publication.
4. English, L. S. (1994). Technological Applications of Immunochemicals *(BIOTOL*). Butterworth-Heinemann, Oxford Freeman & Co.
5. Green, M. R. and Sambrook, J. (2012) Molecular cloning: a laboratory manual. Cold Spring Harbor Laboratory Press, New York.
6. Janeway, Travers, Walport and Shlomchik (2005). Immuno Biology- The immune system in health and disease. Garland Science Publishing, New York, USA.
7. Schmidt, G. D. and Roberts, L. S. (2001). Foundation of Parasitology. McGraw Hill Publishers.
8. Smyth, J. D. (1994). Animal Parasitology. Cambridge University Press.