Semester-III

Undergraduate Diploma in Botany

Discipline Specific Elective: Plant Tissue Culture

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Plant Tissue Culture	4	4	0	0	Undergraduate certificate in Botany	Nil

UNDERGRADUATE DIPLOMA IN BOTANY		
Programme : ***Undergraduate Diploma in Botany***	**Year: II**	**Semester: III**
Subject: Botany		
Course: BOT DSE 1	**Plant Tissue Culture**	

Course Outcomes:

The successful students will be able to:

1. Learn the basic concepts, principles and processes in plant cell and tissue culture.
2. Understand the use of tissue culture techniques in plant improvement.
3. Apply the concepts and principles of plant cell and tissue culture in biotechnological and agricultural fields.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Introduction and historical background of Plant tissue culture. Principle, scope, utility and advantage of plant tissue culture, totipotency, general laboratory techniques, equipments (autoclave, laminar air flow, and incubator shaker) and their working principle, sterilization techniques, media preparation, plant growth regulators.	**15**
2	Callus and its types, callus differentiation and organogenesis, callus culture. Concept of clonal propagation, *In-Vitro* root and shoot propagation, different types of cultures (solid and suspension cultures).	**15**
3	Somatic embryogenesis and synthetic seeds, protoplast isolation and culture, somatic hybridization, somaclonal variation, cryopreservation.	**15**
4	Demonstration of tools and techniques used in plant tissue culture laboratory. Sterilization of media, instruments, and explants, formulation of Murashige and Skoog (MS) medium.	**15**

Suggested Readings

- Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text Springer
- Bhojwani, S. S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice,Revised Edition, Elsevier
- Bhojwani, S.S, Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
- Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations (Elsevier).
- Collins, H.A. and Edwards, S. (1998). Plant Cell Culture. Bioscientific Publishers, Oxford, UK.
- Jain, S.M., Sopory, S.K. and Veilleus, R.E. (1996). In Vitro Haploid Production in Higher Plants, Vols, 1-5., Fundamental Aspects and Methods. Kluwer Academic Publishers, Dordrecht, The Netherland.
- Kartha, K.K. (1985). Cryopreservation of Plant Cells and Organs. CRC

Press, Boca Raton. Florida, USA.
- Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition Springer.
- Vasil, I.K. and Thorpe, T.A. (1994). Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.

Semester-IV

Undergraduate Diploma in Botany

DISCIPLINE SPECIFIC ELECTIVE (DSE)- Ethnobotany

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Ethnobotany	**4**	**4**	**0**	**0**	**Undergraduate certificate in Botany**	

UNDERGRADUATE DIPLOMA IN BOTANY		
Programme : ***Undergraduate Diploma in Botany***	**Year: II**	**Semester: IV**
Subject: Botany		
Course: BOT DSE 2	**Ethnobotany**	

Course Outcomes:

The successful students will be able to:

1. Learn the proper documentation and presentation of traditional knowledge about plants.
2. Use important plants used by the tribal communities for various purposes.
3. Learn the conservation of wild growing plants and their socio-economic impacts.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Introduction, concept, scope and objectives of ethnobotany; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals/tribes of India with special reference to Uttarakhand and their life styles. Plants used by the tribal communities.	**15**
2	Importance of a) Field work b) Herbarium c) Ancient Literature d) Temples and sacred places e) Indigenous knowledge system in ethnobotanical studies. Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).	**15**
3	Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadirachta indica* b) *Ocimum sanctum* c) *Vitex negundo* d) *Gloriosa superba* e) *Tribulus terrestris* f) *Pongamia pinnata* g) *Cassia fistula* h) *Indigofera tinctoria*. Role of ethnobotany in modern medicine *Rauvolfia serpentina, Trichopus zeylanicus,*	**15**

	Artemisia,Withania as example.	
4	Visit to local sites for documentation of ethnobotanically important plants. Preparation of ethnobotanical profile of a tribal community, listing and identification of plants used by tribal communities. Documentation of herbal remedies used by local healers.	**15**

Suggested Readings

- Colton C.M. (1997). Ethnobotany-Principles and applications. John Wiley and sonsChichester.
- Jain S.K. (1981). Glimpses of Indian. Ethnobotany, Oxford and I B H, New Delhi.
- Jain S.K. (1989). Methods and approaches in ethnobotany. Society of Ethnobotanists,Lucknow, India.
- Jain S.K. (1990). Contributions of Indian ethnobotany. Scientific publishers, Jodhpur.
- Jain S.K. (1995). Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.
- Rajiv K. Sinha (1996). Ethnobotany The Renaissance of Traditional Herbal Medicine –INA –SHREE Publishers, Jaipur).
- Rama Ro, N and A.N. Henry (1996). The Ethnobotany of Eastern Ghats in AndhraPradesh, India. Botanical Survey of India. Howrah.

Semester-V

Bachelor of Science in Botany

No. of Hours-60

DISCIPLINE SPECIFIC ELECTIVE (DSE)- Conservation and Management of Natural Resources

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Conservation and Management of Natural Resources	4	4	0	0	Undergraduate diploma in Botany	Nil

BACHELOR OF SCIENCE IN BOTANY		
Programme : ***Bachelor of Science in Botany***	**Year: III**	**Semester: V**
Subject: Botany		
Course: BOT DSE 3	**Conservation and Management of Natural Resources**	

Course Outcomes:

The successful students will be able to:

1. Understand the importance, benefits and services of biodiversity.
2. Learn the strategies for the conservation of biodiversity.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Plant diversity and its scope- Genetic diversity, Species diversity, ecosystem diversity, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, Methodologies for valuation. Loss of Biodiversity; Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss.	**15**
2	Management of Plant Biodiversity: Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, red and green data book, Biodiversity information management and communication.	**15**
3	Conservation of Biodiversity: Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development. Role of plants in Human Welfare: a) Importance of forests their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d) Alcoholic beverages through ages. Fruits and nuts: Important cereals, pulses, vegetables, fruits, fibers, oils, spices, medicinal plants and their commercial importance. Wood and its uses. National and state institutes related to the activity.	**15**
4	Visit to a biodiversity-related institution (e.g., herbarium, botanic garden, forest department nursery) or in situ conservation site (e.g., sacred grove, national park) and ex situ conservation site (e.g., seed bank, botanical garden, nursery). Identification and ethnobotanical documentation of at least 10 important plants used for food (cereals, pulses, fruits, spices), fiber, oil, beverages, and medicine.	**15**

Suggested Readings

- Barbour, M.G., Burk, J.H. and Pitts, W.D. (1987). Terrestrial Plant Ecology. Benjamin/Cummings Publication Company, California
- Baskin and Baskin, (2001). Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination Elsevier
- Kormondy, E.J. (2017). Concept of Ecology. Pearson India.
- Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity – Principles andPractices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
- Odum, E.P. (1983). Basic Ecology Saunders, Philadelphia
- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.
- Smith, R.L. (1996). Ecology and Field Biology Harper Collins, New York.

Semester-VI

Bachelor of Science in Botany

DISCIPLINE SPECIFIC ELECTIVE (DSE)- Fundamentals of Molecular Biology

No. of hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
BOT DSE VI Fundamentals of Molecular Biology	4	4	0	0	**Undergraduate diploma in Botany**	**Nil**

BACHELOR OF SCIENCE IN BOTANY		
Programme : ***Bachelor of Science in Botany***	**Year: III**	**Semester: VI**
Subject: Botany		
Course: BOT DSE 4	**Fundamentals of Molecular Biology**	

Course Outcomes:

The successful students will be able to:

- Understand the structure of nucleic acids and their types.
- Understand key events of Molecular biology comprising mechanism of DNA replication, transcription and translation in Prokaryotes and Eukaryotes.
- Learn about the genomes and gene structure.

Credits: 4	**Discipline Specific Elective**	
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**	
Unit	**Topic**	**No. of Hours (60)**
1	Nucleic acids as genetic material (Griffith's experiment, Avery, MacLeod and McCarty's experiment, Hershey-Chase experiment), Structure and functions of Nucleic acids. Genome and its organization: (genes, coding sequence, regulatory sequence, intron, exon, nucleosome structure and packaging of DNA into higher order structures).	**15**
2	DNA replication, genetic code, principles of gene regulation, negative and positive regulation, concept of lac and trp operons, and regulation of gene expression. Damage and repair of DNA: Causes (spontaneous, chemical agent, radiation) and types of DNA damage and mechanism of DNA repair.	**15**
3	Genomes and gene structure: gene families, transcriptomics,	**15**

	proteomics and biological databases. Genome sequencing techniques and applications: Sequencing strategies, the shotgun method, massively parallel sequencing and its applications, and next-generation sequencers. Cloning: Cloning vectors, c-DNA synthesis and cloning, genomic DNA and c-DNA libraries, Enzymes used in recombinant DNA techniques, and molecular markers, Polymerase Chain Reaction, Electrophoresis, DNA fingerprinting and blotting techniques.	
4	Introduction to biological databases (NCBI, EMBL, DDBJ, UniProt): searching for gene/protein sequences and Basic BLAST **analysis** to find sequence similarity. Demonstration of PCR (Polymerase Chain Reaction) and Agarose gel electrophoresis – loading, running, and analyzing DNA.	**15**

Suggested Readings

- Lodish, H., Berk, A., Zipursky, S.L. Maztsudaira, P., Baltimore, Dand Darnell, l. (2016). Molecular Cell Biology (8th Edition). W.H. Freeman and Co., New York, USA.
- Alberts, B., Bray,D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2014). Molecular Biology of the Cell. Garland Publishing Inc., New York.6th edition.
- Watson, J.D. (2013).Molecular Biology of the Genes, Banjamin.7th Edition.
- Buchanan, B.B., Gruissem, W. and Jones, R.L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
- Lewin, B. (2000). Genes VII. Oxford University Press, New York.
- Wolfe, S.L. (1993).Molecular and Cellular Biology. Wadsworth Publishing Co.California.
- Stent, G.S.(1986).Molecular genetics. Bishen Singh Mahendra Pal Singh, Dehradun.
- Barry, J.M. and Barry. B.M. (1973). Molecular Biology, Prentice Hall of India. New Delhi.

Semester VII

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Plant Biotechnology	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Honours Degree in Botany***	**Year: IV**	**Semester: VII**
Subject: Botany		
Course: BOT DSE 5	**Course Title: Plant Biotechnology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the process and techniques involved in bio- technology and plant tissue culture.
2. Analyze the tools and methodologies used in genetic engineering
3. Evaluate the methods and applications of recombinant DNA technology.
4. Understand the blotting techniques, DNA sequencing, and plant genetic engineering.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours(60)
1	Biotechnology: Principle and scope, bio-safety guidelines. Plant cell and tissue culture: Concept of cellular totipotency, principle of root and shoot generation *in vitro,* clonal propagation, applications of cell and tissue culture. Callus culture, organ culture, cell suspension culture, cryopreservation, protoplast culture, organogenesis, somatic embryogenesis, artificial seed, somatic hybridization, hybrids and cybrids, and somaclonal variation.	**15**
2	Recombinant DNA technology: Tools of genetic engineering, enzymes, cloning vectors (plasmids, cosmids, lamda phage, shuttle vectors, BACs, and YACs). Cloning strategies, Screening and selection of transformants.	**15**
3	Gene libraries (a general account): Genomic DNA libraries, cDNA libraries. Hybridization- colony hybridization, Southern hybridization, Northern hybridization, Western hybridization, DNA sequencing techniques: Maxam and Gilbert sequencing, Sanger sequencing Genetic Engineering of plants: Aims, transformation techniques (*Agrobacterium* mediated transformation, electroporation, microinjection, and biolistics), strategies for development of transgenic plants with suitable examples (Golden rice, flavr savr tomato, Bt cotton, moondust carnations). Biosafety of transgenic plants.	**15**
4	Micro pipetting Techniques (Learn accurate pipetting techniques). Preparation of Solutions and Buffers (Prepare standard solutions and buffers used in biotechnology labs). DNA Extraction (Extract and purify DNA from biological samples). Polymerase Chain Reaction (PCR) (Amplify specific DNA sequences).	**15**

Suggested readings

- Brown,T.A.(2018).Genomes 4. John Wiley and Sons (Asia) Pvt. Ltd. Singapore.
- Chrispeels, M.J. and Gepts, P. (2017). Plants, Genes and Agriculture. Oxford University Press.

- Rai, A. C. (2009). Plant Biotechnology Laboratory Manual. I.K. International Publishing House. (A comprehensive manual offering a wide range of plant biotechnology experiments).
- Jolles, O. and Jornvall, H. (2000). Proteomics in Function Genomics. Birkhauser.Verlag, Basel, Switzerland.
- Shantharam, S. and Montogmery, J.F. (1999). Biotechnology, Biosafety and Biodiversity. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Collins, H.A. and Edwards, S. (1998). Plant Cell Culture. Bioscientific Publishers, Oxford, UK.
- Callow, J.A., ford-Lioyd, B.V. and Newbury, H.J. (1997). Biotechnology and Plant Genetic Resources: Conservation and Use. Cab International, Oxon, UK.
- Jain, S.M., Sopory, S.K. and Veilleus, R.E. (1996). In Vitro Haploid Production in Higher Plants, Vols, 1-5., Fundamental Aspects and Methods. Kluwer Academic Publishers, Dordrecht, The Netherland.
- Glazer, A.N. and Nikaido, H. (1995). Microbial Biotechnology, W.H. Freeman and Company, New York, USA.
- Primose, S.B. (1995). Principles of Genome Analysis. Blackwell Science Ltd, Oxford, UK.
- Vasil, I.K. and Thorpe, T.A. (1994). Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.
- Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.
- Kartha, K.K. (1985). Cryopreservation of Plant Cells and Organs. CRC Press, Boca Raton. Florida, USA.

Semester VII

DISCIPLINE SPECIFIC ELECTIVE (DSE) – AN INTRODUCTION TO MICROBIOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Microbiology	4	4	0	0	Bachelor of Science in Botany	Nil

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor of Botany With Honours***	**Year: IV**	**Semester: VII**
Subject: Botany		
Course: BOT DSE 6	**Course Title: An Introduction to Microbiology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the occurrence, general characters, types, reproduction and life cycle of the major microbial groups and their role in food, clinical and industrial microbiology.
2. Evaluate the classificatory approaches and advances in bacterial, viral and lichen taxonomies.
3. Demonstrate proficiency in basic microbiological techniques, including microscopy, bacterial staining, culture methods, and biochemical tests for microbial identification.
4. Explain the factors affecting microbial growth, including environmental conditions, nutritional requirements, and growth kinetics, and apply principles of microbial control and sterilization.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	General account of Microorganisms: History of microbiology, Golden Era of Microbiology, characteristic features of bacteria, General account of actinomycetes, classification of microorganism-five kingdom classification, Microbial growth- measurement of microbial growth, Batch, Fed-batch and continuous culture, endophytic microorganisms.	**15**
2	Morphology and structure of bacterial cells: Morphology of bacterial cells based on size, shape and arrangement, fine	**15**

	structure of bacterial cells (of both Gram negative and Gram positive bacteria) capsule, cell wall, cell appendages (flagella, fimbrae, pilli), Structure of plasma membrane, cytoplasmic inclusions-mesosomes, chlorosome. Ribosome- Site of protein synthesis, Microbial genetics- transformation, conjugation and transduction.	
3	Morphology and structure of viruses: History, morphology, fine structure, shape and classification of viruses. Mycophages and prions, Tobacco mosaic virus (TMV), T4 Bacteriophage and HIV- their fine structure, genome organization and multiplication, Bacteriophage therapy, Overview of Corona virus. Medical microbiology, Aquatic microbiology, Aero microbiology, Food microbiology, Soil Microbiology, Industrial microbiology, Geochemical microbiology.	**15**
4	Microscopy Techniques (Introduce students to basic microscopy techniques and observation of microorganisms). Bacterial Staining: Gram Staining (Differentiate between Gram-positive and Gram-negative bacteria). Microbial Identification: Biochemical Tests (Identify unknown bacterial species based on biochemical characteristics). Antimicrobial Sensitivity Test (Determine the susceptibility of bacteria to antibiotics).	**15**

Suggested readings

- Tortora, G. J., Funke, B.R. and Case C.L.(2021). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 13th edition.
- Madigan, Bender, Buckley, Sattley, Stahl. (2019). Brock Biology of Microorganisms. Pearson. 15th edition.
- Cappuccino, J. G., Welsh, J. (2019). Microbiology: Laboratory Manual. Pearson.
- Marjorie, Kelly. and Cowan, Heidi Smith. (2017). Microbiology: A Systems Approach. McGraw Hil lNew York, 5th edition.
- Kathleen Park, Talaro and Barry Chess. (2017). Foundations in Microbiology. Mc Graw Hill New York, 10th edition.

- Willey, Joanne, Sherwood, Linda., Woolverton, Christopher J.(2017). Prescott's Microbiology. McGraw Hill New York, 11th edition.
- Cappuccino, J. G., Sherman, N. (2016). Microbiology: A Laboratory Manual. Pearson.
- Harley, J. P. (2013). Microbiology: Laboratory Exercises. McGraw-Hill Education.
- Mukherjee, K.G. and Singh V.P (1997). Frontiers in Applied Microbiology. Rastogi Publ. Meerut.
- Power, C.B. and Daginawala H.F. (1996). General Microbiology. Vol 2. Himalaya Pub. House, New Delhi.
- Kaushik, P. (1996). Introductory Microbiology. Emkay Publ, Delhi.
- Pelczar, M.J., Chan, ECS and Kreig, N.R. (1993). Microbiology. McGraw Hill, New York. Fifth Edition.
- Alexander, M. (1991). Microbial Ecology. John Wiley and Sons. New York.
- Doelle, H.W. and C.G, Heden (1986). Applied Microbiology, Kulwer Academic Press, London.
- Miller, B.M. and W. Litsky (1976). Industrial Microbiology. Mc Graw Hill New York.

Semester VII

No. of Hours-60

DISCIPLINE SPECIFIC ELECTIVE (DSE) – PLANT DEVELOPMENT AND REPRODUCTIVE BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Plant Development and Reproductive Biology	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany With Honours***	**Year: IV**	**Semester: VII**
Subject: Botany		
Course: BOT DSE 7	**Course Title: Plant Development and Reproductive Biology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the morphological characteristics of flower.
2. Study the fundamental concepts of root, shoot and leaf development.
3. Understand various stages of plant development.
4. Understand the developmental biology of male and female gametophyte, pollen-pistil interaction.
5. Study the basic idea of embryogenesis and seed development process, apomixes and polyembryony.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Morphology: Morphology of flower, stamen and carpel, Floral characteristics, structure of the pistil, Pollen stigma interactions, Plant adaptations–physiological and their morphological characteristics (xerophyte, hydrophyte and halophyte). Shoot development: Organization of the shoot apical meristem (SAM): control of cell division and tissue differentiation especially xylem and phloem: secretary ducts and laticifers. Leaf growth and differentiation, structural development and classification of stomata and trichomes.	**15**

2	Root Development: Organization of root apical meristem (RAM), vascular tissue differentiation, lateral root, root hairs, ABCD model of flower, Florigen pathway. Male gametophyte: Structure of anthers, microsporogenesis, role of tapetum, pollen development, pollen germination, pollen tube growth and guidance, pollen allergy. Female gametophyte: Ovule development, megasporogenesis, development and organization of the embryo sac, structure of the embryo sac cells.	**15**
3	Pollination: pollination mechanism and vectors. Pollen-pistil interaction and fertilization: pollination mechanism and vectors, sporophytic and gemetophytic self-incompatibility, double fertilization. Seed development and fruit growth: Endosperm development during early maturation and desiccation stages: embryogenesis, cell lineages during late embryo development, polyembryony, apomixis. Latent life- dormancy: Importance and types of dormancy, seed dormancy, bud dormancy.	**15**
4	To study the androecium and gynoecium of different families. To study the type of inflorescence of different families. Study of meristems through permanent slides and photographs. Tissues (parenchyma, collenchyma and sclerenchyma), complex and secretary tissues. Anatomy of monocot and dicot stem; monocot and dicot leaf; monocot and dicot root. Adaptive anatomy: Xerophytes, Hydrophytes, Epiphytes Normal and abnormal secondary growth in different plants. To study the type of anthers and T.S. of the anther To study the pollen grains of different families. To study the types of placentation. To study the types of pollination and seed dispersal mechanisms (photographs and specimens)	**15**

Suggested readings

- Bhatnagar S.P, Dantu, P.K. Bhojwai S.S. (2018). The embryology of Angiosperms. Vikas Publ. House. New Delhi.

- Lalit M. Srivastava. (2002). Plant Growth and Development. Hormones and Environment.Academic Press. 1st Edition.
- Raghavan V. (1999). Developmental biology of flowering plants. Springer Velag. New York.
- Howell, S.H. (1998). Molecular genetics of plant Development. Cambridge Univ. Press.
- Fonkot, De. (1994). Plant growth and Development. A molecular approach. Academic Press. San Diego.
- Lyndon. R.F. (1990). Plant Development. The Cellular Basis. Unnin Hyman. London.

Semester VIII

DISCIPLINE SPECIFIC ELECTIVE (DSE) - CYTOGENETICS

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Cytogenetics	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany With Honours***	**Year: IV**	**Semester: VIII**
Subject: Botany		

Course: BOT DSE 8	Course Title: Cytogenetics

Course Outcomes:

After the completion of the course the students will be able to:

1. Apply the concepts of Mendelian genetics to solve problems on linkage, crossing over and gene mapping.
2. Analyze human pedigree and apply the principles of population genetics to work out problems on genotype frequency and Hardy-Weinberg equilibrium. Understand the Chromosomal aberrations and their role in genome evolution with special reference to crop plants.
3. Understand modern breeding methods in improving agricultural crop varieties.
4. Understand the process of cell cycle its regulation and the mechanism of apoptosis.

Credits: 4	Discipline Specific Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: Asper Univ. rules

Unit	Topic	No. of Hours (60)
1	Mendelian principles: Dominance, Segregation, independent assortment; extension of Mendelian principles (co dominance, incomplete dominance, gene interactions, pleiotropy); linkage and crossing over, sex linked, sex limited and sex influenced characters. Genetic recombination and gene mapping: Recombination, role of Rec A and Rec B,C,D enzymes, gene mapping methods (linkage maps, tetrad analysis, mapping with molecular markers); population genetics - gene pool, gene frequency, Hardy-Weinberg law.	15
2	Structural and numerical alterations in chromosome: Origin, meiotic behaviour and consequences of duplication, deletion, inversion and translocation. Mutation: spontaneous and induced mutation; physical and chemical mutagens; molecular basis of mutation; DNA damage and repair mechanisms; transposable elements, mutations induced by transposons; cell cycle and apoptosis, cancer at cellular level.	15

3	Chromosome structure: Packaging of DNA, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes; euchromatin and heterochromatin; Nuclear DNA content, C- value paradox; Cot-curves and their significance Gene structure and expression: genetic fine structure; cis-trans test; introns and exons; RNA splicing multiple alleles, pseudoallele, regulation of gene expression in prokaryotes and eukaryotes.	**15**
4	To study Mendelian and Non- Mendelian gene interaction ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4) through seeds. Evaluate the genetic hypothesis employing the Chi square test To observe the various stages of mitosis and meiosis with the help of onion root tip and bud respectively.	**15**

Suggested readings

- Lodish, H., Berk, A., Zipursky, S.L. Maztsudaira, P., Baltimore, Dand Darnell, l. (2016). Molecular Cell Biology (8th Edition). W.H. Freeman and Co., New York, USA.
- Alberts, B., Bray,D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2014). Molecular Biology of the Cell. Garland Publishing Inc., New York.6th edition.
- Watson, J.D. (2013).Molecular Biology of the Genes, Banjamin.7th Edition.
- Buchanan, B.B., Gruissem, W. and Jones, R.L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
- Lewin, B. (2000). Genes VII. Oxford University Press, New York.
- Atherly, A.G., Girton, J.R. and McDonald, J.F. (1999). The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
- Gupta, P.K. (1998). Cytogenetics. Rastogi Publications, Meerut. Hartl, D.L. and Jones, E.W. (1998). Genetics: Principles and Analysis (4nd Edition). Jones and Bartlett Publishers, Massachusetts, USA.
- Malacinskim G.M.D. and Freifelder, D. (1998). Essentials of Molecular Biology (3rdEdition). Jones and Bartlett Publishers, Inc. London.
- Kleinsmith, L.J. and Kish, V.M. (1995). Principles of Cell and Molecular Biology (2nd Edition). Harper Collins College Publishers, New York, USA.
- Wolfe, S.L. (1993).Molecular and Cellular Biology. Wadsworth Publishing Co.California.

Semester VIII

DISCIPLINE SPECIFIC ELECTIVE (DSE) - ECOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Ecology	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany with Honours***	**Year: IV**	**Semester: VIII**
Subject: Botany		
Course: BOT DSE 9	**Course Title: Ecology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the scope and concepts of ecology and discuss the biosphere, biomes and biogeography.
2. Analyze the process of ecological succession.
3. Evaluate the importance of the major world ecosystems.
4. Distinguish between species, populations, communities, ecosystem and biomes.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Major terrestrial biomes; Zonoecotones, Orobiomes and Pedobiomes, Fresh water aquatic ecosystems; Marine ecosystems. Community structure and attributes; Edges and ecotones; Keystone species and control of community structure. Types of species interactions, herbivory, carnivory, pollination, symbiosis (obligate and facultative symbiosis).	**15**
2	Population Ecology: Characteristics of population; population growth curves; population regulation life history strategies (r and k selection); population genetics and natural selection. Habitat and niche: Concept of habitat and niche; niche width and overlap, fundamental and realized niche. Biodiversity: Levels of Biodiversity, Uses of biodiversity; Biodiversity, ecosystem services and functions. Distribution of biodiversity; Gradients of biodiversity; Hotspots; Threats to biodiversity. Extinction of species: Biodiversity assessment and inventory; Conservation of biodiversity; Indices; Biodiversity and its conservation; International efforts for conserving biodiversity. Climate change and conservation: Greenhouse gases; sources, trends and role; ozone layer and ozone hole; Consequences of climate change; Principles of conservation.	**15**
3	Ecological succession: Causes, mechanism and types, changes involved in succession; Concept of climax. Ecosystem: Structure and functions; energy dynamics (Tropical organization, energy flow pathways, ecological efficiencies); litter fall and decomposition (mechanism, substrate quality and climatic factors); Global biogeochemical cycles of C, N, P and S (pathways, processes in terrestrial and aquatic ecosystems); nutrient use efficiency; Global hydrological cycle.	**15**
4	Vegetation analysis for Community Structure: Quadrat Method, Importance Value Index (IVI), Distribution pattern, Shannon Index (Shannon and Weiner Index), Simpson's index (Concentration of dominance). Population Structure and Regeneration Status, Estimation of Plant Biomass. Estimation of Net Primary Productivity, Forest Floor Biomass, Measurement of leaf area.	**15**

Suggested readings

- Kormondy, E.J.(2017). Concept of Ecology. Pearson India.
- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.
- Baskin and Baskin, (2001). Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination Elsevier.
- Smith, R.L. (1996). Ecology and Field Biology Harper Collins, New YorkBarbour, M.G., Burk, J.H. and Pitts, W.D. (1987). Terrestrial Plant Ecology. Benjamin/Cummings Publication Company, California
- Odum, E.P. (1983). Basic Ecology Saunders, Philadelphia.

Semester VIII

DISCIPLINE SPECIFIC ELECTIVE (DSE) - PLANT SYSTEM PHYSIOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITYAND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Plant System Physiology	**04**	**4**	0	0	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany with Honours***	**Year: IV**	**Semester: VIII**
Subject: Botany		

Course: BOT DSE 10	Course Title: Plant System Physiology

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the mechanism of transport and translocation of water and analyze the mechanisms of acclimation and adaptation of plants to stress conditions.
2. Understand the process of transpiration, photosynthesis and respiration and analyze these processes in various groups of plants.
3. Gain awareness on the nitrogen cycle and the role of microbes and plants in the nitrogen cycle.
4. Understand the role of plant growth regulators and photoreceptors in plant growth and development.
5. Demonstrate the ability to measure the rate of photosynthesis using various techniques and interpret the results in relation to light intensity and other environmental factors.
6. Perform chlorophyll extraction and use spectrophotometry to quantify chlorophyll a and b in plant tissues, understanding their role in photosynthesis and plant health.
7. Design and conduct experiments to study the effects of various environmental factors, including light and temperature, on seed germination and seedling development.

Credits: 4	Discipline Specific Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: Asper Univ. rules

Unit	Topic	No. of Hours (60)
1	Membrane transport and translocation of water and solutes: Plant – water relations, mechanism of water transport through xylem, phloem loading and unloading, passive and active solute transport, membrane transport of proteins. Signal transduction and sensory photobiology: Receptors, phospholipids signaling, phytochromes and cryptochromes.	15

2	Photosynthesis: General concepts and historical background, steps of photosynthesis, Emerson's effect, two pigment systems, Calvin cycle, photorespiration and its significance. C4 cycle, CAM pathway Respiration: Glycolysis. TCA cycle, electron transport chain and ATP synthesis, pentose- phosphate pathway, glyoxylate cycle. Nitrogen fixation and metabolism: Biological nitrogen fixation, mechanism of nitrate uptake and reduction, ammonia assimilation.	**15**
3	Plant growth regulators: Physiological effects and mechanism of auxins, gibberellins, cytokinins, ethylene, abscisic acid, polyamines, jasmonic acid, Hormone receptors and vitamins, phytochrome and cryptochrome. Photoperiodism and vernalization and their significance; Floral induction and development Stress physiology: Plant responses to biotic and abiotic stresses, mechanisms of biotic and abiotic stress tolerance, water deficit and drought resistance, salinity stress, freezing and heat stress, oxidative stress.	**15**
4	To measure the rate of photosynthesis in aquatic plants using the floating leaf disk assay. To determine the stomatal density on the leaves of different plant species. To measure the rate of transpiration in plants using a potometer. Measure the rate of respiration in plant tissues. To extract and quantify chlorophyll from plant leaves using spectrophotometry.	**15**

Suggested readings

- Taiz, L; Zeiger, E; Moller, I. M. and Murphy A. (2023). Plant Physiology and Development. Publisher:Sinauer Associates print of Oxford University Press. 6th Edition.
- Huner, N.P.A, and Hopkins, W. G. (2008). Introduction to Plant Physiology. Wiley 4th Edition.
- Devi, P. (2000). Principles and methods of Plant Molecular Biology, Biochemistry and Genetics. Agrobios.
- Buchanan, B.B, Gruissem W. and Jones, R.L. (1996). Biochemistry and Molecular Biology of plants by Enzymes: A practical introduction to structure, mechanism and data analysis. R. A. Copeland.
- Scott, R.P.W. (1995). Techniques and Practice of Chromatography. Taylor and Francis, Routlledge.

Semester IX

DISCIPLINE SPECIFIC ELECTIVE (DSE) – EVOLUTIONARY BIOLOGY OF PLANTS

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Evolutionary Biology of Plants	**4**	**4**	**0**	**0**	**Bachelor of Science in Botany**	**Nil**

BACHELOR IN BOTANY WITH HONOURS		
Programme : ***Bachelor in Botany With Honours***	**Year: V**	**Semester: IX**
Subject: Botany		
Course: BOT DSE 11	**Course Title: Evolutionary Biology of Plants**	
Course Outcomes: After the completion of the course the students will be able to: 1. Understand the essential theories of evolution 2. Differentiate between micro and macroevolution and the forces shaping evolution 3. Construct phylogenetic trees based on morphological and molecular data 4. Understand the evolution of life and different group of plants.		

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	**Historical Perspective of evolutionary concepts:** Pre-Darwinian ideas, Lamarckism, Darwinism, Post-Darwinian era – Modern synthetic theory, Neo-Darwinism, Pre-biotic conditions and events; Evolution of eukaryotes from prokaryotes.	**15**
2	**Evidences of Evolution:** Paleobiological– Concept of Stratigraphy and geological timescale; fossil study, Taxonomic –Transitional forms/evolutionary intermediates, living fossils. **Microevolution and Macroevolution:** Hardy Weinberg equilibrium; Founder effect, Natural and artificial selection. Levels of selection. Gene trees, species trees; Patterns of evolutionary change, Mutation, Gene flow, Selection, Genetic Drift, Co-evolution.	**15**
3	**Evolution of Land Plants**: Species concept, Modes of speciation – Allopatric; sympatric; peripatric; Origin of land plants – Terrestrial algae and bryophytes; Early vascular plants – Stelar evolution; seed habit and evolution of seed, adaptive strategies of different group of plants.	**15**
4	Study of Lamarckism, Darwinism, and Neo-Darwinism through the (Specimens/slides/photographs) various examples. Study of different types of fossils, connecting links/transitional forms and Living fossils (Specimens/slides/photographs) To study the various evolutionary events in geological timescale through the (specimens/slides/photographs). Sampling of quantitative characters (continuous and discontinuous) in a population (height, weight, number of nodes etc).	**15**

Suggested readings

- Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2020). Biology. San Francisco, SF: Pearson Benjamin Cummings.
- Ridley, M. (2004). Evolution. III Edn. Blackwell Pub., Oxford.
- Hall, B. K., Hallgrimson, B. (2008) Strickberger's Evolution. IV Edn. Jones and Barlett.
- Zimmer, C., Emlen, D. J. (2013). Evolution: Making Sense of Life. Roberts & Co.
- Futuyma, D. (1998). Evolutionary Biology. III Edn. Sinauer Assoc. Inc.
- Barton, Briggs, Eisen, Goldstein and Patel. (2007). Evolution. Cold Spring Harbor Laboratory Press.
- k, M. (2017). Evolution, 4th Ed. Sinauer, Sunderland, MA: Sinauer Associates.

Semester IX

DISCIPLINE SPECIFIC COURSE (DSE) – PLANT PATHOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Plant Pathology	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: IX**
Subject: Botany		
Course: BOT DSE 12	**Course Title: Plant Pathology**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the general characteristics of plant pathogenic organisms including fungi, bacteria, viruses and mycoplasma.
2. Study the interactions between plant and pathogen in relation to the environment and mechanism of disease development by pathogens.
3. Understand the genetics of host parasite interaction.
4. Understand the various enzymes and toxins involved in disease development.
5. Study various important plant diseases, their disease cycle and control measures.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	A brief history of plant pathology in India Types of pathogens, symptoms of different plant diseases. **Inoculum:** Inoculum types, theory of inoculums, survival and longevity of inoculums, inoculums production, potential and density. **Plant microbe interaction:** molecular basis of host recognition, pathogenesis: pre-penetration, penetration and post penetration events, factors affecting disease development (host factors, environmental factors, virulence susceptibility). **Dissemination of pathogens:** Means of dissemination (active and passive dissemination). **Genetics and host parasite interaction:** Concept of compatibility and specificity, gene for gene relationship, genetics of resistance, source of resistance, inheritance of resistance in the host. **Enzymes and toxins:** Enzymes involved in disease development, toxins and their role in plant health.	**15**
2	**Disease resistance:** (i) Protection (structural, chemical, absence of nutrients and common antigens). **Defense** (histological defense, chemical- polyphenols, prohibitins, inhabitins, phytoalexins, lectins). **Genetic resistance:** resistant genes, biotechnological approaches for transfer of R- genes into susceptible plant. **Seed pathology:** Seed borne pathogens, mechanism of seed infections in field and during storage, transmission of pathogens through seeds, seed health testing methods, market disease of fruits and vegetables. **Disease control:** Cultural practices, chemical methods (insecticides, systemic and non-systemic chemical), biological control: Introduction, Biological control of insects and pests, use of resistance varieties and plant quarantine.	**15**
3	Brief account, structure, importance, disease cycle and control of the following diseases: (i)Damping-off, (ii) Wilt, (iii) Root rot, stem rot and fruit rot (iv) Mildews (powdery and downy), (v) Rusts, smuts, (vi) Leaf	**15**

	spots and leaf blights. General characteristics, importance, disease cycle and control of the following: (i) Bacterial disease, (ii) Viral disease, (iii) Mycoplasma disease.	
4	Study of various instruments used in Plant Pathology laboratory. Media preparation, isolation and culturing of plant pathogens Study of various fungal, bacterial and viral diseases - symptoms with the help of live or preserved specimens /digital resources. Study of causal organism with the help of temporary tease/section mounts.	**15**

Suggested readings

- Mehrotra, R. S. (2013). Plant Pathology. Tata Mc Grow Hill Publishing Co Ltd. New Delhi.
- Agrios, G.N. (2011). Plant Pathology. Elsevier.
- Bouarab, N. K., N. Bissow and F. Daayf. (2009). Molecular Plant Microbe Interactions.
- Mehrotra, R. S. and Agrawal, A. (2003). Plant Pathology. Tata Mc Grow Hill Publishing Co Ltd. New Delhi.
- Lucas, J.A. (1988). Plant Pathology and Plant Pathogens. Third edition. Blackwell.
- Singh, R. S. (1988). "Plant diseases". Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Singh R.S. (2018). Plant Diseases. 10th Edition Medtech, New Delhi.
- Sharma, P.D. (2014). Plant Pathology. Rastogi Publications, Meerut.

Semester IX

DISCIPLINE SPECIFIC COURSE (DSE) – Protected Agriculture – Hydroponics and Organic Cultivation

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Protected Agriculture: Hydroponics and Organic Cultivation	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: IX**
Subject: Botany		
Course: BOT DSE 13	**Course Title: Protected Agriculture: Hydroponics and Organic Cultivation**	

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand various aspects of hydroponics, aquaponics and organic cultivation.
2. Become economically self-reliant by growing and marketing organic herbs, vegetables, microgreens and fruits.
3. Gain practical training in establishing a hydroponic facility.
4. Understand good agricultural practices associated with protected agriculture.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Introduction to protected agriculture: Types of protected agriculture (hydroponics, aquaponics and organic farming), definition, history, terminology, importance and advantages over traditional agriculture, limitations and challenges.	**15**
2	Plant growth requirements : Physical parameters - light (quality and quantity) artificial light, light balancers; pH, conductivity, salinity (Dissolved Oxygen-DO, Total Dissolved Solid - TDS) and temperature; Chemical parameters- mineral nutrient requirements, deficiencies, toxicities, growth regulators (auxins, gibberellins, cytokinins and abscisic acids); Growth media- types, properties, uses, nutrient formula and preparation of solutions.	**15**
3	Hydroponic growing systems: Basic concepts and designs (closed and open systems techniques, Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket and other small-scale systems), systems layout. Strengths and weaknesses of various systems, site considerations, components and methods for nutrient delivery. Organic farming and its management: Organic farming and associated management practices. Marketing of the organic produce.Government institutes and policies related to protected farming. Pest and disease management.	**15**
4	Study of various instruments used in hydroponics. Preparation of growth media for hydroponics. Estimation of NPK, DO, TDS, pH of growing media. Demonstration of different irrigation techniques in hydroponics	**15**

Suggested readings

- Hasan, M., Sabir, N., Singh, A.K., Singh, M.C., Patel, N., Khanna, M., Rai, T., Pragnya, P. (2018). Hydroponics Technology for Horticultural Crops, Tech. Bull. TB-ICN 188/2018. Publ. by I.A.R.I., New Delhi-110012 INDIA.
- Misra S., Misra S., Misra R.L. (2017). Soilless Crop production. Daya Publishing House, Astral International (P) Ltd., New Delhi.
- Palaniappan S. P., Annadurai K. (2018). Organic Farming: Theory & Practice. Scientific Publisher. 5. Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (2019). Aquaponics Food Production Systems. Springer, Cham.
- Jones, J. B. (2014). Complete Guide for Growing Plants Hydroponically. CRC Press.
- Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming. Akta Prakashan, Nadiad.

Semester X

DISCIPLINE SPECIFIC ELECTIVE (DSE) – BIOINFORMATICS AND BIOSAFETY NORMS

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Bioinformatics and Bio-safety Norms	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: X**
Subject: Botany		
Course: BOT DSE 14	**Course Title: Bioinformatics and Biosafety Norms**	

Course outcomes: After the completion of the course the students will be able to

1. Understand the basics of bioinformatics and develop awareness of the interdisciplinary nature of this field.
2. Learn about biological databases, sequence retrieval, alignment, and phylogenetic analysis using various tools.
3. Understand the basic concept of Intellectual Property rights

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	**Topic**	**No. of Hours (60)**
1	Introduction to Bioinformatics Historical background; Aims and scope; Genomics, Transcriptomics, Proteomics, Metabolomics, Systems biology. Role of bioinformatics in drug discovery; Applications and Limitations of bioinformatics.	**15**
2	Biological databases Introduction to biological databases - Primary, secondary and composite databases; Study of following databases: NCBI (GenBank, PubChem, PubMed and BLAST; introduction to EMBL, DDBJ, UniProt, PDB and KEGG.	**15**
3	Basic concepts of Intellectual Property Rights (IPRs). The implications of the Intellectual Property Rights on the Convention on Biological Diversity (CBD).	**15**

4	Biological databases (NCBI, EMBL, UniProt, PDB) Literature retrieval from PubMed. Protein Structure retrieval from PDB (in pdb format) and visualisation by viewing tools (Ras Mol/ J mol/Mol*/Swiss 3D Viewer/Pymol).	**15**

Suggested readings

- Ghosh, Z., Mallick, B. (2008). Bioinformatics – Principles and Applications, 1st edition. New Delhi, Delhi: Oxford University Press.
- Baxevanis, A.D., Ouellette, B.F., John (2005). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd edition. New Jersey, U.S.: Wiley & Sons, Inc.
- Roy, D. (2009). Bioinformatics, 1st edition. New Delhi, Delhi: Narosa Publishing House.
- Andreas, D., Baxevanis, B.F., Francis, Ouellette. (2004). Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition. New Jersey, U.S.: John Wiley and Sons.
- Paroda. R.S. & R.K. Arora (1991). Plant Genetics Resources Conservation and Management concepts and approaches. New Delhi.
- Krattigar. F. Anatole. et al. (1994 Ed.) Widening Perspectives on Biodiversity. Dehradun.
- Yamin. F. (1995) The Biodiversity Conservation and Intellectual Property Rights. Switzerland.

Semester X

DISCIPLINE SPECIFIC ELECTIVE (DSE) – ADVANCES IN PLANT TAXONOMY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Advances in Plant Taxonomy	**4**	**4**	**0**	**0**	**Honours Degree in Botany**	**Nil**

MASTER OF SCIENCE IN BOTANY		
Programme : ***Master of Science in Botany***	**Year: V**	**Semester: X**
Subject: Botany		
Course: BOT DSE 15	**Course Title: Advances in Plant Taxonomy**	

Course outcomes: After the completion of the course the students will be able to

1. Understand the naming of the plant through plant nomenclature.
2. Learn the phylogeny and classification of angiosperms of system their use and utility.
3. Identify various angiosperms families with specific key characters.
4. Learn various advanced tools used to study plant taxonomy.
5. Understand the latest molecular techniques used in plant taxonomy.
6. Explore the impact of bioinformatics on plant classification.
7. Study the role of phylogenetic analysis in plant taxonomy.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	**Topic**	**No. of Hours (60)**
1	History of different systems of classification (introduction only). Important systems- Bentham and Hooker, Hutchinson, A. Takhtajan, A. Cronquist, Robert Thorne, Angiosperm Phylogeny Group (APG IV) classification. A brief account of major contributions made by the following taxonomists: C. Linnaeus, J.D. Hooker, William Roxburgh and Duthie., International Code of Nomenclature (ICN) for Algae, Fungi, and Plants.	**15**
2	Taxonomic tools, histological, cytological, phytochemical, serological, biochemical, and molecular techniques. Relevance of taxonomy to conservation. Modern techniques in plant taxonomy including: molecular phylogenetic, DNA Bar Coding, DNA extraction, amplification, sequencing and Digital herbarium data base (Access Digital Herbarium Data Base) Search for records of your plant species and related taxa.	**15**

	Compare your specimens with digital records. Use of Electrophoresis, PCR, HPLC and other instruments useful in molecular taxonomy, Operational Taxonomic Unit (OTU) and OTU Clustering.	
3	Some important families: Magnoliaceae, Myrtaceae, Scrophulariaceae, Acanthaceae, Verbenaceae, Amaranthaceae, Cannabaceae, Moraceae, Orchidaceae, Zingiberaceae, Cyperaceae, Poaceae. Update the plant nomenclature with different website (Plants of the World Online (PWO) Kew Science, Global Biodiversity Information Facility (GBIF) International Plant Nomenclature Index (IPNI), Tropicos), e-flora.	**15**
4	To study the vegetation type(s) and flora(s) of different areas in the local areas, and training in collection and preservation. To study the molecular techniques used in plant taxonomy. To study the advanced tools used in plant taxonomy	**15**

Suggested readings

- Kochhar S.L. (2016). Economic Botany. Cambridge University Press, London.
- Angiosperm Phylogeny Group (APG-2016). An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
- Saxena, N.B. and Saxena, S. (2012). Plant Taxonomy. Pragati Prakashan.
- Sambamurty A.V.S.S. (2010). Taxonomy of Angiosperms. I.K. International Pvt. Ltd.
- Singh, G. (2010). Plant Systematics. CBS PUB• & DIST PVT Limited INDIA. Sharma,O.P. (2009). Plant Taxonomy. Tata McGraw-Hill Publishing Company Limited, New Delhi.
- Gaur R.D. (1999). Flora of District Garhwal, N.W. Himalaya Transmedia, Srinagar Garhwal.
- Bhattacharya B. and B.M. Joshi. (1998). Flowering plants. Taxonomy and phylogeny Norsa publishing house New Delhi.

- Heywood V.H. and D.M. Moore. (1984). Current concept in plant taxonomy. Systematic special volume 25. London.
- Davis P.H. and Heywood V.H. (1973). Principles of angiosperms taxonomy. Robert E. Kreign Pub. Co. New York.
- Heywood V.H. (1970). Plant taxonomy London.
- Bensen L. (1957). Plant Classification reprint. Oxford & IBH N. Delhi.
- Lawrence G.H.M. (1951). Taxonomy of vascular plants. Mac Millan N.York.

Semester X

DISCIPLINE SPECIFIC ELECTIVE (DSE) – PLANT BREEDING

No. of Hours- 60

CREDITDISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Plant Breeding	**04**	4	0	0	**Bachelor of Science in Botany**	**Nil**

MASTERS OF SCIENCE IN BOTANY		
Programme : ***Masters of science in Botany***	**Year: V**	**Semester: X**
Subject: Botany		
Course: BOT DSE 16	**Course Title: Plant Breeding**	

Course Outcomes:

After the completion of the course the students will be able to:

Understand the principles of plant breeding, including its important achievements and undesirable consequences of plant breeding.
Understand the process of hybridization, advantages and limitations.
Understand the plant breeding systems and heterosis and role of mutation in plant breeding.

Credits: 4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: Asper Univ. rules**

Unit	Topic	No. of Hours (60)
1	Plant breeding: Introduction and objectives; breeding systems, important achievements and undesirable consequences of plant breeding); methods of crop improvement; centres of origin and domestication of crop plants, plant genetic resources, acclimatization; selection methods	**15**
2	Hybridization: for self-pollinated, cross-pollinated and vegetatively propagated plants–procedure, advantages and limitations; Inbreeding depression and heterosis (history, genetic basis and applications). Crop improvement and breeding (role of mutations; polyploidy; distant hybridization and biotechnology in crop improvement).	**15**
3	Effects of aneuploidy on plant phenotypes; Transmission of monosomics and trisomics and their uses, Chromosome mapping of diploid and polyploidy species, evolution of major crop plants (wheat and rice).	**15**
4	Introduction to plant breeding techniques: handling and maintenance of breeding populations, Study of pollination mechanisms in self-pollinated and cross-pollinated crops, Selection methods: Demonstration of pure-line selection and mass selection methods. Study of polyploidy and its effects on plant morphology using prepared slides/specimens, Chromosome analysis: Karyotyping and chromosome mapping in diploid and polyploid species.	**15**

Suggested readings

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