FOUR YEAR UNDER GRADUATE (FYUG) PROGRAMME

UNDER NATIONAL EDUCATION POLICY 2020

BOTANY

NORTH-EASTERN HILL UNIVERSITY

SHILLONG

Preface:

The four-year undergraduate program (FYUP) in Botany offers a comprehensive curriculum covering a wide array of topics essential for understanding plant biology and its interdisciplinary applications. Students begin with fundamental courses on plant diversity, delving into the biology of the different taxonomic groups which will form the basis of understanding the ensuing aspects of plant biology laid out in the curriculum. The course content encompasses fundamental concepts in plant anatomy, morphology, physiology, and ecology, equipping students with a strong foundation in Plant Sciences. Through hands-on laboratory experiments and fieldwork, students will gain understanding into the practical aspects of plant biology such as ecology, taxonomy, genetics, development and biotechnology. With a carefully modulated blend of theoretical learning and hands-on practical exposure, graduates of the FYUP will be equipped to emerge as skilled plant biologists prepared to address the different challenges of plant ecology, agriculture, environmental sustainability, and biotechnological innovations.

Programme Outcomes (POs):

1. Students will gain an understanding of the biology of different plant taxonomic groups and their major classification systems.

2. Students will be acquainted with the economic importance of selected plants, their parts used, their characteristics, cultivation methods and processing.

3. Students will gain fundamental understanding of the biology of bacteria, viruses and fungi and their applications.

4. Students will gain awareness of plant biodiversity richness, its value and strategies for conservation and sustainable utilisation of biodiversity wealth.

5. Students will be introduced to principles of plant function, such as physiology, metabolism, biochemistry, and growth and development.

6. The course will familiarise students of the complex interrelationship between plants and environment; plant community patterns and processes, and ecosystem functions.

7. Students will gain comprehensive understanding of cell biology, molecular biology, genetics and plant breeding.

8. Students will be acquainted with biotechnological interventions in plant biology and gain understanding of the applications of plant biotechnology.

9. Students will acquire knowledge of biofertilizers, their types and the different methods of preparation.

10. Students will be able to conduct research in the field of Plant Sciences and demonstrate integrity, objectivity, and accountability in research, management and decision-making.

1st Semester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BOT-100	Plant Diversity I: Algae, Bryophytes and Pteridophytes (Major)	3	1	4	75
BOT-100	(Minor)	3	1	4	75
MDC-110----119	Any of the available course as notified by the University from time to time.	3	-	3	45
AEC-120----129	Any of the available course as notified by the University from time to time	3	-	3	45
SEC-130----139	Any of the available course as notified by the University from time to time	3	-	3	45
VAC-140	Environmental Sciences	3	-	3	45
Total		**18**	**2**	**20**	**330**

2nd Semester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BOT-150	Plant Diversity II: Gymnosperms and Paleobotany, Angiosperm Morphology, Plant Anatomy (Major)	3	1	4	75
BOT-150	(Minor)	3	1	4	75
MDC-160---169	Any of the available course as notified by the University from time to time	3	-	3	45
AEC-170---179	Any of the available course as notified by the University from time to time	3	-	3	45
SEC-180---189	Any of the available course as notified by the University from time to time	3	-	3	45
VAC-190---199	Any of the available course as notified by the University from time to time	3	-	3	45
Total		**18**	**2**	**20**	**330**

BOT – Botany; MDC – Multi Disciplinary Course; AEC – Ability Enhancement Course; SEC – Skill Enhancement Course; VAC – Value Added Course; VTC – Vocational Education and Training Course

3rd Semester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BOT-200	Economic Botany and Ethnobotany and Phytogeography (Major)	3	1	4	75
BOT-201	Angiosperm Taxonomy (Major)	3	1	4	75
MDC-210---219	Any of the available course as notified by the University from time to time	3	-	3	45
AEC-220---229	Any of the available course as notified by the University from time to time	2	-	2	30
SEC-230---239	Any of the available course as notified by the University from time to time	3	-	3	45
VTC-240---249	Any of the available course as notified by the University from time to time	1	3	4	105
Total		**15**	**5**	**20**	**375**

4th Semester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BOT-250	Mycology and Plant Pathology (Major)	3	1	4	75
BOT-251	Microbiology (Major)	3	1	4	75
BOT-252	Reproductive Biology of Angiosperms (Major)	3	1	4	75
BOT-253	Biodiversity and Conservation Biology (Major)	3	1	4	75
VTC-260---269	Any of the available course as notified by the University from time to time	1	3	4	105
Total		**13**	**7**	**20**	**405**

5th Semester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BOT-300	Plant Physiology (Major)	3	1	4	75
BOT-301	Plant Biochemistry (Major)	3	1	4	75
BOT-302	Plant Ecology (Major)	3	1	4	75
BOT-302	Angiosperm Taxonomy, Ecology and Economic Botany (Minor)	3	1	4	75
BOT-303	Internship	-	4	4	120
	Total	**12**	**8**	**20**	**420**

6th Semester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BOT-350	Genetics and Plant Breeding (Major)	3	1	4	75
BOT-351	Molecular Biology (Major)	3	1	4	75
BOT-352	Plant Stress biology (Major)	3	1	4	75
BOT-353	Plant Biotechnology (Major)	3	1	4	75
VTC-360---369	Any of the available course as notified by the University from time to time	1	3	4	105
	Total	**13**	**7**	**20**	**405**

3rd SEMESTER

BOT-200 **Economic Botany, Ethnobotany and Phytogeography** **Total Credits: 4 (Contact Hours:75) Total Marks:100**

Course Objectives:
This course is designed to acquaint students with certain plants which provide resources to mankind.

- The course will familarise students with cultivation methods and processing of some economically important crops.
- It will also give an idea about various aspects of ethnobotany and phytogeography, with special emphasis to India.

Learning Outcomes:
On completion of the course, students are expected to:

- Have knowledge of various categories of economically important plants.
- Learn about cultivation and processing of rubber and tea.
- Identify teak and sal, with their distinguishing characters and method of cultivation.
- Understand the concept of ethnobotany and the relation between plants and indigenous communities, with emphasis on ethnobotany of North-Eastern India.
- Understand traditional knowledge and legal aspects of it.
- Understand the basic concepts of phytogeography and mechanism of plant distribution.

(Theory) **Credits: 3 (Contact Hours:45)**

Unit 1.

1. Vavilov's centers of origin of cultivated plants.
2. Study of economically important plants – cereals, pulses, oil yielding, spices, condiments, fibres, ornamentals and aromatic (with scientific names, families and parts used of at least three plants under each category).
3. Economic importance, cultivation and processing of tea and rubber.
4. Wood characteristics, cultivation and uses of timber-yielding plants (Teak and Sal); economic importance, cultivation and processing of aromatic (*Cymbopogon* spp) and medicinal plants (*Rauwolfia* spp).

Unit 2.

1. Ethnobotany and traditional knowledge; study of at least five ethnobotanical plants from each of the following categories: folk medicine, wild edibles used by the tribes of Northeast India.
2. Biopiracy and Intellectual Property Rights.

Unit 3.

1. Floristic regions of India.
2. Continuous and discontinuous plant distribution (definitions, types); theories of discontinuous plant distribution in India.
3. Plant endemism
4. Plant migration: definition and mechanism; barriers to plant migration.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours:30)

1. Qualitative detection of starch, protein, fat and cellulose in plant materials by chemical tests.
2. Study of at least ten economically important plant parts and plant products prescribed in syllabus.
3. Submission of ten specimens each of economically and ethnobotanically important plants/plants produce.
4. Identifying characters and economic/ conservational importance of at least three endemic plant species of Meghalaya (based on field observation/ specimens/ illustrations)

Suggested readings:

1. Bhattacharya, K., Ghosh, A. and Hait, G. 2020. A Textbook of Botany: Vol IV. New Central Book Agency, Kolkata.
2. Hill, A.F. 2012. Economic Botany: A Textbook of Useful Plants and Plant Products. 2nd edition. Surjeet Publications.
3. Jain, S.K. 1981. Glimpses of Indian Ethnobotany. Oxford IBH, New Delhi.
4. Jain, S.K. 1987. A Manual of Ethnobotany. Scientific Publishers, Jodhpur.
5. Jain, S.K. and Mundgal, V. 1999. Handbook of Ethnobotany. Bishen Singh Mahendra Pal Singh, Dehradun.
6. Kochar, S.L. 2016. Economic Botany : A Comprehensive Study. 5th edition. Cambridge English.
7. Negi, S.S. 2004. Handbook of Forest Ecology and Biology. International book distributors, Dehradun.
8. Puri, G.S. 1990. Forest Ecology. Oxford IBH, New Delhi
9. Santra, S.C., Chatterjee, T.P. and Das, A.P. 2012. College Botany- Practical. Volume 2. New Central Book Agency.
10. Sen, S. 2016. Economic Botany. New Central Book Agency.
11. Singh, V., Pande, P.C. and Jain, D.K. 2018. Economic Botany. 3rd revised edition. Rastogi Publications, Meerut.

BOT-201 **Angiosperm Taxonomy** **Total Credits: 4**
(Contact Hours:75)
Total Marks:100

Course Objectives:

- This course is designed to acquaint students with the concept and principles of plant systematics, major systems of classification and the distinctive characteristic features of certain important monocot and dicot families.

Learning Outcomes:

On completion of the course, students are expected to:

- Acquire a concept on plant systematics, different taxa and understand their positions in taxonomic hierarchy and know the major systems of plant classification.
- Ability to classify and describe plants in scientific terms and identification of plants using taxonomic keys.
- Have the required knowledge on collection and preservation of plant specimens through herbarium technique.

(Theory) **Credits: 3**
(Contact Hours: 45)

Unit 1.

1. Introduction to systematics – plant identification, classification and nomenclature.
2. Concept of taxa (family, genus, species); categories and taxonomic hierarchy.
3. Types of taxonomic keys: single access (dichotomous) and multi-access.

Unit 2.

1. Major systems of classification – artificial (Linnaeus), natural (Bentham and Hooker), phylogenetic (Hutchinson) and APG system.
2. I.C.N. – principles of botanical nomenclature, types and typification, rules and limitations of principles of priority. Nomenclature of cultivated plants.
3. Herbarium: methods of preparation of herbarium specimens (sheets, dried specimens, illustrations and bottled specimens); importance of herbarium, important herbaria of India.

Unit 3.

1. Distinguishing features and economic importance of the following dicotyledonous families: Ranunculaceae, Fabaceae, Asteraceae and Solanaceae.
2. Distinguishing features and economic importance of the following monocotyledonous families: Liliaceae, Orchidaceae and Poaceae.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Taxonomic studies of plants belonging to both dicot and monocot families mentioned in the theory paper 201: flower dissection, drawing and description in technical terms and identification of the plant specimen up-to genus.
2. Techniques of preparation of herbarium sheets of flowering plants and submission of at-least 5 herbarium sheets of different taxa.
3. Preparation of taxonomic keys based on own observation of at least three species of the same genus.
4. One field study of relevance to the course content and submission of field report.

Suggested readings:

1. Bendre, A.M. and Kumar, A. 2019. A Textbook of Practical Botany-2. Rastogi Publications, Shivaji Road, Meerut, India.
2. Bhattacharya, K., Ghosh, A. and Hait, G. 2013. A Textbook of Botany. Vol II. New Central Book Agency, Kolkata.
3. Datta S.C. 2018. Systematic Botany. New Age International Private Limited.
4. Gupta, R.K. 1989. Textbook of Systematic Botany. Atma Ram & Sons, Delhi.
5. Jain, S.K. and Rao, R.R. 2016. Handbook of Field and Herbarium Methods. Today and Tomorrow's Printers and Publishers, New Delhi.
6. Jeffrey, C. 1982. An Introduction of Plant Taxonomy. Cambridge University Press, Cambridge.
7. Mitra, D., Guha, J. and Chaudhury, S.K. 2018. Studies in Botany. Vol I. Moulik Library, Kolkatta.
8. Naik, V.N. 2014. Taxonomy of Angiosperms. Tata McGraw-Hill.
9. Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row, New York.
10. Shankar, U. 2021. Enumeration of the Flora of Northeast India - Onelist of over 10,000 taxa of flowering plants. Arshuma Famous Books, Agra, India.
11. Singh, G. 2018. Plant Systematics: Theory & Practice. 3rd edition. Oxford & IBH Pvt Ltd., New Delhi.
12. Sinha, S.K. 2014. A Textbook of Plant Taxonomy. Anmol Publications Pvt. Ltd. Delhi.

4th SEMESTER

BOT-250 **Mycology and Plant Pathology** **Total Credits: 4**
(Contact Hours:75)
Total Marks:100

Course Objectives:
This course id designed to

- Familiarize the students with habitats, classification, structure, life cycle and evolutionary trends of Fungi and about the ecological significance of Fungi and Lichen.
- To acquaint with various plant diseases, causal organisms and their control.

Learning Outcomes:
On completion of this course, the students will be able to:

- Identify, collect and preserve different types of fungi and lichen.
- Develop a basic understanding about the structure and life cycle of fungi and lichens.
- Identify diseases in crop plants and measures for their prevention and control.

(Theory) **Credits: 3**
(Contact Hours: 45)

Unit 1.

1. General features of fungi, classification of fungi by Ainsworth (1973) and Hawksworth (1995).
2. Range of vegetative structure and reproduction in fungi.
3. Types of fungal spores and mode of their liberation.
4. Economic importance of fungi.

Unit 2.

1. General characteristics of Mastigomycotina, Ascomycotina, Basiodiomycotina and Deuteromycotina.
2. Life cycle of *Phytophthora, Rhizopus, Erysiphe, Agaricus, Fusarium.*
3. Lichens: general characteristics, growth forms and range of thallus organization; economic importance of lichens.

Unit 3.

1. Terms and concepts, general symptoms and geographical distribution of diseases; diagnosis, prevention and control of plant diseases; plant quarantine measures.
2. Symptoms, diagnosis and disease cycles of:
   a. Early blight of potato, White rust of crucifers and Black stem rust of wheat.
   b. Citrus canker, Angular leaf spot disease of cotton.
   c. Tobacco Mosaic disease, Vein clearing in Malvaceae.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Study of the vegetative and reproductive parts of the specimens prescribed in unit II with the help of temporary preparations and permanent slides: sectioning, drawing, description, identification and classification of the specimens.
2. Study of diseased specimens prescribed in unit III by temporary preparations and permanent slides.
3. Collection, identification and submission of at least 5 diseased plant specimens.

Suggested readings:

1. Agrios, G.N. 2005. Plant Pathology. 5th edition. Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. 1996. Introductory Mycology. John Wiley &Sons (Asia) Singapore. 4th edition.
3. Dube, H.C. 2022. An Introduction to Fungi. 4th revised edition. Scientific Publishers, India.
4. Mehrotra, R. S. 2011. Plant Pathology. Tata McGraw-Hill Publishing Company Limited, New Delhi.
5. Mehrotra, R. S. and Aggrawal, A. 2017. Plant Pathology. 3rd edition. Tata McGraw-Hill Publishing Company Limited, New Delhi.
6. Mishra, B. K. 2017. Mycology and Phytopathology. Kalynai Publishers, New Delhi.
7. Sethi, I.K. and Walia, S.K. 2011. Text book of Fungi and Their Allies. Macmillan Publishers India Ltd.
8. Sharma, P. D. 2017. Mycology and Phytopathology. Rastogi Publication, Meerut.
9. Sharma, P.D. 2016. Plant Pathology. 2nd edition. Rastogi Publication, Meerut, India.
10. Webster, J. and Weber, R. 2007. Introduction to Fungi. 3rd edition. Cambridge University Press, Cambridge.

BOT-251 **Microbiology** **Total Credits: 4**
(Contact Hours:75)
Total Marks:100

Course Objectives:

- To provide the basic knowledge about the microbial world and various microbial techniques for microbial study.
- To gain understanding of bacteria and viruses, their morphology, classification, ultrastructure, reproduction and importance.
- To provide basic information of the different applications of microorganisms.

Learning Outcomes:

On completion of this course, the students will be able to:

- Understand the concepts of basic microbiological techniques.
- Understand in detail, about structure, classification and importance of bacteria and viruses.
- Gain knowledge about application of microorganisms in different fields.

(Theory) **Credits: 3**
(Contact Hours: 45)

Unit 1.

1. Microscopy: principles and applications of bright field microscopy.
2. Ultra-structure of a bacterial cell; gram positive and gram-negative cell wall.
3. Basic concepts of Archaea, Mycoplasma and Cyanobacteria.
4. Bacterial reproduction (asexual and sexual methods).

Unit 2.

1. Discovery and classification of viruses (Baltimore system).
2. General structure and symmetry of virus; structure of T_4 and TMV.
3. Replication of virus (general account): lytic and lysogenic cycles.
4. Economic importance of viruses with brief reference to vaccine production.

Unit 3.

1. Microbial nutrition (nutritional requirements, nutritional types) and growth (growth characteristics, monoauxic growth- batch-culture).
2. Role of microorganisms in nitrogen fixation and decomposition of organic matter.
3. Basic concepts of food spoilage, food poisoning and food preservation.
4. Antibiotics: sourcse, types and mode of action.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Studies on microbiological techniques: sterilization (dry and moist heat), preparation of different types of culture media – plates (nutrient agar medium / potato dextrose agar) and their inoculation by soil inoculum.
2. Preparation of slant, stad and pouring of plate.
3. Calibration of microscope and measurement of microbial spores (fungal/bacterial).
4. Study of gram positive and gram negative bacteria (curd and leguminous root nodules) by Gram staining technique.
5. Demonstration of fungal or bacterial population density calculation (Yeast / spores) using haemocytometer.

Suggested readings:

1. Anathanarayan, R., Paniker, C.K. J. (Kanugo, R and Saxena, S. eds.). 2022. Text Book of Microbiology. Orient and Longman, New Delhi.
2. Dubey, R.C. and Maheshwari, D.K. 2013. Text book of Microbiology. 4th edition. S. Chand & Company Ltd., New Delhi.
3. Frazier, W.C., Wasthoff, D.C and Vanitha, N.M. 2017. Food Microbiology. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
4. Gray N F. 2004. Biology of Wastewater Treatment. 2nd edition. Imperial College Press, London.
5. Patel, A.H. 2011. Industrial Microbiology. Laxmi Publications.
6. Pelczer, M. J. and Chan, E.C.S. and Krieg, NR. 2023. Elements of Microbiology. 5th edition. Affiliated East West Press Private Limited New Delhi.
7. Prescott, L.M., Harley, J.P. & Klein, D.A. 2008. Microbiology. Mac Graw Hill Higher Education.
8. Ramesh, Vijaya. 2019. Environmental Microbiology. MJP Publisher.
9. Sharma, P.D. 2020. Microbiology. 4th edition. Rastogi Publication, Meerut.
10. Singh, R.P. 2020. Microbiology. Kalyani Publishers.
11. Stainer, RY, Ingraham, JL, Wheelis, ML., and Painter, PR. 2000. General Microbiology. The Macmillan Press Ltd.
12. Subba Rao, N.S. 1999. Soil microorganisms and plant growth. 2nd edition. Science Publishers, U.S.

BOT-252 **Reproductive Biology of Angiosperms** **Total Credits: 4**
(Contact Hours:75)
Total Marks:100

Course Objectives:

- To provide knowledge of the basic concepts in plant morphogenesis, embryology and organ development, in both monocot and dicot plants.

Learning Outcomes:

On completion of this course, the students will be able to:

- Comprehend developmental processes in plants, including the processes of fertilization, embryogenesis and seed development.
- Understand the complete life cycle of an angiopsermic plant.
- Appreciate the interactions between the developmental pathways resulting in the differentiation of plant body.

(Theory) **Credits: 3**
(Contact Hours: 45)

Unit 1.

1. Anther: anther wall (structure and functions), microsporogenesis, callose deposition and its significance. Microgametogenesis; pollen wall, pollenkitt.
2. Pollen morphology; palynology and its scope.
3. Ovule: general structure; special structures–endothelium, obturator, aril, caruncle and hypostase; female gametophyte: megasporogenesis (monosporic, bisporic and tetrasporic)
4. Megagametogenesis (details of polygonum type); organisation and ultrastructure of mature embryo sac.

Unit 2.

1. Fertilization: structure of stigma and style; path of pollen tube in pistil; double fertilisation.
2. Self incompatibility: basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); physiological and biochemical basis of self incompatibility; methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination, intraovarian and in vitro pollination, modification of stigma surface, parasexual hybridization.
3. Endosperm: types, development, structure and functions; endosperm haustoria.
4. Embryo: general pattern of development of dicot and monocot embryo; suspensor: structure and functions.

Unit 3.

1. Seed: structure and development, classification.
2. Polyembryony: introduction, classification, causes and applications.
3. Apomixis: categories, types, causes and practical importance.
4. Pollen allergy: diagnosis and management.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Preparation of slides using acetolysis method and study of pollen morphology.
2. Studies on pollen germination in Brewbaker and Kwack's medium.
3. Ovule: types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; tenuinucellate and crassinucellate. (permanent slides/specimens/photographs).
4. Endosperm: dissections of developing seeds for endosperm with free-nuclear haustoria.
5. Embryogenesis: study of development of dicot embryo through permanent slides; dissection of developingseeds for embryos at various developmental stages.

Suggested readings:

1. Bhattacharya K, Majumdar M.R. and Bhattacharya, S. 2006. A textbook of Palynology. New Central Book Agency Pvt Ltd, Kolkata.
2. Bhojwani, S.S. and Bhatnagar, S.P. 2011. The Embryology of Angiosperms. Vikas Publishing House. Delhi. 5th edition.
3. Johri, B M. 2011. Embryology of Angiosperms. Springer Verlag, Berlin.
4. Maheshwari, P. 2020. An introduction to embryology of Angiosperms. Tata McGraw Hill, New Delhi.
5. Pandey, A. K. 2000. Introduction to Embryology of Angiosperms. CBS Publishers and Distributors, New Delhi.
6. Pulliah, I., Laksminarayana, K. and Rao, H. 2019. Plant Reproduction. 2nd edition. Scientific Publishers, Jodhpur.
7. Raghavan, V. 1999. Development Biology of Flowering Plants. Springer, New Delhi.
8. Raghavan, V. 2000. Developmental Biology of Flowering Plants. Springer, Netherlands.
9. Shivanna, K.R. and Rangaswami, N.S. 1993. Pollen Biolog:, A Laboratory Manual. Narosa Publishing House, New Delhi.
10. Shivanna, K.R. 2003. Pollen Biology and Biotechnology. CRC press.

BOT-253 Biodiversity and Conservation Biology Total Credits: 4
(Contact Hours:75)
Total Marks:100

Course Objectives:

- Insights to biodiversity and global ecological crisis, sustainable development and pros and cons of human intervention.
- To appreciate and recognise the need to conserve biodiversity.
- Address environmental issues related to biodiversity.
- Importance of various conservation strategies, laws and regulatory authorities.
- Create social awareness in biodiversity conservation and sustainable utilisation of bioresources

Learning Outcomes:

On completion of this course, the students will be able to:

- Understand biodiversity and it's value to mankind.
- Assess the value of biodiversity wealth of our state and nation.
- Analyze various threats to our biodiversity and able to suggest measures for conservation strategies.
- Contribute in creating social awareness on the need for sustainable utilization of biodiversity.

(Theory) Credits: 3
(Contact Hours: 45)

Unit 1.

1. Concepts of biodiversity: genetic diversity, species diversity, ecosystem diversity.
2. Value of biodiversity- intrinsic, consumptive, productive use, social, ethical, aesthetic and option values. Utilitarian values of biodiversity- goods, services and information.
3. Biodiversity at global, national and local levels. India as a mega diversity nation.

Unit 2.

1. Hotspots of biodiversity, criteria for determining hot spots, biodiveristy hot spots in India: Himalayas, Indo Burma, Sundaland and Western Ghats and Sri Lanka.
2. Threats to biodiversity; species extinction: extinction process, mass extinctions; endangered and endemic plant species of India. IUCN Red data book and red list.
3. Conservation of biodiversity- *in-situ* conservation: protected area network, biosphere reserves, national parks, sanctuaries, sacred groves. *Ex situ* conservation: gene banks, botanical gardens, bio-parks, seed bank, cryopreservation.

Unit 3.

1. Biodiversity policy and legislation: Indian biodiversity act 2002, Biodiversity rules 2006, Access and beneifeit sharing guidelines.
2. Conservation practices in India and world, organizations involved in resource conservation: IUCN, WWF, UNEP, UNESCO, Biodiversity International, IPGRI, FAO, BSI.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Field Survey for studying plant species diversity (gymnosperm and angiosperm) in any locality.
2. To prepare an inventory of threatened plants of your campus and its vicinity.
3. One seminar presentation on topics relevant to unit 1, 2, 3.
4. A report based on a visit to National Park/ Wildlife Sanctuary/ Biodiversity Park or any other wildlife conservation site.

Suggested readings:

1. Fiedler P.L and Kareiva, P.M. 1997. Conservation Biology. Chapman and Hall International Thompson Publishing.USA.
2. Gabriel M. 2000. Biodiversity and Conservation. Oxford and IBH publishing company Pvt Ltd. New Delhi.
3. Krishnamoorthy, K.V. 2004. An Advanced Text Book on Biodiversity- Principles and Practice. Oxford and IBH publishing company Pvt. Ltd., New Delhi.
4. Krishnamurthy, K.V. 2003. Text book on Biodiversity. Science Publishers, New Hampshare.
5. Kumar, U. and Sharma, A.K. 2008. Plant Biotechnology and Biodiversity Conservation. Agrobios, India.
6. Leveque, C. and Mounolou, J. 2003. Biodiversity. New York: John Wiley.
7. Negi, S.S. 2002. Biodiversity and its Conservation in India. Indus Publishing Company.
8. Pal, D. K. 2019. Ecosystem Services and Tropical Soils of India. Springer.
9. Primack, R.B. 2014. Essentials of Conservation Biology. 6th edition. OUP, USA.
10. Shankar, U. 2021. Enumeration of the Flora of Northeast India - Onelist of over 10,000 taxa of flowering plants. Arshuma Famous Books, Agra, India.
11. Sharma P.D. 2003. Ecology and Environmental Sciences. Rastogi Publications, Meerut, India.
12. Swaminathan, M.N. & Jain, R.S. 1982. Biodiversity: Implications for Global Security. Macmillan.
13. Trivedi, P. C. 2007. Global Biodiversity Status and Conservation. Pointer publishers, Jaipur India.
14. Wilson E.D. 2001. Diversity of Life. Penguin Books Ltd.

5th SEMESTER

BOT-300 **Plant Physiology** **Total Credits: 4**
(Contact Hours:75)
Total Marks:100

Course Objectives:

- The course aims to give students a greater appreciation of the plant world we depend on and to stimulate student learning of basic concepts in plant and biological science.
- This course provides an introduction to basic principles of plant function, primarily covering physical processes in plants, metabolism, and introducing principles of growth and development.

Learning Outcomes:

After completing this course, students should be able to:

- Correlate morphology, anatomy, cell structure and biochemistry with plant functioning.
- Describe how cell, tissue and whole-plant structures are related to their function.
- Explain the uptake and utilisation of nutrients in plants.
- Describe how plants synthesise and use energy.
- Understand how hormones control plant growth and development.
- Explain the fixation and metabolism of nitrogen in plants.
- Apply the knowledge of physiological aspects of flowering and seed dormancy in practical field.
- Apply knowledge of physiological processes in plants to new research on how plants function and are used by humans.

(Theory) **Credits: 3**
(Contact Hours: 45)

Unit 1.

1. Water relations in plants: concepts of diffusion, imbibition, osmosis (endosmosis, exosmosis and osmotic pressure), plasmolysis. Water potential and its components. Concepts of symplast, apoplast and transmembrane movement of water.
2. Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal transpiration- starch-sugar hypothesis, proton transport theory.
3. Macro- and micronutrients, criteria for essentiality, Functions and deficiency symptoms of macro elements- N, P, K, Ca and Mg. Functions and deficiency symptoms of micronutrients-Zn, Mn, B and Cu. Hydroponics and its applications.
4. Mechanism of mineral salt absorption: passive absorption – diffusion, facilitated diffusion, ion exchange. Active absorption- types and mechanism: cytochrome pump theory, protein lecithin theory.

Unit 2.

1. Photosynthesis: photosynthetic pigments, absorption spectrum and action spectrum, red drop and Emerson's effect, photosystems I and II, photosynthetic electron transport chain-cyclic and non-cyclic, photolysis of water. C_3, C_4 and CAM pathway. Blackman's law of limiting factors.
2. Respiration: respiratory substrates and respiratory quotient. Mechanism of aerobic respiration – glycolysis, Krebs cycle and electron transport chain.
3. Photorespiration: mechanism and significance.
4. Mechanism of biological nitrogen fixation: requirements for nitrogen fixation, nitrogenase enzyme complex (components and function), pathway of nitrogen fixation in symbiotic and non-

symbiotic systems; ammonia assimilation- GDH and GS-GOGAT system.

Unit 3.

1. Physiology of flowering: photoperiodism, concept of florigen, CO-FT model for long-distance transport of flowering stimulus, ABC model of flowering (in brief), vernalization.
2. Phytochrome: chemical nature and physiological role; cryptochrome.
3. Seed dormancy: causes and methods to overcome dormancy.
4. Physiological roles and commercial applications of auxins, gibberellins, cytokinins, abscisic acid, ethylene. Brief introduction to brassinosteroids, jasmonic acid, salicylic acid and strigolactones.

Unit 4. (Practical) Credit: 1
(Contact Hours: 30)

1. Determination of osmotic potential of plant cell sap by plasmolytic and gravimetric method.
2. Microscopic observation of different types of stomata in monocot and dicot plants.
3. Study of transpiration rate in dorsiventral leaves by Blackman's apparatus.
4. Separation of plant pigments by paper chromatography method.
5. Determination of effect of CO_2 concentration on photosynthesis by bubble count method.
6. Determination of RQ of germinating seeds using Ganong's respirometer.

Suggested readings:

1. Bhatla, S.C. and Lal, M.A. 2018. Plant Physiology: Development and Metabolism. Springer Nature, Singapore Pvt. Ltd.
2. Devlin, R.M. 2017. Outline of Plant Physiology. Scientific International.
3. Ghosh, A., Hait, G. and Bhattacharya, K. 2015. A Textbook of Botany: Vol III. New Central Book Agency, Kolkata.
4. Jain V.K. 2017. Fundamentals of Plant Physiology. S Chand Publishers.
5. Jain, J. L., Jain, S. and Jain, N. 2020. Fundamentals Of Biochemistry. S. Chand & Co Ltd., India.
6. Mitra, D., Guha, J. and Chaudhury, S.K. 2000. Studies in Botany Vol II. Moulik Library, Kolkata.
7. Mukherjee, S. and Ghosh, A.K. 2009. Plant Physiology. 3rd edition. New Central Book Agency.
8. Nelson, D. L. and Cox, M. M. 2012. Lehninger Principles of Biochemistry. 6th edition. W.H. Freeman and Co. Publishers.
9. Pandey, S.N. and Sinha, B.K. 2001. Plant Physiology. 3rd edition. Vikas Publishing House Pvt. Ltd, New Delhi.
10. Salisbury, F.B and Ross, C.W. 2006. Plant Physiology. 3rd edition. CBS Publishers and Printers, New Delhi.
11. Taiz, L. and Zeiger, E. 2002. Plant Physiology. Sinauer Associates, USA.
12. Verma, S.K. 2013. Text book of Plant Physiology and Biochemistry. S. Chand & Company, New Delhi.

BOT-301 **Plant Biochemistry** **Total Credits: 4**
(Contact Hours:75)
Total Marks:100

Course Objectives:

- To impart comprehensive knowledge on the fundamental concepts of Biochemistry.
- The course is aimed at achieving the main goal that students will be able to comprehend the scope and inter- relationships between the different topics to be transacted during theory classes. This will ensure that they will have a firm grasp of basic Biochemical Principles which will serve as a strong foundation for further learning in similar or related fields.

Learning Outcomes:

- The students will have gained comprehensive knowledge on basic molecular structure, properties and functions of nutrients, Bioenergetic considerations based upon the laws of Thermodynamics, Enzyme catalysis, basic mathematical concepts related to enzyme activity via Michaelis-Menten's Kinetics and its reciprocal form i.e., Lineweaver-Burke plots, Fundamentals of Chemiosmotic mechanism of ATP formation and secondary plant products.
- Students will have gained practical experience and developed foundational analytical skills by performing the varied collection of introductory level experiments designed to cover the breadth and depth of the Topics as prescribed in this paper.

(Theory) **Credits: 3**
(Contact Hours: 45)

Unit 1.

1. Chemical foundations of biochemistry: basic biochemical terms and their significance (molecular weight, equivalent weight, molarity, normality, pH, buffer solutions).
2. Structure, classification and function of carbohydrates, amino acids and lipids.
3. Levels of protein structure (primary, secondary, tertiary and quaternary).

Unit 2.

1. Laws of thermodynamics (-1, 0, 1, 2 & 3), biological energy transformation (Gibbs free energy, enthalpy and entropy, spontaneous and induced processes, reversible and irreversible processes).
2. Enzyme sructure and function (three-dimensional structure, active site, allosteric site) and IUBMB nomenclature and classification, cofactors and co-enzymes (with special reference to vitamins) and their functions.
3. Theories of mode of enzyme action (lock and key, induced fit hypothesis), mechanism of catalysis (activation energy; general acid-base, nucleophilic-electrophilic catalysis).
4. Michaelis-Menten kinetics (mathematical derivation of Michaelis-Menten constant and equation) and Lineweaver Burke plots.

Unit 3.

1. Redox potential and electrochemical gradient.
2. Ultra-structure of mitochondria; ATP-synthase: ultra-structure and function of the various components.
3. Mitchells chemiosmotic hypothesis, oxidative phosphorylation and production of ATP in mitochondria.
4. Secondary plant products: properties and functions of phenolics, anthocyanins and terpenoids.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Preparation of solutions (weight/volume, molar, normal).
2. Separation of amino acids, sugars and lipids by paper/thin layer chromatography.
3. Preparation of standard curve and estimation of unknown for:
   a. Starch by I_2-KI method.
   b. Soluble proteins by Lowry's method.
   c. Lipids by sodium dichromate method.
4. Study of acid phosphatase activity in plant material (effect of substrate concentration and temperature).

Suggested readings:

1. Atkins, Peter. 2010. The Laws of Thermodynamics-A Very Short Introduction. Oxford University Press.
2. Berg, J.M., Stryer, L., Tymoczko, J.L and Gatto, G.J. 2015. Biochemistry. 8th edition. W.H. Freeman & Co Ltd.
3. Berg, J.M., Tymoczko, J.L. and Stryer, L. 2011. Biochemistry. 5th edition. W.H. Freeman & Co.
4. Buchanan, B.B., Wilhelm, G. and Russel, J. 2003. Biochemistry and Molecular Biology of Plants. ASPB. US.
5. Jain, J. L., Jain, S. and Jain, N. 2020. Fundamentals Of Biochemistry. S. Chand & Co Ltd., India.
6. Mathews, C.K., Van Holde, K.E. & Ahern, K.G. 2000. Biochemistry. Macmillan Worth.
7. Monk, P. 2004. Physical Chemistry-Understanding our Chemical World. John Wiley & Sons Ltd, England.
8. Nelson, D.L. and Cox, M.M. 2017. Lehninger, Principles of Biochemistry. 7th edition. W.H. Freeman & Co.
9. Taiz, Lincoln and Zeiger, Eduardo. 2010. Plant Physiology. International edition. Sinauer Associates, USA.
10. Verma, S.K. 2013. Text book of Plant Physiology and Biochemistry. S. Chand& Company, New Delhi.
11. Voet, D.J., Voet, J.G. & Pratt, C.W. 2008. Principles of Biochemistry. John Wiley Inc.

BOT-302 **Plant Ecology (Major)** **Total Credits: 4 (Contact Hours:75) Total Marks:100**

Course Objectives:

- To introduce the students with the basic principles of ecology. The course also aims at making them understand complex community patterns and processes, and ecosystem functioning.

Learning Outcomes:

The course will familiarise the students

- With complex interrelationship between organisms and environment;
- Make them understand methods to studying vegetation, community patterns and processes and ecosystem functions.
- The knowledge is critical in evolving strategies for sustainable natural resource management and also for biodiversity conservation.

(Theory) **Credits: 3 (Contact Hours: 45)**

Unit 1.

1. Ecological factors: climatic (light, temperature, precipitation and fire), edaphic (soil formation process, soil types, soil texture, soil profile and soil organic matter), physiographic (slope and aspect of mountain) and biotic factors (living organisms in an ecosystem). Concept of limiting factors, Liebig's law of minimum, Shelford's law of tolerance.
2. Ecological levels of organization: organism, population, community, ecosystem, landscape, biome and biosphere.
3. Ecological adaptations: morphological and anatomical adaptations of hydrophytes, xerophytes, epiphytes and halophytes.

Unit 2.

1. Population ecology: attributes of plant populations: density, mortality, natality, survivorship curves, age structure, territoriality and population growth.
2. Population interactions: mutualism, commensalism, proto-cooperation, ammensalism, parasitism, predation and competition.
3. Community ecology: qualitative and quantitative attributes of community; ecological niche, ecotone and edge effect; community dynamics: primary and secondary succession, stages of succession; hydrosere and xerosere.

Unit 3.

1. Structural attributes of ecosystem: abiotic components (inorganic elements, organic compounds and climatic regimes) and biotic components (producers, macroconsumers and microconsumers).
2. Functional attributes of ecosystem: flow of energy: energy flow models (box and pipe model and Y channel model), concepts of productivity, food chain and food web.
3. Biogeochemical cycles: hydrological cycle, gaseous cycle (carbon) and sedimentary cycle (phosphorus).

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Determination of pH of soil samples of various sites using pH meter.
2. Determination of soil organic matter content of different soil samples by Walkley and Black's rapid titration method.
3. Determination of requisite size and requisite number of quadrats for the study of a plant community.
4. Determination of frequency, density and abundance by quadrat method.
5. Study of morphological and anatomical features of xerophytes, hydrophytes and epiphytes.

Suggested readings:

1. Ambasht, R.S. and Ambasht, N.K. 2023. A Text Book of Plant Ecology. 16th edition. CBS Publishers and Distributors, New Delhi.
2. Begon, M. and Harper, J.L. 2000. Essentials of Ecology. Blackwell Publishing.
3. Begon, M. Townsend, C.R. and Harper, J.L. 2006. Ecology from Individuals to Ecosystem. 4th edition. Blackwell Publishers.
4. Dash, M.C. 2001. Fundamentals of Ecology. 2nd edition. McGraw hill Companies.
5. Hill, M.K. 2020. Understanding Environmental Pollution. 4th edition. Cambridge University Press, Cambridge.
6. Koromondy, E.J. 2017. Concepts of Ecology. 4th edition. Pearson Education.
7. Misra, K.C. 1988. Manual of Plant Ecology. 3rd edition. Oxford and IBH Publishing Co. New Delhi.
8. Mitra, D., Guha, J. and Chaudhury, S.K. 2000. Studies of Botany. Vol II. Moulik Library, Kolkata.
9. Mohapatra, A.C., Barik, S.K. and Rao, C.S. 2000. Man and Environment. Star Publ. House, Shillong.
10. Molles, M.C. 2015. Ecology – Concepts and Applications. 7th edition. McGraw Hill Education.
11. Odum, E.P. 2017. Fundamentals of Ecology. 5th edition. Cengage India Private Limited.
12. Sharma, P.D. 2013. Ecology and Environment. Rastogi Publishers.
13. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand publishing, Delhi.
14. Tiwari, S.C. 2005. Concepts of Modern Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.
15. Weaver, J.E. and Clements, F.E. 1986. Plant Ecology. 2nd edition. Tata McGraw, New Delhi.

BOT-302 **Angiosperm Taxonomy, Ecology and Economic Botany (Minor)** **Total Credits: 4 (Contact Hours:75) Total Marks:100**

Course Objectives:

- This course is designed to familiarize students with the concept and principles of plant taxonomy and basic concepts of ecology; also, to acquaint students with certain plants which provide resources to mankind.

Learning Outcomes:

On completion of the course, students are expected to:

- Acquire a concept on plant systematics, different taxa and understand their positions in taxonomic hierarchy and know the major systems of plant classification.
- Ability to classify and describe plants in scientific terms and identification of plants using taxonomic keys.
- Have the required knowledge on collection and preservation of plant specimens through herbarium techniques.
- Understand and interpret the complex interrelationship between organisms and environment; and to understand vegetation, community patterns and processes and ecosystem functions.
- Know certain categories of economically important plants, their characteristics, cultivation and processing.

(Theory) **Credits: 3 (Contact Hours: 45)**

Unit 1.

1. Artificial, natural and phylogenetic classification systems; outline of Bentham and Hooker's system of classification.
2. Plant nomenclature: ICN, principles of nomenclature; herbaria: collection, preparation and functions.
3. Distinguishing features and economic importance of Ranunculaceae, Fabaceae, Asteraceae, Poaceae and Orchidaceae.

Unit 2.

1. Basic concepts of ecology; ecological factors: climatic, edaphic, biotic and physiographic; ecological adaptations; positive and negative population interactions.
2. Ecological succession; ecosystem structure: biotic components.
3. Functional attributes of ecosystem: primary productivity; flow of energy, food chains and food webs, ecological pyramids.

Unit 3.

1. Economically important cereals, pulses, spices, condiments, fiber yielding plants (scientific names and families of at least three plants of each category and the parts used).
2. Vavilov's centers of origin of cultivated plants.
3. Cultivation and processing of tea and rubber; cultivation and processing of aromatic (*Citronella)* and medicinal plants (*Cinchona*); wood characteristics and uses of timber yielding plants (Teak, Sal).

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Taxonomic studies of angiosperm plants belonging to families mentioned in unit-1 of paper Bot-302 by flower dissection, drawing and description in technical language, and identification up to genera.
2. Qualitative detection of starch, protein, fat and cellulose in plant materials by chemical tests.
3. Study of economically important plants or plant products prescribed in Paper 302.
4. Techniques for preparation of herbarium sheets of flowering plants and submission of at least 5 herbarium sheets.

Suggested readings:

1. Ambasht, R.S. and Ambasht, N.K. 2011. A Text Book of Plant Ecology. 15th edition. CBS Publishers and Distributors, New Delhi.
2. Bhattacharya, K., Ghosh, A. and Hait, G. 2013. A Textbook of Botany: Vol II. New Central Book Agency, Kolkata.
3. Dash, M.C. 2001. Fundamentals of Ecology. 2nd edition. McGraw Hill Companies
4. Gupta, R.K. 2006. Textbook of Systematic Botany. 7th edition. CBS.
5. Hill, A.F. 2003. Economic Botany: A Textbook of Useful Plants and Plant Products. Textbook Publishers
6. Koromondy, E.J. 2017. Concepts of Ecology. 4th edition. Pearson Education.
7. Misra, K.C. 1988. Manual of Plant Ecology. 3rd edition. Oxford and IBH Publishing Co. New Delhi.
8. Mitra, D., Guha, J. and Chaudhury, S.K. 2000. Studies in Botany. Vol I. Moulik Library, Kolkatta.
9. Mitra, D., Guha, J. and Chaudhury, S.K. 2000. Studies of Botany, Vol II. Moulik Library, Kolkat
10. Naik, V.N. 2014. Taxonomy of Angiosperms. Tata McGraw-Hill.
11. Odum, E.P. 1971. Fundamentals of Ecology. 3rd edition. W.B. Saunders co., Philadelphia.
12. Pandey, B. P. 2009. Economic Botany. 5th edition. S Chand & Company.
13. Sen, S. 2016. Economic Botany. New Central Book Agency.
14. Sharma, P.D. 2013. Ecology and Environment. Rastogi Publishers.
15. Singh, G. 2018. Plant Systematics: Theory & Practice. 3rd Edition. Oxford & IBH Pvt Ltd., New Delhi.
16. Singh, V., Pande, P.C. and Jain, D.K. 2018. Economic Botany. 3rd revised edition. Rastogi Publications, Meerut.
17. Sinha, S.K. 2014. A Textbook of Plant Taxonomy. Anmol Publications Pvt. Ltd., Delhi.
18. Tiwari, S.C. 2005. Concepts of Modern Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.

BOT-303 **Internship** **Total Credits: 4**
(Contact Hours:120)
Total Marks:100

Course Objectives:

- To provide a learning opportunity at the field/experiment level.
- To provide opportunity to understand various researches going on Plant Sciences.
- To equip them with technical skills as future researchers.

Learning Outcomes:

On completion of the course, students will be able to:

- Experience working on different plants and microbes.
- Learn practical application of plants and microbes.
- Learn from the field and experiments the importance of plants and microbes.

Sl. No.	Evaluation of Interns	Marks Distribution	Credits
1.	Field Work/ Experiments (at least 72 hours)	50	2
2.	Internship Report	25	1
3.	Presentation and Viva	25	1
	Total	**100**	**4**

Suggested readings on Internship:

1. Aniket Singh. (2018). The complete book of internships in India: Intern abroad this summer. Notion Press, Incorporated.
2. Woodard, E. (2015). The ultimate guide to internships: 100 steps to get a great internship and thrive in it. Allworth Press.
3. McLachlan, J. E., & Hess, P. F. (2015). Get an internship and make the most of it: Practical information for high school and community college students. Rowman & Littlefield Publishers.
4. Green, M. E. (1997). Internship success: Real-world, step-by-step advice on getting the most out of internships. VGM Career Horizons.
5. Khoury, R. J., & Selby, J. (2021). How to intern successfully: Insights and actions to optimize your experience. Waterside Productions.
6. Shindell, R. (2019). Total internship management supervisor's handbook: A manager's guide to delivering an amazing internship experience. Intern Bridge, Incorporated.
7. Labor, S. L. (2020). Student internship success workbook (Supervisor's guide): 20+ Lessons and activities for student intern career readiness. Independently published.

6th SEMESTER

BOT-350 **Genetics and Plant Breeding** **Total Credits: 4**
(Contact Hours:75)
Total Marks:100

Course Objectives:

- To develop understanding on mechanism of cell division and organisation of genetic material.
- To impart knowledge on genetic basis of inheritance.
- To develop an understanding of chromosomal abnormalities and sex chromosomes.
- To gain an awareness of plant breeding and crop improvement.

Learning Outcomes:

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

- Cell cycle and its regulation in eukaryotes.
- Organisation and inheritance of hereditary material.
- Principles of Mendelian genetics, their deviations and the evolution and inheritance of sex chromosomes.
- Chromosomal aberrations and their genetic significance.
- Principles of crop breeding and crop improvement in self- and cross-pollinated plants.

(Theory) **Credits: 3**
(Contact Hours: 45)

Unit 1.

1. Eukaryotic cell cycle - G1, S, G2 and M phase; mechanism of meiosis (stages, chromosome pairing, chiasma formation, recombination, synaptonemal complex). Cell cycle checkpoints, positive and negative regulation of cell cycle.
2. Eukaryotic chromosome: morphology and ultrastructure; Polytene and Lampbrush chromosomes; chromosomal theory of inheritance and sex-linked inheritance.
3. Extra-nuclear inheritance: inheritance of plastid genes in *Mirabilis jalapa* and cytoplasmic male sterility in plants.

Unit 2.

1. Mendelian genetics - laws of inheritance; multiple alleles (ABO blood group and self incompatibility in plants); deviations from Mendelism: incomplete dominance and co-dominance, complementary gene interaction, supplementary gene interaction, epistasis (dominant and recessive) and duplicate genes; linkage and crossing over.
2. Mechanisms of sex determination: environmental, chromosomal and genetical.
3. Chromosomal aberrations in plants: structural (deletion, duplication, inversion and translocation) and numerical (aneuploidy and euploidy).

Unit 3.

1. Principles of crop improvement: domestication, introduction, hybridisation and artificial selection; pure line selection and mass selection.
2. Hybrid varieties: methods of development, merits, demerits and achievements. Breeding in asexually propagated crops: clonal selection.
3. Heterosis and inbreeding depression. Gene mutation; mutation breeding and its application in crop improvement.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Study and identification of mitotic stages in onion root tips.
2. Study and identification of meiotic stages in flower buds.
3. Study of monohybrid and dihybrid ratios and their modifications by using Chi square test of significance.
4. Numerical exercises on linkage and crossing over.
5. Emasculation, bagging, tagging and pollination techniques in self-pollinated and cross-pollinated plants.

Suggested readings:

1. Acquaah, G. 2020. Principles of Plant Genetics and Breeding. 3rd edition. Wiley-Blackwell.
2. Brown, T. 2012. Introduction to Genetics - A Molecular Approach. Taylor and Francis.
3. Gardner, E.J., Simmons, M.J. and Snustad, D.P. 2002. Principles of Genetics. 8th edition. John Wiley & Sons Inc.
4. Griffiths, Anthony J.F., Doebley, J. and Peichel, C. 2020. Introduction to Genetic Analysis. W.H. Freeman.
5. Gupta, P.K. 2014. Genetics. Rastogi Publications, Meerut.
6. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. 2018. Lewin's genes XII. Jones and Barlett.
7. Lodish, H., Berk, A., Matsudaira, P., Kaiser, C.A., Krieger, M., Scott, M.P., Zipursky, L. and Darnell, J. 2004. Molecular Cell Biology. W.H. Freeman.
8. Singh, B.D. 2022. Plant Breeding: Principles and Methods. 12th edition. MedTech Science Press.
9. Singh. B.D. 2022. Fundamental of Genetics. Medtech Science Press, New Delhi.
10. Snustad, D.P. and Simmons M.J. 2015. Principles of Genetics. John Wiley and Sons.
11. Strickberger, M.W. 2015. Genetics. Pearson Education India.
12. Verma, P.S. and Agarwal, V.K. 2016. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand and Co., New Delhi.

BOT-351 **Molecular Biology** **Total Credits: 4**
(Contact Hours:75)
Total Marks:100

Course Objectives:

- To develop an understanding of nucleic acids and their respective structural conformations.
- Students will be able to gain fundamental knowledge of gene concept and organisation of genes.
- Students will be equipped to understand the three fundamental aspects of molecular biology: Replication, Transcription and Translation; and the processes involved.

Learning Outcomes:

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

- Understand nucleic acid structure, organisation and replication.
- Understand gene structure and mechanisms of gene expression.
- Understand protein synthesis, protein modifications and trafficking.
- Practice hands-on skills in fundamental molecular biology techniques.

(Theory) **Credits: 3**
(Contact Hours: 45)

Unit 1.

1. DNA as the carrier of genetic information (Griffith's, McLeod and McCarty experiment).
2. Chemistry of nucleic acids - structure of purines and pyrimidines; properties of nitrogenous bases and nucleotides; structure and properties of DNA and its A, B and Z conformations.
3. Structure and properties of RNA - mRNA and t-RNA.
4. Chemistry of DNA synthesis (Kornberg's discovery); semi-conservative model of DNA replication, enzymes involved in DNA replication.

Unit 2.

1. Modern concept of gene - cistron, recon and muton.
2. General features of gene organisation in prokaryotes and eukaryotes; organisation of a typical eukaryotic gene - exons, introns, regulatory sequences, promoter, enhancer.
3. Mechanism of transcription in prokaryotes; gene regulation in prokaryotes - *lac* operon and *trp* operon in *E. coli*.
4. mRNA processing: mRNA splicing, group I and group II intron splicing, alternative splicing, 5'cap, 3'polyA tail.

Unit 3.

1. Ribosome structure and assembly; genetic code: ambiguity, degeneracy and universality of genetic code, wobble hypothesis.
2. Protein synthesis: charging of t-RNA, mechanisms of initiation, elongation and termination of polypeptides in prokaryotes.
3. Post-translational modification of proteins: acetylation; phosphorylation; ubiquitination; methylation; glycosylation.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Isolation of DNA from common plants using CTAB method.
2. Agarose gel electrophoresis of DNA.
3. Quantification of nucleic acids and estimation of nucleic acid purity by UV-VIS spectrophotometry.
4. Estimation of soluble protein from plant tissues by Bradford's assay.

Suggested readings:

1. Brown, T. 2012. Introduction to Genetics - A Molecular Approach. Taylor and Francis.
2. Griffiths, Anthony J.F., Doebley. J. and Peichel, C. 2020. Introduction to Genetic Analysis. W.H. Freeman.
3. Klug, W.S., Cummings, M.R, Spencer, C.A., Palladino, M.A. and Killian, D.J. 2019. Concepts of Genetics. 12th edition. Pearson.
4. Krebs, J.E., Goldstein, E.S.and Kilpatrick, S.T. 2017. Lewin's Genes XII. 12th edition. Jones & Bartlett Learning.
5. Lodish, H., Berk, A., Matsudaira, P., Kaiser, C.A., Krieger, M., Scott, M.P., Zipursky, L. and Darnell, J. 2004. Molecular Cell Biology. W.H. Freeman.
6. Malacinski, G.M. 2015. Freifelder's Essentials of Molecular Biology. 4th edition. Jones & Bartlett Student edition, Viva Publisher.
7. Snustad, D.P. and Simmons, M.J. 2015. Principles of Genetics. John Wiley and Sons.

BOT-352 **Plant Stress Biology** **Total Credits: 4**
(Contact Hours:75)
Total Marks:100

Course Objectives:

- Provide students with understanding of plant stress and and its causes.
- Provide an understanding of plant response and acclimation to stresses.
- Students will also learn about the stress-sensing mechanisms in plants and their adaptations to stress.

Learning Outcomes:

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

- Understand plant responses to stress and the mechanisms involved.
- Learn stress sensing mechanisms and role of bio-molecules in plant stress responses.
- Understand the principles of crop improvement programmes for combating stress.
- Acquire basic experimental skills for study of plant stress biology.

(Theory) **Credits: 3**
(Contact Hours: 45)

Unit 1.

1. Plant responses to stress: water, light, high temperature, chilling, heavy metal and salt; interaction between biotic and abiotic stress.
2. Mechanisms of stress resistance: draught, water, high temperature and chilling; role of membrane lipids in temperature stress tolerance, heat-shock proteins.

Unit 2.

1. Stress sensing mechanisms - calcium modulation, phospholipid signaling, productions and scavenging of reactive oxygen species (ROS).
2. Plant-pathogen interaction - genetics and zig-zag model; roles of pathogenesis-related (PR) proteins, hypersensitive response (HR); systemic acquired resistance (SAR): events associated with establishment of SAR, SAR activators, SAR genes.

Unit 3.

1. Hormone regulation of stress responses - roles of Abscisic acid, Salicylic acid and Jasmonic acid in plant stress responses; roles of enzymes SOD, CAT, APX and GPX in plant stress responses.
2. Basic principles of crop improvement programmes under stress.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Comparative study of plants/seedlings subjected to different degrees of drought, light and heat stress by estimation of proline.
2. To study the effect of salt and heavy metal stress on seed germination and seedling growth of any two plants.
3. Estimation of superoxide dismutase (SOD), catalase (CAT) and peroxidase (POD) activity in plant seedlings in the presence and absence of stress.

Suggested readings:

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. (eds). 2000. Biochemistry & Molecular Biology of Plants. 2nd ed.. Wiley Blackwell, U.K.
2. Dwivedi, P. and Dwivedi, R.S. 2005. Physiology of abotic stress in plants. Agrobios, India.
3. Hopkins, W.G. and Huner, A. 2008. Introduction to Plant Physiology. 4th edition. John Wiley and Sons, U.S.A.
4. Panda, S.K. 2002. Advances in Stress Physiology of Plants. Scientific Publishers, Jodhpur.
5. Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A. 2018. Plant Physiology and Development. International 6th edition. Sinauer Oxford University Press.

BOT-353 **Plant Biotechnology** **Total Credits: 4**
(Contact Hours: 75)
Total Marks:100

Course Objectives:

- To understand the fundamental aspects of plant tissue culture.
- Students will be equipped to gain fundamental understanding of techniques applied in plants for the production of transgenics.
- To understand the role of biotechnology in production of GM crops.
- Gain an understanding of biosafety and bioethics in plant biotechnology.

Learning Outcomes:

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

- Gain fundamental understanding of plant tissue culture techniques and their applications in plant biotechnology.
- Understand the different techniques for production of GM crops.
- Gain an understanding of biosafety and bioethics.
- Practice hands-on skills in fundamental techniques of plant biotechnology.

(Theory) **Credits: 3**
(Contact Hours: 45)

Unit 1.

1. Totipotency, organogenesis and embryogenesis.
2. Tissue culture media: composition and types of media. Callus culture, single cell culture, suspension culture and their significance.
3. Organ culture: meristem, embryo and anther culture; production of haploid plants and their significance.
4. Somatic hybridization: protoplast isolation, fusion and culture, identification and selection of hybrid cells; somaclonal variation; somatic embryogenesis, artificial seeds and their cryopreservation.

Unit 2.

1. Concept of gene cloning: tools and techniques.
2. Cloning vectors - plasmids, viral vectors, cosmids and bacteriophage.
3. Analysis of transgenic plants for the presence, integration and expression of transgenes; gene silencing in transgenic plants.

Unit 3.

1. Achievements in plant biotechnology (production of GM crops, metabolites, medicines and edible vaccines).
2. Concerns about GM crops: environmental, biosafety and ethical issues.
3. Applications of plant biotechnology in phytoremediation, climate-resilient agriculture and bio-fuel production.

Unit 4. **(Practical)** **Credit: 1**
(Contact Hours: 30)

1. Preparation of Murashige and Skoog medium for tissue culture.
2. Initiation of callus culture of carrot root tissue.
3. Initiation of anther culture for haploid production.
4. Isolation of protoplasts from leaves by enzymatic method.

Suggested readings:

1. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K. and Walter, P. 2022. Molecular Biology of The Cell. 7th edition. W.W. Norton & Company.
2. Bhojwani, S.S. and Razdan, M.K. 2003. Plant Tissue Culture: Theory and Practice. Elsevier.
3. Brown, T.A. 2020. Gene Cloning and DNA Analysis: An Introduction. 8th edition. Wiley Blackwell.
4. Griffiths, A.J.F., Doebley, J., Peichel, C. and Wassarman, D.A. 2020. Introduction to Genetic Analysis. 12th edition. WH Freeman & Co.
5. Howe, C. 2015. Gene Cloning and Manipulation. Cambridge University Press.
6. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. 2017. Lewin's Genes XII. 12th edition. Jones & Bartlett Learning.
7. Malacinski, G.M. 2015. Freifelder's Essentials of Molecular Biology. 4th edition. Jones & Bartlett student edition, Viva Publisher.
8. Prasad, B.K. 2016. Outline of Plant Biotechnology. Kalyani Publishers.
9. Slater, A., Scott, N.W. and Fowler, M.R. 2008. Plant biotechnology: the genetic manipulation of plants. 2nd edition. Oxford.
10. Snustad, D.P. and Simmons, M.J. 2015. Principles of Genetics. 7th edition. Wiley.
11. Strickberger, M.W. 2015. Genetics. Pearson Education India.
12. Tamarin, R.H. 2017. Principles of Genetics. 7th edition. McGraw Hill.
13. Watson, J., Baker, T., Bell, S., Gann, A., Levine, M. and Losick, R. 2013. Molecular Biology of the Gene. 7th edition. Pearson.