University of Lucknow
Master of Science Programme
Regulations 2020

1. **Applicability**
   These regulations shall apply to the **Master in Botany** programme from the session 2020-21.

2. **Minimum Eligibility for Admission**
   A three/four-year Bachelor's degree or equivalent in Science with Botany in Final Year awarded by a University or Institute established as per law and recognised as equivalent by this University with minimum 45% percentage marks or equivalent grade shall constitute the minimum requirement for admission to the Master in Botany programme.

3. **Programme Objectives**
   The M.Sc. Botany programme covers all aspects of plant sciences and involves classical, modern and inter-disciplinary approaches. The proposed syllabus endeavours to provide training in botanical skills through lectures, projects, excursions, practical exercises and seminars/presentations.

4. **Programme Outcomes**
   After completing the two year M.Sc. Programme in Botany, the student would have gathered:
   - Knowledge about plants and botanical skills needed for teaching and research, and an understanding of environmental issues needed to become naturalists or conservationists.
   - Critical and reflective thinking to enable them to make an honest assessment of their strengths and weakness, so that they put in the necessary efforts to carve a better future for themselves.
   - Communication skills through effective presentations and interactive sessions in the class.
   - Problem-solving skills to help generate confidence for a more substantive life.
   - Interest in reading quality books so as to engage in a life-long learning process, helping all along the way, beginning with home and reaching society.
   - Ability to lend in-depth knowledge if handling pre-university students, for generating enhanced interest in the subject.
   - Knowledge of the social and health issues that plague the modern society, contributing in their own little ways, showing empathy and spreading awareness.
   - Computational biology component to enable ease of handling computer-based applications.

5. **Specific Programme Outcomes (PSOs)**
   PSO1: The students will recognize the diversity of life forms exhibited by Viruses, Bacteria, Algae, Fungi, Lichens, Bryophytes and Pteridophytes, and understand the variations in microscopic techniques needed to study them. They will learn about plant diseases and methods and practices for controlling them.

   PSO2: The students will learn about the past and present flora of Gymnosperms and Angiosperms, classification, structure (morphology and anatomy) of plants/plant

parts/plant organs, reproduction, structure and chemical composition of genetic material, process of genetic inheritance, evolution theories, breeding methods for crop improvement and statistical methods to analyze biological data.

PSO3: The students will understand the ecological plant diversity and soil-plant interactions. They will carry out an in depth study of the structure of plant cells and macromolecules, structural organization of the cell, various physiological and metabolic processes taking place in plants and their significance.

PSO4: The students will get the necessary training for writing thesis/preparing project report based on the information collected through review of literature.

6. Course Structure

The course structure of the Master in Botany programme shall be as under:

Course No.	Name of the Couse	Credit	Course Type
	Semester I		
BOT-CC-101	**Microbiology: Plant Virology and Bacteriology**	**04**	**Core Course**
BOT-CC-102	**Fungi, Plant Pathology and Lichens**	**04**	**Core Course**
BOT-CC-103	**Algae and Bryophytes**	**04**	**Core Course**
BOT-CC-104	**Pteridophytes, Gymnosperms and Palaeobotany**	**04**	**Core Course**
BOT-CC-105	**Practical based on BOT-CC-101 to BOT-CC-104**	**04**	**Core Course**
BOT-VC-101	**Conservation of Plant Diversity**	**04**	**Value added course (Credited)**
	Semester Total	**24**	
	Semester II		
BOT-CC-201	**Plant Development and Reproduction**	**04**	**Core Course**
BOT-CC-202	**Plant Systematics**	**04**	**Core Course**
BOT-CC-203	**Cytogenetics and Molecular Genetics**	**04**	**Core Course**
BOT-CC-204	**Plant Breeding and Biostatistics**	**04**	**Core Course**
BOT-CC-205	**Environment, Ecology and Plant Soil Relationship**	**04**	**Core Course**
BOT-CC-206	**Practical based on BOT-CC-201 to BOT-CC-205**	**04**	**Core Course**
BOT-VNC-201	**Art of Bonsai**	**00**	**Value added course (Non-Credit)**
	Semester Total	**24**	
	Semester III		
BOT-CC-301	**Plant Physiology**	**04**	**Core Course/ MOOC**
BOT-CC-302	**Practical based on BOT-CC-301**	**04**	**Core Course**
BOT-EL-301A	**Applied Botany-I**	**04**	**Elective**
BOT-EL-301B	**Analytical Techniques and Computer Applications**		
BOT-EL-302A	**Mushroom Cultivation**	**04**	**Elective**
BOT-EL-302B	**Ecotourism**		
BOT-IN-301	**Summer Internship**	**04**	**Internship**
BOT-IER-301	**Plant Resource Utilization**	**04**	**Inter-departmental Course**
	Semester Total	**24**	
	Semester IV		
BOT-CC-401	**Cell Biology and Plant Biochemistry**	**04**	**Core Course**
BOT-EL-401A	**Applied Botany-II**	**04**	**Elective**
BOT-EL-401B	**Biotechnology and Human Welfare**		
BOT-EL-402A	**Plant Disease Management**	**04**	**Elective**
BOT-EL-402B	**Gardening and Landscaping**		
BOT-MT-401	**Master Thesis**	**08**	**Master Thesis**
BOT-IRA-401	**Natural Resources and their Conservation**	**04**	**Intra-departmental Course**
	Semester Total	**24**	
	GRAND TOTAL	**96**	

BOT – Botany; CC – Core Course; VC – Value added course (Credited); VNC - Value added course (Non Credited); EL –Elective; IN – Summer Internship; IER – Interdepartmental Course; IRA – Intradepartmental Course

7. Course Outlines

M.Sc. BOTANY (SEMESTER – I)
BOT-CC-101: MICROBIOLOGY: PLANT VIROLOGY AND BACTERIOLOGY
4 Credits/40 Hours

Course Outcomes:
After completion of the course the student will:

- Learn about the prokaryotic domains, and their major phyla; cellular organization and functioning of prokaryotic cells, organization of the bacterial genome and plasmids, DNA replication, methods of genetic recombination in bacteria; gene expression and Operon concept.
- Understand metabolic diversity in bacteria; biotechnological applications of microbes in various spheres; mode of action of antibiotics and the development of antibiotic resistance in microbes.
- Develop an understanding of viruses and study their properties; classification based on morphological and genomic traits; transmission characteristics and molecular basis of interaction between the vectors and viruses; biochemistry of host-virus interactions.
- Understand the process of viral infection, replication, genome expression strategies; structural diversity of bacteriophage and the functioning of the genetic switch; biology of the viroid.
- Learn about the techniques involved in the purification of viruses; use of serological and nucleic acid hybridization techniques in viral diagnosis; modern approaches in the control of plant viruses; role of microbes in recombinant DNA technology.

Unit–I
Development of Microbiology
Bacterial and Archaeal groups based on molecular phylogeny
Bacterial cell structure and function of cell components
Bacterial genome structure, plasmids, replication, expression
Unit–II
Nutritional types of bacteria and anoxygenic photosynthesis
Biological nitrogen fixation
Antibiotics and their mode of action, bacterial resistance to antibiotics
Methods of genetic recombination in bacteria
Unit–III
Nomenclature and classification of plant viruses
Particle morphology and genome organization of tobacco mosaic tobamovirus (TMV), brome mosaic bromovirus (BMV), and cauliflower mosaic caulimovirus (CaMV)
Hypersensitivity in host-virus interaction
Molecular aspects of virus-vector relationship in transmission
Unit–IV
Replication of TMV and CaMV
Gene expression strategies in plant viruses
Structure, replication and pathogenicity of viroids
Life cycle of lytic and lysogenic bacteriophage
Unit–V
Purification of plant viruses
Virus detection by serological and nucleic acid hybridization methods
Modern methods of plant virus disease control
Role of microbes in recombinant DNA technology
Practical based on Units I-V

Suggested Readings:

1. Matthew's Plant Virology, R. Hull, 4th edition, 2003, Elsevier.
2. Prescott's Microbiology, J. Willey, L. Sherwood, 10th edition, 2017, McGraw-Hill Education.
3. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology, Edited by A. Hofmann, S. Clokie, 8th edition, 2018, Cambridge University Press.
4. Plant Pathology, G.N. Agrios, 5th edition, 2005, Elsevier.
5. Alcamo's Fundamentals of Microbiology, J.C. Pommerville, 2nd edition, 2013, Jones and Bartlett Learning.
6. Microbiology: An Introduction, G.J. Tortora, B.R. Funke, C.L. Case, 11th edition, 2016, Pearson India Education.

M.Sc. BOTANY (SEMESTER – I)
BOT-CC-102: FUNGI, PLANT PATHOLOGY AND LICHENS
4 Credits/40 Hours

Course Outcome:
After completion of the course the student will:

- Have a general idea of classification and features of fungi.
- Have a comparative knowledge of structure and life cycle of selected fungi and allied organisms.
- Know the fungal disease symptoms and their management.
- Understand the host pathogen interactions and also host defense mechanisms.
- Have an understanding of the epidemiology, symptoms, etiology, prevention and control of fungal diseases.
- Learn about plant diseases caused by fungal-like organisms, nematodes and abiotic factors
- Have an idea of the classification, structure, distribution, reproduction and importance of lichens.

UNIT-I
Thallus organization and cell structure.
Nutritional types of fungi: biotrophs, hemibiotrophs, symbionts and necrotrophs.
Reproduction, hormonal mechanism of sexual reproduction, parasexuality, life cycles.
Fungal systematics and phylogeny
UNIT-II
Myxomycota and Plasmodiophoromycota- *Stemonitis, Arcyria, Plasmodiophora*
Oomycota-*Saprolegnia, Achlya, Pythium, Phytophthora, Sclerospora, Peronospora*
Chytridiomycota- *Synchytrium, Allomyces, Monoblepharis*
Zygomycota- *Zygorhynchus, Pilobolus, Choanephora, Entomophthora.*
Ascomycota-Yeasts, *Aspergillus, Taphrina, Protomyces, Penicillium, Erysiphe, Phyllactinia, Chaetomium, Claviceps, Morchella*
Basidiomycota- *Auricularia, Puccinia, Uromyces, Melampsora, Tolyposporium, Ustilago, Tilletia, Urocystis, Graphiola, Clavaria*
UNIT-III
Concept of plant disease, Classification of plant diseases.
Pathogenesis and disease development; role of enzymes and toxins in pathogenesis.
Plant disease diagnosis; Koch's postulates with special reference to parasitism.
Host-pathogen interaction, Host defense mechanisms
Disease forecasting
UNIT-IV
Green ear disease of bajra- *Sclerospora graminicola,* Damping off of seedling and fruit rot- *Pythium,* Stem gall of coriander- *Protomyces macrospores.*
Peach leaf curl- *Taphrina deforman,* Ergot of rye- *Claviceps purpurea,* Rust of gram- *Uromyces Ciceris– aurientinii.*
Rust of linseed- *Melampsora lini,* Rust of wheat- *Puccinia recondita, P. striiformis*
Covered smut of barley- *Ustilago hordei,* Loose smut of oats- *Ustilago avenae,* Loose smut of bajra- *Tolyposporium penicillariae*
Mitosporic fungi and diseases- Leaf spot and shot holes- *Alternaria spp.,* Tikka disease of groundnut- *Cercospora spp.,* Foot rot of gladioli- *Fusarium spp.* Red rot of sugarcane- *Colletotrichum falcatum*
Diseases caused by nematodes-Ear cockle of wheat- *Anguina tritici,* Root knot of vegetables- *Meloidogyne incognita*
Abiotic/Non pathogenic diseases- Black tip of mango, Black heart of potato
UNIT-V

A general account, classification and distribution of Lichens A comparative study of lichen thallus organization, cell structure, physiology and reproduction Chemotaxonomy of Lichens Lichenometry
Practical based on **Units I-V**

Suggested Readings:

1. Introductory Mycology by Alexopoulos, Mims and Blackwell; John Wiley & Sons Publications, 1996.
2. Text Book of Mycology by A.K. Sarbhoy; ICAR Publications, New Delhi, 2006.
3. Plant Pathology by R.S. Mehrotra & A. Aggarwal; Tata McGraw-Hill Publishing, 1980.
4. Plant Pathology by George N. Agrios; Academic Press, 1997.
5. Protocols in Medicinal and Aromatic Plants by Shukla and Dikshit; Today and Tomorrow's Printers and Publisher, India, 2016.
6. Introduction to Fungi, J. Webster and R. Weber, 2007, 3rd edition, Cambridge University Press.
7. The Fungi, S.C. Watkinson, N.P. Money, L. Boddy, 3rd edition, Elsevier Science Publishing Co Inc

M.Sc. BOTANY (SEMESTER – I)
BOT-CC-103: ALGAE AND BRYOPHYTES
4 Credits/40 Hours

Course Outcomes:
After completion of the course the student will:

- Have knowledge of the classification and general features of Algae
- Understand the thallus organization, cell structure, reproduction, phylogeny and inter-relationships of selected members of Cyanophyta, Chlorophyta, Rhodophyta and other groups of Algae
- Have knowledge of the classification, general features, ecology, physiology and reproductive biology of Bryophytes
- Have an idea of the spore diversity, peristome structure and moss protonema
- Know the diversity in gametophytic and sporophytic organization in Mosses, Liverworts and Hornworts
- Know the origin, phylogeny, evolution and fossil history of Bryophytes

Unit - I
Introduction to Algae: General characteristics, life cycle and classification (by Fritsch, Smith, Lee), modern trends for algal classifications (molecular and chemotaxonomy), Fossil algae, Microscopy, cell organelles (cell wall, flagella, nucleus, eye-spot, pyrenoids), pigments, reserve food products, Algal blooms
Introduction to Bryophytes: General characteristics, life cycle, Classification, Origin, Phylogeny and Fossil history of Bryophytes
Unit – II
A comparative study of range of thallus organization, cell structure, reproduction (asexual and sexual), phylogeny and inter-relationships of the following classes of Algae: Cyanophyceae: *Oscillatoria*, *Nostoc*, *Spirulina* Euglenophyceae: *Euglena* Dinophyceae: *Gymnodinium* Charophyceae: *Cosmarium*, *Closterium* Ulvophyceae: *Cladophora* Chlorophyceae: *Volvox*, *Stigeoclonium*
Unit - III
A comparative study of range of thallus organization, cell structure, reproduction (asexual and sexual), phylogeny and inter-relationships of the following classes of Algae: Bacillariophyceae: *Melosira* Xanthophyceae: *Botrydium* Phaeophyceae: *Padina*, *Dictyota* Rhodophyceae: *Gelidium*, *Corallina*
Unit - IV
A comparative study of gametophytic and sporophytic organization in following orders of Mosses and Liverworts- **Mosses** Sphagnales: *Sphagnum* Andreaeales: *Andreaea* Takakiales: *Takakia* Buxbaumiales: *Buxbaumia* Bryales: *Physcomitrium, Fontinalis*, *Splachnum* Polytrichales: *Polytrichum* **Liverworts** Calobryales: *Haplomitrium* (*Calobryum*)

Metzgeriales: *Pallavicinia*, *Riccardia*
Jungermanniales: *Jungermannia*, *Porella*, *Ptychanthus*, *Radula*
Sphaerocarpales: *Riella*, *Sphaerocarpous*
Monocleales: *Monoclea*
Marchantiales: *Plagiochasma*, *Asterella*, *Lunularia*, *Dumortiera*, *Targionia*

Unit – V

A comparative study of gametophytic and sporophytic organization in following orders of Hornrworts-

Hornworts:

Anthocerotales: *Anthoceros*
Notothyladales: *Notothylas, Dendroceros, Megaceros*

Ecology, Physiology Reproductive biology of Bryophytes
Endemism and endemic liverwort genera of India
Spore diversity, dispersal and germination.
Moss protonema, protonemal differentiation and bud induction
Moss peristome and their role

Suggested Readings:

1. Phycology, 5th Ed., Robert Edward Lee, Publisher-Cambridge University Press, 2018.
2. Introduction to the Algae, 2nd Ed., Bold and Wynne, 1984.
3. Introductory Phycology, H. D. Kumar, 1990.
4. Algae, 1st Ed, O. P. Sharma, 2011.
5. Principales and Techniques of Biochemistry and Molecular Biology, 8th Ed., Wilson and Walker, 2018.
6. Biology of Bryophytes. - R.N. Chopra and P.K. Kumra. New Age International (P) Limited, New Delhi 1988.
7. An Introduction to Bryophyta. (Diversity, Development and Differentiation). – A.Rashid. Vikas Publication House Pvt. Ltd., 1998.
8. Bryophytes – A Broad Perspective. - Prem Puri. Atma Ram & Sons, Delhi & Lucknow, 1985.
9. Cryptogamic Botany. Bryophytes and Pteridophytes. Vol.II.G.M. Smith. Tata McGraw-Hill Publishing Company Limited, New Delhi, 1972.
10. The Structure and Life of Bryophytes.– E.V. Watson, BI publications, 1964.

M. Sc. BOTANY (SEMESTER – I)
BOT-CC-104: PTERIDOPHYTES, GYMNOSPERMS AND PALAEOBOTANY
4 credits/40 hours

Course Outcomes:

After completion of the course the student will:

- Have a general concept of Pteridophytes regarding their classification, phylogenetic associations.
- Have knowledge of major evolutionary trends in Pteridophytes viz. stelar and telome theory.
- Learn about the alternation of generation within various forms and economic significance of Pteridophytes.
- Understand the evolutionary trends, geographical distribution, affinities and inter- relationships, morphology, anatomy and reproductive biology of fossil and living members of different groups of Pteridophytes.
- Have a general concept of gymnosperms regarding their classification, phylogenetic associations and economic importance.
- Have knowledge of evolutionary trends, geographical distribution, affinities and
- Inter-relationships, morphology, anatomy of different orders of Cycadopsida.
- Know the evolutionary trends, geographical distribution, affinities and inter-relationships, morphology, anatomy and reproductive biology of members of Coniferopsida.
- Understand the evolutionary trends, geographical distribution, affinities and inter-relationships, morphology, anatomy and reproductive biology of Gnetopsida.
- Know about fossils, their formation and role in stratigraphy.

UNIT-I
General characteristics of Pteridophytes
Criteria and comparative systems of classification of Pteridophytes
Origin and evolution of Pteridophytes- Algal and Bryophytic origin
Different types of fossils.
Comparative study of the following- Rhyniopsida:*Rhynia* Psilopsida: *Psilotum, Tmesipteris*
Lycopsida: Asteroxylales- *Asteroxylon, Zosterophyllum* Lepidodendrales- *Lepidodendron, Sigillaria* Isoetales- *Isoetes, Stylitis*
Equisetopsida: Hyeniales- *Hyenia* Sphenophyllales- *Sphenophyllum, Cheirostrobus* Calamitales- *Calamites*
UNIT-II
Evolution of stelar system in Pteridophytes
Evolution of Telome theory in Pteridophytes
Comparative account of apogamy and apospory
Economic importance of Pteridophytes
Comparative study of morphology of sporophytes, soral arrangement, sporangial characters and development of gametophytes in different major groups of Ferns: Eusporangiatae: Ophioglossales- O*phioglossum*; Marattiales- *Marattia*
Protoleptosporangiatae: Osmundales- *Osmunda*

Leptosporangiatae: Schizeales- *Lygodium*; Pteridales- *Pteris, Adiantum, Ceratopteris, Actionopteris* Dicksoniales- *Dicksonia*; Davalliales-*Davallia*; Hymenophyllales- *Hymenophyllum*; Gleicheniales- *Gleichenia*; Cyatheales- *Cyathea*; Polypodiales- *Polypodium*; Aspidiales- *Asplenium, Dryopteris* Marsiliales- *Regnellidium, Pilularia*; Salviniales- *Salvinia, Azolla*
UNIT-III
Classification, Distribution, Evolutionary tendencies and Economic importance of Gymnosperms
Pteridospermales: A general account of the order with reference to families- (i) Lyginopteridaceae (ii) Medullosaceae (iii) Glossopteridaceae (iv) Corystospermaceae (v) Peltaspermaceae (vi) Caytoniaceae Cycadales: A general account Nilssoniales: A general account. Bennettitales (Cycadeoideales): A general account, affinities and inter-relationships among the families (i) Williamsoniaceae (ii) Wielandiellaceae (iii) Cycadeoideaceae Pentoxylales: A general account and evolutionary tendencies
UNIT-IV
Cordaitales: A general account of the order with reference to families- (i) Eristophytaceae (ii) Cordaitaceae (iii) Poroxylaceae Ginkgoales: A general account with special reference to *Ginkgo* Coniferales: Evolution of megastrobilus and seed-scale complex in various families. Study of various fossil genera, their reported structures with reference to families- (i) Lebachiaceae (ii) Voltziaceae (iii) Palissyaceae Comparative morphological anatomical and reproductive studies in living genera with reference to families- (i) Pinaceae (ii) Araucariaceae (iii) Taxodiaceae (iv) Cupressaceae (v) Cephalotaxaceae (vi) Podocarpaceae. Taxales: A general account with special reference to *Taxus*
UNIT-V
Gnetales - A general comparative account with reference to *Ephedra, Gnetum* and *Welwitschia* (Affinities and inter-relationships, morphology, anatomy and reproductive biology) Study of fossils: Methods of preservation, investigation and importance in stratigraphy. Continental drift and geological time scale.
Practical based on Units I-V

Suggested Readings:

- The Morphology of Pteridophytes, K.R. Sporne, Hutchinson & Co Publishers Ltd., 1962.
- An Introduction to Pteridophyta: Diversity and differentiation, A. Rashid, Vikas Publication House Pvt. Ltd., 1999.
- Cryptogamic Botany: Bryophytes and Pteridophytes, G.M. Smith, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1972.
- The Biology and Morphology of Pteridophytes N.S. Parihar, The Indian Universities Press Allahabad, 1965.
- Gymnosperms, S.P. Bhatnagar, A. Moitra, New Age International (P) Limited, 1996.
- An introduction to Gymnosperms, Cycas and Cycadales, Divya Darshan Pant, BSIP, 2002.
- Gymnosperms- Structure and Evolution, C. J. Chamberlain, CBS Publishers and Distributors, 1986.
- The Morphology of Gymnosperms, K.R. Sporne, Hutchinson & Co. (Publishers) Ltd, 1965.
- Botany for Degree Students, Vol. V- Gymnosperms, P.C. Vasishta, A.K. Sinha, A. Kumar, S. Chand & Co. Ltd., 1976.
- Gymnosperms- Extinct and Extant, C.M. Govil, Krishna Prakashan Media (P) Ltd, 2007.
- Embryology of Gymnosperm, Hardev Singh, Gebruder Borntraeger, Berlin, 1978.
- Gymnosperms of India and Adjacent Countries, K.C. Sahani, Bishen Singh

Mahendra Pal Singh, 1990.
- Botanical Monograph No. I – *Gnetum*., P. Maheshwari and V. Vasil, CSIR, New Delhi, 1961.
- *Pinus*, P. Maheshwari and R.N. Konar, CSIR, New Delhi, 1971.

M.Sc. BOTANY (SEMESTER – II)
BOT-CC-201: PLANT DEVELOPMENT AND REPRODUCTION
4 Credits/40 Hours

Course outcomes:
After completion of the course the student will:

- Understand the differentiation and development of different plant organs and specialized structures.
- Have knowledge of differentiation, development and functions of different tissues.
- Have an understanding of morphological nature of the flower along with its development and evolutionary history.
- Understand the concept of microsporogenesis and microsporogenesis.
- Understand the phenomenon of sexual incompatibility.
- Have knowledge of fertilization and post fertilization changes leading to fruit and seed formation.
- Have an understanding of the phenomenon of morphogenesis.

Unit-I
Development of Root: Organization of RAM, cell fates, Differentiation of vascular tissue, Formation of aerial roots, root hairs
Development of Shoot: Cytological analysis of SAM, Growth and differentiation of shoot
Tissue differentiation: Cambium, Xylem, Phloem; their function, factors and development
Root-shoot Transition; Stem-Node-Leaf continuum
Origin, differentiation and growth: Leaf, Mesophyll, Epidermis (including cuticle, stomata and trichomes) and Venation
Secretary ducts, Laticifers: Structure and formation
Plant surface–structure and function of Lenticels, Hydathodes, Domatia, Epiphyllus branches, Epicuticular waxes, Extra floral nectaries and Hydropoten
Unit-II
General morphology of floral parts, floral meristem
Formation of floral organs and their morphological nature
Genetics of floral organ differentiation, Homeotic mutants in *Arabidopsis* and *Antirrhinum*
Accessory floral organs: Epicalyx, Involucre, Cupule, Corona, Nectaries
Epigyny
Origin, history and evolution of Angiosperm flower
Unit-III
Microsporogenesis: Structure, function and development of male gametophyte
Megasporogenesis: Types of ovules, their evolution and ontogeny, organization and development of embryo sac, involvement of genes/gene functions during Megagametogenesis
Sexual incompatibility: Barriers to fertilization and methods to overcome sexual incompatibility, pollen tube structure and growth, Dioecism
Unit-IV
Double Fertilization, post fertilization metabolic and structural changes in embryo sac
Endosperm: Structure and development; Polyploidy in reproductive organs and tissues
Embryogenesis; Physiological and morphogenetical relationship of endosperm and embryo
Polyembryony, Apomixis: Classification, causes and applications
Structure and growth of fruit and seed
Unit-V
Experimental and applied embryology
Morphogenetic Phenomenon- Symmetry, Polarity, Correlation, Differentiation, Totipotency and Regeneration and Phyllotaxy
Factors affecting Morphogenetic Phenomenon: Genetic, Physical and Chemical
Practical based on Units I-V

Suggested Readings:

1. Fahn (1967) Plant Anatomy, Pergamon Press
2. A.J. Eames and L.H. Mac Daniels (1972) An Introduction to Plant Anatomy, Mc Graw Hill
3. BM Johri (1984) Embryology of Angiosperms, Springer-Verlag, Berlin
4. E.F. deVogel (1980) Seedling of Dicotyledons, Centre for Agricultural Publishing and Documentation, Wageningen.
5. E.W. Sinnott (1960) Plant Morphogenesis, McGraw-Hill Book Company, Inc. New York
6. G. Erdtman (1952) Pollen Morphology and Plant Taxonomy-Angiosperms: An Introduction to Palynology I, The Chronica Botanica Comp. Waltham, Mass, USA
7. K. Esau (1971) Anatomy of Seed Plants, John Wiley & Sons
8. K. Ramesh Rao & KBS Juneja (1971) Field Identification of Fifty Important Timbers of India, FRI Publication
9. P.K.K. Nair, Ed. (1980) Glimpses in Plant Research. Aspects of Reproductive Biology Vol VI
10. S.S. Bhojwani, S.P. Bhatnagar, P.K. Dantu (2015) The Embyology of Angiosperms, Vikas Publishing House Pvt. Ltd., New Delhi, India.
11. V. Raghavan (2000) Developmental Biology of Flowering Plants, Springer-Verlag, New York.
12. V. Singh, P.C. Pande and D.K. Jain (1987) Anatomy of Seed Plants, Rastogi Publications, Meerut
13. Y.V. Chadha (1994) Elements of Morphogenesis, Awasthi Associates, Allahabad, India.
14. Phytomorphology (Trends in Plant Sciences), Golden Jubilee Issue 2001.
15. A.W. Wardlaw (1968). Morphogenesis in Plants: A contemporary Study, Methuen & Comp. Ltd.

M. Sc. BOTANY (SEMESTER–II)
BOT-CC-202: PLANT SYSTEMATICS
4 Credits/40 hours

Course Outcomes:
After completion of the course the student will:

- Have an idea of the principles and relevance of different classification systems and their phylogenetic significance.
- Have clear concept of ethnobotany, phytogeographical distribution of plants, speciation, Herbaria etc.
- Be well versed with the modern tools of taxonomy viz. morphological, anatomical, reproductive, cytological and chemical parameters.
- Become aware of the distinguishing taxonomic features and interrelationships of selected Dicot and
  Monocot families.
- Know the special features of Insectivorous/Parasitic and Saprophytic families.
- Understand the economic utility of plants as cereals, pulses, spices, fibres, timber etc.

Unit-I
Principles of Systematics, relevance and role of Systematics
Approaches to classification, Phenetic, Phylogenetic and cladistics; Relative merits and demerits of major systems of classification viz. Bentham and Hooker, Engler and Prantl, Hutchinson, Cronquist, Dahlgen and Thorne; APG system
Unit-II
Herbarium and Botanical Gardens. ICN (History, Principles and Applications), Protologue and Botanic literature (Monographs, Icones, Floras and Taxonomic literature)
Species Concept: Various models; Speciation and Variation.
Phytogeography with special reference to discontinuous areas, endemism, hotspots and hottest hotspots
GIS and Phylocode
Unit-III
Modern tools and evidence of taxonomy viz: Morphology and Anatomy: Epidermis and other structures associated with it, Node, Leaf, Flower Embryology, Palynology, Reproductive Biology, Ovular morphology and Seed Coat; Cytotaxonomy, Phytochemistry, Sieve Elements, Plastids and Ecology.
Unit-IV
Sexual dioecism; Interesting taxonomic features and inter-relationships of following Dicot families: Acanthaceae, Aizoaceae, Amaranathaceae, Asclepiadaceae, Asteraceae, Betulaceae, Bombaceae, Cactaceae, Caesalpiniaceae, Capparaceae, Caryophyllaceae, Casurinaceae, Cucurbitaceae, Ericaceae, Euphorbiaceae, Fagaceae, Fumariaceae, Malvaceae, Mimosaceae, Nelumbonaceae, Nymphaeaceae, Papaveraceae, Paplionaceae, Passifloraceae, Polygonaceae, Primulaceae, Ranunculaceae, Rosaceae, Rubiaceae, Scrophulariaceae, Tiliaceae, Trochodendraceae. Special features of Insectivorous/Parasitic and Saprophytic families.
Unit-V
Origin and evolution of Angiosperms
Interesting taxonomic features and inter-relationships of following Monocot families and treatment of monocots in evolutionary systems of classification**:** Alismataceae, Arecaceae, Commelinaceae, Cyperaceae, Liliaceae, Orchidaceae, Poaceae, and Zingiberaceae.
Ethnobotany- Its concepts, relevance and ethnic uses
Biodiversity and its conservation
Practical based on Units I-V

Suggested Readings:

1. J. Harborne, B.L. Turner and D. Boulter- Chemotaxonomy of Leguminosae, Academic Press, London, 1971.
2. John Firminger Duthie- Flora of Upper Gangetic Plains, Shiva offset Press, vol.I, 1903, vol.II, 1911.
3. John Hutchinson- The Families of Flowering Plants, Clorendon Press, 1959.
4. Arthur John Cronquist- The Evolution and Classification of Flowering Plants, Shiva offset Press, 1981.
5. P.H. Davis and B.H. Heywood- Principles of Angiosperm Taxonomy, Princeton Press, 1963.
6. Alfred Barton Randle- The Classification of Flowering Plants, Harvard University, 1904.
7. Gurcharan Singh- Plant Systematic, Oxford & IBH Publishing Company Pvt. Ltd., 1999.
8. Tod F. Stuessy-Plant Taxonomy, Shiva offset Press, 2002.
9. Peter H.A. Sneath and Robert R. Sokal- Numerical Taxonomy, Wayne State University Press, 1973.
10. T. Pullaiah- Taxonomy of Angiosperms, Regency Publications, New Delhi, 1998.

M.Sc. BOTANY (SEMESTER–II)
BOT-CC-203: CYTOGENETICS AND MOLECULAR GENETICS
4 Credits/40 Hours

Course outcomes:
After completion of the course the student will:

- Have a comprehensive, detailed understanding of the structure and chemical basis of chromosome and the physical basis of inheritance and heredity.
- Have an understanding of linkage and crossing over and methods of mapping genes
- Understand different mechanisms of inheritance, including Mendelian and non-Mendelian systems.
- Understand the role of genetic mechanisms in evolution through practical demonstration of aberrations, mutation and polyploidy.
- Learn about the molecular basis of inheritance through comprehensive knowledge of the structure, replication and function of DNA and RNA.
- Learn about the regulatory mechanisms for gene expression in the cell, along with a detailed conceptualization of the cell cycle, genetic code and apoptosis.

UNIT-I
Chromosome structure, nucleosome, solenoid and packaging of DNA, molecular organization of centromere and telomere, nucleolus, euchromatin and heterochromatin, karyotype analysis, banding patterns, special chromosomes-polytene chromosomes, lampbrush chromosomes, B chromosomes.
Nucleic acids, Nuclear DNA content, C-value paradox, unique, moderately repetitive and highly repetitive DNA, conformation of nucleic acids (A, B, Z DNA), DNA sequencing and amplification
Linkage and Recombination: Concept and Types of Linkage, Three point test crosses, Molecular mechanism of recombination.
UNIT-II
Mendelian inheritance and interaction of genes: Complementary, Epistasis, Inhibitory, Duplicate, Polymeric, Lethal and Additive interaction of genes.
Cytoplasmic Inheritance: Cytoplasmic inheritance involving chloroplast (*Mirabilis jalapa*, *Zea mays*) and Mitochondria (petite yeasts and cytoplasmic male sterility in higher plants)
Quantitative Inheritance: Continuous variation, Inheritance of quantitative traits like kernel colour in wheat, corolla length in *Nicotiana*, cob length in *Zea mays*.
Population genetics: Gene and genotype frequencies, Hardy-Weinberg law, Factors affecting Hardy-Weinberg equilibrium
UNIT-III
Cell-Cycle: Cell multiplication and turn over, cell cycle control mechanism, role of cyclins and ubiquitins, apoptosis
Structural changes in chromosomes: Duplication, deficiency, inversion and translocation heterozygotes. Cytological consequences of crossing over in inversion and translocation heterozygotes.
Numerical alterations in chromosomes: Origin of euploids and aneuploids, Production of autopolyploids, allopolyploids and haploids, Induction and characterization of trisomics and monosomics.
Mutation: Spontaneous and induced mutation, physical and chemical mutagens, molecular basis of mutations, transposable elements in prokaryotes and eukaryotes, site directed mutagenesis, DNA damage and repair mechanism.
UNIT-IV
Genetic Code, history and properties.
Gene concept and structure: Organization and structure of prokaryotic and eukaryotic genes, multigene families, structure and role of promoters, Genome Projects.
In situ hybridization to locate transcripts in cells- FISH, GISH, Restriction mapping.
Allele concept, multiple alleles, isoalleles, pseudoalleles.
UNIT-V
DNA Replication: Mechanism of prokaryotic and eukaryotic DNA replication, replication apparatus,

Origin of replication, priming and DNA polymerases.
Transcription: RNA polymerases and their role, transcription in prokaryotes and eukaryotes, RNA processing, Ribonucleoproteins, structure of RNAs.
Gene Regulation in prokaryotes and eukaryotes: Operon concept (Lac, Tryptophan) positive and negative regulation of prokaryotic genes, eukaryotic transcription factors. transcriptional and translational control.
Practical based on Units I-V

Suggested Readings:

1. Lewin's GENES XII , 12th edition- by Jocelyn E. Krebs, Elliott S. Goldstein , Stephen T. Kilpatrick, Cenveo Publishers, 2018.
2. Molecular Biology of the Gene- by James D. Watson, A. Baker Tania, P. Bell Stephen, Gann Alexander, Dorling Kindeley, 2006.
3. Principles of Genetics- by Gardner, Simmons, Snustad, Replika Press, 1984.
4. Molecular Biology of the Cell, 6th edition- by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Garland Science, 2015.
5. iGenetics: A Mendelian Approach- by Peter J Russell, Pearson, 2010.
6. Keith Wilson and John Walkers Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 1975.
7. Molecular Cell Biology- by Harvey Lodish, Arnold Berk , Chris A. Kaiser, Monty Krieger, Mathew P. Scott, Anthony, Brest Cher, Hidde Ploegh, Paul Matsudaira, W.H. Freeman & company, 1986.
8. Genetics: A Conceptual Approach- by Benjamin A. Pierce, W.H. Freeman & company, 2003.
9. Genetics: Analysis of Genes and Genomes- by Daniel L. Hartl, Elizabeth W. Jones, Jones & Bartlett publishers, 2001.

M.Sc. BOTANY (SEMESTER–II)
BOT-CC-204: PLANT BREEDING AND BIOSTATISTICS
4 Credits/40 Hours

Course outcomes:
After completion of the course the student will:

- Be able to analyze the historical evolution of plant breeding and the key scientific and technical advances that have influenced its development.
- Gain knowledge of the different plant reproductive systems and their effect on genetic variability.
- Understand the strategies and processes of selection and breeding based on the reproductive mechanisms.
- Understand the importance of identifying genes, isolating them, determining their function and controlling their expression.
- Be able to identify genetic variability, and also locate the genetic regions associated with traits of interest for breeding, and determining the connection between phenotypic and genetic variability.
- Be able to use statistical methods to analyse results.

UNIT-I
Importance, scope and major achievements of plant breeding.
Germplasm; kinds of germplasm, collection, evaluation and organizations concerned with germplasm, *in-situ* and *ex-situ* conservation.
Modes of reproduction in crop plants; sexual and asexual reproduction, apomixis, identification of apomictic plants.
Incompatibility; genetic, physiological and biochemical basis of incompatibility, utility of self incompatibility.
Male sterility; genetic and cytoplasmic male sterility and its applications.
UNIT-II
Plant introduction; types of introduction, procedure, uses of plant introduction and organizations associated with introduction.
Pure line selection, mass and progeny selection, procedure and achievements.
Pedigree selection, recurrent selection and their applications.
Role of mutation in plant breeding, isolation of useful mutants and major achievements.
Role of polyploidy in crop improvement.
UNIT-III
Hybridization- kinds of hybridization, procedure of hybridization, types of hybridization and utility of hybridization.
Hybrid breeding in self- and cross-pollinated crops.
Back cross breeding
Types of hybrids – single cross hybrid, three way cross hybrid, double cross hybrid, synthetic and composite crosses.
Heterosis; theories of heterosis, inbreeding depression.
UNIT-IV
Protoplast fusion and somatic hybrids.
Method of gene transfer and transgenics.
Marker assisted selection.
Breeding for disease resistance, salinity tolerance and quality traits.
UNIT-V
Importance and scope of biostatistics in biological studies.
Statistical terms and graphical representation of data.
Measures of central tendency.
Measures of dispersion: range, mean deviation, standard deviation, variance and deviation.

Correlation and regression and their role in selection.
Tests of significance: differences in means, standard error of mean, standard error of SD, students 't' test, Chi Square test.
Practical based on Units I-V

Suggested Readings:

1. Introduction to Plant Breeding, R.C. Chaudhary, Oxford & IBH Publishers, 1982.
2. Plant Breeding, V. Kumaresan, Saras Publication, 2015.
3. Plant Breeding Principles & Methods, B.D.Singh, Kalyani Publishers, 1983.
4. Fundamentals of Plant Breeding, Phundan Singh, Kalyani Publishers, 2017.
5. Principles of Plant Breeding, I.D.Tyagi, Jain brothers, 2015
6. Plant Breeding Methods, Mahabal Ram, PHI Learning Pvt. Ltd., 2014.
7. Principles of Plant Breeding, Robert W. Allard, John Wiley & sons, 1960.
8. Plant Breeding: Scholar Select, Liberty Hyde Bailey, Arthur Witter Gilbert, 2018.

M.Sc. BOTANY (SEMESTER – III)
BOT-CC-205: ENVIRONMENT, ECOLOGY AND PLANT-SOIL RELATIONSHIP
4 Credits/40 Hours

Course outcomes:
After completion of the course the student will:

- Be aware of the current issues related to different types of pollution and also the significance of indicator plants.
- Have in-depth knowledge of environmental issues related to ozone depletion and air pollution leading to climate change.
- Have knowledge of biotic responses to various environmental factors constituting the ecosystem.
- Become aware of community and population dynamics along with principles of plant distribution.
- Have knowledge of soil types and their properties along with method of soil formation.

Unit-I
Pollution of air, water and soil; radioactive and noise pollution and its causes and prevention.
Indicator Plants.
Unit-II
Acid rain, Ozone depletion.
Green house effect and Global warming.
UNIT-III
Plant responses to environmental factors (climate, edaphic, Biotic, topographic and geographic factors)
Ecosystems: Concept, ecosystem component and major ecosystems of the world.
Ecosystem functioning (Tropic organization and Ecological efficiency), Community dynamics-successional changes.
Unit-IV
Characteristics of communities, methods of study (Life forms, growth form and biological spectrum) and classification of plant communities.
Population dynamics: Principles of population regulation.
Phytogeography: Vegetational zone, important forest types of India.
Interpretative Phytogeography, Principles and concepts of plant distribution.
Unit-V
Soil and natural medium for plant growth, Origin of soil, Minerals as a source of plant nutrients.
Soil forming process and its impact on soil profile development, properties of soils, Soil texture and structure
Ion exchange, calcareousness, salinity, sodicity. Organic matter.
Practical based on Units I-V

Suggested Readings:

1. The nature and properties of soils, Nyle C. Brady and Ray R. Weil, Pearson Education Pvt. Ltd., 2002
2. Environmental Science, Richard T. Wright and Bernard J. Nebel, Prentice Hall India Pvt. Ltd., 2002
3. Encyclopedia of Ecology, Environment and Pollution Control, R. Swarup, S.N. Mishra, V.P. Jauhari, Mittal Publication, New Delhi, 1999
4. Natural Resource Conservation, 10th edition, Daniel D. Ohiras, Pearson Publication, 2019
5. Environmental Science, S.C. Santra, New Central Book Agency Pvt. Ltd., 2001
6. Fundamentals of Ecology, 3rd edition, E.P. Odum, Natraj Publication, 1971

M.Sc. BOTANY (SEMESTER–III)
BOT-CC-301: PLANT PHYSIOLOGY
4 Credits/40 Hours

Course outcomes:
After completion of the course, the student will -

- Understand the significance of plant water relations, essentiality of mineral nutrients for plants growth and development.
- Have complete insight into various perspectives of photosynthesis and the function of plants as primary producers of food.
- Understande how plants undergo respiration (respiratory pathways) and provide energy (oxidative phosphorylation) for food synthesis
- Study how plants synthesize lipids.
- Gain an understanding of physiology of flowering in response to light and temperature.
- Understand the mechanisms developed by plants to overcome abiotic stress.
- Be able to demonstrate proficiency in the experimental techniques and methods of analysis for various physiological processes.

Unit-I
Plant and water relations: Properties of water, diffusion, osmosis, water potential and its components.
Translocation of water and solutes: Water absorption by roots, Transport of water and solutes, Phloem loading and unloading
Transpiration: Types and mechanism of stomatal opening and closing.
Mineral Nutrition: Essential and beneficial elements, Role and deficiency effects of essential nutrient elements.
Unit-II
Photochemistry and Photosynthesis: Historical background and action spectra, Photosynthetic pigments and light harvesting complexes, Photosystem I and II, Photolysis of water.
Mechanism of electron transport: Photophosphorylation-cyclic, non-cyclic, Proton transport and ATP synthesis in chloroplast- ATP synthetase.
Carbon assimilation: Calvin cycle, Photorespiration (C2 Cycle) and C4 cycle and their regulation; CAM pathway; Photosynthetic responses to light, CO_2 and temperature, Synthesis of starch and sucrose.
Unit-III
Respiration: Aerobic and anaerobic respiration, Glycolysis, Pentose phosphate Pathway, Kreb's Cycle and their regulation, Substrate level Phosphorylation. Gluconeogenesis, Glyoxylate cycle.
Electron Transport System and ATP synthesis: NADPH DH in plant mitochondria, F_1-F_0 ATPase, Alternate oxidase system, Chlororespiration.
Lipid Metabolism: Lipid Metabolism: Synthesis of fatty acids (saturated and unsaturated) and lipids (phospholipids). α, β and ω oxidation
Unit-IV
Plant growth: Growth stages, Apical dominance, germination, dormancy (bud and seed), **Flowering:** Floral evocation, Photoperiodism (types, critical day length), Vernalization and devernalization.

Florigen concept and pathways affecting flowering. **Phytochrome**: Its structure and functions. Biological clock and circadian rhythms.
Unit-V
Abiotic Stress Responses: Plant responses to abiotic stress. Stress Proteins (HSP, LEA etc.). Water Stress- deficit/drought and water logging Temperature Stress- Heat, chilling and freezing Light stress- High light intensity/UV radiations Oxidative stress- reactive oxygen and nitrogen species, antioxidative defense system.
Practical based on Unit I-V

Suggested Readings:

1. Plant Physiology and Development (2018), Lincoln Taiz, Eduardo Zeiger, Ian M. Moller, Angus Murphy, Sinauer and Oxford University Press
2. Plant Physiology (2010), Hans Mohr, Peter Schopfer, G. Lawlor and D.W. Lawlor; Springer Publication.
3. Abiotic Stress Adaptation in Plants: Physiological, Molecular and Genomic Foundation (2010), Ashwani Pareek, S.K. Sopory, Hans J. Bohnert and Govindjee; Springer Publication.
4. Plant Physiology (2012), Mukherjee, S. and A.K. Ghosh; Tata McGraw Hill Publishers (P) Ltd. New Delhi.
5. Introduction to Plant physiology, (2009) 4th edition, William G. Hopkins, Norman P. A. Hüner; Wiley& Sons Ltd.
6. Marschner's Mineral Nutrition of Higher Plants (2011), Petra Marschner; Elsevier Science Publishing Co Inc.
7. Plant Physiology (2006), Lincoln Taiz, Eduardo Zeiger, 4th edition; Sinnauer Associates, USA.
8. Plant Physiology (2006), Salisbury, F.B and C.W. Ross; CBS Publishers and Printers, New Delhi.
9. Introductory Plant Physiology (1989), Noggle, R. and Fritz; Prentice Hall of India.
10. Mineral Nutrition of Plants (1986) Horst Marschner, Academic Press, New York.

M.Sc. BOTANY (SEMESTER-IV)
BOT-CC-401: CELL BIOLOGY AND PLANT BIOCHEMISTRY
4 Credits/40 Hours

Course outcomes:

After completion of the course, the student will –

- Gain knowledge of the structural and functional aspects of the cytoskeletal system.
- Understand the plant cell structure and its significance in metabolic processes.
- Understand the structure and role of membranes in ion transport.
- Know about the structure and functions of carbohydrates, lipids, amino acids and proteins.
- Have an understanding of assimilation of nitrogen and sulfur.
- Gain an understanding of the plant growth hormones and their utility
- Gain a complete insight of plant enzymes and their function in living cells.
- Know the role of receptors in signaling the plant to perform the various metabolic functions.
- Learn about the secondary metabolites which are found in plants and how they are synthesized.
- Have an idea of programme cell death

Unit-I
Cell components: Structural and functional aspects of cytoskeleton system, role in cell organization and movement, organization of microtubules, microfilaments and plasmodesmata. Ultrastucture and function of microbodies, golgi apparatus, lysosomes, peroxisomes, endoplasmic reticulum, vacuole, ribosomes, nucleus and nucleolus. Structure, genome organization and function of mitochondria and chloroplast. Structural organization and functions of:Cell wall and Plasma membrane **Membrane transport:** Structure and functions of ion carriers, channel proteins.Ion pumps (Na^+/K^+ and Ca^{2+} pumps), Aquaporins, Membrane transport protein- Plasma membrane H^+-ATPase, vacuolar H^+-ATPase and H^+pyrophosphatases, ABC transporters
Unit-II
Classification, structure and functions of: Carbohydrates- Monosaccharides, oligosaccharides, polysaccharides (storage and structural) Amino acids- protein, non- protein, essential and non-essential. Proteins- simple and conjugated Lipids- Fatty acids, simple and compound lipids. **Nitrogen and sulfur metabolism:** Biological nitrogen fixation, nitrogenase enzyme complex, nodule formation and nod factors. Mechanism of nitrate reduction-nitrate and nitrite reductase. Ammonia assimilation. Assimilation of sulfur.
Unit-III
Plant growth hormones: Biosynthesis, function and mechanisms of action of- Auxins. Gibberellins. Cytokinins. Abscisic acid, Ethylene. Brasssinosteroids, Polyamines, Jasmonic acid and Salicyclic acid.
Unit-IV

Enzymes:
General aspects, characteristics and classification.
Factors affecting enzyme activity
Active sites and mode of action.
Regulation of enzyme activity and allosteric mechanism
Enzyme inhibition -reversible and irreversible, competitive and non-competitive.
Enzyme kinetics and Michaelis- Menton equation.
Signal transduction:
Overview, role of membranes, receptors and G- proteins.
Ca-calmodulin cascade, phospholipid signalling, Cyclic nucleotides- adenylcyclase.
Protein kinases-receptor like protein kinase (RLKs), mitogen activated protein kinase (MAPK), cyclin dependent protein kinase (CDK).
Protein phosphatase, Auxin, GA and ABA signal transduction.

Unit-V

Secondary metabolites and their function: Cutins, Suberins, Lignin, Anthocyanins, Chalcones, Isoflavones, Stilbenes, Terpenes, Sterols.
Secondary metabolic pathways:
Shikimic acid pathway- Phenylalanine, tyrosine and tryptophan
Acetate Malonate pathway- Phenylpropanoids
Acetate Mevalonate pathway- Terpenes
Nitrogen containing compounds- Alakaloids, Cyanogenic glycosides, Glucosinolates
P**rogrammed cell death (PCD):**
Concept of PCD and its types in plants during vegetative and reproductive stages, Developmental and stress-induced PCD.
PCD and plant senescence and its characteristics.

Suggested Readings:

1. Lehninger Principles of Biochemistry (2017), David L Nelson & Michael Cox; WH Freeman & Co., New York, San Francisco.
2. Signal Transduction: Principles, Pathways, and Processes (2016), Lewis Cantley, Tony Hunter, Richard Sever; Cold Spring Harbor Press
3. Biochemistry (2015), Jeremy M. Berg. Lubert Stryer, John Tymoczko, Gregory Gatto; W. H. Freeman & Co., New York, San Francisco.
4. Biochemistry and Molecular Biology of Plants (2015), Buchanan, Gruissem& Jones; Wiley Blackwell/IK International Pvt Ltd, New Delhi.
5. Fundamentals of Biochemistry (2011) Donald Voet & Judith Voet; C.W John Wiley and Sons Inc, New York and Toronto.
6. Plant Biochemistry, (2010), Hans-Walter Heldt and Birgit Piechulla; Academic Press
7. Biochemistry and Molecular Biology (2009), W.H. Elliot and D.C .Elliott, Oxford University Press.
8. Introduction to Plant Structure and Development (2010), Charles Beck An Introduction to Plant Structure and Development; Cambridge University Press.
9. Cell Cycle Control and Plant Development (2007), Edited by Dirk Inze; Blackwell publishing Ltd.
10. Cell and Molecular Biology.(2007), J.G. Karp; John Wiley & Sons, USA.
11. Davies P J. (2004) Plant Hormones: Biosynthesis, Signal Transduction, Action. 3rd Edition, Kluwer Academic Publisher, Dordrecht, The Netherlands**.**
12. Plant Biochemistry (2000), P.M. Dey &J.B. Harborne; Academic Press.

M.Sc. BOTANY (SEMESTER – IV)
BOT- MT-401: Master Thesis
8 Credits

The students will submit the thesis/Dissertation on the assigned topic of their interest in contemporary plant science.