

**P.G. DIPLOMA IN FLORICULTURE
(ANNUAL SYSTEM)**

SCHEME OF EXAMINATION w.e.f. session 2019-20 under CBS

Code	Nomenclature	Duration	Max. Marks	Credit
Theory Papers				
PGDF-101	Essentials of Floriculture	3 Hrs.	80	4
PGDF-102	Improvement of Ornamental Plants	3 Hrs.	80	4
PGDF-103	Seed Production and Micro-Propagation	3 Hrs.	80	4
PGDF-104	Agro technology and Marketing	3 Hrs.	80	4
Practical Papers				
PGDF-105	Based on Paper PGDF-101 & 102	4 Hrs.	80	4
PGDF-106	Based on Paper PGDF-103 & 104	4 Hrs.	80	4
PGDF-107	Seminar		20	1
		Total	500	25 Credit

SYLLABUS

PGDF-101 Essentials of Floriculture

**Max. Marks: 80 (Theory),
Duration: 3 hours Credit-4**

Note: Nine question will be set in all. Question No. 1 will be compulsory and short answer type covering the entire syllabus. Remaining eight questions will be set unit-wise and four questions from each unit. The candidates will be required to attempt Question no. 1 and four more selecting two questions from each unit. All questions carry equal marks.

UNIT-1

1. History and scope of Floriculture
2. Layout structure and management of nursery.
3. Green House Plants.
4. Types and varieties of Dahlia, Chrysanthemum, Gladiolus and Bougainvillea.
5. Cultivation of cacti, succulents, orchids, and water plants.
6. Prolonging the vase life of flowers.

UNIT-2

1. Importance and types of house plants.
2. Effects of factors light, temperature, mineral nutrients, fertilizers, integrated nutrient use.
3. Soil formation, soil structure, soil characteristics and soil fertility assessment.
4. Plant care, training, diseases, pests, control measures.
5. Mycorrhiza and soil fertility management.
6. Methods of growing indoor plants, containers for house plants, dish garden, terrarium, hanging basket.
7. Managing Plant environment-green house, green house covering material, environmental controls, mist chambers.
8. Media and soil mixtures for growing plants.

Suggested Readings:

1. S.K. Bhattacharjee and Lakshman Chandran De. 2010. Advanced Commercial Floriculture, Vols. I and II Aavishkar Pub., Second Revised and Enlarged Edition, 798.
2. D. Ravinath. 2007. Floriculture: A Viable Business. Excel Books
3. S.Prasad, U. Kumar. 2010. A Handbook of Floriculture). Agrobios (India)
4. John M. Dole and Harold F. Wilkins. 2004. Floriculture: Principles and Secies : Prentice Hall; 2 edition (2nd Edition)

5. Paul V. Nelson (Author). 2002. Greenhouse Operation and Management. Prentice Hall; 6 edition (6th Edition)

PGDF-102 Improvement of Ornamental Plants

Max. Marks: 80 (Theory),

Duration: 3 hours Credit-4

Note: Nine question will be set in all. Question No. 1 will be compulsory and short answer type covering the entire syllabus. Remaining eight questions will be set unit-wise and four questions from each unit. The candidates will be required to attempt Question no. 1 and four more selecting two questions from each unit. All questions carry equal marks.

UNIT-1

1. History and overview.
2. Role of Introduction and selection for domestication.
3. Variation and genetic mechanism associated with flower characters like double ness and color in important annuals, bulbs and shrubs.
4. Vegetative propagation: Principles and practices of clone selection.
5. Techniques of cutting, budding, grafting and layering
6. Propagation by specialized stems and roots.

UNIT-2

1. General account of improvement of Roses, Chrysanthemum, Dahlia, Gladiolus, Lilies, Marigold, Zinnia, Carnation, Bougainvillea, Hibiscus rosa sinensis.

Suggested Readings:

1. J.S. Arora.2007, introductory ornamental horticulture. Kalyani Publications.
2. Allan M. Armitage and Judy M. Laushman. 2008 Speciality Cut Flowers: The Production of Annuals, Perennials, Bulbs and Woody Plants for Fresh and Dried Cut Flowers. Timber Press; REV
3. Gwen Kelaidis and Saxon Holt. 2008. Hardy Succulents: Tough Plants for Every Climate. Storey Publishing, LLC.
4. Christopher Brickell. Royla Horticulture Society. Encyclopedia of Plants and Flowers (Rhs).
5. D.G. Hessayon. 2005. The House Plant Expert. Expert; 2nd edition.

PGDF-103 Seed production and Micro propagation

**Max. Marks: 80 (Theory),
Duration: 3 hours Credit-4**

Note: Nine question will be set in all. Question No. 1 will be compulsory and short answer type covering the entire syllabus. Remaining eight questions will be set unit-wise and four questions from each unit. The candidates will be required to attempt Question no. 1 and four more selecting two questions from each unit. All questions carry equal marks.

UNIT-1

1. Seed development, structure and stages of seed development.
2. Apomixis and Polyembryony: a general account.
3. Seed production systems
4. Techniques for seed production and handling
5. Seed testing and seed storage
6. Seedling production system
7. Field seedlings, field nurseries

UNIT-II

1. Principles of tissue culture and micropropagations
2. Types of tissue culture systems.
3. Media preparation, sterilization, types of media, methods and applications
4. Protoplast and cell suspension cultures
5. Synthetic seeds
6. Micropropagation of orchids and Carnation.
7. Clonal selection of micropropagated plant

Suggested Readings:

1. Introductory ornamental Horticulture 2007. J.S. Arora, Kalyani Publishers.
2. Advances in ornamental Horticulture, S.K. Bhattacharjee. 2006, Pointer Publishers.
3. Post Harvest Technology of flowers and ornamental plants. S.K. Bhattacharjee 2005, Pointer Publishers.
4. Advanced Commercial Floriculture, S.K. Bhattacharjee 2010. Aaviskar Publishers.
5. Ornamental Horticulture by Vishnu Swarup, Mac Milan Publishers.
6. Plant Propagation by M.K. Sadhu 1989. New Age International Publishers.
7. Propagation of tropical and sub-tropical horticulture crops. Bose, T.K., Mitra, S.K. and Sadhu, M.K. Noya Prakash Publisher

Note: Nine question will be set in all. Question No. 1 will be compulsory and short answer type covering the entire syllabus. Remaining eight questions will be set unit-wise and four questions from each unit. The candidates will be required to attempt Question no. 1 and four more selecting two questions from each unit. All questions carry equal marks.

UNIT-1

1. Scope and importance of commercial floriculture in India
2. Production techniques- both conventional and modern for ornamental plants like Roses, Chrysanthemum, Gladiolus, Tuberose and Gerbera for domesticated and export markets.
3. Hybrid seed production, Post harvest technology of cut flowers in respect of commercial flower crop production of dry flowers.

UNIT- II

1. Indian floriculture industry: An overview
2. Strategies for marketing of floriculture products, IPR and quarantine laws
3. Cut flowers as specialty crops, cut flower industries
4. Trading flowers and potted plants
5. Value addition in floriculture: cosmetics and perfume industry and outdoor designing.
6. Cutting, grading, packaging and marketing of cut flower crops (Aster, Carnation, Chrysanthemum, Gladiolus, Narcissus, Orchids and Antirrhinum) for national and International market.

Suggested Readings:

1. Introductory ornamental Horticulture 2007. J.S. Arora, Kalyani Publishers.
2. Advances in ornamental Horticulture, S.K. Bhattacharjee. 2006, Pointer Publishers.
3. Post Harvest Technology of flowers and ornamental plants. S.K. Bhattacharjee 2005, Pointer Publishers.
4. Advanced Commercial Floriculture, S.K. Bhattacharjee 2010. Aaviskar Publishers.
5. Ornamental Horticulture by Vishnu Swarup, Mac Milan Publishers.
6. Plant Propagation by M.K. Sadhu 1989. New Age International Publishers.
7. Propagation of tropical and sub-tropical horticulture crops. Bose, T.K., Mitra, S.K. and Sadhu, M.K. Noya Prakash Publisher.

BOTANY DEPARTMENT
KURUKSHETRA UNIVERSITY KURUKSHETRA
M.Sc. BOTANY Scheme of Examination (CBCS)w.e.f. 2019-20

Semester I

Paper code	Title of paper	Type of paper	Hours /week	Credits	Marks + Internal Assessment	Total
BOT-101	Algae & Fungi	Core	4	4	80 + 20	100
BOT-102	Bryophytes & Pteridophytes	Core	4	4	80 + 20	100
BOT-103	Cytogenetics & plant breeding	Core	4	4	80 + 20	100
BOT-104	Ecology	Core	4	4	80 + 20	100
BOT-105	Practical based on 101 + 102	Core	8	4	80 + 20	100
BOT-106	Practical based on 103 + 104	Core	8	4	80 + 20	100
Total				24		600

Semester II

Paper code	Title of paper	Type of paper	Hours/ week	Credits	Marks + Internal Assessment	Total
BOT-201	Microbiology and Biostatistics	Core	4	4	80 + 20	100
BOT-202	Natural Resources & Biodiversity	Core	4	4	80 + 20	100
BOT-203	Gymnosperms & Ethnobotany	Core	4	4	80 + 20	100
BOT-204	Molecular genetics	Core	4	4	80 + 20	100
BOT-205	Seminar	Core	1	1	25	25
BOT-206	Plants for human welfare	Open Elective	2	2	40 + 10	50
BOT-207	Practical based on 201 + 202	Core	8	4	80 + 20	100
BOT-208	Practical based on 203 + 204	Core	8	4	80 + 20	100
Total				27		675

Semester III

Paper code	Title of paper	Type of paper	Hours/ week	Credits	Marks + Internal Assessment	Total
BOT-301	Plant physiology & biochemistry	Core	4	4	80 + 20	100
BOT-302	Taxonomy & economic botany	Core	4	4	80 + 20	100
BOT-303	Biotechnology & genetic engineering	Core	4	4	80 + 20	100
BOT-304	a) Advanced Phycology (elective) b) Applied Mycology (elective) c) Restoration Ecology (elective) d) Advanced Plant Physiology (elective) e) Biophysical & biochemical techniques (elective)	Elective	4	4	80 + 20	100
BOT-305	Seminar	Core	1	1	25	25
BOT-306	Biodiversity and its conservation	Open Elective	2	2	40 + 10	50
BOT-307	Practical based on 301	Core	6	3	60 + 15	75
BOT-308	Practical based on 302 + 303	Core	6	3	60 + 15	75
BOT-309	Practical based on 304	Core	4	2	40 + 10	50
Total				27	675	

Semester IV

Paper code	Title of paper	Type of paper	Hours/ week	Credits	Marks + Internal Assessment	Total
BOT-401	Plant growth & development	Core	4	4	80 + 20	100
BOT-402	Biology of Reproduction and Anatomy	Core	4	4	80 + 20	100
BOT-403	Plant Tissue Culture	Core	4	4	80 + 20	100
BOT-404	a) Applied phycology (elective) b) Principles of Plant Pathology (elective) c) Conservation Biology (elective) d) Plant Growth Regulators (elective) e) Genomics (elective)	Elective	4	4	80 + 20	100
BOT-405	Practical based on 401	Core	6	3	60 + 15	75
BOT-406	Practical based on 402 + 403	Core	6	3	60 + 15	75
BOT-407	Practical based on 404	Core	4	2	40 + 10	50
Total				24	600	

Total Credits = 102**Total Marks = 2550**

SEMESTER – I

Paper – BOT-101

Algae & Fungi

Credit -4

MM-80

Objectives: To educate and train the students for professional and research career in the field of Algology & Mycology.

Outcome: The learning outcome is an advanced academic education to broaden the knowledge in comparison to that obtained in Bachelor's degree programme. The acquired knowledge will provide professional qualification for work in biological laboratories and research centres.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

1. Criteria for algal classification (pigments, reserve food, flagella etc.) and their taxonomic importance.
2. Comparative account of important systems of classification and recent trends.
3. Thallus organization in algae and evolutionary trends.
4. Economic importance of algae as food, feed, uses in industries etc and algal biofertilizers.

Unit-II

5. (a) Biodiversity of algae in different habitats (terrestrial, freshwater and marine).
(b) Ecological diversity of algae in unusual habitats (thermal, psychrophilic, subaerial, symbiotic etc.).
6. Thallus organization in algae and evolutionary trends.
7. Dynamics and consequences of algal blooms and red tides (Freshwater and Marine). Algae as major components of phytoplankton.
8. Morphological features and life cycle patterns of major divisions with suitable examples (Cyanophyta, Chlorophyta, Xanthophyta, Bacillariophyta, Phaeophyta, and Rhodophyta).

Unit- III

9. General characters of fungi: Thallus organization, nutrition and reproduction.
10. Classification of fungi by Ainsworth & Bisby (1983), Alexopoulos et. Al (1996).- phylogeny of fungi- characters used in classification.
11. General account of Myxomycota, mastigomycota, Zygomycota, Ascomycota, Basidiomycota and Mitosporic fungi. Different kinds of spores and their dispersal.
12. Concept of Homothallism, Heterothallism, alternation of generations and parasexuality.

Unit – IV

13. Economic importance of fungi in nutrient cycling, decomposition, humus formation, decay and deterioration of wood & timber.
14. Causal organisms, symptoms and management of : late and early blight of potato, downy mildew of grapes, green ear disease of ground nut, apple scab, karnal bunt of wheat, rust of wheat, tikka disease of ground nut
15. Lichens: structure, reproduction and economic importance

Suggested Readings:

1. Ahluwalia, A.S. (Ed.). *Phycology: Principles, Processes and Applications*. Daya Publishing House, New Delhi. 2003.
2. Carr, N.G. & Whitton , B.A. (1982): *The biology of Cyanobacteria* Blackwell Scientific Publ., Oxford, U.K.
3. Dubey, R.C. (2014): *Advanced Biotechnology*, S Chand & Cmpany Pvt. Ltd., New Delhi.
4. Fatma, T. (2005): *Cyanobacterial and Algal Metabolism and Environmental Biotechnology*, Narosa Publihers.
5. Fay, P & C van Baalen (1987): *The cyanobacteria*, Elsevier Science Publishers, B.V. Amsterdam, Netherlands.
6. Gupta, R.K. & Pandey, V.D. (2007): *Advaces in Applied Phycology*, Daya Publishing House, Daryaganj, New Delhi.
7. Hoek, C. Van Den, Mann, D.G. & Jahns, H.M. (1995): *Algae: An Introduction to Phycology*, Cambridge University Press, U.K.
8. Kaushik, B.D. (1987): *Laboratory methods for Blue-green Algae*, Associated Publishing Co., New Delhi.
9. Morris, I. (1980): *The Physiological Ecology of Phytoplankton (studies in Ecology, Vol.7)*, Blackwell Scientific Publ., USA.
10. Prescott, L.M., Harley, J.P. & Klein, D.A. (1996): *Microbiology*, 3rd edition, Wm. C. Brown Publishers, USA.
11. Singh, B.D. (1998): *Biotechnology*, Kalyani Publishers, New Delhi.
12. Singh, R.P. (1990): *Introductory Biotechnology*, Central Book Depot, Allahabad, India.
13. Sze, P. (1993): *A. Biology of the Algae*, Wm. C. Brown Publishers, U.K.
14. Venkataraman, G.S. ((1969): *The Cultivation of Algae*, IARI, New Delhi.
15. Alexopoulos, C.J. Mins, C.W. & Blackwell, M. 1995: *Introductory Mycology*, John Willy and Sons. Inc.
16. Bilgrami, K.S. & Dubey H.C. (1986): *A text book of Modern Plant Pathology*, Vikas, Publ Ltd., N.Delhi.
17. Bilgrami, K.S.A. & Verma R.N. (1981): *Physiology of fungi*, Vikas Publ. Ltd., New Delhi.
18. Biswas, S.P. & Biswas, A. 1984: *An Introduction to Viruses*, Vani Education Books, New Delhi.
19. Butler, E.J. & Jones, S.G. (1978): *Plant Pathology*, Periodical Expert Book Agency, New Delhi.
20. Clifton, A. 1958: *Introduction to the Bacteria*. McGraw Hill Books Co. New York.
21. Mehrotra, R.S. & Aneja, K.R. 1990: *An introduction of Mycology*, New Age International Press, N.Delhi.
22. Moore-landekar, E.J. (1972): *Fundamentals of the fungi*, Prentice Hall, Eaglewood, U.K.
23. Mundukar, B.B. (1967): *Fungi & Plant Diseases*, Mac million Co. Ltd., USA.
24. Webster, J. 1985: *Introduction of Fungi*. Cambridge University, Press.

Objectives: The course has been conceived to equip students with the knowledge of characteristics, structure and development of gametophyte and sporophyte in bryophytes & pteridophytes.

Outcome: After studying this paper students will be able to classify bryophytes and distinguish these from other groups of plants. They will also be able to understand origin and evolution of sporophyte in bryophytes & pteridophytes.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

1. General characteristics features of Bryophytes. General account of structure and development of gametophyte, sporophyte of Marchantia, Peltia and Anthoceros.
2. General account of structure and development of gametophyte and sporophyte of Sphagnum, Funaria & Polytrichum.

Unit -II

3. Biology of reproduction- *In Vitro* regulation of gametangia formation: effect of physical and chemical factors
4. Ecological importance of bryophytes: Bryophytes as indicators of pollution and minerals; role of Bryophytes in succession

Unit-III

5. General characteristics of Pteridophytes and their classification
6. Comparative morphology and reproduction of the following:
Psilophytales (Rhynia, Zosterophyllum), Psilotales (Psilotum), Lycopodiales (Lycopodium, Selaginella), Lepidodendrales (Lepidodendron), Sphenophyllales (Equisetum)

Unit- IV

7. Comparative morphology and reproduction of the following :
Ophioglossales (Ophioglossum, Botrychium), Marattiales (Marattia, Angiopteris), Osmundales, Filicales (Pteris, Dryopteris), Marsileales and Salviniiales
8. Economic and Ecological significance of Pteridophyte in succession.

Suggested Readings:

1. Parihar, N.S. 1965. An Introduction to Embryophyta Vol. I. Bryophyta, Central Book Depot, Allahabad, India.
2. Schofield, W.B. 1985. Introduction to Bryology, Macmillan, New York.
3. Chopra, R.N. and Kumra, P.K. 1988. Biology of Bryophytes. Wiley Eastern Ltd., New Delhi.
4. Chopra, R.N. & Bhatla, S.C. 1990. Bryophyte Development: Physiology and Biochemistry. CRC Press, Boca Raton, USA.
5. Rashid, A. 1998. An Introduction to Bryophyta. Vikas Publishing House Pvt. Ltd. New Delhi.

6. Watson, E.V. 1967. The Structure and Life of Bryophytes. B.I. Publications, New Delhi.
7. Glime, J.M and Saxena D. 1991. Uses of Bryophytes. Today and Tomorrow's Printers and Publishers, New Delhi.
8. Richardson, D.H.S. 1981. The Biology of Mosses. Blackwell Scientific Publications, Oxford, London.
9. Parihar, N.S. 1977. The Biology and Morphology of Pteridophytes. Central Book Depot. Allahabad.
10. Rashid, A. 1976. An Introduction to Pteridophyta (Diversity and Differentiation). Vikas Publishing House Pvt. Ltd., New Delhi.
11. Sporne, K.R. 1985 (reprint) The Morphology of Pteridophytes. B.I. Publications Pvt. Ltd., Delhi.

Paper – BOT-103 - CYTOGENETICS AND PLANT BREEDING

Credit -4 MM-80

Objective: The purpose of this paper is to acquaint the students about structure and functions of a chromosome in detail. The course also explains the chromosomal variations and their effects on biological system. Further, it aims to draw attention to methods used for crop improvement.

Outcome: This paper would help the students to know the role of chromosomes and chromosomal rearrangements in generation of variations. They will also be familiar with methods used to change the traits of a plant to create the desired genotype/phenotype.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

1. Chromatin structure and organization: Chromosome structure and DNA packaging; euchromatin and heterochromatin.
2. Organization of plastid and mitochondrial genomes.
3. Special Chromosomes: Structure, occurrence and behaviour of polytene, lampbrush, B and sex chromosomes.
4. Karyotype: Karyotype analysis and its evolution; FISH, CGH and flow cytometry.

Unit-II

5. Cell cycle: Cell cycle phases, checkpoints and regulation.
6. Chromosome banding techniques and their applications.
7. Linkage and crossing over: Molecular mechanism of crossing over and role of different enzymes; linkage groups.
8. Chromosome mapping- Two point and three point test crosses.

Unit-III

9. Sex determination: Chromosomal and gene determining sex in plants, animals, *Drosophila* and humans; Gene dosage compensation.
10. Structural alterations in chromosomes – Origin, meiosis and breeding behaviour of duplication, deficiency, inversion and translocation heterozygotes.
11. Variation in chromosome number: Haploids, aneuploids and euploids- origin, production, effects and uses; polyploidy and crop improvement.

Unit-IV

12. Principles of plant breeding: Principles and objectives; methods of breeding self and cross pollinated crops, heterosis and hybrid vigour; utility of hybrids in genetics and plant breeding.
13. Asexual breeding systems: Methods of breeding of vegetatively propagated crops; Non-conventional methods; gene variability.
14. Male sterility: Concept; classification; genetic control; inheritance pattern and breeding utility.

Suggested Readings:

1. Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P (2008) Molecular Biology of the Cell (5th Ed.). Garland Publishing Inc., New York.
2. Gustafson JP (2002) Genomes, Kluwer Academic Plenum Publishers, New York, USA.
3. Karp G (1999) Cell and Molecular Biology, John Wiley and Sons, USA.
4. Krebs JE, Goldstein ES and Kalpatrick ST (2010) Lewin's Essential Genes (2nd Ed.), Jones and Barlett Publishers.

5. Lewin B (2010) Gene X, Jones and Barlett Publishers.
6. Lodish H, Berk A, Kaiser, CA, Krieger M, Scott MP Bretscher A Ploegh H and Matsudaira P (2008) Molecular Cell Biology (6th Ed), W.H. Freeman and Company, New York, USA.
7. Pierce BA (2012) Genetics- A Conceptual Approach (4th Ed.), W.H. Freeman and Company, New York, USA.
8. Poehlman JM and Sleper DA (1995) Breeding Field Crops, AVI. Publ., U.S.A.
9. Russell PJ (2006) Genetics (5th Ed.), Addison Wesley Longman, California, USA.
10. Snustad P and Simmons MJ (2011) Principles of Genetics. (6th Ed.), John Wiley, New York.
11. Weaver RF (2005) Molecular Biology, McGraw Hill International Edition.
12. Watson, JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene (6th Ed.), CSHLP, New York

Objectives: Critically engage with concepts of Ecological principles and importance of environment and the problems related with it at global and local level.

Outcome: By understanding the concepts of ecological principles and environmental issues, the student will be able to develop attitude, value system and ethics towards environment related issues.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

1. The Environment: Physical environment, biotic environment, biotic and abiotic interactions; Tolerance range and limiting factors, ecotypes
2. Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
3. Population ecology: Concept, characteristics, population growth and regulation, species interactions—mutualism, competition, allelopathy, predation, parasitism, Life-history strategies and r-and K selection, concept of metapopulation – demes and dispersal, interdemec extinctions, age structured populations

Unit-II

4. Community structure and organization; Nature of communities, community structure and its attributes; species diversity, Edges and ecotones, vegetation characteristics (analytical and synthetic characters, methods of analysis.
5. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.

Unit-III

6. Ecosystem organization: structure and functions; primary production (global pattern and controlling factors); energy dynamics—trophic levels, energy flow pathways and ecological efficiencies.
7. Decomposition (mechanism, substrate quality and climatic factors); global biogeochemical cycles of C, N, P, & S, ecosystem stability (resistance and resilience).

Unit-IV

8. Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.
9. Global atmosphere changes: Environmental pollution, global environmental change and its consequences (CO₂ fertilization, global warming sea level rise and UV radiation).
10. Biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

Suggested Readings :

1. Botkin, D.B. and E.A. Keller (2004). Environment Science: Earth as a Living Planet, John Wiley & Sons Inc., New York.
2. Miller (Jr.) and G. Tyler (1994) : Living in the Environment. Wadsworth Publishing Company, Belmont, California.
3. Odum, E.P. (1983), Basic Ecology, Sanders, Philadelphia.
4. Peter H. Raven, P.H. and Berg , L. R. Berg. 2005. Environment, 5th Edition. John Wiley & Sons Inc., New York.
5. Ramakrishnan, P.S. 2000. Ecology and Sustainable Development. National Book Trust, India
6. Robert Ricklefs (2001). The Ecology of Nature. Fifth Edition. W.H. Freeman and Company.
7. Singh, J.S., Singh, S.P. and Gupta, S.R. 2006. Ecology, Environment and Resource Conservation, Anamaya Publishers, New Delhi.
8. Smith, R.L. (1996), Ecology and Field Biology, Harper Collins, New York.
9. Steffen, W., A. Sanderson, P. D. Tyson, J. Jager, P. M. Matson, B. Moore, III, F. Oldfield, K. Richardson, H. J. Schnellhuber, B. L. Turner, II, and R. J. Wasson. 2004. Global change and the Earth system: a Planet under Pressure. Springer-Verlag, New York, New York, USA Reference books.
10. Townsend, C.R., Begon, M. And Harper, J.L. 2003. Essentials of Ecology. Second Edition. Blackwell Publishing, Oxford.

Paper – BOT-201 – Microbiology and Biostatistics

Credit -4 MM- 80

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

1. Structure & replication of viruses and bacteriophage; transmission & control of viruses; Isolation & purification of Plant Viruses.
Diseases caused by Viruses: TMV, Tristeza of citrus
2. Cyanobacteria: Salient features and Biological Importance.

Unit-II

3. Growth, culture and maintenance of microorganisms
Microbial growth and measurement, environmental factors influencing growth.
4. Control of micro organisms: Physical methods(High temperature, dry hot or hot air sterilization, moist air sterilization, low temperature, filtration, lyophilisation, Radiation), Chemical methods (Disinfectants and antiseptics)

Unit-III

5. Microbial interaction: Functions of symbiotic relationships, types of symbiosis, commensalism, synergism, mutualism-(Lichens, Bacterial endosymbionts of protozoa, Nitrogen fixing symbiosis, mycorrhizae), parasitism.
6. Environmental Microbiology: Microbiology of fresh, marine and extreme environment, Biofilms, Bioremediation of polluted environment, Bioleaching.

Unit-IV

7. Biostatistics: Brief description and tabulation of data and its graphical representation.
8. Measures of central tendency and dispersion.
9. Mean, mode, median, range standard deviation, variance idea of two types of errors and level of significance, tests of significance (F & t test); chi-square test.
10. Simple Linear Regression and Correlation.

Suggested Readings:

1. Gupta R & Mukherji K G (2001). Microbial technology, APH Publ. co., New Delhi.
2. Pelezar, MJ, Chaing, ECS & Krieg, NR (1993). Microbiology, Tata McGrawHill Publ. New Delhi.
3. Prescott, LM., Harley, JP & Klein, DA (1996). Microbiology Wm. C. Brown Publ. USA.
4. Ronald, M Atlas (1995). Principles of microbiology. Mosby-Year Book, Inc. St. Louis, Missouri, USA.
5. Singh R.P. (1990): Introductory Biotechnology, Central Book Depot, Allahabad, India.
6. Sumbali, G. 2005: The Fungi, Narosa Publ. House, New Delhi.
7. Statistics for Biologists (1974) Campbell R.C. Cambridge University Press, Cambridge.

Paper 202: Natural Resources and Biodiversity Credit -4 MM-80

Note:-

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short –answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section-wise with two questions from each unit I, II, III & IV. The candidates will be required to attempt Q. No. 1 and four more selecting one question from each section.

Unit-I

- 1) Resources: Types, Renewable and non-renewable resources; resources degradation and conservation.
- 2) Land resources: Land degradation and desertification; management of waste lands in India.
- 3) Water resources: Pools of water and Hydrological cycles, surface water and ground water; water-use and management.
- 4) Environmental pollution of air, water and soil-types, sources and effects.

Unit-II

- 5) Forest resources: Forests and their importance, Non timber forest produce, forest resources of India and forest management.
- 6) Types of energy resources, renewable sources of energy-wind energy, wave energy, Energy from biomass, bioconversion technologies, energy plantation and petrocrops.
- 7) Ecosystem restoration and Environment impact assessment- Brief account.

Unit- III

- 8) Principles of resources conservation and conservation strategies.
- 9) Biological diversity: importance, concept and levels biodiversity, threats to biodiversity- habitat loss and fragmentation, exotic species, pollution, species extinctions; IUCN categories of threat.
- 10) Distribution and global patterns of biodiversity.
- 11) Terrestrial and marine hotspots of biodiversity; Hotspots of biodiversity in India.

Unit- IV

- 12) *In situ* conservation of biodiversity: Protected area in India-sanctuaries, national parks, biosphere reserves.
- 13) Conservation of biodiversity of wetlands, mangroves and coral reefs.
- 14) *Ex situ* biodiversity conservation: principles and practices, field gene banks, seed banks and cryopreservation.
- 15) Sustainable development: concept, principles and strategies; sustainability indicators.

Suggested Readings:

1. Ball, J.B. 2001. Global forest resources: history and dynamics. In: *Forest Handbook Volume 1*, Evans, J. (ed.) Blackwell Science, Oxford.
2. Chape, S., Fish, L. Fox, P. and Spalding, M. 2003. United Nations list of protected areas. UCN/UNEP/World Conservation Monitoring Centre, Gland, Switzerland/Cambridge.
3. Gopal, B. (ed.) 1987. Ecology and Management of Aquatic Vegetation of the Indian Subcontinent. W. Junk by. The Hague.
4. Heywood, V.(Ed.) (1995) Global Biodiversity Assessment. United Nations Environment Programme, Cambridge University Press, Cambridge.
5. Huston, M.A. 1994. *Biological Diversity: The Coexistence of Species on Changing Landscapes*. Cambridge University Press, Cambridge.
6. Owen, O.S., Chiras, D.D. and Reganold, J.P. 1998. Natural Resource Conservation: Management for Sustainable Future. Seventh Edition. Prentice Hall. Upper Sadle River, New Jersey.
7. Raven, P.H. and Berg, L.R. 2005. Environment , 5th Edition, John Wiley & Sons Inc., New York.
8. Singh, J.S. and Singh, S.P. 1992. *Forests of Himalaya, Structure, Functioning and Impact of Man*. Gyanodaya Prakashan, Nainital, India.
9. Singh, J.S., Singh, S.P. and Gupta, S.R. 2006. Ecology, Environment and Resource Conservation, Anamaya Publishers, New Delhi.

Objective: This course is intended to provide the basic understanding of morphology and reproduction in pteridophytes and gymnosperms. It also describes the modern methods of propagation of gymnosperms.

Outcome: After studying this paper students will be able to classify pteridophytes and gymnosperms. They will also be able to describe heterospory, origin of seed habit and evolutionary trends in stele and spore producing organs. Besides above, they will also be able to understand the phenomena of apogamy, apospory and their experimental induction.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

1. Classification of gymnosperms and their distribution in India.
2. Brief account of the following families:
Lyginopteridaceae, Medullosaceae, Glossopteridaceae, Caytoniaceae.

Unit – II

3. General account of the following orders:
Cycadeoidales(Cycadeoidea), Pentoxylales, Cordiales
4. Comparative account of Structure and reproduction in the following orders:
Cycadales (Cycas), Ginkgoales (Ginkgo).

Unit- III

5. Coniferales (Pinus, Cedrus), Ephedrales (Ephedra), Welwitschiales, Gnetales
6. Economic importance of gymnosperms, Role of Gymnosperms in Biodiversity.
7. Modern methods of propagation of gymnosperms: somatic embryogenesis, haploids and protoplast culture

Unit-IV

8. Ethnobotany: History and importance of ethnobotany, ethnomedicobotany, ethnozoology, ethnoveterinary, ethnomusicology and ethnoagriculture
9. Wild edible plants used as emergency food by tribals in India, methods and techniques in ethnobotanical study and research.
10. Traditional plants: Cereals, pulses, vegetables, spices and mushrooms, wild edible fruits and seeds. Plants in folk songs and proverbs. Sacred grooves, Impact of modernization.

Suggested Readings:

1. Bhatnagar, S.P. and Moitra, A. 1996. Gymnosperms, New Age International Pvt. Ltd., New Delhi.
2. Sporne, K.R. 1965. The Morphology of Gymnosperms. B.I. Publications Pvt. Ltd., New Delhi.
3. Bierhorst, D. W. 1971. Morphology of Vascular Plants. Macmillan. New York.
4. Cotton, C.M. 1996. Ethnobotany- Principles and Applications, Centruy School Book by service Film setting Ltd.
5. Dahlgren. R.H., Clifford, T and P.F Yeo 1985. The families of the monocotyledons; structure, Evolution and Taxonomy. SpingeVerag, NY.

6. Gary J, Martin, 2004. Ethnobotany- A Methods Manual, Chapman and Hall. U.K.
7. Jain S.K. 1981. Glimpses of Indian Ethnobotany. Oxford and IBH, New Delhi.
8. Jain S.K. 1987. A manual of ethnobotany. Scientific publisher Jodhpur.
9. Jain S.K. and Mundgal, 1999. Handbook of ethnobotany, London.
10. Pursrglove, J.W. 1972. Tropical Crops-Monocotyledons and Dicotyledons of ethnobotany, ethnomedicine, ethnoecology, ethnic communities.
11. Rao, P.C. 2006. Medicinal plants: Ethanobotanical Approach, Agribios, India.
12. Trivedi, P.C. 2006. Medicinal plants: Ethanobotanical Approach, Agribios, India.
13. Yoganarasimhan, S.N. Medicinal Plants of India-Vol-I- Karnataka, Interline Publishing Pvt. Ltd.

Objective: This course is intended to provide the basic understanding of biological processes such as DNA replication, transposition and mutations. A key thrust of this paper is towards the molecular mechanisms involved in the control of gene expression and regulation.

Outcome: The students are expected to have better understanding of basic life processes. It will also impart knowledge about the regulation of various metabolic pathways.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

UNIT-I

1. Eukaryotic genome: Different forms of DNA, C- value paradox, unique and repetitive DNA, gene families, hybridization kinetics and split genes.
2. Transposable elements: Mechanisms of transposition; transposons in bacteria, maize, *Drosophila* and yeast.
3. DNA Replication: Semi-conservative, bidirectional, replication origins, replication machinery.

UNIT-II

4. Mutations: types, isolation of mutants, molecular basis of mutations.
5. DNA damage and repair: Causes of DNA damage; Photoreactivation, excision, mismatch, post replication and error prone repair systems.
6. Fine structure of gene: *cis-trans* test, rII locus, fine structure analysis of eukaryotes.
7. Bacterial genetics: conjugation, transduction and transformation.

UNIT- III

8. Transcription: Initiation, elongation and termination in prokaryotes and eukaryotes, RNA polymerases.
9. RNA Processing: Processing of mRNA, rRNA and tRNA.
10. Genetic code: Deciphering the genetic code, characteristics.
11. Translation: Initiation, elongation and termination in prokaryotes and eukaryotes.

UNIT-IV

12. Regulation of gene expression in prokaryotes: Operon concept, lac operon regulation by positive and negative mechanism, trp operon, regulation by negative and attenuation.
13. Regulation of gene expression in eukaryotes:
 - a) Transcriptional level – Regulatory sequences, nucleosome positioning, chromatin 647itrogenis, histone modifications.
 - b) Post-transcriptional level – RNA splicing, RNA stability.
 - c) Translational level and post-translational level.

Suggested Readings:

1. Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P (2008) Molecular Biology of the Cell (5th Ed.). Garland Publishing Inc., New York.
2. Brown TA (1999) Genomes. John Wiley & Sons (Asia) Pvt. Ltd., Singapore.
3. Burns GW and Bottino PJ (1989) The Science of Genetics, Macmillan Publishing Co. New York.
4. Clark D (2005) Molecular abiology, Understanding the Genetic Revolution. Elsevier Inc. C. California.
5. Gustafson JP (2002) Genomes. Kluwer Academic Plenum Publishers, New York, USA.
6. Hartl DL (1999) Genetics Principles and analysis. (4th Ed.) Jones and Bartle, Boston.
7. Henry RJ (1997) Practical Applications of Plant Molecular Biology, Chapman & Hall, London, UK.

8. Klug WS and Cuning MR (1996) Essentials of Genetics. Prentice Hall London.
9. Krebs JE, Goldstein ES and Kalpatrick ST (2010) Lewin's Essential Genes (2nd Ed.), Jones and Barlett Publishers.
10. Lewin B (2005) Genes VIII. Oxford University Press, New York.
11. Lodish H, Berk A, Kaiser, CA, Krieger M, Scott MP Bretscher A Ploegh H and Matsudaira P (2008) Molecular Cell Biology (6th Ed), W.H. Freeman and Company, New York, USA.
12. Pierce BA (2012) Genetics- A Conceptual Approach (4th Ed.), W.H. Freeman and Company, New York, USA.
13. Russell PJ (2006) Genetics (6th Ed.), Addison Wesley Longman, California, USA.
14. Snustad P and Simmons MJ (2011), Principles of Genetics. (6th Ed.), John Wiley, New York.
15. Swanson CP, Mertz T and Young WJ (1981) Cytogenetics- The Chromosome in Division, Inheritance and Evolution (2nd Ed.), Englewood Cliffs, Prentice Hall, New Jersey.
16. Weaver RF and Hedrick PW (1997). Genetics (3rd Ed.) WMC Brown, Chicago.
17. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene (6th Ed.), CSHLP, New York.

PAPER – BOT-206 – PLANTS FOR HUMAN WELFARE CREDIT -2 MM-50

Objective: This course is intended to provide the basic understanding the origin, morphology, cultivation of major crops. It also deals with the traditional knowledge and utility of some common spices, condiments, medicinal plants and horticulture crops.

Outcomes: The students are expected to have better understanding of origin of agriculture. They will also be able to identify the plant sources of medicines, spices, oil, fibres, dyes, gum and timbers.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

Plants and Civilization: Origin of agriculture

Origin crop plants: Idea about centre of origin of common crop plants

Major cereals and pulses

Spices and condiments (Saffron, Clove, Cardamom, Ginger, Turmeric, Cinnamon, Capsicums, Asafetida, Coriander, Fennel, Fenugreek)

Unit –II

Medicinal plants: Importance of medicinal plants – role in human health care

Traditional knowledge and utility of some common medicinal plants-*Sarp Gandha, Isabgol, Vasaka, Neem, Bhiringraj, Amla, Harrad, Bahera, Arjun, Punarnava, Brahmi, Kasondi, Ghritkumari, Quinine and Eucalyptus*

Hallucinogenic plants – general account

Unit –III

Nutritive and medicinal value of some fruits and vegetables (Guava, Sapota, Orange, Mango, Banana, Lemon, Pomegranate, Moringa, Cabbage)

Beverages (Coffee, Tea, Chocolate, Cola)

Common ornamental plants

Common food adulterants

Unit-IV

Common timber yielding plants and minor forest products

General account of Fibers, dyes, tannins, gums and resins

Insecticides from plants (Pyrethrum)

Suggested Readings:

Kochar, S.L. 1981. Economic Botany in the Tropics. Macmillan India Ltd., Delhi.
 Hill, A.F. 1952. Economic Botany (2nd Ed.) McGraw Hill, New York.
 Cobley, L.S. and Steele, W.M. 1976. An Introduction to the Botany of Tropical Crops (2nd Ed.) Longmans, London.
 Simmonds, N.W. 1976. Evolution of Crop Plants Longman, London, New York.
 SambaMurthy, AVS and Subrahmanyam, N.S. 1989. A Text Book of Economic Botany. Wiley Eastern Ltd., Delhi
 Schery, R.W. 1972. Plants for Man. Prentice Hall. Englewood Cliffs, N.J. USA
 Simpson B. B. M. C. Ogorzaly 2001. Economic botany: plants of our world, 3rd ed. McGraw-Hill, New York, New York, USA.

SEMESTER – III

Paper – BOT-301 Plant Physiology and Plant Biochemistry Credit -4 MM-80

Objective: The course would deal with the study of plant physiology especially the water transport, absorption, mineral nutrition, photosynthesis, respiration and nitrogen metabolism.

Outcome: The students will be able to understand the physiology and basic metabolism of plants. They will be able to answer the questions regarding water transport, absorption, mineral nutrition, photosynthesis, respiration and nitrogen metabolism.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

Water: Passive and active absorption of water.

Plant water relations: Concept and components of water potential, soil water relationship, transpiration and factors governing transpiration, antitranspirants.

Unit-II

Mineral Nutrition: Role and mode of action of micro and macro-nutrients.

Photosynthesis: Photo-oxidation of water, cyclic and non-cyclic photophosphorylation, photorespiration and its significance. The sequence of reactions in photosynthesis, the path of carbon assimilation (C3 and C4 cycles, CAM pathway).

Unit-III

Respiration: Glycolysis, Krebs cycle, electron transport chain and ATP synthesis, pentose phosphate pathway, glyoxylate cycle.

Nitrogen Metabolism: Biochemistry of nitrogen fixation, nitrogen fixation in legumes, nitrate assimilation, ammonium assimilation, biosynthesis of amino acids.

Unit-IV

Lipid Metabolism:

Fatty acid biosynthesis, Alpha and beta oxidation and conservation into carbohydrates.

Enzymes: Structure, properties and functions of enzymes, factors affecting rates of enzymatic reactions, isozymes, allosteric enzymes.

Suggested Readings:

Bonner, J. And Varner, J.E. (1976). Plant Biochemistry, IIIrd Edition, Academic Press, New York and London.
 Buchanan, B.B., Gruissem, W. And Jones, R.L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
 Davies, Peter J. (1995). Plant Hormones: Physiology, Biochemistry and Molecular Biology. 2nd Edition. Kluwer Academic Publishers, The Netherlands.
 Dey, P.M. and Harborne, J.B. (1997), First Indian Edition, Plant Biochemistry. Academic Press, Harcourt Asia Pvt. Ltd.
 Garrett, R.H. and Grisham, C.M. (1999). Biochemistry. Second edition. Saunders College Publishing, Philadelphia.
 Hopkins, W.G. (1995) Introduction to Plant Physiology, John Wiley and Sons.
 Krishnamoorthy, H.N. (1993). Physiology of Plant Growth and Development. Atma Ram and Sons, Delhi.

Kumar, H.D. and Singh, H.N. (1993). Plant Metabolism. Second edition, Affiliated East-West Press Pvt Ltd. New Delhi.

Lehninger, A.L. (1978). Biochemistry. Kalyani Publishers, Ludhiana, India (Indian edition).

Lehninger, A.L, Nelson, D.L. and Co MM 1993 Principles of Biochemistry Second edition, CBS Publishers.

Moore, Thomas. C. (1989). Biochemistry and Physiology of Plant Hormones. Second edition (Reprint 1994), Narosa Publishing House, New Delhi..

Noggle, G.R. and Fritz, G.J. (1983). Introductory Plant Physiology, Prentice-Hall of India Pvt. Ltd., New Delhi, Second edition Seventh reprint, 1993.

Salisbury, F.B. and Ross, C.W. (1992). Plant Physiology. Fourth edition, Wadsworth Publishing Co. Belmont, California, USA.

Singhal, G.S. Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee (editors) (1999). Concepts in Photobiology: Photosynthesis and Photomorphogenesis. Narosa Publishing House, New Delhi.

Srivastava, L.M. (2006). Plant Growth and Development : Hormones and Environment. Academic Press. Published by Elsevier India Pvt. Ltd., New Delhi.

Taiz, L and Zeiger, E. (1998). Plant Physiology. Second edition. Sinauer Associates, Inc., Publishers, Massachusetts, USA

Trehan, K. (1990). Biochemistry. Second edition, Wiley-Eastern Ltd., New Delhi.

Trivedi, P.C. (2006). Plant Molecular Physiology: Current Scenario and Future Projections. Aavishkar Publishers, Distributors, Jaipur.

Weil, J.H. (1990). General Biochemistry. Sixth edition. Wiley-Eastern, New Age International Publishers, New Delhi.

Wilkins, M.B. (1987). Advanced Plant Physiology, ELBS, Longman, England. Zubay, Geoffrey. (1989). Biochemistry. Mc.Millan Publishing Co. New York.

Objective: The course would deal with the study of the basic concepts of plant taxonomy and botanical nomenclature. The course is also designed to know about the origin of agriculture and economic importance of major crop plants.

Outcome: The students will be able to understand the different systems of classification of angiosperms. They will also be able to identify the plant sources of medicines, spices, oil, fibres, dyes, gum and timbers.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

The Species concept, Taxonomic hierarchy, Species, Genus and Family

Taxonomic evidence: Morphology, anatomy, palynology.

Taxonomic Tools: Herbarium and Floras.

Botanical Gardens and herbaria in India; Botanical Survey of India its organization and role.

Unit-II

Salient Features of the International Code of Botanical Nomenclature.

Systems of angiosperm classifications of Benthom and Hooker, Engler and Prantl, Hutchinson, Cronquist, Takhtajan, Dahlgren and Thorne,

Relative merits and demerits of these systems.

Unit-III

Origin of agriculture: World centers of primary diversity of domesticated plants.

Origin, botany, cultivation and uses of cereals (wheat, rice), Sugarcane, Potato

Oil yielding plants (groundnut, mustard, sunflower)

Unit-IV

Botany, origin, uses of important fibres (Cotton, Jute),

General account of important spices (Ginger, Turmeric, Cinnamon, Clove, Cardamom, Chilies, Pepper, Fennel, Coriander, Cumin, Asafetida, Nutmeg, Mace, and Saffron),

General account of important medicinal plants (Aconite, Cinchona, Belladonna, Digitalis, Glycyrrhiza, Rauwolfia, Papaver, Vasaka, Aloe and Ginseng). A brief account of major Indian Medicinal plants(Amla, Neem, Arjun, Harad, Bahera, Isabgol, Ashwagandha, Bhringraj and Senna)

General account of important timber, dye, gums and tannin yielding plants

Suggested Readings:

Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper and Row Publishers Inc.

Lawrence, G.H.M. 1951. Taxonomy of vascular plants. The Macmillan C., New York.

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

Sivarajan, V.V. 1984. Introduction to Principles of Plant Taxonomy. Oxford IBH Pub. Co., New Delhi.

Kochar, S.L. 1981. Economic Botany in the Tropics. Macmillan India Ltd., Delhi.

Hill, A.F. 1952. Economic Botany (2nd Ed.) McGraw Hill, New York.

Cobley, L.S. and Steele, W.M. 1976. An Introduction to the Botany of Tropical Crops (2nd Ed.) Longmans, London.

Simmonds, N.W. 1976. Evolution of Crop Plants Longman, London, New York.

SambaMurthy, AVS and Subrahmanyam, N.S. 1989. A Text Book of Economic Botany. Wiley Eastern Ltd., Delhi

Judd, W.S.; Campbell. C.S., Kellogg, E.A. and Stevens, P.F. 1999. Plant Systematics A Phylogenetic Approach. Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, U.S.A.

Schery, R.W. 1972. Plants for Man. Prentice Hall. Englewood Cliffs, N.J. USA

Simpson B. B. M. C. Ogorzaly 2001. Economic botany: plants of our world, 3rd ed. McGraw-Hill, New York, New York, USA.

Hancock. J. F. 2004. Plant evolution and the origin of crop species. 2nd edition. CABI Publishing, Cambridge, MA USA.

Radford, A. E., W. C. Dickison, J. R. Massey, C. R. Bell. 1976. Vascular Plant Systematics Harper and Row, New York.

Objective: This course is intended to provide knowledge about Recombinant DNA Technology, DNA cloning, gene amplification, genetic transformation methods and transgenic plants.

Outcome: The students will have better understanding of genetic engineering, PCR, genetic transformation and transgenic plants.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

Techniques used in DNA Technology: Gel Electrophoresis, PFGE, Southern and Western blotting, Dot blots, Chemical synthesis of genes, DNA chip technology.

Isolation of genes, Sequencing of genes: Maxam & Gilbert's method, Sanger's method and next-generation sequencing technologies,

Brief account of proteomics and genomics.

Unit-II

DNA cloning methods, using vectors (Plasmids, phages, cosmids, phagemids, transposons, artificial chromosomes, BAC, YAC, MAC), cloning in bacteria and eukaryotes, genomic and C-DNA Libraries.

Gene amplification by PCR: different types, DNA finger printing, molecular probes: 653itrogeni and applications.

Unit-III

Gene transfer methods in plants: plasmid mediated, electroporation, cation precipitation, liposomes, microinjection and particles gun technology, expression of transgenes.

Transgenic plants: production of transgenic plants with respect to insect resistance, herbicide resistance, resistance against biotic and abiotic factors, transgenics for male sterility and edible vaccines

Unit-IV

Yeast and algal biomass as source of single cell protein, oils and vitamins, microbial fermentation technology in food industry.

Plant and microbial biopesticides, bioremediation and phytoremediation.

Suggested readings

- Bajaj, Y.P.S. 2000. Biotechnology in Agriculture and Forestry-44- Transgenic Trees, Springer Pub., New York, USA
Bajaj, Y.P.S. 2000. Biotechnology in Agriculture and Forestry-46-Transgenic Trees, Springer Pub., New York, USA
Brown, T.A. 1999 Genomes. John Wiley & Sons (Asia) Pvt. Ltd., Singapore
Dawson, M.T. Powell, R, and L. Gannon, F.1996. Gene Technology, BIOS Sci. Pub. Ltd., Oxford, UK.
Erich, H.A.(Ed.) 1989, PCR Technology – Principles and applications for DNA Amplification, Stockton Press, New York, USA
Glazer, A.N. and Nikaido, H. 1995. Microbial Biotechnology, W.H. Freeman & Company, New York, USA
Glover, D.M. and Hames, B.D.(Eds.) 1995. DNA Clonning 1 – A Practical Approach, OIRL Press, Oxford, UK
Gupta, P.K. 1996. Elements of Biotechnology, Rastogi & Co., Pub., New Pub., Meerut, India.
Hammond, J., McGarvey, P. And Yusibov, V. (Eds.) 1999. Plant Biotechnology – New Products and Applications, Springer Pub., New York, USA.
Henry, R.J. 1998. Practical Applications of Plant Molecular Biology, Chapman & Hall, London, UK
Keller, G.H. and Manak, M.M. 1993. DNA Probes, Mac Millan Pub. Ltd. UK.
Lea, P. And Leegood, R.C. 1999. Plant Biotechnology and Molecular Biology (2nd Ed.) John Wiley & Sons, Ltd., England.
Lewin, B. 2005. Genes VIII,Osford University Press, Oxford, UK
Lindsey, K. And Jones, M.G.K. 1990. Plant Biotechnology in Agriculture, Prentice Hall Int. Pub., London, UK
Malaacinski, G.M. and Freifilder, D. 1998. Essentials of Molecular Biology 3rd Ed.), Jones & Bartlett Pub., London, UK
Miesfield, R.L. 1999. Applied Molecular Genetics, Wiely Liss, New York, USA.
Nicklin, J., Graeme-Cook, K.Paget, T. And Killington, R. 1999. Instant Notes in Mircobiology, VIVA Books Pvt. Ltd., New Delhi, India
Purohit, S.S., Kothari, P.R. and Mathur, S.K. 1993. Basic and Agricultural Biotechnology, Agro Botanical Pub. Bikaner, India.
Rehm, H.I. and Reed, S.G. (Eds.) 1995. Fundamentals of Genetic Engineering, Pallicut, London, UK.
Scragg, A. 1999. Environmental Biotechnology, Pearson Education Ltd., England, UK

Shantharam, S. And Montgomery, J.F. 1999. Biotechnology, Biosafety and Biodiversity. Oxford & IBH Pub. Pvt. Ltd., New Delhi, India.
Sheehan, D. (Ed.) 1997. Bioremediation Protocols, Humana Press, Totowa, USA
Snustad, D.P. and Simmons, M.J. 2000. Principles of Genetics (2nd Ed.) John Wiley & Sons. Inc., New York, USA
Trehan, K. 1990. Biotechnology, New Age Int. Pvt. Ltrd. New Delhi India.
Twyman, R.M. 1999. Advanced Molecular Biology, VIVA Books Pvt. Ltd., New Delhi, India.

Objectives: To acquaint the PG students with importance of Phycology (Algology) towards its contribution to the famous '*Green Revolution*' of the nation, thereby making India self-reliant in food grain production.

Outcome: To come out with the trained professionals having the knowledge of nutritional requirements of algae for their mass/ large scale cultivation with particular reference to ecological biodiversity of algae & algal bio-fertilizers in Haryana.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

- 1) Limits to algal growth in natural waters.
- 2) Dynamics and consequences of freshwater marine & algal blooms; Causative factors for eutrophication and its impact.
- 3) A brief account of phycological researches in India.

Unit-II

- 4) Mineral nutrition in algae with emphasis on Calcium, Magnesium, Sodium, Iron, Molybdenum, & Silica.
- 5) Synchronous & continuous cultures and their uses; Physiology of nutrient regulated algal growth.
- 6) A brief account of culture techniques, media for algal growth and measurement techniques.

Unit-III

- 7) Algae in water supplies, on ancient monuments and bio-fouling of ships.
- 8) Ecological biodiversity of algae in unusual habitats with suitable examples.
- 9) Paddy field algal flora as N₂-economy builders of the nation.

Unit-IV

- 10) Physiological and biochemical aspects on algal flora exposed to heavy metals.
- 11) Kinetics of heavy metal uptake and its bioaccumulation.
- 12) Mechanisms of adaptation against tolerance to toxicants, pesticides and salt.

Suggested Readings:

1. Ahluwalia, A.S. (Ed.). *Phycology: Principles, Processes and Applications*. Daya Publishing House, New Delhi. 2003.
2. Becker, E.W. (1994): *Microalgae – Biotechnology & Microbiology*, Cambridge University Press, Cambridge, U.K.
3. Carr, N.G. & Whitton , B.A. (1982): *The biology of Cyanobacteria* Blackwell Scientific Publ., Oxford, U.K.
4. Dubey, R.C. (2006): *Introduction to Biotechnology*, Delhi Book Trust, New Delhi.
5. Dubey, R.C. (2014): *Advanced Biotechnology*, S Chand & Cmpany Pvt. Ltd., New Delhi.
6. Fatma, T. (2005): *Cyanobacterial and Algal Metabolism and Environmental Biotechnology*, Narosa Publihers.
7. Fay, P & C van Baalen (1987): *The cyanobacteria*, Elsevier Science Publishers, B.V. Amsterdam, Netherlands.
8. Graham, L.E. & Wilcox, L.W. (1999): *Algae*, Benjamin Cummings, USA.
9. Gupta, R.K. & Pandey, V.D. (2007): *Advaces in Applied Phycology*, Daya Publishing

Paper – BOT-304(b) – APPLIED MYCOLOGY (ELECTIVE) Credit -4 MM-80

Objectives: The course has been envisaged to make the students aware about the role of fungi in Industry, as biofertilizer, as biocontrol agents, and biodeteriorating agents. Besides this, the course will be helpful in acquainting the students with the various techniques of culturing and isolation of fungi from various sources, culture media and preservation of fungi.

Outcome: After successfully completing the course, the students will understand the role of fungi as biofertilizers, as food spoilers and in production of some industrially important products. The students will also learn the various techniques used for culturing of fungi, sterilization of media and maintenance of cultures.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

Primary metabolites production by fungi: industrial alcohol, organic acid, beer.

Secondary metabolites production by fungi: Antibiotics, steroid transformation,. Enzymes, amino acids, growth regulators, vitamins

Unit-II

Fungi as biofertilizers : Endomycorrhizae and ectomycorrhizae.

Fungi as biocontrol of plant pathogens and weeds.

Biodeterioration of materials: Paper, painted surface, wood.

Unit-III

Food processing by fungi: Bread, cheese, oriental food and baker's yeast.

Fungal sources of health food: Single cell protein, edible mushrooms.

Spoilage of food and fungal toxicity.

Unit-IV

Culturing and preservation of fungi: isolation of fungi, culturing of fungi, establishing a pure culture, aseptic technique, maintenance of culture collection, culture collection and identification centres.

Common culture media and sterilization techniques.

Suggested Readings:

Alexopoulos, C.J. Mins, C.W. & Blackwell, M. (1995): Introductory Mycology, John Willy and Sons. Inc.

Bilgrami, K.S.A. & Verma R.N. (1981): Physiology of fungi, Vikas Publ. Ltd., New Delhi.

Biswas, S.P. & Biswas, A. (1984): An Introduction to Viruses, Vani Education Books, New Delhi.

Butler, E.J. & Jones, S.G. (1976): Plant Pathology, Periodical Expert Book Agency, New Delhi.

Clifton, A. (1958): Introduction to the Bacteria. McGraw Hill Books Co. New York.

Dubey, R.C. (2005): A Text Book of Biotechnology, S Chand & Co. Ltd., New Delhi.

Bilgrami, K.S. & Dubey H.C. (1986): A text book of Modern Plant Pathology, Vikas, Publ. Ltd., N.Delhi.

Gupta, R. & Mukerji, K.G. (2001): Microbial Technology, APH Publ. Co., New Delhi.

Mehrotra, R.S. & Aneja, K.R. (1990): An introduction of Mycology, New Age International Press, N. Delhi.

Michael J. Pelezar, E.C.S. Chaing & N.R. Krieg, 1993: Microbiology. Tata McGraw Hill Publ. N. Delhi.

Mundukur, B.B. (1967): Fungi & Plant Diseases, Pochillion Co. Ltd., USA.

Prescott, L.M., Harley, J.P. & Klein, D.A. (1996): Microbiology, 3rd edition, Wm. C. Brown Publ., USA.

Ronald M. Atlas (1995): Principles of Microbiology. Mosby-Year Book, Inc. St. Louis, Missouri, USA.

Moore-landekar, E.J. (1972): Fundamentals of the fungi, Prentice Hall, Eaglewood, U.K.

Sumbali, G. (2005): The Fungi, Narosa Publ. House, New Delhi.

Paper – BOT-304(c) – RESTORATION ECOLOGY (ELECTIVE) Credit -4

MM-80

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Objectives: To develop the abilities of students to critically engage with concepts and theory in Restoration ecology from interdisciplinary perspectives and at an advanced level.

Outcomes: Student will be able to embrace the implications of the basic principles of restoration ecology for the future of restoration of degraded ecosystems and their management.

Unit-I

- 1) Restoration-Terms and definitions, Importance of ecological restoration: strategies of Restoration-Natural recovery, active restoration, rehabilitation.
- 2) Restoration plan and rehabilitation measures.
- 3) Natural and anthropogenic disturbances: Characteristics and sources, effects on structural and functioning of terrestrial and aquatic ecosystems.

Unit-II

- 4) Rehabilitation of salt affected soils.
- 5) Prevention and mitigation of invasive species; Habitat fragmentation.
- 6) Ecosystem stability: Structural and functional stability.
- 7) Climate change mitigation and Biological carbon sequestration.

Unit-III

- 8) Sustainable forestry management and agroforestry.
- 9) Biotechnological Tools of Restoration.
- 10) Environmental impact and risk assessment.

Unit-IV

- 11) Degradation and Restoration of forest and grassland ecosystems.
- 12) Degradation and restoration of aquatic resources: River corridors, wetlands and lakes. Adaptive restoration of wetlands; Waste water recycling and waste management.
- 13) Reclamation of mining sites, Bioremediation and Phytoremediation.

Suggested Readings :

1. Botkin, D.B. and E.A. Keller (2004). Environment Science: Earth as a Living Planet, John Wiley & Sons Inc., New York.
2. Carson, Rachel . 1962. Silent spring. Boston, Houghton Mifflin
3. Manahan, S.E. 2000. Environmental Chemistry. Seventh Edition. Lewis Publishers, New York
4. Mitsch, W.J. and Jorgensen, S.E. (eds.) 1989. Ecological Engineering: An Introduction to Ecotechnology. John Wiley and Sons, New York.
5. Morgan, R.K. Environmental Impact Assessment; A methodological Perspective. Kluwer Academic Publishers, London.
6. Pierzynski, G.M., Sims, J.T. and Vance, G.F. 2000. Soils and Environmental Quality. Second Edition. CRC press, New York.
7. Singh, J.S., Singh, S.P. and Gupta, S.R. 2006. Ecology, Environment and Resource Conservation, Anamaya Publishers, New Delhi.
8. Bradshaw, A.D. and Chadwick, M.J. (1980). The Restoration of Land Ecology and Reclamation of Derelict and Degraded Land Blackwell Scientific Publication, Oxford, England.
9. Pace, M.L. and Groffman, P.M. (Eds.) (1998). Success, limitations and Frontiers in Ecosystem Science, Springer Verlag, New York.
10. Packard, S. And Mutel C.F. eds. (1997). The Tall Grass Restoration Handbook, Island Press, Washington, DC.
11. Petts, G. And Calow P. Larsen, P. (1996). River Restoration a Blackwell Science, Oxford, England.
12. Urbanska, K.M. Webb, N.R. and Edwards, P.J. (1998). Restoration Ecology and Sustainable Development. (Cambridge University Press, Cambridge).
13. USEPA (2000). Principles for the Ecological Restoration of Aquatic Resources. EPA 841-F-00-003. Office of Water (4501F), United States Environmental Protection Agency, Washington, DC. 4pp.

Paper – BOT-304(d) – ADVANCED PLANT PHYSIOLOGY (ELECTIVE) Credit-4 MM-80

Objective: The course would deal with advances in plant physiology especially photosynthesis, respiration and responses of the plants to abiotic stresses.

Outcome: The students will be able to understand the physiological advances in response of plants to water, salt and temperature stress. They will also be acquainted with advances in photosynthesis and respiration.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

Water stress:

Drought, its definition and quantification, water deficit and plant growth, physiological and biochemical functions, responses injury affected by drought, Adaptive strategies for drought resistance.

Osmotic adjustment, osmoprotectants.

Water logging/ oxygen deficiency and its effects on plant growth.

Unit-II

Salt and temperature stress:

Salt stress; Saline and alkaline soils, salt stress injury, mechanism of salt stress and halophytes.

Temperature stress; high temperature stress, heat shock proteins, chilling and frost injury and mechanism of tolerance.

Unit-III

Photosynthesis:

The four major complexes of thylakoids.

The path of carbon in photosynthesis (C₃, C₄ and CAM plants)

Rubisco, structure and its association with the mechanism of carboxylation and oxygenation of RUBP.

Effect of environmental factors on photosynthetic rates. Translocation of photosynthates and its importance in sink growth.

Unit-IV

Respiration:

Cyanide insensitive respiration: Mechanism and significance.

Comparison between normal electron transport chain and alternate oxidase pathway of respiration.

Glycolic acid metabolism and photorespiration.

Glyoxylate cycle.

Respiration in intact plants and tissues.

Suggested Readings:

Bonner, J. And Varner, J.E. (1976) Plant Biochemistry, Academic Press, New York and London (Third Edition).

Buchanan, B.B., Gruissem, w. And Jones, R.L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.

Cooper, T.G. (1977). Electrophoresis. In : The Tools of Biochemistry. John Wiley and Sons., New York.

Dey, P.M. and Harborne, J.B. (1997), First Indian edition, (2000). Plant Biochemistry. Academic Press, Harcourt Asia Pvt. Ltd.

Noggle, G.r. and Fritz, G.J. (1983). Introductory Plant Physiology. Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd edition (Seventh reprint, 1992).

Salisbury, F.B. and Ross, G.W. (1992). Plant Physiology. Fourth Edition, Wadsworth Publishing Co. Belmont, California, USA.

Sawhney, S.K. and Singh, Randhir. (2000). Introductory Practical Biochemistry, Narosa Publishing House, New Delhi.

Solmos, T. (1977). Cyanide resistant respiration in higher plants. In : Ann. Rev. Pl. Physiol. 28: 279-297.

Objective: This paper aims to provide an introduction to various tools and techniques used to gain insight into cell structure and biological processes. The focus is on studying the techniques used for isolation, purification and characterization of biomolecules.

Outcomes: This paper is meant for students to gain in-depth knowledge of various methods used in characterization the biomolecules.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

- 1. Microscopic techniques:** Introduction; Light microscope; Phase contrast microscope; Fluorescent microscope; Electron microscope (EM) – SEM, TEM and STEHM; Scanning probe microscopes- scanning tunneling microscope and atomic force microscope; Different fixation and staining techniques.
- 2. Centrifugation:** Principles of sedimentation; Types, care and safety aspects of centrifuges; Differential centrifugation; Density gradient centrifugation and their applications.

Unit-II

- 3. Chromatographic techniques:** Theory of chromatography; Types of chromatography- Paper chromatography, Thin layer chromatography, Adsorption chromatography, Partition chromatography, Affinity chromatography, Ion exchange chromatography, HPLC and Size-exclusion chromatography.
- 4. Spectrophotometry:** Colorimetry; UV and Visible spectrophotometry.

Unit-III

- 5. Electrophoresis:** Principle; Agarose gel electrophoresis; Polyacrylamide gel electrophoresis; 2-Dimensional gel electrophoresis; Capillary electrophoresis; Microchip electrophoresis and Isoelectric focusing.
- 6. Mass spectrometry:** Introduction; Theory; Mass spectrometer; Ionization of molecules; Mass analysers- MALDI; Detectors and Applications.

Unit-IV

- 7. Immunotechniques:** Antibody generation; Detection of molecules using ELISA, RIA, Immunoprecipitation and Immunofluorescence microscopy; Detection of molecules in living cells.
- 8. Radioisotope techniques:** Radioactive isotopes; Nature of radioactivity; Detection and measurement of different types of radioisotopes normally used in biology; Incorporation of radioisotopes in biological tissues and cells; Molecular imaging of radioactive material; Disposal of radioactive wastes and safety guidelines.

Suggested Readings:

- Hegy G, Kardos J, Kovacs M, Csizmadia AM, Nyitray L, Pal G, Radnai L, Remenyi A Venekei I (2013) Introduction to Practical Biochemistry, Eotvos Lorand University, Hungary.
- Plummer DT (1990) An Introduction to Practical Biochemistry, Tata Mc-Graw-Hill Publishing Company Ltd., New Delhi.
- Prescott L and Harley J Klein D (2005) Microbiology (6th Ed) Mc Graw-Hill.
- Ranade R and Deshmukh S (2013) Handbook of Techniques in Biotechnology, Studium Press (India) Pvt. Ltd. New Delhi.
- Sawhney SK and Singh R (2000) Introductory *Practical Biochemistry (Ed.)*, Narosa Publishing House Pvt. Ltd., New Delhi.
- Wilson K and Walker J (2010) Principles and Techniques of Biochemistry and Molecular Biology (7th Ed.), Cambridge University Press, New Delhi.

Objectives: This paper is meant for students to gain in-depth knowledge of different levels, threats and distribution of Biodiversity and focus on the different approaches for biodiversity conservation.

Outcome: The student will be able to appreciate the value of biodiversity. They will also develop the skills necessary to work efficiently in areas of *in-situ* and *ex-situ* conservation.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

1. Biodiversity: importance, levels of biodiversity- species, genetic and ecosystem diversity, threats to biodiversity- habitat loss and fragmentation, exotic species, pollution, overexploitation, IUCN categories of threat
2. Distribution and global patterns of biodiversity
3. Biodiversity and ecosystem services
4. Terrestrial and marine hotspots of biodiversity; hotspots of biodiversity in India.

Unit-II

5. Principles and importance of conservation biology; In- situ conservation of biodiversity- Sanctuaries, national parks, biosphere reserves.
6. Ex-situ conservation of biodiversity: Principles and practices, field gene banks, seed banks and cryopreservation
7. Approaches for biodiversity conservation: tropical forests, wetlands and aquatic ecosystems
8. Major approaches to Management, Indian case studies on conservation/management strategy (Project tiger, biosphere reserves)

Suggested Readings :

- Chape, S., Fish, L., Fox, P. and Spalding, M. 2003. United Nations list of protected areas. IUCN/UNEP/World Conservation Monitoring Centre, Gland, Switzerland/Cambridge
- Gopal, B. (ed.) 1987. Ecology and Management of Aquatic Vegetation of the Indian Subcontinent. W. Junk bv. The Hague.
- Heywood, V.(Ed.) (1995). Global Biodiversity Assessment. United Nations Environment Programme, Cambridge University Press, Cambridge, U.K.
- Hunter (Jr.) M.L. (1996); Fundamentals of Conservation Biology, Blackwell Science. Meffe G.K. and C. Ronals Corroll (1994) Principles of Conservation Biology, Sinaur Associates, Inc., Sunderland. Massachusetts.
- Peter H. Raven, P.H. and Berg , L. R. Berg. 2005. Environment, 5th Edition. John Wiley & Sons Inc., New York.
- Singh,J.S., Singh,S.P. and Gupta, S.R. 2006. Ecology, Environment and Resource Conservation, Anamaya Publishers, New Delhi.
- Soule, M.E. (ed.) (1986) : Conservation Biology. The Science of Scarcity and Diversity. Sinaur Associates, Inc., Sunderland, Massachusetts.

SEMESTER – IV

Paper – BOT-401 PHYSIOLOGY OF PLANT GROWTH AND DEVELOPMENT Credit-4 MM- 80

Objective: The course would deal with different aspects of plant growth and development especially germination and dormancy of seeds, plant growth regulators, senescence and abscission, photomorphogenesis and response of plant to different abiotic stresses.

Outcome: The students will be able to understand the basic concepts of plant growth and development.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

Plant Growth: Growth concepts, Growth curves, Growth analysis.

Germination and Dormancy of seeds ; factors affecting dormancy and its regulation by plant growth regulators and environmental factors.

Stress Physiology: Response of plants to abiotic stresses: abiotic stress affecting plant productivity. Basic principles of crop improvement programme under stress.

Unit-II

Plant Growth Regulators: Discovery, biosynthetic pathways, transport, influence on plant growth and mechanism of action of: Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic acid.

Unit-III

Senescence and Abscission:

Physiological and biochemical changes associated with senescence and chlorogenesis .

Tropism: Phototropism, nature of receptors, role of hormones, Geotropism and nastism.

Unit-IV

Sensory Photobiology:

Phytochromes: mechanism of phytochrome action, photomorphogenesis and cryptochromes .

The Flowering Process:

Photoperiodism and its significance, importance of dark periods, role of vernalization.

Nature and events during flowering, florigen concept, chemical control of flowering.

Suggested Readings:

Audus, L.J. (1972). Plant Growth Substances. Vol.I Chemistry and Physiology. Leonard Hill, London.

Bonner, J. And Varner, J.E. (1976). Plant Biochemistry, IIIrd Edition, Academic Press, New York and London.

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

Davies, Peter J. (1995). Plant Hormones: Physiology, Biochemistry and Molecular Biology. 2nd Edition. Kluwer Academic Publishers, The Netherlands.

Dey, P.M. and Harborne, J.B. (1997), First Indian Edition, Plant Biochemistry. Academic Press, Harcourt Asia Pvt.Ltd.

Garrett, R.H. and Grisham, C.M. (1999). Biochemistry. Second edition. Saunders College Publishing, Philadelphia.

Hopkins, W.G. 1995 Introduction to Plant Physiology, John Wiley and Sons.

Krishnamoorthy, H.N. (1993). Physiology of Plant Growth and Development. Atma Ram and Sons, Delhi.

Kumar, H.D. and Singh, H.N. (1993). Plant Metabolism. Second edition, Affiliated East- West Press Pvt Ltd. New Delhi.

Lehninger, A.L. (1978). Biochemistry. Kalyani Publishers, Ludhiana, India

- Lehninger, A.L, Nelson, D.L. and Co MM 1993 Principles of Biochemistry Second edition, CBS Publishers.
- Moore, Thomas. C. (1989). Biochemistry and Physiology of Plant Hormones. Second edition (Reprint 1994), Narosa Publishing House, New Delhi..
- Noggle, G.R. and Fritz, G.J. (1983). Introductory Plant Physiology, Prentice-Hall of India Pvt. Ltd., New Delhi, Second edition Seventh reprint, 1993.
- Salisbury, F.B. and Ross, C.W. (1992). Plant Physiology. Fourth edition, Wadsworth Publishing Co. Belmont, California, USA.
- Singhal, G.S. Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee (editors) (1999). Concepts in Photobiology: Photosynthesis and Photomorphogenesis. Narosa Publishing House, New Delhi.
- Srivastava, L.M. (2006). Plant Growth and Development : Hormones and Environment. Academic Press. Published by Elsevier India Pvt. Ltd., New Delhi.
- Taiz, L and Zeiger, E. (1998). Plant Physiology. Second edition. Sinauer Associates, Inc., Publishers, Massachusetts, USA
- Trehan, K. (1990). Biochemistry. Second edition, Wiley-Eastern Ltd., New Delhi.
- Trivedi, P.C. (2005). Applied Botany. Aavishkar Publishers, Distributors, Jaipur.
- Trivedi, P.C. (2006). Plant Molecular Physiology: Current Scenario and Future Projections. Aavishkar Publishers, Distributors, Jaipur.
- Weil, J.H. (1990). General Biochemistry. Sixth edition. Wiley-Eastern, New Age International Publishers, New Delhi.
- Wilkins, M.B. (1987). Advanced Plant Physiology, ELBS, Longman, England.
- Zubay, Geoffrey. (1989). Biochemistry. Mc.Millan Publishing Co. New York.

Objective: The course would deal with history of Embryology. It also describe the technique and applications of *in vitro* culture of reproductive organs.

Outcome: The students will be able to describe the structure and development of reproductive structures and the process of reproduction in plants.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit I

History of plant embryology

Male gametophyte: structure of anther, microsporogenesis, role of tapetum,

Pollen development, male sterility;

Pollen germination, pollen tube growth and guidance; pollen allergy

Unit II

Female gametophyte; ovule development, megasporogenesis;

Organization of the embryo sac, structure of the embryo sac cells.

Pollination, Pollination mechanisms and vectors,

Unit III

Pollen pistil interaction and fertilization; structure of pistils; pollen-stigma interaction sporophytic and gametophytic incompatibility, double fertilization

Endosperm development, polyembryony; 663itrogen

Experimental Embryology: in vitro fertilization Anther, Pollen and embryo culture,

Unit IV

Anatomy in relation to taxonomy.

Anomalous secondary Structure: Anomalous secondary growth, anomalous position of cambium, abnormal behaviour of normal cambium, accessory cambium formation and its activity, extrastelar cambium, Interxylary and intraxylary phloe, presence of medullary bundles, cortical bundles, presence of exclusive phloem and xylem bundles, secondary growth in monocots.

Suggested Readings:

Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th Ed.), Vikas Publishing House, New Delhi.

Shivanna, K.R. and Johri, B.M. 1985. The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd., New Delhi.

Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge Univ. Press, Cambridge.

Johri, B.M. (ed.) Embryology of Angiosperms. Springer-Verlag, Heidelberg, Berlin,

Esau, K. 1965. Plant Anatomy. John Wiley & Sons New York.

Fahn, A. 1967. Plant Anatomy. Pergamon Press, London, New York.

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

Eames, A. J. 1961. Morphology of Angiosperms. McGraw Hill Book Company, New York

Objective: This course seeks to impart detailed knowledge of micropropagation, somatic embryogenesis, haploid production, somatic hybridization, cryopreservation and secondary metabolite production.

Outcome: The students will gain in-depth knowledge of plant cell and tissue culture techniques, *In vitro* haploid production, plant breeding, synthetic seeds and secondary metabolite production.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit I

1. History of Plant Tissue Culture, Basic concept, principles and scope of plant cell and tissue culture, concepts of cellular differentiation; Totipotency; basic techniques of plant tissue culture; callus formation, organogenesis and embryogenesis.
2. Protoplast isolation, fusion and culture, somatic hybridization, hybrid selection and regeneration. Cybrids and their application.

Unit-II

3. *In vitro* haploid production and its significance, Anther/Pollen culture and ovary culture; Embryo and ovule culture Production of triploids through endosperm culture.
4. Micropropagation: meristem culture and virus-free plants; Cryopreservation of plant cell and tissue cultures and establishment of gene banks.

Unit-III

5. Somaclonal variations and isolation of useful mutants; mechanisms and applications in genotype improvement.
6. Role of plant cell cultures in Bioreactor types and application in cell culture and secondary metabolite production.

Unit-IV

7. Somatic embryogenesis, production of synthetic seeds, importance, limitation and their utilization.
8. Application of tissue culture in forestry and agriculture; status of tissue and cell culture technology in India edible vaccines, and their prospects

Suggested Readings

1. Ammirato, P.V., D.A. Evans, N.D. Sharp and Y.P.S. Bajaj (1990). Hand Book of Plant Cell Culture, Vols. 1-5. McGraw Hill Publishing Company, New York.
2. Bhojwani, S.S. and Razadan, M.K. 1996. Plant Tissue Culture: Theory and Practice (A revised Edition), Elsevier Science Pub., New York, USA
3. Collins, H.A. and Edwards, S. 1998, Plant Cell Culture, Bios Scientific Pub., Oxford, U.K.
4. Kartha, K.K. 1985. Cryopreservation of Plant Cells and Organs, CRC Press, Boca Raton, Florida, U.S.A.
5. Razadan, M.K. 1993. An introduction to Plant Culture. Oxford & IBH Pub., Co., New Delhi, India

Paper – BOT-404(a) ADVANCED PHYCOLOGY (ELECTIVE) Credit -4 MM-80

Objectives: To impart knowledge about the wider perspectives of the '*Nitrogen economy builders of the nation*' in the context of fast changing industrializing Haryana as well as which has been traditionally an agricultural economy.

Outcome: To nurture and develop the trained human resources/ professionals to identify research problems, formulate testable objectives, develop appropriate methods & experimental designs, implement research projects in wider perspective of algalization.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

- 1) Photosynthesis and Chromatic adaptations in algae: pigments, photosynthetic membrane organization, oxygenic & anoxygenic photosynthesis.
- 2) Relationship of CO₂-assimilation with nitrogen assimilation: source of energy & reductants.
3. Nutrient uptake kinetics in algae.

Unit-II

- 4) Importance of N₂-fixing genera in Indian paddy fields for the improvement of soil fertility.
- 5) Heterocyst, its differentiation and role in N₂-fixation.
- 6) Mechanism N₂-fixing fixation: 665itrogenise and its *in vivo* activity.
- 7) Uptake kinetics of nitrogenous compounds, their transport and assimilation.

Unit-III

- 8) Algal immobilization: methods and applications.
- 9) Technologies for the reclamation, restoration & maintenance of *usar* soils and its fertility.
- 10) Restoration of degraded ecosystems through algae. Importance of algal flora for the treatment of wastewaters (activated sludge system) for the production of useful biomass & energy-rich fuel.

Unit-IV

- 11) Concept of algalization and biofertilizers.
- 12) Strain improvement for the production of nitrogenous compounds. Biological & technical aspects of outdoor mass culture of algae.
- 13) A brief account of commercial potentials of algae, algal products & their uses.

Suggested Readings:

1. Ahluwalia, A.S. (Ed.). *Phycology: Principles, Processes and Applications*. Daya Publishing House, New Delhi. 2003.
2. Becker, E.W. (1994): *Microalgae – Biotechnology & Microbiology*, Cambridge University Press, Cambridge, U.K.
3. Carr, N.G. & Whitton , B.A. (1982): *The biology of Cyanobacteria* Blackwell Scientific Publ., Oxford, U.K.
4. Dubey, R.C. (2006): *Introduction to Biotechnology*, Delhi Book Trust, New Delhi.
5. Dubey, R.C. (2014): *Advanced Biotechnology*, S Chand & Cmpny Pvt. Ltd., New Delhi.
6. Fatma, T. (2005): *Cyanobacterial and Algal Metabolism and Environmental Biotechnology*, Narosa Publihers.
7. Fay, P & C van Baalen (1987): *The cyanobacteria*, Elsevier Science Publishers, B.V. Amsterdam, Netherlands.
8. Graham, L.E. & Wilcox, L.W. (1999): *Algae*, Benjamin Cummings, USA.

Paper – BOT-404(b) PRINCIPLES OF PLANT PATHOLOGY (ELECTIVE) Credit -4 MM-80

Objectives: The course has been conceived to equip the students with mechanism of infection of fungi, various defence mechanism employed by the plants to protect themselves against plant pathogens. Besides, the course deals with epidemiology, role of environmental factors for disease development, disease forecasting, applications of biotechnology in plant pathology and methods adopted for disease management.

Outcome: The students will understand various mechanisms involved during pathogenesis and disease epidemiology, plant disease forecasting and transmission and spread of plant pathogens. The students will learn the applications of biotechnological techniques in plant pathology after completing the course.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

How pathogens attack plants : chemical weapons of pathogens (enzymes and toxins)
How plants defend themselves against pathogens: structural defense and biochemical defense.

Unit-II

Plant disease epidemiology and plant disease forecasting: Importance of disease forecasting services, methods used in plant disease forecasting.
Management of plant pathogens: cultural, chemical and biological methods.

Unit-III

Applications of biotechnology in Plant Pathology: The use of tissue culture techniques (callus culture, apical meristem culture and protoplast fusion), Recombinant DNA technology, use of monoclonal antibodies in plant pathology.
Effect of environmental factors on disease development.

Unit-IV

Mycotoxin producing fungi during storage and major mycotoxins produced by them.
Host-pathogen interaction of population level: transmission and spread of plant pathogens.

Suggested Readings:

- Agrios, G.N. (2005): Plant Pathology, Acad. Press, Inc. California.
Alexopoulos, C.J. Mins, C.W. & Blackwell, M. (1995): Introductory Mycology, John Willy and Sons. Inc.
Biswas, S.P. & Biswas, A. (1984): An Introduction to Viruses, Vani Education Books, New Delhi.
Clifton, A. (1958): Introduction to the Bacteria. McGraw Hill Books Co. New York.
Mehrotra, R.S. & Aneja, K.R. (1990): An introduction of Mycology, New Age International Press, New Delhi.
Mehrotra, R.S. and Ashok Aggarwal (2003): Plant Pathology, Tata Mc Graw Hill Publ. Ltd., New Delhi.
Michael J. Pelezar, E.C.S. Shan & N.R. Krieg (1993): Microbiology. Tata Mc Graw Hill Publ. New Delhi.
Ronald M. Atlas (1995): Principles of Microbiology. Mosby-Year Book, Inc. St. Louis, Missouri, USA.
Singh, R.S. (1990): Plant Disease, 6th Edition, Oxford, IBH Publ., New Delhi.
Sumbali, G. (2005): The Fungi, Narosa Publ. House, New Delhi.
Webster, J. (1985): Introduction of Fungi. Cambridge University, Press.

Paper – BOT-404(c) CONSERVATION BIOLOGY (ELECTIVE) Credi-4 MM-80

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Objectives: The student will be able to appreciate the value of Biodiversity and focus on the relationship between living organisms and the terrestrial, freshwater and marine environments, coupled with the interactions that results from natural and anthropogenic processes.

Outcomes: Student will develop the skills necessary to work efficiently in areas like conservation, EIA, environment management, monitoring and education and also gets an objective, scientific and realistic approach to conservation science.

Unit-1

- 1) Principles, characteristics and importance of conservation biology
- 2) Conservation values and ethics, Role of species in conservation

Unit-II

- 3) Global biodiversity I: Patterns and Processes
- 4) Global biodiversity II: Losses, Pattern of species vulnerability, Habitat fragmentation and degradation, Synergistic interactions
- 5) Biodiversity and ecosystem services

Unit-III

- 6) Biodiversity of wetlands, mangroves and coral reefs- A general account
- 7) Biosphere reserves and RAMSAR sites in India, The Design of Conservation Reserves
- 8) Major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere Reserves)

Unit-IV

- 9) Importance of genetic resources and conservation of crop genetic resources
- 10) International and National efforts to conserve biodiversity: Convention on biological diversity, CITES, Ramsar convention; National Biodiversity strategy
- 11) Role of remote sensing and GIS and biodiversity conservation

Suggested Readings :

- Chape, S., Fish, L., Fox, P. And Spalding, M. 2003. United Nations list of protected areas. IUCN/UNEP/World Conservation Monitoring Centre, Gland, Switzerland/Cambridge
- Gopal, B. (ed.) 1987. Ecology and Management of Aquatic Vegetation of the Indian Subcontinent. W. Junk bv. The Hague.
- Heywood, V.(Ed.) (1995). Global Biodiversity Assessment. United Nations Environment Programme, Cambridge University Press, Cambridge, U.K.
- Hunter (Jr.) M.L. (1996); Fundamentals of Conservation Biology, Blackwell Science. Meffe G.K. and C. Ronals Corroll (1994) Principles of Conservation Biology, Sinaur Associates, Inc., Sunderland. Massachusetts.
- Huston, M.A. 1994. Biological Diversity: The Coexistence of Species on Changing Landscapes. Cambridge University Press, Cambridge.
- Peter H. Raven, P.H. and Berg , L. R. Berg. 2005. Environment, 5th Edition. John Wiley & Sons Inc., New York.
- Singh,J.S., Singh,S.P. and Gupta, S.R. 2006. Ecology, Environment and Resource Conservation, Anamaya Publishers, New Delhi.
- Soule, M.E. (ed.) (1986) : Conservation Biology. The Science of Scarcity and Diversity. Sinaur Associates, Inc., Sunderland, Massachusetts.
- Turner, M.G., Gadner,R.H. and O'Neill, R.V. 2001. Landscape Ecology: In theory and Practice, Pattern and Processes. Spinger Verlag, New York.

Paper – BOT-404(d) PLANT GROWTH REGULATORS (ELECTIVE) Credit -4 MM-80

Objective: The course would deal with the study of regulation of different growth regulators to fruit and seed physiology. The advances in senescence, abscission and mechanism of action of various phytohormones will also be studied.

Outcome: The students will be able to understand the recent advances in phytohormones, fruit and seed physiology. They will also be acquainted with advances in senescence and abscission also.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

Phytohormones

Recent advances in the biosynthesis and regulation of cytokinins and ethylene

Current scenario in the mechanism of action of gibberellins, abscisic acid, salicylic acid, jasmonic acid and brassinosteroids.

Unit-II

Seed Physiology

Seed viability and seed dormancy

Metabolism of germinating seeds.

Environmental and hormonal control of seed dormancy and germination.

Unit-III

Senescence and Abscission

Process of induction

Metabolic changes.

Role of plant growth regulators

Unit-IV

Fruit Physiology

Climacteric and non-climacteric fruits, fruit ripening.

Post-harvest storage of fruits – quality maintenance, physiological and biochemical studies under different kinds of storage conditions.

Suggested Readings:

Krishnamoorthy, H.N. (1993). Physiology of Plant Growth and Development. Atma Ram and Sons, Delhi.

Khan, A.A (1977). The Physiology and Biochemistry of Seed Dormancy and germination. North-Holland Publishing Co., Amsterdam, New Oxford.

Moore. T.C. (1989). Biochemistry and Physiology of Plant Hormones. Second edition (Reprint 1994), Narosa Publishing House, New Delhi.

Saymour, G.B., Taylor, J.E. and Tucker, G.A. (1993). Biochemistry of Fruit Ripening. Chapman and Hall, London.

Stahl, E. (1965). Thin Layer Chromatography, a laboratory handbook. Academic Press, London.

Taiz, L. And Zeiger, E. (1998). Plant Physiology. Second edition, Sinauer Associates, Inc., Publishers, Massachusetts, USA.

Wilkins, M.B. (1987). Advanced Plant Physiology. ELBS-Longman, England.

Srivastava, L.M. (2006). Plant Growth and Development : Hormones and Environment. Academic Press. Published by Elsevier India Pvt. Ltd., New Delhi.

Trivedi, P.C. (2005). Applied Botany. Aavishkar Publishers, Distributors, Jaipur.

Objective: This course seeks to impart detailed knowledge of basic methods involved in genome studies, their organization and function.

Outcomes: This paper would provide students an understanding about how the genetic information is stored in the genome and the mechanisms by which this information is used by the organism. They are also expected to know about the various databases used for storage and analysis of genome information.

Note: Nine questions will be set in all. Question No.1 will be compulsory covering the entire syllabus. The remaining eight questions will be set with two questions from each Unit. The candidate will be required to attempt one question from each unit. All questions will be of equal marks.

Unit-I

1. **Genome:** Completely sequenced prokaryotic (T_4 , and λ phages; *E. coli*) and eukaryotic genomes (*Saccharomyces cerevisiae*, *Caenorhabditis elegans*, *Drosophila melanogaster*, *Arabidopsis thaliana*, *Oryza sativa*, *Mus musculus* and *Homo sapiens*); Mitochondrial and Chloroplast genomes.
2. **Mapping of Genome:** Genetic mapping- using DNA markers and Linkage analysis; Physical mapping- restriction mapping, Fluorescent *in-situ* hybridization and Sequence Tagged Sites (STSs) mapping.

Unit-II

3. **Genome sequencing:** Chain termination and chemical degradation methods; Next generation sequencing (NGS)- Pyrosequencing, SOLiD sequencing, Bridge amplification sequencing, Assembly of a contiguous DNA sequence- shotgun and clone contig methods, Human Genome Project.
4. **Understanding a Genome Sequence:** Gene location using 1.) ORF scanning, Automatic annotation, Homology searches and comparative genomics. 2.) Experimental techniques- northern hybridization, cDNA sequencing and RACE.

Unit-III

5. **Identification of a Gene Function:** Using computer analysis; Experimental analysis- gene inactivation and overexpression; Directed mutagenesis; Reporter genes and Immunocytochemistry.
6. **Analysis of the Transcriptome:** Expressed Sequence Tags (ESTs); Serial analysis of gene expression (SAGE); Differential Display (DD); Representational Difference Analysis (RDA) and DNA Microarrays.
7. **Proteome Analysis:** Using 2-D; Protein identification; Protein-DNA and Protein- Protein interactions and Biochips.

Unit-IV

8. **Biological Databases:** Introduction; Primary and Specialized Databases; Database Scheme; Database Annotation; Retrieval System; Nucleotide Databases; Protein Databases; Genomic Databases and Resources; Gene Databases and Resources; Transcriptome Databases; Mutation Databases; Mitochondrial Databases and Resources.
9. **Computational Methods for Analysis of Genome Sequence Data:** Introduction; Dot-Plot Matrix; Sequence pairwise alignment; Database searching; Multiple alignment; Alignment profiles to recognize distantly related protein or protein modules; Methods for sequence assembly; Linguistic analysis of biosequences; Prediction of RNA secondary structures; Protein sequence analysis; Evolutionary and phylogenetic analysis.

Suggested Readings:

1. Birren B, Green ED, Klapholz S, Myers RM and Roskams J (1997) Genome Analysis, CSHL Press.
2. Brown TA (1999) Genomes. John Wiley & Sons (Asia) Pvt. Ltd., Singapore.
3. Brown TA (2002) Genomes 2, Wiley-Liss, New York
4. Brown TA (2007) Genomes 3, Garland Science Publishing New York, London.
5. Chawla HS (2009) Introduction to Plant Biotechnology (3rd Ed.). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
6. Dale JW, Schantz MV and Plant N (2012) From Genes to Genomes (3rd Ed.), John Wiley and Sons, Ltd. UK.
7. Dawson, MT, Powell R and L Gannon F (1996) Gene Technology, BIOS Sci. Pub. Ltd., Oxford, UK. DNA Amplification, Stockton Press, New York, USA.
8. Glick B and Pasternak JJ (2003), Molecular Biotechnology (3rd Ed), ASM Press, Washington.
9. Hartl DL and Ruvolo M (2011) Genetics- Analysis of Genes and Genomes (8th Ed.), Jones and Bartlett Publishers, Inc., USA.
10. Hunt SP and Livesey FJ (2000) Functional Genomics, Oxford University Press, New York. London.

11. Lewin B (2005) Genes VIII, Oxford University Press, Oxford, UK
12. Li WH (1997) Molecular Evolution, Sinauer Associates, Inc., USA.
13. Saccone C and Pesole G (2003), Handbook of Comparative Genomics, John Wiley and Sons, Inc., Hoboken, New Jersey.
14. Sambamurty AVSS (2007) Molecular Genetics, Narosa Publishing House Pvt. Ltd., New Delhi.
15. Singer M and Berg P (1991) Genes and Genomes: A Changing Perspective; University Science Books, CA, USA.