SYLLABUS

Under Graduate Course (UG) CBCS

(As per National Education Policy-2020)

B.Sc. PART-I (2025-26) (SEMESTER I & II)

B.Sc. PART-II (2026-27) (SEMESTER III & IV)

B.Sc. PART-III (2027-28) (SEMESTER V & VI)

Department of Botany

JAI NARAIN VYAS UNIVERSITY JODHPUR

Preamble

The bachelor's degree program in Botany aims to provide a comprehensive learning environment that fosters cognitive development and critical thinking skills of students. The program intends to equip students with the latest subject matter, both theoretical and practical, to enhance their core competency and facilitate discovery learning. The curriculum also aims to mould responsible citizens who are aware of domain-independent knowledge, including communication and critical thinking, and enable graduates to prepare for national and international competitive examinations.

Upon graduation, students would acquire core competencies in Botany and related areas, including the ability to identify major plant groups and compare their characteristics, understand the genetic diversity of organisms, explain various plant processes, and demonstrate experimental techniques in their specialization. Additionally, the program intends to develop analytical abilities and critical thinking skills in students to address practical problems effectively. Graduates would also possess digital skills, ethical and moral values, and psychological strengths to become team players and independent learners.

The program aims to critically evaluate ideas and arguments, identify problems, and propose solutions using creative approaches acquired through interdisciplinary experiences. Graduates would accurately interpret collected information and use taxonomical information to evaluate and formulate a plant's position in taxonomy. They would also apply the scientific method to questions in botany, present scientific hypotheses and data, and access primary literature to evaluate scientific content. Graduates would be able to apply mathematical tools and physical principles to analyze biological situations, identify major groups of organisms, and explain ecological interconnectedness. Finally, graduates would demonstrate proficiency in experimental techniques and methods of analysis in their specialization within biology.

The University Grant Commission (UGC) has recommended the implementation of the NEP 2020 to standardize teaching practices among universities and facilitate students' mobility across institutions by considering credits. The credit-based semester system provides flexibility in designing curricula and assigning credits based on course content and teaching hours. Under this system, students can choose courses, learn at their own pace, take additional courses, and earn more credits than required, promoting interdisciplinary learning. The syllabus includes a semester-wise course distribution, detailed course outlines, and suggested reading materials.

Aims of the Program

1. To foster a dialogue about plants and their significance in a holistic environment, rather than focusing solely on theoretical aspects through didactic monologues.
2. To equip students with the latest theoretical and practical subject matter in order to foster core competency and discovery learning, allowing graduates to pursue further discipline-specific studies or begin domain-related employment.
3. To develop responsible citizens who possess domain-independent knowledge, including critical thinking and communication skills.
4. To prepare graduates for national and international competitive examinations, including UGC-CSIR NET and Civil Services Examination.

Program Outcomes (PO)

Core Competency:

1. Students will be able to identify major groups of plants and compare the characteristics of lower (e.g., algae and fungi) and higher (angiosperms and gymnosperms) plants.
2. Students will be able to explain the evolution of organisms using the evidence-based comparative botany approach and understand genetic diversity on earth. They will also be able to explain various plant processes and functions, metabolism, concepts of gene and genome, and how an organism's function is influenced at the cell, tissue, and organ level.
3. Students will be able to understand the adaptation, development, and behaviour of different life forms and trace the energy pyramids through nutrient flow on earth.
4. Students will be able to demonstrate experimental techniques and methods in their area of specialization in botany.

Analytical Ability:

Students will be able to apply scientific methods to address different questions by formulating hypotheses, collecting data, and critically analyzing the data to decipher the degree to which their scientific work supports their hypothesis.

1. Critical Thinking and Problem-Solving Ability:
   Students will increase their understanding of fundamental concepts and their applications of scientific principles. They will become critical thinkers and acquire problem-solving capabilities.
2. Digital Skills:
   Students will acquire digital skills and integrate fundamental concepts with modern tools.
3. Ethical and Psychological Strengthening:
   Students will strengthen their ethical and moral values and be able to deal with psychological weaknesses.
4. Teamwork:
   Students will learn teamwork skills in order to efficiently serve institutions, industry, and society.
5. Independent Learning:
   The program outcome will lead to students gaining knowledge and skills for further higher studies, competitive examinations, and employment, in addition to generic skills, especially in botany. Learning outcomes-based curriculum would ensure equal academic standards across the country and a broader picture of their competencies.

Program Specific Outcomes (PSOs)

The program aims to provide a comprehensive education in plant biology that encompasses both traditional and modern approaches. It seeks to equip learners with an in-depth understanding of plants and their diversity, as well as their importance for human welfare and economic value. This program is primarily aimed to introduce students to the richness of plant diversity found in surrounding areas. The curriculum comprises practical sessions and interactions that will aid learners in acquiring practical experience and enhancing their analytical abilities.

PSO1: Students will have an in-depth understanding of the fundamental principles of botany, including plant morphology, anatomy, physiology, ecology, cytology, and genetics; as well as

advanced aspects, including plant biotechnology and molecular biology.

PSO2: Student will be able to understand diversity of plants and microbes, their morphology, architecture, reproduction, and habitat.

PSO3: Students will gain hands-on experience on plant identification, species distribution, and ecological surveys, and develop an appreciation for the diversity and complexity of natural systems.

PSO4: Students will develop a scientific aptitude and critical thinking skills, including the ability to analyze, evaluate, and synthesize scientific information, and to apply scientific knowledge to solve real-world problems.

PSO5: Students will develop effective oral and written communication skills, including the ability to present scientific data, write scientific reports, and communicate scientific concepts to both scientific and non-scientific audiences.

PSO6: Students will be prepared for lifelong learning, including continuing education, professional development, and the pursuit of advanced degrees in botany or related fields.

Discipline Course Outcome (COs)

Introduction: The program aims to provide a comprehensive education in plant biology that encompasses both traditional and modern approaches. It seeks to equip learners with an in-depth understanding of plants and their diversity, as well as their importance for human welfare and economic value. This course is primarily aimed to introduce students to the richness of plant diversity found in surrounding areas. The curriculum comprises practical sessions and interactions that will aid learners in acquiring practical experience and enhancing their analytical abilities. The subject-specific outcomes will be the following-

1. Students will be able to understand the diversity of plants and microbes, their morphology, architecture, reproduction, and habitat.
2. Students will be able to comprehend the various types of plants and their characteristics, as well as their interactions with other organisms in their environment.
3. In addition, the program also focuses on the study of microbes that cause plant diseases, their symptoms, and methods of control. This will assist students in recognizing how diseases can harm plants and how to prevent or manage them.
4. Finally, the course also addresses the economic value of plants and their role in human welfare. Students will gain knowledge about how plants can be utilized for food, medicine, fuel, and other purposes, and how these applications contribute to sustainable development.

Jai Narain Vyas University, Jodhpur
Department of Botany
(NEP -2020)
B.Sc. Three Year Degree

Discipline wise Minimum Credit Required for three-degree program						
Course	**Credit**					
	Year I		**Year II**		**Year III**	
	I	**II**	**III**	**IV**	**V**	**VI**
Discipline Centric Core Course (DCC)	6 (4T+2P)	6 (4T+2P)	6 (4T+2P)	6 (4T+2P)	-	-
Discipline Specific Elective Course (DSE) interdisciplinary	-	-	-	-	6 (4T+2P)	6 (4T+2P)
Discipline Specific Elective Course (DSE) interdisciplinary					6 (4T+2P)	6 (4T+2P)
Discipline Specific Elective Course (DSE) interdisciplinary					6 (4T+2P)	6 (4T+2P)
Discipline Centric Core Course (DCC) (Other than Botany)	6 (4T+2P)	6 (4T+2P)	6 (4T+2P)	6 (4T+2P)		
Discipline Centric Core Course (DCC) (Other than Botany)	6 (4T+2P)	6 (4T+2P)	6 (4T+2P)	6 (4T+2P)		
Ability Enhancement Course EC Eng/ Hin	2					
Ability Enhancement Course EC Env		2				
Skill Enhancement Course SEC	2	2	2	2	2	2
Total Credit	22	22	20	20	20	20
additional summer training course /vocational course						

Discipline Centric Core Course (Botany):

Year 1	**Eligibility: 10+2 from any recognized Board with Biology** **Prerequisite: Subject in 10+2 Class**						
Course	**SEM**	**Level**	**Code**	**Course Nomenclature**	**Credit**		
					T	**P**	**Total**
DCC	**I**	**5**	**DCCBOT5001T**	**Algae, Fungi, Microbes and Plant Pathology**	**4**		**6**
		5	**DCCBOT5001P**	**Practical for Algae, Fungi, Microbes and Plant Pathology**		**2**	
DCC	**II**	**5**	**DCCBOT5002T**	**Bryophytes, Pteridophytes Gymnosperms and Palaeobotany**	**4**		**6**
		5	**DCCBOT5002P**	**Practical for Bryophytes, Pteridophytes Gymnosperms and Palaeobotany**		**2**	
Year 2	**Prerequisite: Subject in Level 5**						
Course	**SEM**	**Level**	**Code**	**Course Nomenclature**	**Credit**		
					T	**P**	**Total**
DCC	**III**	**6**	DCCBOT6001T	Anatomy, taxonomy and embryology, of angiosperm and Cell biology, genetics of plants	**4**		**6**
		6	DCCBOT6001P	Practical for Anatomy and taxonomy of angiosperm and Cell biology, genetics of plants		**2**	
DCC	**IV**	**6**	DCCBOT6002T	Ecology, Physiology and Biotechnology of plant	**4**		**6**
		6	DCCBOT6002P	Practical for Ecology, Physiology and Biotechnology of plant		**2**	

Discipline Specific Elective

Course	SEM	Level	Code	Course Name	Credit
DSE-I	V	7	DSEBOT7101T	Economic Botany and Ethnobotany	4
			DSEBOT7101P	Practical for Economic Botany and Ethnobotany	2
DSE -II			DSEBOT7102T	Reproductive biology of flowering plant	4
			DSEBOT7102P	Practical for Reproductive biology	2
DSE-III			DSEBOT7103T	Development al Biology of Angiosperms: Form, Anatomy & Function	4
			DSEBOT7103P	Practical for Development al Biology of Angiosperms: Form, Anatomy & Function	2
DSE-IV			DSEBOT7104T	Applied Phycology	4
			DSEBOT7104P	Practical for Applied Phycology	2
DSE-V			DSEBOT7105T	Plant Systematics	4
			DSEBOT7105P	Practical for Plant Systematics	2
DSE-VI			DSEBOT7106T	Genetics, cytogenetics and Breeding of plants	4
			DSEBOT7106P	Practical for Genetics, cytogenetics and Breeding of plants	2
DSE-VII			DSEBOT7107T	Biostatistics and Bioinformatics	4
			DSEBOT7107P	Practical for Biostatistics and Bioinformatics	2
DSE-VIII			DSEBOT7108T	Plant Biotechnology	4
			DSEBOT7108P	Practical for Plant Biotechnology	2
DSE I	VI	7	DSEBOT7201T	Biochemistry and plant metabolism	4
			DSEBOT7201P	Practical for Biochemistry and	2
DSE II			DSEBOT7202T	Plant Molecular Biology	4
			DSEBOT7202P	Practical for Plant Molecular Biology	2
DSE III			DSEBOT7203T	Genetic Engineering	4
			DSEBOT7203P	Practical for Genetic	2

DSE IV			DSEBOT7204T	Genomics, Proteomics and	4
			DSEBOT7204P	Practical for Genomics,	2
DSE V			DSEBOT7205T	Advances in plant molecular	
			DSEBOT7205P	Practical for Advances in plant	
DSE VI			DSEBOT7206T	Desert Ecology and soil	
			DSEBOT7206P	Practical for Desert Ecology	
DSE VII			DSEBOT7207T	Environmental Monitoring and Ecosystem Restoration	
			DSEBOT7207P	Practical for Environmental	
DSE VIII			DSEBOT7208T	Plant Pathology	
			DSEBOT7208P	Practical for Plant Pathology	
DSE IX			DSEBOT7209T	Crop Genetics and Plant Breeding	
			DSEBOT7209P	Practical for Crop Genetics and Plant Breeding	
DSE X			DSEBOT7210T	Advanced Tools & Analytical Techniques in Plant Biology	
			DSEBOT7210P	Practical for Advanced Tools & Analytical Techniques in Plant Biology	
Dissertation /Project/ Field Work		7	DSE-BOT7601P	Dissertation /Project/ Field Work	2

Skill Enhancement Courses (SEC) Any one/ SEM with fulfilling prerequisites

SEMESTER	Skill Course Code	Skill Nomenclature	Credit
SEM I	SECBOT1011	Anatomy and micro-technique	2
	SECBOT1012	Ethnobotany	2
SEM II	SECBOT1021	Organic Farming	2
	SECBOT1022	Hydroponic and Aeroponic Farming	2
SEM III	SECBOT101	Herbal Technology	2
	SECBOT102	Molecular Technique	2
	SECBOT103	Nursery and Gardening	2
	SECBOT104	Conservation and Management of Biodiversity	2

SEM IV	SECBOT201	Advanced Tools and Techniques in Plant Biology	2
	SECBOT202	Micropropagation Technique	2
	SECBOT203	Biological Data Analysis Using Software	2
	SECBOT204	IPR (Intellectual Property Rights)	2
SEM V	SECBOT301	Nursery Gardening and Landscaping	2
	SECBOT302	Mushroom Culture and Technology	2
	SECBOT303	Horticulture	2
	SECBOT304	Plant Aromatics and Perfumery	2
	SECBOT305	Floriculture	2
	SECBOT306	Green Belt Development for Smart Cities	2
SEM VI	SECBOT401	Biofertilizers	2
	SECBOT402	Bioinoculants for Agriculture and Sustainable Development	2
	SECBOT403	Fruits and Vegetable Processing	2
	SECBOT404	Food Waste and By-Product Utilisation	2

Course Outcome (COs)

DCC-BOT5001T/P Algae, Fungi, Microbes and Plant Pathology

Course Objective:

1. To teach students the basic characteristics of algae, fungi, and microbes, including their morphology, classification, and life cycle.
2. To provide hands-on experience in the identification and study of algae, fungi, and microbes, as well as in the diagnosis and management of plant diseases.

Course outcome:

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

1. describe the diversity of algae, fungi, and microbes and their ecological roles in various environments.
2. understand the principles and methods of plant pathology, including the causes, symptoms, and control of plant diseases.
3. identify the algae, fungi, and microbes on the basis of their morphological characteristics.

DCCBOT5002T/P Bryophytes, Pteridophytes, Gymnosperms and Palaeobotany

Course Objective:

1. To teach students the basic characteristics of bryophytes, pteridophytes, and gymnosperms, and their economic importance.
2. To develop an understanding about the fossil plants, and their use in reconstructing plant evolutionary history.

Course outcome:

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

1. describe and identify the morphology, anatomy, reproduction, and life cycles of bryophytes, pteridophytes, and gymnosperms.
2. classify bryophytes, pteridophytes, and gymnosperms, and explain their economic and ecological significance.
3. analyze and interpret plant evolutionary history, using fossil plants.

DCC-BOT6001T/P Taxonomy, Embryology and Anatomy of Angiosperms and Cytology

Course Objective:

- To introduce students to the taxonomy and diversity of angiosperms,
- To provide students with an understanding of the anatomical and embryological structures of angiosperms, cell biology and genetics.

Course outcome:

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

1. classify angiosperms based on their morphological characteristics, using the principles and methods of plant taxonomy.
2. identify and describe the anatomical and embryological structures of angiosperms, including their developmental processes and functions.
3. understand the cytological processes in the plant cells and their regulation, including mitosis, meiosis, and chromosomal behaviour.
4. to understand the principles and practices of genetics and plant breeding, and their applications for crop improvement.

DCCBOT6002T/P Plant Physiology, Ecology and Biotechnology

Course Objective:

To provide students with an understanding of principles and processes of plant physiology, ecology, and biotechnology, and to cultivate an appreciation of their importance.

Course outcome:

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

1. describe the principles and processes of plant physiology, including plant growth and development, and metabolism.
2. understand the ecological relationships between plants and their biotic and abiotic environment, including plant community structure and ecosystem function.
3. understand the principles and applications of plant biotechnology, including genetic engineering, and tissue culture, to address problems in plant breeding, and agriculture.

SEMESTER I

DCCBOT5001T: Algae, Fungi, Microbes and Plant Pathology

Unit I

(12 hours)

General characters and classification of algae. Important features of Chlorophyceace, Charophyceae, Xanthophyceae, Phaeophyaceae, and Rhodophyceae. Structure and life history of *Volvox, Chara, Vaucheria, Ectocarpus and Polysiphonia*.

Unit II

(12 hours)

General characters and classification of Fungi. Important features of Mastigomycotina Zygomycotina, Ascomycotina, Basidiomycotina, and Deuteromycotina. Structure and life history of *Albugo, Rhizopus, Aspergillus, Agaricus, Puccinia* and *Alternaria.*

Unit III

(12 hours)

Morphology, anatomy and reproduction of Lichens. Brief account on *Parmelia* and *Usnea*. Mycorrhiza: ectomycorrhiza, endomycorrhiza and their significance. Economic and Ecological importance of Algae, Fungi and Lichen

Unit IV

(12 hours)

General characters, structure and multiplication of viruses. Structure of Tobacco mosaic virus (TMV) and Yellow Vein Mosaic Virus (YVMV). Transmission of plant viruses. Structure and replication of Bacteriophages. General account of Viroids and Prions. Bacteria: General characters, structure, nutrition, reproduction and economic importance of Bacteria. Cyanobacteria–Important features and Life history of Nostoc and Oscillatoria. Nitrogen fixation–by Cyanobacteria (Blue green algae).

Unit V

(12 hours)

Brief account of Mycoplasma and Phytoplasma. Symptoms, causal organism and disease cycle of plant diseases with special reference to green ear disease of Bajra, loose smut of wheat, citrus canker, little leaf of brinjal and root knot nematode disease of vegetables. Non-parasitic disease, i.e. Black heart disease of potato. General account of plant disease management.

DCCBOT5001P: Practical for Algae, Fungi, Microbiology and Plant Pathology

(60 hours)

Suggested Laboratory Exercises:

1. Algae: Microscopic preparation and study of following algal materials: *Volvox, Chara, Ectocarpus, Sargassum* and *Polysiphonia.*
2. Fungi: Microscopic preparation and study of following fungal materials: *Albugo*, *Rhizopus*, *Aspergillus*, *Puccinia*, *Agaricus* and *Alternaria*.
3. Lichens: Study of *Parmelia* and *Usnea*
4. Viruses: Tobacco mosaic virus (TMV) and YVMV.
5. Bacteria: Gram staining of bacteria, Root nodules -Rhizobia (specimen), Cyanobacteria: Microscopic preparation and study of *Nostoc* and *Oscillatoria*.
6. Pathology: Study of symptoms of following diseases (specimen or photographs): Green ear disease of bajra, Loose smut of wheat, Black rust of wheat, Citrus canker, Little leaf of brinjal, Root knot nematode disease, Black heart disease of potato

Suggested Reading

Bold, H.C., Alexopoulous,C.J. and Delevoryas, T. Morphology of Plant and Fungi (4thEd.) Harper &Foul Co., New York, 1980.

Pandey, S.N. and Trivedi, P.S. A Text Book of Botany 2000 Volume I, Vikas Pub. House Pvt. Ltd., New Delhi.

Singh, V., Pande, P.C. and Jain, D.K. A Text Book of Botany, Rastogi & Co., Meerut, 2001.

Vashista, B. R. Botany for Degree Students (Algae, Fungi, Bryophyta), S. Chand & Co. Ltd., New Delhi,2002.

Alexopoulos, C.J., and Mims. Introductory Mycology, John Wiley and Sons, New York, 2000.

Bilgrami, K.S. and Dube, H.C. A Text Book of Modern Plant Pathology, Vikas Publ. House, New Delhi, 1976.

Biswas, S.B. and Biswas, A. An Introduction to Viruses, Vikas Publ. House, New Delhi, 2000.

Clifton, A. Introduction to Bacteria, McGraw Hill Co., New York, 1985.

Dube, H.C. Fungi, Rastogi Publication, Meerut, 1989.

Kaushik, P. Microbiology, Emkay Publication,2001.

Palezer, Chanand King. Microbiology, McGraw Hill Book Co., London,1995.

Amrita Rohilla, Handbook of Bacteriology. Oxford Book Company. 2013

P. C. Trivedi. Bacteriology Structure, Reproduction, Plant Diseases and Management. Nova Science Publishers. 2021

Pathak, V.N. Fundamentals of Plant Pathology, Agro Botanica. 2000.

Purohit, S.S. Microbiology, Agro. Bot. Publication, Jodhpur, 2002.

Sharma, O.P. Fungi, Today and Tomorrow, Publication,2000.

Sharma, P.D. Microbiology and Plant Pathology, Rastogi Publ. Meerut, 2003.

Singh, V. and Srivastava, V. Introduction to Bacteria, Vikas Publication,1998.

Panday B.P. Botany- Microbiology and plant pathology. S. Chand. Publication 2022

SECBOT1011. Plant Anatomy and Microtechnique

(30 hours)

Course outcome

1. Develop conceptual skill about plant anatomy of stem, root, and leave
2. Gain knowledge about developing micro-technique for fixing, embedding of plant material.
3. Learn the basic tools and techniques for micrometry and microscopy

Unit I

Introduction, History, Histology, Plant Anatomy, Role of Histopathology, Laboratory Information Management System, Safety

Unit II

Staining: Type, Fixation, Plant anatomy process: Tissue selection, Techniques in Tissue processing and staining, Tissue embedding techniques, embedding medium, and their property; Trimming, facing, and roughing blocks.

Unit III

Microtome: types, components, Techniques and Quality assurance; Microtome maintenance
Microscopy: Principle of microscopy, components, type of microscope, micrometry

Practical

1. Microtome functioning
2. Tissue processing of stem/root/leaf of monocot/dicot plant
3. Tissue Staining stem/ root/ Leaf of monocot/dicot Plant
4. Tissue embedding stem/ root/ leaf
5. Microtome sectioning of embedded material

Suggested Reading

1. Microtomy: Microtome and its applications, Tilak Chandak, Minal Chaudhary, Vinita Chandak, LAMBERT Academic Publishing, 2012.
2. Essentials of Microtomy, Sidney John Gray, Butterworths, 1972
3. Microscopic Preparation Techniques for Plant Stem Analysis. Holger Gärtner and Fritz H. Schweingruber. Verlag Dr. Kessel, Remagen ISBN: 378-3-941300-76-7, 2013.

SECBOT1012. Ethno-botany

(30 hours)

Unit I

Ethno-botany: Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) Intoxicants and beverages c) Resins and oils and miscellaneous uses

Unit II

Methodology of Ethnobotanical studies a) Field work b) Herbarium c) Ancient Literature d) Temples and sacred places e) Indigenous knowledge system; Role of ethno-botany in modern Medicine; 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 with special example *Rauvolfia serpentina, Trichopus zeylanicus, Artemisia, Withania*.

Unit III

Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).

Ethnobotany and legal aspects; Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.

Practical Exercises

1. To study the major and minor ethnic groups or Tribals of India, and their life styles
2. To develop methodology of Ethnobotanical studies a) Field work b) Herbarium c) Ancient Literature d) Temples and sacred places e) Indigenous knowledge system
3. Role of ethnobotany in modern medicine with special example *Rauvolfia serpentina, Trichopus zeylanicus, Artemisia, Withania*
4. National and state institutes related to the activity.

SEMESTER II

DCCBOT5002T: Bryophytes, Pteridophytes Gymnosperms and Palaeobotany

Unit I

(12 hours)

General characters, alternation of generations, and classification of Bryophyta. Characters and Classification of Hepaticopsida, Anthocerotopsida and Bryopsida. Structure and life history of *Riccia, Marchantia, Anthoceros* and *Sphagnum*.

Unit II

(12 hours)

Geological time scale, Fossils: types and Fossilization. General characters and classification of Pteridophytes. Stelar systems in Pteridophyta. Brief account on fossil *Rhynia*. Important characters of Psilophyta; Structure and life cycle of *Psilotum*.

Unit III

(12 hours)

Important characters of Lycophyta, Sphenophyta and Pterophyta. Structure and life cycle of *Lycopodium Selaginella, Equisetum, Adiantum* and *Marsilea*. Heterospory and seed habit in Pteridophyta.

Unit IV

(12 hours)

General characteristics, classification and evolution of gymnosperms. Important characters of Cycadophyta, Coniferophyta. Morphology, anatomy, reproduction and life cycle of *Cycas* and *Pinus*.

Unit V

(12 hours)

Important characters of Gnetphyta. Morphology, anatomy, reproduction and life cycle of *Ephedra*. Economic importance of Bryophyta, Pteridophyta and Gymnosperms.

DCC- BOT5002P: Practical for Bryophytes, Pteridophytes Gymnosperms and Palaeobotany (60 hours)

Suggested Laboratory Exercises:

Bryophytes: Study of external morphology and microscopic preparations of following Bryophytes: *Riccia, Marchantia, Anthoceros* and *Sphagnum*.

Pteridophytes: Study of external morphology of *Lycopodium, Selaginella, Equisetm, Adiantum* and *Marsilea*. Microscopic study of temporary double stained preparations of stem/rhizome of *Lycopodium, Selaginella, Equisetum* and *Marsilea*. Study of permanent or digital resources of L.S. of cone of *Lycopodium, Selaginella* and *Equisetum*. L.S. of Sporophyll of *Adiantum* and H.L.S. of sporocarp of *Marsilea*.

Gymnosperms: Study of external morphology of plant parts of *Cycas*: young and old foliage leaf, scale leaf, male cone, microsporophyll, megasporophyll and mature seed (if available). Microscopic temporary double stained preparations of rachis and leaflet of *Cycas*. Study of T.S. of normal and Corolloid root by permanent slides. Study of external morphology of plant parts of *Pinus* habit, long and dwarf shoot, male and female cone. Microscopic temporary preparation of *Pinus* needle. Microscopic temporary preparative on of pollen grains (W.M.) of *Pinus*. Study through permanent slides T.S. stem: young and old; male/female cone of *Pinus*. Study of habit and structure of whole male and female cone of *Ephedra*. Microscopic preparation of T.S. of *Ephedra* stem. Microscopic preparation of parts of male and female flowers of *Ephedra*.

Palaeobotany: Image specimen of *Rhynia*.

Suggested Readings:

Bold, H.C., Alexopolous, C.J. and Delevoryas, T. Morphology of plant and fungi (4th ed.), Harper and Foul, Co., New York, 1980.

Gifford, E.M. and Foster, A.S. Morphology and Evolution of Vascular Plants, W.H. Freeman and Company, New York, 1988.

Pandey, S.N., Mishra, S.P., Trivedi, P.S. A Text Book of Botany Vol. II, Vikas Pub. House Pvt. Ltd., New Delhi 2000.

Raven, P.H. Evert, R.F. and Eichhom, S.C. Biology of plants, (5th ed.), W.H. Reema and Co., Worth Publication, New York, U.S.A., 1999.

Sharma, O.P. Pteridophytes, Today and Tomorrow Publication, 2000.

Sporne, K.R. The Morphology of Gymnosperms, B.I. Publ. Pvt., Bombay, Calcutta, Delhi, 1991.

Vashista, P.C. Gymnosperm, S. Chand & Co. Ltd., New Delhi, 2002.

Vashista, P.C. Pteridophyta, S. Chand & Co. Ltd., New Delhi, 2002.

Wilson, N.S. and Rothewall, G.W. Palaeobotany and evolution of Plants, (2nd ed.), Cambridge University Press, U.K., 1993.

SECBOT1021. Organic Farming

(30 hours)

Learning objectives:

● The objective of the course is to provide hands-on experience to students on various aspects of organic farming.

● To make students self-reliant and employable by providing the necessary knowledge and experience to establish organic farming.

Learning Outcomes:

After completing the course, learners will be able to:

● Develop the basic of organic farming in agricultural land of any given location (pilot scale and/or industrial scale).

● Develop and implement a marketing strategy for the product.

● Apply the knowledge to fulfill certification rules and various government policies.

● establish themselves as entrepreneurs (organic products).

Unit I

Study of Organic Farming as an integrated approach. Soil analysis-physical testing and assessment of soil types, weighment, water movement, soil conditioners, etc. Manure preparation and introduction to compost, composting and its value addition quality test. Study of Indigenous Technology Knowledge (ITK) for nutrient, insect, pest disease and weed management.

Unit II

Study of various agriculturally useful Biofertilizers. Biocontrol agents including Integrated Pest Management. Study of traditional organic input preparation/formulation of Biofertilizer, biopesticides, plant health promoters like Panchgavya, Beejamrut etc. Study of the system of organic certification and inspection.

Unit III

Branding of rural products, FSSAI, marketing, packaging and handling of organic produce. Current Government schemes related to organic farming. Visit organic farms to study the various components and their utilization.

Essential Readings:

1. Dhama, A.K. (2014). Organic Farming for Sustainable Agriculture (2nd edition), Agrobios (India), Jodhpur.

2. Sharma, Arun K. (2013). A Handbook of Organic Farming, Agrobios (India), Jodhpur

3. Palaniappan, S.P. and Anandurai, K. (1999). Organic Farming – Theory and Practice. Scientific Pub. Jodhpur

4. Thapa, U and Tripathy, P. (2006). Organic Farming in India, Problems and prospects, Agritech, Publising Academy, Udaipur.

5. Jaivik Kheti Sahayak Pustika- National Centre for Organic and Natural Farming, Department of Agriculture & Farmers Welfare, GoI.

Suggestive Readings:

1. National Program for Organic Production-APEDA, Ministry of Commerce & Industry, GoI.

SECBOT1022. HYDROPONIC AND AEROPONIC FARMING

(30 hours)

Learning objectives:

● The objective of the course is to provide hands-on experience to students on various aspects of hydroponics and aeroponics.

● To make students self-reliant and employable by providing the necessary knowledge and experience to establish hydroponic and aeroponic systems.

Learning Outcomes:

After completing the course, learners will be able to:

● develop basic hydroponics and aeroponics facilities at any given location (pilot scale and/or industrial scale).

● devise and implement a strategy for marketing of the product.

● apply the knowledge to fulfill certification rules and various government policies.

● establish themselves as entrepreneurs (Hydroponic cultivator).

Unit I

Study of techniques used in hydroponics (Circulating methods such as Nutrient Film Technique (NFT), Deep Flow Technique (DFT), Dutch bucket; Non circulating methods such as Root dipping, Floating, Capillary action; Aeroponics such as root mist and fog feed techniques).

Unit II

Study of various instruments used in hydroponics (Pressure gauge, Filters, PVC Tanks, Venturi/Reciprocating Pump/Mixing tank, EC meter, pH meter, TDS meter, water pump, net cups, air pump, thermometer, lux meter, drip irrigation system. Construction of sustainable hydroponic and aeroponic units (including greenhouse facilities)

Unit III

Preparation of growth media for Hydroponics. Estimation of NPK, DO, TDS, pH of growth media. Study of suitable conditions for Hydroponics-quality, light intensity, photoperiod and temperature. Growing a leafy vegetable/fruity vegetable/medicinal herb /aromatic plant in Hydroponics /Aeroponic solution. Study of safety measures, certification standards and government policies. Visit to Hydroponic/Aquaculture/Aeroponic farm/Institute.

Laboratory exercise

1. Preparation of nutrient for hydroponics
2. Growing leafy vegetable/medicinal herbs/aromatic plant through aeroponics submit report
3. Visit to Hydroponic/Aquaculture/Aeroponic farm/Institute and submit the report.

Essential Readings:

1. Meier Schwarz. (1995). Soilless Culture Management. Advanced Series in Agricultural Sciences, vol 24.Springer, Berlin.

2. Hasan, M.; Sabir, N.; Singh, A.K.; Singh, M.C.; Patel, N.; Khanna, M.; Rai, T.; and Pragnya, P. (2018). Hydroponics Technology for Horticultural Crops, Tech. Bull. TBICN 188/2018.Publ. by I.A.R.I., New Delhi.

3. Misra, R.L., Misra S. (2017). Soilless Crop production. Daya Publishing House, Astral

Suggestive Readings:

1. Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (2019). Aquaponics Food Production Systems.Springer, Cham.

SEMESTER- III

DCCBOT6001T. ANATOMY, TAXONOMY AND EMBRYOLOGY OF ANGIOSPERM AND CELL BIOLOGY, GENETICS OF PLANTS

Course Objective:

- To introduce students to the taxonomy and diversity of angiosperms,
- To provide students with an understanding of the anatomical and embryological structures of angiosperms, cell biology and genetics.

Course outcome:

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

1. classify angiosperms based on their morphological characteristics, using the principles and methods of plant taxonomy.
2. identify and describe the anatomical and embryological structures of angiosperms, including their developmental processes and functions.
3. understand the cytological processes in the plant cells and their regulation, including mitosis, meiosis, and chromosomal behaviour.
4. to understand the principles and practices of genetics and plant breeding, and their applications for crop improvement.

Unit I

(12 hours)

Plant Anatomy: Structure and function of Meristematic and permanent tissues, Concept of tissue system, Classification of meristems, Apical meristem (SAM and RAM), Organization of SAM and RAM, Primary anatomy of root, stem and leaf of monocot and dicot, types of trichome and stomata, Normal and abnormal secondary growth.

Unit II

(12 hours)

Plant taxonomy: Components of taxonomy; Taxonomic resources: Herbarium, Botanical gardens, Flora. Principles and rules of Botanical Nomenclature. Systems of classification – Bentham and Hooker (upto series), Takhtajaan, Angiosperm Phylogeny Group (APG). Diversity of flowering plants as illustrated by members of the families Ranunculaceae, Caryophyllaceae, Papaveraceae, Cucurbitaceae, Apiaceae, Asteraceae, Acanthaceae, Apocynaceae, Lamiaceae, Euphorbiaceae, and Poaceae.

Unit-III

(12 hours)

Plant Embryology: Microsporangium, Microsporogenesis, Microgametogenesis, Pollen embryosac, Megasporangium – Structure of typical Angiosperm ovule. Types of ovules, Megagametogenesis, type of female gametophyte (embryosac, Structure of mature embryosac; Pollination and fertilization, double fertilization, Endosperm – Types and its biological importance. Embryogenesis: Dicot and Monocot embryo development; Structure Dicot and Monocot seed.

Unit IV

(12 hours)

Cell Biology: Structure and function of cell wall, plasma membrane, ribosomes, Endoplasmic reticulum, Golgi apparatus, mitochondria, chloroplast, lysosomes, peroxisomes and nucleus.

Chromosomal structure, Organization of chromosomes, Lampbrush and polytene chromosomes, Karyotype and idiogram. Cell division: mitosis and meiosis. Variation in Chromosome number (Numerical aberrations and structural)

Unit V

(12 hours)

Genetics: Chromosome theory of inheritance, Mendelian and non-mendelian inheritance crossing over and linkage; Concept of sex determination and Sex chromosomes.

Genetic material: DNA structure. Mechanism of DNA replication (Prokaryotes and eukaryotes), Transcription (Prokaryotes and eukaryotes); Types of structures of RNA, RNA polymerases; Translation, (Prokaryotes and eukaryotes), genetic code. Regulation of gene expression in Prokaryotes: Lac operon.

DCCBOT6001P. PRACTICAL FOR ANATOMY AND TAXONOMY OF ANGIOSPERM AND CELL BIOLOGY, GENETICS OF PLANTS

(60 hours)

1. To prepare at least 2 herbarium specimens and identify them using available resources (Literature, herbaria, e-resources, taxonomic keys) and classify up to family level (according to Bentham and Hooker's classification).
2. Description of taxa using semi-technical terms and identification of the families according to Bentham and Hooker's classification.
   Note: Any twelve families from the following list to be studied with at least two specimens (or one where limitations exist).
   List of Suggested Families
   Ranunculaceae (*Ranunculus, Delphinium*), Caryophyllaceae (*Dianthus, Saponaria*), Papaveraceae (*Papaver, Argemone*), Cucurbitaceae (any *Cucurbits*), Apiaceae (*Coriandrum*), Asteraceae (*Helianthus, Sonchus*), Acanthaceae (*Adhatoda, Barleria*), Apocynaceae (*Catharanthus, Thevetia, Nerium, Calotropis*), Lamiaceae (*Ocimum, Salvia*), Euphorbiaceae (*Euphorbia pulcherrima, Ricinus*) and Poaceae (*Triticum*)
3. Prepare temporary whole mounts/ sections to study organisation of apical meristem of root, shoot and vascular cambium.
4. Distribution and types of parenchyma, collenchyma and sclerenchyma through temporary preparations / digital resources/ permanent slides.
5. Prepare temporary stained mounts (maceration, sections) to observe xylem: tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
6. Study the types and features of wood: ring porous; diffuse porous; tyloses; heartwood and sapwood through specimens, permanent slides and digital resources.
7. Prepare temporary whole mounts/ sections to observe phloem: sieve tubes-sieve plates; companion cells; phloem fibres.
8. Study epidermal system: cell types, stomata types; trichomes: non-glandular and glandular through temporary whole mounts/peels/using enamel.
9. Prepare temporary whole mounts/ sections to study organisation of root: monocot (Maiz), dicot (*Tinospora*), secondary growth in roots.
10. Prepare temporary whole mounts/ sections to study organisation of stem: monocot (Maiz. Triticum, Dracaena), dicot (Sunflower)- primary and secondary growth; Cortical Anomalous behaviour of vascular bundle: Cortical vascular bundle (*Nyctanthes*),

Medullary (*Achyranthes*), bicollateral (*Cucurbits*), phloem wedges in *Bignonia*, included phloem in *Leptadenia/Salvadora*; periderm; lenticels.

11. Prepare temporary whole mounts/ sections to study organisation of leaf: isobilateral (Maize), dorsiventral (Nerium), Kranz anatomy (Maize).
12. To study the anther development and various stages through temporary preparation/digital resources/permanent slides
13. To study the development and various type of ovule through temporary preparation/digital resources/permanent slides
14. To study the development of embryo in monocot and dicot through temporary preparation/digital resources/permanent slides
15. Prepare temporary mounting of root tip to study the mitosis
16. To study the various cellular organelles through temporary preparation/digital resources/permanent slides
17. To study and demonstrate the genetic ratios (9:3:3:1; 3:1; 1:1, 1:2:1)
18. Instruments and equipment used in molecular biology.
19. Isolation of Genomic DNA from bacteria/plants
20. Examination of the purity of DNA by agarose gel electrophoresis.
21. Quantification of DNA by UV-spectrophotometer
22. Estimation of DNA by diphenylamine method.

Suggested Reading

1. Plant Systematics. Arun K. Pandey & Shruti Kansana. 2020. Jaya Publishing House.

2. Bole, P. V. and Vaghani, Y. (1986) Field guide to the common trees of I ndia. Oxford University Press; Bombay.

3. Brandis, D. (1906) Indian Trees (London, 5th edition. 1971). International Book Distributors; Dehra Dun.

4. Dallwitz, M. J., Paine, T. A. and Zurcher, E. J. (2003). Principles of interactive keys. http://delta-intkey.com

5. https://www.naace.co.uk/school-improvement/ict-mark/

6. https://www.socitm.gov.uk, (2002) Learning in the 21st century Executive briefing A Socitm Insight publication, July 2002 Socitm.

7. K. B. Anjaria, (2015)"Electronic Herbarium and Digital Database Preparation of Common Trees of Anand District, Gujarat" MRP submitted to UGC, WRO, Pune 2015 (unpublished)

8. Lizeron Eremias and R. Subash.(2013) "E-Content Development: A Milestone In The Dynamic Progress Of E- Learning" International Journal of Teacher Educational Research (IJTER) Vol.2 No.1 January, 2013 ISSN: 2319- 4642

9. Pandey, B.P. 2007. Botany for Degree Students: Diversity of Seed Plants and their Systematics, Structure, Development and Reproduction in Flowering Plants. S. Chand & Company Ltd,New Delhi.

10. Stace, C. A. 1989. Plant Taxonomy and Biostatistics (2nd Ed.). Edward Arnold, London.

11. Singh, G. 1999. Plant Systematics: Theory and Practice. Oxford and IBH, New Delhi.

12.Dutta A.C. 2016. Botany for Degree Students. Oxford University Press.

13. Davis, P. H. and V. H. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd,London.

14. Heywood, V. H. and D. M. Moore (Eds). 1984. Current Concepts in Plant Taxonomy. Academic Press, London.

15.Austin, R. 2002. Elements of planting design. New York: John Wiley & Sons.

16.Bertauski, T. 2005. Designing the landscape: An introductory guide for the landscape designer. Upper Saddle River, NJ: Pearson Prentice Hall.
17.Thomas, H., and S. Wooster. 2008. The complete planting design course: Plans and styles for every garden. London: Octopus Publishing Group.
18. Scarfone, S. 2007. Professional planting design: An architectural and horticultural approach for creating mixed bed plantings. New York: John Wiley & Sons.
19.Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied Publishers.

SECBOT101. Herbal Technology

(30 hours)

Course outcome

1. Develop conceptual skill about traditional Indian medicinal system, herbal medicines, their processing, storage and marketing.
2. Gain knowledge about developing commercial enterprise of herbal medicines.
3. Learn the basic tools and techniques for phytochemical analysis and propagation of the medicinal plants.

Unit I

Herbal medicines: history and scope - definition of medical terms - role of medicinal plants in Siddha systems of medicine; cultivation - harvesting - processing - storage - marketing and utilization of medicinal plants.

Unit II

Pharmacognosy - systematic position medicinal uses of the following herbs in curing various ailments; Tulsi, Ginger, Fenugreek, Indian and Ashoka.

Phytochemistry - active principles and methods of their testing - identification and utilization of the medicinal herbs; *Catharanthus roseus* (cardiotonic), *Withania somnifera* (drugs acting on nervous system), *Clerodendron phlomoides* (anti-rheumatic) and *Centella asiatica* (memory booster).

Unit III

Analytical pharmacognosy: Drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds). Medicinal plant banks micro propagation of important species (ashwagandha, neem and tulsi- Herbal foods-future of pharmacognosy).

Laboratory exercise

1. Study the various medicinal plant
2. study the identification and utilization of active component in *Catharanthus roseus*
3. Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds)
4. Micropropagation technique for ashwagandha
5. National and state institutes related to the activity.

Suggested readings

1. Arber, A. (1999). Herbal plants and Drugs. Mangal Deep Publications.
2. Chopra, R.N., Nayar S.L. and Chopra, I.C. (1956). Glossary of Indian Medicinal Plants, C.S.I.R, New Delhi.
3. Green, A. (2000). Principles of Ayurveda, Thomsons, London.
4. Kokate, C.K. (1999). Pharmacognosy, Nirali Prakashan.
5. Miller, L. and Miller, B. (1998). Ayurveda and Aromatherapy. Banarsidass, Delhi.
6. Sivarajan V.V. and Balachandran I. (1994). Ayurvedic drugs and their plant source. Oxford IBH publishing Co.

SECBOT102 Molecular Technique

(30 hours)

Course outcome

1. Develop conceptual skill about various molecular technique and using the equipment for molecular analysis.
2. Gain knowledge about using the spectrophotometry analysis technique.
3. Learn the basic tools and techniques for protein characterization

Unit I

Methods of isolation, purification and quantification of nucleic acids. Principle and applications of electrophoresis. Nucleic acid hybridization, Concepts of PCR and Quantitative RT-PCR.

Unit II

Protein purification techniques: size-exclusion, ion- exchange and affinity chromatography. Quantitative and Qualitative analysis of Proteins: Dye-binding methods, native and denaturing SDS- PAGE, Western immunoblotting, ELISA.

Unit III

Tools and techniques used in proteomics: 2-DE, Mass spectrometry, peptide mass fingerprinting. Recombinant protein expression and purification from *E. coli.*

Laboratory Exercises

1. Preparation of different reagents, buffers and media.
2. Isolation of genomic DNA from plants.
3. Isolation of proteins from plants.
4. Demonstration of DNA/RNA and protein quantitation using Nanodrop.
5. Agarose gel electrophoresis and Gel documentation.
6. Demonstration of PCR, RT-PCR and Southern/Northern Blotting
7. One-dimensional SDS-PAGE protein profiling
8. Demonstration of 2-DE and Western immunoblotting

Suggested Readings

Sambrook, J. and Russell, D.W. 2001. Molecular Cloning – A Laboratory Manual, Vols I – III, Cold Spring Harbor Laboratory, USA.

Gelvin, S.B. and Schilperoort, R.A. (eds) 1994. Plant Molecular Biology Manual, 2nd edition, Kluwer Academic Publishers, Dordrecht, The Netherlands.

Glick, B. R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.

SECBOT103. Nursery and Gardening

(30 hours)

Course outcome

1. Develop conceptual of nursery and gardening.
2. Gain knowledge about developing commercial enterprise of nursery.

Unit I

Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.

Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy-Seed storage: Seed banks, factors affecting seed viability, genetic erosion – Seed production technology - seed testing and certification

Unit II

Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants – green house - mist chamber, shed root, shade house and glass house

Unit III

Gardening: definition, objectives and scope - different types of gardening-landscape and home gardening - parks and its components - plant materials and design-computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting.

Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures.

Laboratory Exercise

1. Study the seed viability
2. Study the technique for preparation of seed sowing, transplanting of plantlets
3. Study the vegetation propagation technique such as air-layering, cutting, grafting
4. Study the rooting medium and growth regulator for treatment of cutting stem
5. Study the cultivation of different vegetable such as cabbage, garlic, tomatoes etc
6. National and state institutes related to the activity.

Suggested readings

1. Agrawal, P.K. (1993). Hand Book of Seed Technology, Dept. of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi.
2. Bose T.K. and Mukherjee, D. (1972). Gardening in India, Oxford and IBH Publishing Co., New Delhi.
3. Jules J. (1979). Horticultural Science. (3rd Ed.), W.H. Freeman and Co., San Francisco, USA.
4. Kumar, N. (1997). Introduction to Horticulture, Rajalakshmi Publications, Nagercoil.
5. Sandhu, M.K. (1989). Plant Propagation, Wile Eastern Ltd., Bangalore, Madras.

SECBOT104. Conservation and Management of Biodiversity

(30 hours)

Course outcome

1. Develop conceptual skill about traditional conservation of biodiversity
2. Student learn about biodiversity management associated with various organization.
3. Learn the basic tools and techniques of conservation method such as in situ and ex situ conservation

Unit I

Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes

Unit II

Loss of Biodiversity; Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss.

Management of Plant Biodiversity: Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.

Unit III

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 relation to Human Welfare: utilization and commercial aspects of Forestry, Avenue trees, Ornamental plants, and alcoholic beverages. Fruits and nuts: Important fruit and nuts crops their commercial importance. Wood and its uses.

Laboratory exercise

1. Study the species diversity using frequency, density and abundance in your campus
2. Study the species diversity using IVI in your campus
3. Study and collection of endangered and endemic plants in your region
4. Study the fruit and nut crops in your regions
5. Study the various Sanctury and National Park and located in map
6. Visit the near institution related to biodiversity conservation such as NBPGR, BSI
7. National and state institutes related to the activity.

Suggested Readings:

1. Plant Conservation and Biodiversity Editors: Hawksworth, David L., Bull, Alan T. (Springer)
2. Biological Diversity and Its Conservation, Sharma Dushyant Kumar, Daya Publishing House
3. A Handbook of Plant Resource Utilization and Conservation, Bijan Bihari Dutta
4. Biodiversity: Concepts and Conservation, B.B. Hosetti, S. Ramkrishna, Aavishkar Publishers, Distributors, Jaipur
5. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
6. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.
7. Barbour, M.G., Burk, J.H. and Pitts, W.D. (1987). Terrestrial Plant Ecology. Benjamin/Cummings Publication Company, California

8. Baskin and Baskin, (2001). Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination Elsevier
9. Kormondy, E.J. (2017). Concept of Ecology. Pearson India.
10. Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity – Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
11. Odum, E.P. (1983). Basic Ecology Saunders, Philadelphia
12. Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.
13. Smith, R.L. (1996). Ecology and Field Biology Harper Collins, New York.

SEMESTER- IV

DCCBOT6002T. ECOLOGY, PHYSIOLOGY AND BIOTECHNOLOGY OF PLANT
(60 hours)

Course Objective:
To provide students with an understanding of principles and processes of plant physiology, ecology, and biotechnology, and to cultivate an appreciation of their importance.

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

1. describe the principles and processes of plant physiology, including plant growth and development, and metabolism.
2. understand the ecological relationships between plants and their biotic and abiotic environment, including plant community structure and ecosystem function.
3. understand the principles and applications of plant biotechnology, including genetic engineering, and tissue culture, to address problems in plant breeding, and agriculture.

Unit I
Ecology: Definition, Ecosystem– Concept, structure and function; Abiotic and biotic components, Food chains and food webs, Ecological pyramids; Biogeochemical and hydrological cycles, Energy flow in an ecosystem.
Primary and Secondary Production and Productivity; Ecological Succession-Definition & types. Processes and types of Hydrosere and Xerosere, cological Adaptations – Hydrophytes, Xerophytes, Halophytes.

Unit II
Plant Physiology: Plant water relation, Mineral Nutrition, Transpiration and translocation; active and passive transport,
Carbon Oxidation: -Krebs cycle, Glycolysis, Fermentation, oxidative pentose phosphate pathway, Oxidative phosphorylation, factors affecting respiration.
Photosynthesis: Pigments, Cyclic and non-cyclic light reaction, C3, C4 and CAM- carbon fixation and Significance

Unit III
Nitrogen Metabolism: Nitrate assimilation, biological nitrogen fixation, Lipid Metabolism: Synthesis and breakdown of triglycerides, -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination,
Developmental roles of Phytohormones (auxins, gibberellins, cytokinins, ABA, ethylene); Autonomic & paratonic movements, Photoperiodism; Phytochrome, photomorphogenesis, Seed Dormancy, Vernalization & Senescence

Unit IV
Plant Biotechnology: Principles, components and techniques of plant tissue cultures, Embryogenesis and organogenesis, Protoplast isolation and culturing, regeneration, fusion of protoplast, somatic hybridization, Somaclonal variation, Plant secondary metabolites production (Shikonin, vinblastine, vincristine). Introduction to Genomics, Proteomics, Bioinformatics and Nanotechnology; genome editing.

Unit V

Genetic engineering: Restriction Endonucleases, ligases, Prokaryotic and eukaryotic cloning vector (pBR322, pUC, lambda, BAC and YAC), gene cloning mechanism and selection of recombinant clone; Gene transfer to plant by direct and indirect method; selectable marker and reporter genes.

Application of genetic engineering: Pest resistant (Bt-cotton); herbicide-resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Biosafety concerns.

DCCBOT6002P. PRACTICAL FOR ECOLOGY, PHYSIOLOGY AND BIOTECHNOLOGY OF PLANT

(60 hours)

1. To determine minimum number of quadrats required for reliable estimation of biomass in herbaceous vegetation
2. To study the frequency, density and abundance of herbaceous species.
3. To estimate Importance Value Index for herbaceous vegetation on the basis of relative frequency, relative density and relative abundance in protected and Gochar land
4. To measure the vegetation cover of grassland through point frame
5. To determine diversity indices (richness Simpson, Shannon-Weaver) in natural fields
6. To estimate bulk density and porosity of soil samples
7. To determine moisture contents, water holding capacity and texture of soil samples
8. To estimate qualitatively nitrate, phosphate and potassium in soil samples
9. To estimate the salinity of given water sample through titration method.
10. To estimate the dissolved oxygen of given water sample through titration method.
11. To study of adaptations in Xerophytes, Halophytes and Hydrophytes.
12. To study the permeability of plasma membrane using different concentrations of organic solvents /Temperature.
13. To prepare the standard curve of protein and determine the protein content in unknown samples
14. Separation of chloroplast pigments by solvent method and paper chromatography.
15. Estimation of total chlorophyll content from different chronologically aged leaves (young, mature and senescence) by Arnon method.
16. Determining the osmotic potential of vacuolar sap by plasmolytic method
17. Determining the water potential of any tuber
18. Separation of amino acids in a mixture by paper chromatography and their identification by comparison with standards
19. To study the regulation of stomatal movement using growth regulators, KCI and anti-transpirants.
20. Determination of osmotic potential of plant cell sap by plasmolytic method using leaves of Rheo / Tradescantia.
21. Study of mineral deficiency symptoms using plant material/photographs.
22. Determination of the RQ of germinating seeds.
23. Test of seed viability by TTC method.
24. Separation of amino acids by paper chromatography.
25. Surface sterilization and aseptic inoculation of suitable explants for activation of axillary shoot bud/induction of cell or callus culture (haploid or somatic cell)
26. Isolation of protoplasts.

27. Plant (Cauliflower/Onion) DNA extraction by Rapid Method
28. Study of methods of gene transfer through photographs: Agrobacterium- mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
29. Study of steps of genetic engineering for production of Bt cotton, Golden rice, FlavrSavr tomato through photographs.

Suggested reading

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. Akhtar Inam 2012, A Laboratory Manual Of Plant, Physiology, Biochemistry And Ecology ISBN: 9788177544589 Edition. Publisher : Agrobios (India)
3. Padmanaban G , Chandrasekaran CN , Thangavelu AU , Dr. Sivakumar R , Kalimuthu N, Dr. Boominathan P , Dr. Anbarasan P, (2016) Advanced Methods in Physiology And Biochemistry (pb. Agrobios.
4. Dashek, WV (ed.) 1997. Methods in Plant Biochemistry and Molecular Biology. CRC Press.
5. Wilson and Walker (2002). Practical Biochemistry: Principles and Techniques. Cambridge University Press.U.K.
6. Thimmaiah, SR. 2004. Standard Methods of Biochemical Analysis. Kalyani Publishers.
7. Henry, RJ. 1997. Practical Application of Plant Molecular Biology. Chapman & Hall, London

SECBOT201. ADVANCED TOOLS AND TECHNIQUES IN PLANT BIOLOGY

(30 hours)

Unit I

Imaging and related techniques: Electron microscopy: Transmission and Scanning electron microscopy, cryofixation, negative staining, shadow casting, freeze-fracture, freeze-etching; Chromosome banding, FISH, GISH, chromosome painting.
Centrifugation: types of rotors, differential and density gradient centrifugation, sucrose density gradient, ultracentrifugation, caesium chloride gradient; marker enzymes for analysis of cellular fractions.

Unit II

Spectrophotometry: Principles and applications of UV, Visible and IR spectrophotometry
Chromatography: Principles and applications of Paper chromatography, Column chromatography, TLC, GLC, Characterization of proteins and nucleic acids.

Unit III

PCR – design of PCR primers, enzymes used for PCR, cloning of PCR products; DNA polymorphism and its applications (RFLP, AFLP, SSR, SNPs); RNA isolation and analysis, cDNA synthesis and qRT-PCR; Extraction of proteins, PAGE (Native and denaturing); Blotting and hybridization techniques: Southern (Radioactive and Non-radioactive), Northern and Western; DNA sequencing – Sanger's dideoxy sequencing; ELISA.

Laboratory Exercise

1. To study the electron microscopy
2. to study the UV-VIS spectrophotometer
3. To demonstrate the TLC of secondary metabolites
4. To study the various PCR
5. To prepare the PCR experiments for cloning of DNA
6. To study the Sanger Dideoxy sequencing

Suggested Readings

1. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.
2. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A.
3. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons. 3rd edition.
4. Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.

SECBOT202. MICROPROPAGATION TECHNIQUE

(30 hours)

Unit I

Basic Concepts of Micropropagation, Basic layout of Mircropropagation setup and Green- house

Unit II

Basic concept of Aseptic Culture establishment; Tools and Techniques of Micropropagation: LAFB, Autoclave, Filter Sterilization

Unit III

Medium composition and Preparation, Hardening and Acclimatization

Laboratory Exercises

1. Selection of explants, surface sterilization and inoculation to initiate cultures of tobacco/cereals/legumes.
2. Experiments on rejuvenation and multiple shoot induction from mature nodal shoot segments of trees/horticultural/floricultural crops.
3. Encapsulation of somatic embryos/buds using alginate.
5. Experiments on root induction from cultured shoots.

Suggested Reading

Bhojwani, S. S. 1990. Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.

Bhojwani, S. S. and Razdan, M. K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York, USA.

Vasil, I. K. and Thorpe, T. A. 1994. Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands

Woung-Young, S. and Bhojwani, S. S. 1999. Morphogenesis in Tissue Cultures (ed.). Kluwer Academic Publishers.

SECBOT203. BIOLOGICAL DATA ANALYSIS USING SOFTWARE

(30 hours)

Unit I

Microsoft Excel Data Analysis: Introduction excel, entering data; Exploring data in excel in Descriptive statistics: data sorting, Mean, Median, Mode, Variance, Normalized Variance, Standard Error, Coefficient of Variance, one -way ANOVA using excel, SATA software

Unit II

Data Visualization in Excel: Charts- Column charts, Bar charts, Pie charts, Linecharts, Area charts, Scatter charts, Surface charts; Power Point Presentation; Data visualization tools: Tableau, Dundas BI, JupyteR, Google charts

Unit III

Biological software: BLAST, Clustal, MEGA, R Programme, RasMol, Cytoscape; Biopython, PyMOL, GROMAC

Practical exercises:

1. Data entering exercise in Microsoft excel.
2. Descriptive statistical function using in excel such as mean, median, mode, variance, normalized variance, standard error, coefficient of variance
3. one-way ANOVA analysis in excel
4. DATA entry in STATA software
5. Data visualization exercise in excel such as column charts, bar charts, pie charts, linecharts, area charts, scatter charts, surface charts
6. Data visualization in google charts
7. Exercises for Power point presentation
8. Data entry, function using in MEGA software
9. DNA/Protein Sequence alignment using MEGA software

Suggested Reading:

1. Beginners Guide to Bioinformatics for High Throughput Sequencing. T W Tan, Eric Lee|2018|
2. Bioinformatics for beginners, R. Amjesh, S.S. Vinodchandra |2019|
3. BIOINFORMATICS FOR BEGINNERS A Comprehensive Guide to Bioinformatics for Beginners. MAXWELL JAMES |2021|
4. Gomez, A. Kwanchai and Gomez, A. Arturo. 1984. Statistical Procedures for Agricultural Research (second Edition), John Wiley & Sons, New York
5. Mishra, B.N. and Mishra M.K. 1989.Introductory Practical Biostatistics. Naya Prakash Publication, Calcutta.
6. Panse, V.G. and Sukhatme, P.V. 1989. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi.

SECBOT204. IPR (INTELLECTUAL PROPERTY RIGHTS)

(30 hours)

Unit I

Introduction to intellectual property right (IPR); Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples. IPR, WTO TRIPS and WIPO.

Unit II

Patents: Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents, Infringement. Copyrights; Trademarks; Geographical Indicators. Industrial Designs

Unit III

Protection of Traditional Knowledge: Objective, Concept of Traditional Knowledge, Bio-Prospecting and Bio-Piracy, Traditional Knowledge Digital Library. Plant Varieties Protection; Rights of farmers, Breeders and Researchers. National gene bank; Information Technology Related IPR: Computer Software and Intellectual Property, Domain Name Protection; Patenting Biotech Inventions

Practical Exercise:

1. to study the fill the IPR file
2. to practice the procedure of patent
3. to study Traditional Knowledge Protection
4. To study the patenting Biotech inventions

Suggested Readings:

1. Acharya, NK. 2001. Text book on Intellectual Property Rights. Asia Law House.
2. Arthur RP and Micheal HD. 2000. Intellectual Property: Patents, Trademarks and Copyright in a nutshell. West Group Publishers.
3. Das, HK. 2010. Text book of Biotechnology 4th edition. Willey India.
4. Erbisch FH &Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
5. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.
6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.
7. Singh, BD. 2010. Biotechnology: Expanding horizons. Kalyani Publishers.
8. Wadhera BL. 2007. Law Relating to Intellectual Property. Universal Law Publishing.
9. Wattal, J. 1997. Intellectual Property Right. Oxford Publication House.

SEMESTER- V

DSEBOT7101T. Economic Botany and Ethnobotany

(60 hours)

Unit I

Origin and domestication of cultivated plants, Centers of diversity of plants, origin of crop plants. Domestication and introduction of crop plants. Concepts of sustainable development; cultivation, production and uses of Cereals, legumes, Spices & beverages.

Unit II

Botany of oils, Fibers, timber yielding plants & dyes, Study of the plants with Botanical names, Family, part used, and economic uses yielding Edible & essential oils; Sugar, Starch; Fibers; Paper, Fumigatories & Masticatories, Rubber, Dyes, Timber, biofuel crops.

Unit III

Commercial production of Flowers, Vegetables, and fruits, Commercial greenhouse cultivation of rose, Gerbera, Gladiolus, Anthurium/lilium/lily, tomato, bell pepper, cucumber, strawberry & Exotic leafy vegetables using Hydroponics.

Unit IV

Ethnobotany: Methodologies of ethnobotanical research: Field work, Literature, Herbaria and Musea and other aspects of ethnobotany. Importance of ethnobotany in Indian systems of medicine (Siddha, Ayurveda and Unani), Role of AYUSH, NMPB, CIMAP and CARI.
Tribal knowledge towards disease diagnosis, treatment, medicinal plants, plant conservation and cultivation.

Unit V

Medicinal aspects: Study of common plants used by tribes (*Aegle marmelos, Ficus religiosa, Emblica officinalis, Eclipta alba, Rauvolfia serpentina, Oxalis and Ocimum sanctum*) Ethnobotanical aspect of conservation and management of plant resources, Preservation of primeval forests in the form of sacred groves of individual species and Botanical uses depicted in our epics. Plants in primary health care: common medicinal plants: *Tinospora, Acorus, Ocimum, Turmeric* and *Aloe*. Indian Pharmacopeia, Quality Evaluation of crude drugs & adulteration

DSEBOT7101P Practical for Economic Botany and Ethnomedicine

(60 hours)

1. Cereals: Wheat (habit sketch, L.S./T.S. of grain, starch grains, micro-chemical tests); rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests)
2. Legume: Pea or ground nut (habit, fruit, seed structure, micro-chemical tests)
3. Source of sugars and starches: Sugarcane (habit sketch; cane juice- micro-chemical tests); potato (habit sketch, tuber morphology, T.S. of tuber to show localization of starch grains, W.M. of starch) grains, micro-chemical tests.
3. Tea- tea leaves, tests for tannin
4. Mustard- plant specimen, seeds, tests for fat in crushed seeds Timbers: section of young stem.
5. Jute- specimen, transverse section of stem, tests for lignin on T.S. of stem and study of fiber following maceration technique.
6. Study of specimens of economic importance mentioned in syllabus
7. Study of common plants used by tribes. *Aegle marmelos, Ficus religiosa, Cynodon dactylon*.
8. Visit a tribal area and collect information on their traditional method of treatment using crude drugs.
9. Familiarize with at least 5 folk medicines and study the cultivation, extraction and its medicinal application.

10. Observe the plants of ethnobotanical importance in your area.
11. Visit to an Ayurveda college or Ayurvedic Research Institute / Hospital

Suggested Reading:

1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
2. Sambamurthy, AVSS & Subrahmanyam, NS (2000). Economic Botany of Crop Plants. Asiatech Publishers. New Delhi.
3. Singh, D.K and K.V. Peter. 2014. Protected cultivation of horticultural crops. New India Publishing Agency, India.
4. Reddy P. Parvatha. 2016. Sustainable crop protection under protected cultivation. Springer, Singapore.
5. Amit Deogirikar. 2019. A Text Book on Protected Cultivation and Secondary Agriculture. Rajlaxmi Prakashan, Aurangabad, India.
6. Singh, B., B. Singh, N. Sabir andMHasan. 2014. Advances in protected cultivation. New India Publishing Agency, India.
7. Sharma, OP. 1996. Hill's Economic Botany (Late Dr. AF Hill, adopted by OP Sharma). Tata McGraw Hill Co. Ltd., New Delhi.
8. Joe J. Hanan. 1997. Greenhouses: Advanced Technology for protected horticulture. CRC Press.
9. Krishnamurthy, K.V. (2004). An Advanced Text rbook of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi
10.N.K. Acharya: Textbook on intellectual property rights, Asia Law House (2001).
11. Manjula Guru & M.B. Rao, Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications (2003).
12. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill (2001).
13. Arthur Raphael Miller, Micheal H.Davis; Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers (2000).
14. Jayashree Watal, Intellectual property rights in the WTO and developing countries, Oxford University Press, Oxford.
15. Jain, S. K. and V. Mudgal. 1999. A Handbook of Ethnobotany. Bishen Singh Mahendra Pal Singh,Dehradun.
16. Jeffrey, C. 1982. An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.London.
17. Joshi, S. G. 2000. Medicinal Plants. Oxford and IBH, New Delhi.
18. Kokate, C. and Gokeale- Pharmocognacy- Nirali Prakashan, NewDelhi.
19. Lad, V. 1984. Ayurveda – The Science of Self-healing. Motilal Banarasidass, New Delhi.
20. Lewis, W. H. and M. P. F. Elwin Lewis. 1976. Medical Botany. Plants Affecting Man's Health. A
a. Wiley Inter science Publication. John Wiley and Sons, New York.
21. Farooqui, A. A. and Sreeraman, B. S. 2001. Cultvation of medicinal and aromatic crops. Universities Press.
22. Harborne, J. B. 1998. Phytochemical methods – a guide to modern techniques of plant analysis 3 rd edition, Chapman and Hall.
23. Yesodha, D., Geetha, S and Radhakrishnan, V. 1997. Allied Biochemistry. Morgan publications, Chennai.1. Gurdeep Chatwal, 1980. Organic chemistry of natural productis. Vol. I. Himalaya Publishing house.
24. Kalsi, P. S. and Jagtap, S., 2012. Pharmaceutical medicinal and natural product chemistry. N.K. Mehra for Narosa Publishing House Pvt. Ltd. New Delhi.
25. Wallis, T. E. 1946. Text book of Pharmacognosy, J & A Churchill Ltd.

DSEBOT7102T. Reproductive biology of flowering plant

(60 hours)

Learning Objectives:

● To understand the scope of reproductive biology, development and structure of male and female reproductive units of the flower, organization of male and female gametophytes, pre-fertilization, fertilization and post-fertilization events.

● To understand the processes and significance of pollen--pistil interactions, apomixis and polyembryony.

● Significance of seed as a diaspore.

Learning Outcomes:

Upon completion of the course, the students will become familiar with:

● The significance and scope of reproductive biological studies in crop production and conservation. Structure and function of anther and ovule, male and female gametophyte.

● The significance of associations of MGU, FGU and double fertilization; embryo and endosperm development, genomic imprinting.

● Pollination and seed dispersal mechanisms, apomixis and polyembryony as alternate pathways of angiosperm reproduction.

● Experiential learning through field trips, scientific photography, videography and documentary preparation. The students will also learn to write scientific reports and present scientific data.

Unit I

Reproduction: Introduction, history and scope of reproductive plant biology; structure and development of flower.

Anther: Structure and functions of Anther wall, microsporogenesis, microgametogenesis; Pollen: Structure and functions of pollen wall, Number Position Character (NPC), pollen viability and storage, Male Germ Unit (MGU) – structure and significance.

Unit II

Pistil: General structure and types of pistil and ovules; megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of Polygonum type); Organization and ultrastructure of mature embryo sac; cell specification; Female Germ Unit – structure and significance.

Pollination: Types (Self, cross, geitonogamy, xenogamy), significance; Structure of the stigma and style; Pollen-pistil interactions; Double fertilization.

Unit III

Self-Incompatibility: Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self-incompatibility (in brief): mixed-pollination, intraovarian and in vitro pollination and fertilization, modification of stigma surface, parasexual hybridization.

Unit IV

Endosperm: Types, development, structure and functions; Embryo: General pattern and comparison of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo, haustorial systems: Embryo patterning.

Unit V

Seed: Structure and importance of seed as diaspore, as storage organ; germination and seedling formation. Polyembryony and apomixis: Introduction, types, causes and applications. Applications of Reproductive biology: Haploid embryos - concept and significance; crop productivity, conservation

DSEBOT7102P. Practical for Reproductive biology of flowering plant

(60 hours)

1. Anther: Wall and its ontogeny, tapetum (amoeboid and glandular), Microspore mother cell, spore tetrads, uninucleate, bicelled and dehisced anther; Temporary stained mounts of T.S. anther to study the organization.
2. Pollen: General morphology, psuedomonads, polyads, pollinia (slides/digital resources, fresh material); Ultrastructure of pollen wall (micrograph); Pollen viability: tetrazolium test/FDA; Germination: calculation of percentage germination in different media using hanging drop/sitting method.
3. Temporary mounts of pollen grains cleared with 1N HCl/KOH to study germ pores; Ultrastructure of male germ unit (MGU) through micrographs.
4. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; tenuinucellate and crassinucellate; Special structures: endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/digital resources).
Female gametophyte: developmental sequence of monosporic embryo sac only; Ultrastructure of Female Germ Unit.
5. Pollination: Adaptations; bagging experiment;.
6. Intra-ovarian pollination; Test tube pollination (through digital resources).
7. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
8. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.
9. Seed dispersal mechanisms (adaptations through live specimens),

Suggested Readings:

1. Bhojwani S.S., Bhatnagar S.P. & Dantu P.K. (2015). The Embryology of Angiosperms, 6th Edition. By VIKAS PUBLISHING HOUSE. ISBN: 978-93259-8129-4.
2. P. Maheshwari, (2004). An introduction to the embryology of Angiosperms. Tata McGraw-Hill Edition, ISBN: 0-07-099434-X.
3. Johri, B.M. (1984). Embryology of Angiosperms. Netherlands: Springer-Verlag. ISBN: 13:978-3-642-69304-5
4. Raghavan, V. (2000). Developmental Biology of Flowering plants. Netherlands: Springer. ISBN: 978-1-4612-7054-6.
5. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.
6. Mangla,Y., Khanduri, P., Gupta, C.K. 2022. Reproductive Biology of Angiosperms: Concepts and Methods.Cambridge University Press ISBN 978-1-009-16040-7.
7. Tandon R, Shivanna KR, Koul M Reproductive Ecology of Flowering Plants: Patterns and Processes 1st ed. 2020 Edition ISBN 978-9811542091.Springer Verlag
8. Kapoor, R., Kaur, I. Koul M.2016. Plant Reproductive Biology and Conservation IK International Publishing House Ltd. India ISBN: 9789382332909

Additional Resources:

1. Shivanna, K.R., Tandon, R. (2020). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London
2. Shivanna, K. R., & Rangaswamy, N. S. (2012). Pollen biology: a laboratory manual. Springer Science & Business Media.

DSEBOT7103T. Developmental Biology of Angiosperms: Form, Anatomy & Function
(60 hours)

Learning Objectives:

● To understand the basics of plant cell structure, and development, growth and organisation of the plant body.

Learning Outcomes:

- Upon completion of the course, the students will
- become familiar with the structure and functions of various components of plant cell
- understand the process of cell growth and its regulation
- comprehend the structure and functions of tissues organising the various plant organs
- get acquainted with the reproductive processes involved in the life cycle of angiosperms
- be able to appreciate the interactions between the developmental pathways resulting in the differentiation of plant body
- recognise the importance of plant developmental biology in the improvement and conservation of plants.

Unit I

Introduction to diversity of plant forms: Historical perspective, methods/tools and techniques in anatomy, basic plant growth-meristems and cell differentiation; Primary and Secondary plant body; Classification of tissues; Simple and complex tissues, Vascular system.

Tissue organization in stem: Organization of shoot apex; Types of vascular bundles; Structure of dicot and monocot stem.

Unit II

Tissue organization in leaf: Initiation and development and maturation of leaf; dermal tissue system, cuticles and special epidermal cells; stomata; structure of dicot and monocot leaf, Kranz anatomy

Tissue organization in root: Organisation of root apex; structure and function of root apex-quiescent centre; root cap; Structure of dicot and monocot root; origin of lateral root.

Unit III

Vascular Cambium: Structure (Axially and radially oriented elements); function and seasonal activity of cambium; Secondary growth in root and stem, Cambial variants in secondary growth in stem: Included phloem and Phloem wedges.

Unit IV

Wood and Periderm: Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Pits and plasmodesmata; Wall ingrowths and transfer cells; Ergastic substances; Development and composition of periderm; rhytidome and lenticels.

Unit V

Adaptive and Defensive Systems: Anatomical adaptations of xerophytes and hydrophytes.; Adcrustation and incrustation; Secretory System: Hydathodes, cavities, lithocysts and laticifers. Application of Plant Anatomy: Applications in systematics, plant development, physiology, forensics and pharmacognosy. Dendrochronology and dendroclimatology.

DSEBOT7103P. Developmental Biology of Angiosperms: Form, Anatomy & Function
(60 hours)

1. Prepare temporary whole mounts/ sections to study organisation of apical meristem of root, shoot and vascular cambium.
2. Distribution and types of parenchyma, collenchyma and sclerenchyma through temporary preparations / digital resources/ permanent slides.
3. Prepare temporary stained mounts (maceration, sections) to observe xylem: tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
4. Study the types and features of wood: ring porous; diffuse porous; tyloses; heartwood and sapwood through specimens, permanent slides and digital resources.
5. Prepare temporary whole mounts/ sections to observe phloem: sieve tubes-sieve plates; companion cells; phloem fibres.
6. Study epidermal system: cell types, stomata types; trichomes: non-glandular and glandular through temporary whole mounts/peels/using enamel.
7. Prepare temporary whole mounts/ sections to study organisation of root: monocot, dicot, secondary growth in roots.
8. Prepare temporary whole mounts/ sections to study organisation of monocot, dicot - primary and secondary growth; phloem wedges in Bignonia, included phloem in Leptadenia/Salvadora; periderm; lenticels.
9. Prepare temporary whole mounts/ sections to study organisation of leaf: isobilateral, dorsiventral, Kranz anatomy.
10. Study the adaptive anatomy in xerophytes and hydrophytes (two each) through temporary preparations / digital resources/ permanent slides.
11. Study secretory tissues: cavities, lithocysts and laticifers through permanent slides / digital resources.
12. Project: submission of permanent slides

Suggested Reading:

1. Beck, C.B. (2010). Plant Structure and Development. Second edition. Cambridge University Press, Cambridge, UK, New York, USA.
2. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
3. Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.
4. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
5. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.

Additional Resources:

1. Bahadur, B. Rajam, M.V., Sahijram, L., Krishnamurthy, K.V. (2015). Plant Biology and Biotechnology. Volume 1: Plant Diversity, Organization, Function and Improvement. 2. Crang, R., Lyons-Sobaski, S., Wise, R. (2018) Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants 1st ed. Springer
3. Cutler, D.F., Botha, T., Stevenson, D.W. (2007). Plant Anatomy - An Applied Aspect. Blackwell Publishing, USA
4. Evert, R.F. (2017) Esau's Plant Anatomy; Meristems, Cells and Tissues Of The Plant Body-Their Structure, Function And Development. 3rd Edn Wiley India.
5. Moza M. K., Bhatnagar A.K. (2007). Plant reproductive biology studies crucial for conservation. Current Science 92:1907.
6. Shivanna, K.R., Tandon, R. (2014). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London

DSEBOT7104T. Applied Phycology

(60 hours)

Learning Objective:

● To gain knowledge about diversity, life forms, life cycles, morphology and economic importance of algae.

Learning Outcomes:

- On completion of the course the students will be able to understand:
- use of algae for environment, human welfare and industries.
- algal culture techniques and their commercial production

Unit I

Scope of phycology: In emerging research areas, environment and industries. Algae as food, feed and fodder: Nutritional value of algae; Common edible algae.

Unit II

Algae in industry: Phycocolloids (Agar-agar, Alginic acid and Carrageenan) and secondary metabolites: Sources and Applications; Pharmaceutical and Nutraceutical uses of algae; Algae in cosmetics; Diatomaceous Earth.

Unit III

Algae in agriculture: Algae as soil conditioners and biofertilizers; Seaweed liquid extract; Seaweed powder; Algal biorefinery residues.

Role of algae in environment: Algae as pollution indicators; wasteland reclamation; Role of algae in wastewater treatment; Ecological importance of Symbiotic associations of algae; Harmful algal blooms; Red tides; Algal toxins.

Unit IV

Gene sequencing and algal systematics; Algae as a model organism (*Chlamydomonas, Chlorella, Acetabularia, Ectocarpus, Porphyra*); Bioluminescent forms; Algae in nanotechnology.

Algae as emerging source of bioenergy: Biofuels (Bioethanol, Biodiesel, Biohydrogen); Algal Biorefinery.

Unit V

Algal culture techniques and commercial production: Isolation, purification and sterilisation of algae; Freshwater and marine culture media (BG-11 and Provasoli ES medium); Photobioreactors and large-scale production of microalgae; Seaweed farming.

DSEBOT7104P Practical for Applied Phycology

(60 hours)

1. Isolation and identification of algal species (any three) in water samples from polluted and non-polluted sources through temporary mounts.
2. Nutritional analysis (protein and carbohydrates) of *Spirulina/ Chlorella*/ anyother available edible algae.
3. Study of algal symbiosis (Azolla fronds) through sectioning or tease mount.
4. Phycocolloid (Agar-agar/ Alginates/ Carrageenan) extraction (demonstration/ digital resources).
5. Microalgal culture - maintain cultures of species isolated in Experiment 1(any three).

6. Commercial applications of algae through photographs/products (edible, cosmetics, biofuels, pharmaceutical, nutraceutical, phyco-remediation).
7. Study of algae as a model organism (any 2) through digital resources.
8. Project work on any applied aspect of algae/ Visit to any Institute or Industry (Report to be submitted).

Suggested Readings:

1. Bold, H.C. and Wynne, M.J. (1985) Introduction to the Algae: Structure and Reproduction, 2nd edition. Prentice-Hall International INC.
2. Chapman, D.J. and Chapman, V.J. (1980) Seaweeds and their uses. 3rdedn. British Library.
3. Kumar, H.D. (1999) Introductory Phycology, 2nd edition. Affiliated East-West Press, New Delhi.
4. Lee, R.E. (2008) Phycology, 4th edition: Cambridge University Press, Cambridge.
5. Sahoo, D. (2000) Farming the Ocean: Seaweed Cultivation and Utilization. Aravali Book International, New Delhi.

Additional Resources:

1. Andersen, R.A. (2005) Algal Culturing Techniques. Elsevier Academic Press.
2. Chapman, D.J. and Chapman, V.J. (1973) The Algae. 2ndedn. Macmillan, London.
3. Fleurence, J. and Levine, I. (2016) Seaweed in Health and Disease Prevention. Academic Press publications.
4. Sahoo, D (2010). Common seaweeds of India. IK International Pvt Ltd.
5. Sahoo, D. and Seckbach, J. (2015) The Algae World. Vol 26 Cellular Origin, Life in Extreme Habitats and Astrobiology. Springer, Dordrecht.
6. Van den Hoek, C. Mann, D.G. and Jahans H.M. (1995) Algae: An Introduction to Phycology. Cambridge University Press.

DSEBOT7105T. Plant Systematics

(60 hours)

Learning Objectives:

The learning objectives of this course are as follows:

- to gain knowledge about the basics of plant systematics.
- to get an insight into the interrelationships of plant systematics and allied subjects.

Learning Outcomes:

By studying this course, students will be able to:

- understand technical terminology used in plant taxonomy.
- apply the terminologies to describe, identify and classify the flowering plants.
- search and analyze taxonomic information from internet-based scientific databases and other resources.
- comprehend and compare various systems of classification.
- recognize diversity in local/regional flora.

Unit I

Plant identification, Classification, Nomenclature, Biosystematics. Identification: Field inventory, Herbarium Techniques, Functions of Herbarium, Important herbaria and botanical gardens of the world and India, Virtual Herbarium, E-flora: Flora, Monographs, Journals

Unit II

Systematics-An Interdisciplinary Science, Evidence from cytology, phytochemistry [Alkaloids, Phenolics, Glycosides, (in brief)] and molecular data (cp.DNA, mt-DNA, nuclear DNA, PCR amplification, sequence data analysis)

Unit III

Taxonomic Hierarchy: Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological & evolutionary)

Botanical Nomenclature: Principles and rules (ICN); Ranks and names; Typification, Author citation, Valid publication, Rejection of names, Principle of priority and its limitations; Names of hybrids and cultivated plants.

Unit IV

Basic Terms and Concepts of Phylogeny: Cladistics: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly, clades and grades). Methodology of Cladistics, Methods of illustrating evolutionary relationships (phylogenetic tree, cladogram).

Unit V

Systems of Classification: Major contributions of Parasara, Charaka, Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan, Cronquist, Bremer and MW Chase; Classification systems of Benthan and Hooker (up to series) and Engler and Prantl (up to series); Angiosperm Phylogeny Group (APG IV) Classification (major clades).

DSEBOT7105P. Practical for Plant Systematics

(60 hours)

1. To prepare at least 2 herbarium specimens and identify them using available resources (Literature, herbaria, e-resources, taxonomic keys) and classify up to family level (according to Bentham and Hooker's classification).

2. Description of taxa using semi-technical terms and identification of the families according to Bentham and Hooker's classification.
Note: Any twelve families from the following list to be studied with at least two specimens (or one where limitations exist).
List of Suggested Families (*mandatory)
Acanthaceae, Rubiaceae, *Apiaceae, Apocynaceae, *Asteraceae, *Brassicaceae, *Euphorbiaceae, *Fabaceae, *Lamiaceae, Liliaceae, *Malvaceae, Moraceae, *Poaceae, *Ranunculaceae, *Solanaceae.

Essential/recommended readings:

1. Simpson, M. G. (2019). Plant systematics. 3rd Edition, Academic press.
2. Singh, G. (2019). Plant Systematics- An Integrated Approach. 4th edition. CRC Press, Taylor and Francis Group.
3. Pandey, A. K., Kasana, S. (2021). Plant Systematics. 2nd Edition. CRC Press Taylor and Francis Group
4. http://www.mobot.org/MOBOT/research/APweb/
5. Maheshwari, J. K. (1963). The flora of Delhi. Council of Scientific & Industrial Research.
6. Maheshwari, J. K. (1966). Illustrations to the Flora of Delhi. Council of Scientific & Industrial Research.
7. Harris, J. G., Harris, M. W. (2001). Plant Identification Terminology: An Illustrated Glossary. Spring Lake, Utah: Spring Lake Pub. Spring Lake, Utah.

Suggestive Readings:

1. The Angiosperm Phylogeny Group, Chase, M.W., Christenhusz, M.J.M, Fay M.F., Byng, J.W., Judd, W.S., Soltis, D.E., Mabberley, D.J., Sennikov, A.N., Soltis, P.S., Stevens, P.F. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical journal of the Linnean Society 181 (1): 1-20.

2. https://www.mobot.org/MOBOT/research/APweb/treeapweb2s.gif

3. https://www.digitalatlasofancientlife.org

4. http://apps.kew.org/herbcat/navigator.do

5. https://efloraofindia.com/

6. https://powo.science.kew.org/

7. Page, R.D.M., Holmes, E.C. (1998). Molecular Evolution: A Phylogenetic Approach. Blackwell Publishing Ltd.

DSEBOT7106T. Genetics, cytogenetics and Breeding of plants

(60 hours)

Unit I

Genetics: Chromosome theory of inheritance, crossing over and linkage; Incomplete dominance and codominance; Interaction of Genes; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Polygenic inheritance; Extra-nuclear Inheritance, Linkage, crossing over, Concept of sex determination and Sex chromosomes; Patterns of Sex determination in plants

Unit II

General Introduction to Cytogenetics: Definition, History, Applications of cytogenetics and Techniques of cytogenetics: Karyotyping, Slide Preparation and Analysis.
Chromosomes: Structure and Organization of chromosome, Concept of karyotype, Preparation of chromosome for karyotype, Role of karyotype in plant species identification.

Unit III

Gene Mapping Methods: Linkage mapping: Two Point and Three Point Test cross, LOD score for linkage testing, QTL mapping, Marker assisted selection (MAS), Mapping by tetrad analysis in Yeast (unordered) and Neurospora (ordered), Somatic cell mapping.
Mutation: Mutation- causes and detection, Types of Mutation- Spontaneous, Induced, Point, Frameshift Mutation, Lethal, Germline vs somatic mutations.

Unit IV

Variation in chromosome structure: Detection, Duplication, Inversion and Translocation. Cytological consequences of crossing over in Inversion and translocation heterozygotes.
Variation in chromosome number: Euploidy and Aneuploidy, Classification, method of production, identification and meiotic behavior of aneuploids (Monosomics, Nullisomics and Trisomics). Ploidy: Origin, production of Autopolyploids and Allopolyploids, evolution of major crop plants (Cotton & Wheat)

Unit V

Plant Breeding: Plant introduction. Agencies of plant introduction in India, Procedure of introduction - Acclimatization – Achievements, Selection - mass selection, pure line selection and clonal selection. Genetic basis of selection methods, Hybridization: Procedure of hybridization, inter generic, inter specific, inter varietal hybridization, Male sterility, Heterosis and its exploitation in plant breeding, Mutation, Molecular Breeding; Application of plant breeding.

DSEBOT7106P Practical for Genetics, cytogenetics and Breeding of plants

(60 hours)

1. Monohybrid cross (Dominance and incomplete dominance)
2. Dihybrid cross (Dominance and incomplete dominance)
3. Gene interactions (All types of gene interactions mentioned in the syllabus)
    a. Recessive epistasis 9: 3: 1.
    b. Dominant epistasis 12: 3: I
    c. Complementary genes 9: 7
    d. Duplicate genes with cumulative effect 9: 6: 1
    e. Inhibitory genes 13: 3

4. Observe the genetic variations among inter and intra specific plants.
5. Preparation of cytological stains and fixatives, preservation.
6. Study of external morphology of metaphase chromosome from suitable plant material employing acetoorcein and fulgen stain.
7. Preparation of C- metaphase chromosomes of appropriate material (*Allium / Aloe*).
8. Study of Meiotic configuration in *Rhoeo* / *Tradescantia* buds.
9. Numerical problem based on Gene mapping using two point and three-point test crosses.
10. Numerical problem based on *Neurospora* tetrad analysis.
11. Karyotype analysis of C-metaphase chromosomes using photograph/slide.
12. Study of Floral Biology and Pollen Viability of any two major crops.
13. Study of hybridization technique in cotton and maize.
10. Induction of polyploidy in any suitable crop plants using colchicine, compare the morphological characters using control.
11. Visit to any Plant Breeding Research Centre and submission of report

Suggested reading

1. Albert B. Bray, D Lewis, J Raff, M. Robert, K. and Walter 1989, Molecular Biology of the Cell (Second Edition) Garland Publishing Inc, New York.
2. Atherly, A.G., Girton, J.R. and McDonald, J.F 1999. The Science of Genetics Saunders College Publishing, Frot Worth, USA.
3. Burnham, C.R 1962. Discussions in Cytogenetics.Burgess Publishing Co. Minnesota.
4. Busch, H. and Rothblum. L 1982.Volume X. The Cell Nucleus rDNA part A. Academic Press.
5. Hartk D.L and Jones, E.W 1998 Genetics: Principles and Analysis (Fourth Edition). Jones and Bartlett Publishers, Massachusetts, USA.
6. Khush, G.S 1973. Cytogenetics of Aneuploids. Academic Press, New York, London.
7. Karp, G. 1999. Cell and Molecular Biology : Concept and Experiments. John Wiley and Sons, Inc., USA.
8. Lewin, B. 2000. Gene VII. Oxford University Press, New York, USA.
9. Lewis, R. 1997. Human Genetics: Concepts and Application (Second Edition). WCB McGraw Hill, USA.
10.Malacinski, G.M and Freifelder, D. 1998: Essentials of Molecular Biology (Third Edition). Jones and B. Artlet Publisher, Inc., London.
11.Russel, P.J. 1998. Genetics (Fifth Edition). The Benjamin/Cummings Publishing Company IND., USA.
12.Snustad, D.P and Simmons, M.J 2000. Principles of Genetics (Second Edition). John Wiley and Sons Inc., USA.
13. Gardner and Simmons Snustad 2005 (Eighth Edition). Principles of Genetics, John Wiley and Sons, Singapore.
14. Sariu C 2004 (Sixth Edition) Genetics. TATA McGraw-Hill Publishing Company Ltd., New Delhi. 15.Ahluwalia K.B 2005 (First Edition). Genetics.New Age International Private Ltd. Publishers, New Delhi.
16.Burus and Bottino 1989. (Sixth Edition). The Science of Genetics. Macmillan Publishing Company, New York (USA).
17.Pawar C.B 2003 (First Edition). Genetics Vol.I and II. Himalaya Publishing House, Mumbai.
18.Strickberger 2005. (Third Edition). Genetics.Prentice Hall of India Pvt. Ltd., New Delhi.
19. Allard R.W 1995. Priniples of Plant Breeding.John Wiley and Sons, Ice., Singapore.
20. Sharma J.R 1994 Principles and practices of Plant Breeding. Tata McGraw-Hill Publishers Company Ltd., New Delhi.
21.Singh B.D 1996 Plant Breeding – Principles and methods. Kalyani Publications, Ludhiana.
22.Chahal G.S and Gosal S.S 2002. Principles and procedures of Plant Breeding, Narosa Publishing House, New Delhi.
23. Verma and Agarwal, Genetics, S. Chand Co, New Delhi.

DSEBOT7107T. Biostatistics and Bioinformatics

(60 hours)

Unit I

Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

Unit II

Bioinformatics: Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics. Databases in Bioinformatics: Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

Unit III

Biological Sequence Databases: National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. EMBL Nucleotide Sequence Database (EMBL-Bank); DNA Data Bank of Japan (DDBJ), Protein Information Resource (PIR); Swiss-Prot: Introduction and Salient Features.

Unit IV

Sequence Alignments: Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Unit V

Molecular Phylogeny: Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

Applications of Bioinformatics: Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement

DSEBOT7107P Practical for Biostatistics and Bioinformatics

(60 hours)

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.
6. Calculation of mean, standard deviation and standard error
7. Calculation of correlation coefficient values and finding out the probability

7 Calculation of 'F' value and finding out the probability value for the F value.

Suggested Readings

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.

2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.

3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

DSEBOT7108T. Plant Biotechnology

(60 hours)

Learning Objectives:

- To understand basic concept of and various fields of biotechnology
- To understand basic concept of *In vitro* cellular and developmental biology
- To understand history of plant tissue culture and applications
- To understand genetic engineering of plants and its applications

Learning Outcomes: At the end of this course students would be able to:

- Students will be able to use various tools and techniques of plant biotechnology for human welfare.
- They will be able to understand the basic concept of *In vitro* cellular and developmental biology and their applied aspects.
- They will be able to understand the basic concept of genetic engineering and their use for the welfare of society.

Unit I

Biotechnology: Basic concept, definitions and history. Major fields of biotechnology and applications. *In vitro* cellular and developmental biology: the basis of biotechnology.

Unit II

In vitro cellular and developmental biology of plants: cell theory and concept of totipotency and pluripotency. History of plant tissue culture: Beginning of plant cell, tissue and organ culture. Applications of plant tissue culture. Contributions of botanist in the field of plant cell, tissue and organ culture.

Unit III

Concept of aseptic culture. Basic tools and techniques in plant biotechnology: sterilization of various instruments, glassware, and culture medium. Various types of culture medium. Surface sterilization of explants and aseptic inoculation. Maintenance of cultures in growth chamber. Hardening of *in vitro* regenerated plantlets and field transfer. Haploid culture and its applications. Germplasms conservation.

Unit IV

Various means of micropropagation of plants: morphogenesis, organogenesis and axillary shoot activation. Somatic embryogenesis and synthetic seeds. Somaclonal variations. Physical and chemical means of protoplast isolations. Various methods of protoplast culture. Somatic hybrids and cybrids.

Unit V

In vitro production of secondary metabolites: various types of bioreactors and its applications. Genetic engineering of plants: various methods of gene transfer in plants and its applications. Bt cotton and golden rice. Biology and genetic engineering of biological nitrogen fixation, applications and prospects. Nanobiotechnology and its applications.

DSEBOT7008P. Practical for Plant Biotechnology

(60 hours)

1. Prepare MS Medium using suitable PGRs for activation of axillary shoot bud. Surface sterilized suitable explant and inoculate under aseptic condition.

2. Prepare MS Medium using suitable PGRs for induction of callus from haploid cells (anther). Surface sterilized suitable explant and inoculate under aseptic condition.

3. Prepare MS Medium using suitable PGRs for induction of callus from somatic cells. Surface sterilized suitable explant (young leaf, apical shoots, nodal shoot segment) and inoculate under aseptic condition.

4. Contribution of botanist in plant biotechnology: Gottlieb Haberlandt, PR White, Ball, Miller and Skoog, Guha and Maheshwari

5. To study Tools for aseptic culture: Laminar air flow bench, Autoclave, growth chamber, Hardening unit, Micropropagation, Somatic embryogenesis

6. Synthetic seeds

7. Organogenesis

8. Bioreactor

9. *In vitro production*: Shikkonin, Diosgenine

9. To study the transgenic plant Bt cotton, Golden rice

Suggested Readings

Bhojwani, S.S. Plant Tissue Culture: Application and Limitation, Elsevier Science Publishers, New York, USA, 1990.

Raghavan, O. Embryogenesis in Angiosperms: A Developmental and Experimental Study, CambridgeUniversity, Press, New York, USA, 1986.

Vasil, I.K. and Thorpe, T.A. Plant Cell and Tissue Culture, Kluwer Academic Publishers, The Netherlands, 1994.

Suggested Readings (for Laboratory Exercises) Ball, R.D. (ed.) Plant Cell Culture Protocols, Humana Press, Inc. New Jersey, USA, 1999.

Dixon, R.A. (ed.) Plant Cell culture: a Practical Approach, IRL, Press Oxford, 1987.

Roberts, J. and Tucker, G.A. (eds.) Plant Hormone Protocols Humana Press, New Jersey, USA 2000.

SECBOT301. Nursery Gardening and Landscaping

(30 hours)

Unit I

Methods of preparation of nursery beds and sowing of seeds. Media for propagation of plants in Nursery Beds, Pots and Mist chamber. Study and practice of different propagation methods viz., cutting, layering, division, grafting and budding. Introduction and practicing Bonsai training, pruning and wiring. Study of different types of gardens (indoor and outdoor) and key features of gardens (Paths & Avenues, Hedges & Edges, Lawn, Flowerbeds, Arches & Pergolas, Fencing, Water bodies, Rock garden).

Unit II

Methods for selection and enlisting of suitable plants for different locations and in different types of gardens. Identification of key horticultural plants, Herbs including different types of grasses –foliage and flowering, Shrubs including hedge plants - foliage and flowering, Avenue trees – foliage and flowering, Climbers, Lianas, Epiphytes, Creepers, Trailers, Aquatic plants, Succulents, Weeds.

Unit III

Study of important gardens of India (any five). Methods of Landscape designing of Residential areas and Public Gardens, Aquatic Garden, Rock Garden, Industrial gardens. Concept and Application of Computer aided Designing (CAD) for landscape designing/Preparation of landscape designs for school and college using CAD technology. Demonstration of different composting methods for Biofertilizers.

Practical Exercise

1. To prepare the media for nursery bed
2. To study the key feature of gardening
3. Study and practice of different propagation methods viz., cutting, layering, division, grafting and budding
4. Identification of key horticultural plants
5. Concept and Application of Computer aided Designing (CAD) for landscape designing
6. Preparation of landscape designs for school and college using CAD technology

Essential Readings:

1. A handbook of Landscape: CPWD

2. Gopalaswamiengar, K. S., Parthasarathy, G., Mukundan, P. (1991). Complete Gardening in India. India: Gopalaswamy Parthasarathy, 'Srinivasa'.

3. Hartmann, H. T., Kester, D. E., Hartmann, H. T., Kester, D. E. (1975). Plant Propagation: Principles and Practices. India: Prentice-Hall.

4. Roy, R. K., Roy, R. K. (2013). Fundamentals of Garden Designing: A Colour Encyclopedia. India: New India Publishing Agency.

5. Littlepage, R., Littlepage, R. (2017). Fundamentals of Garden Design: An Introduction to Landscape Design. (n.p.): CreateSpace Independent Publishing Platform.

Suggestive reading:

1. Hodge, G., Hodge, G. (2014). Practical Botany for Gardeners: Over 3,000 Botanical Terms Explained and Explored. United Kingdom: University of Chicago Press.

2. The Royal Horticultural Society Gardening Manual. (2000). United Kingdom: Dorling Kindersley.

SECBOT302. Mushroom Culture and Technology

(30 hours)

Unit I

Introduction, history. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India- *Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus*.

Unit II

Cultivation methods: Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low-cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation - Low-cost technology, Composting technology in mushroom production

Unit III

Storage and nutrition: Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition- Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.

Food preparation: Delicacies of mushroom and its value addition, Research Centers - National level and Regional level. Cost benefit ratio - Marketing in India and abroad, Export Value.

Practical Exercise

1. To preparation the medium for mushroom cultivation
2. To demonstrate the medium sterilization, preparation of spawn, multiplication
3. To demonstrate the Composting technology in mushroom production
4. To visit the research center and submit the report

SECBOT303. Horticulture

(30 hours)

Unit I

Introduction to Horticulture; Garden tools and safety. Lawn making and lawn care: recognizing soils and drainage systems, types of grasses. Choosing the appropriate plants (species selection) for plantation in different seasons and locations (Outdoor, roof-top, balcony, rock gardens); Flowering annuals, herbaceous perennials, vines and climbers, ornamental trees, bulbous and foliage plants, cacti and succulents.

Unit II

Vegetable Garden: Sowing, raising seedlings, transplantation methods; choosing the right vegetables for the season. Seed germination, viability tests and comparison of other parameters of seeds (stored from different years/different temperatures). Weeding, manuring, and irrigation methods used in lawns, parks, and vegetable gardens. Propagation and plant care: propagation by layering, cutting and other methods. Pruning: pruning roses, shrubs, and trees. Supporting plants: bamboos, strings, and enclosures.

Unit III

Maintenance and care of lawns and gardens: understanding diseases caused by pests and pathogens; protecting garden plants from infections, treating the plants with organic and biopesticides. Bonsais: Art and craft. Methods and plantation approaches in various garden designs: Japanese, Mughal, Buddhist, English and Indian Gardens. Enhancing beauty of a garden using flowering plants, Garden walls, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Borders, aquatic garden with flowers; Case studies: Some selected gardens of India.

Practical exercises

1. To prepare and demonstrate the Lawn making and lawn care
2. To develop vegetable garden with selected vegetable
3. To test the seed germination and seed viability
4. To demonstrate the propagation by layering, cutting and other methods
5. To study the art and craft of Bonsais
6. To study the methods and plantation approaches in various garden designs: Japanese, Mughal, Buddhist, English and Indian Gardens
7. One week internship on field or in a company/organization (Landscape Design) that shall be facilitated by the college and report to be submitted

Essential Readings:

1. Edmondson, J.L., Cunningham, H., Densley Tingley, D.O. et al. (2020). The hidden potential of urban horticulture. Nat Food **1,** 155–159.
2. Musser E., Andres. (2005). Fundamentals of Horticulture. New Delhi, Delhi: McGraw Hill Book Co. 2.
3. Sandhu, M.K. (1989). Plant Propagation. Madras, Bangalore: Wile Eastern Ltd.
4. Bird, C. (Ed.). (2014). The fundamentals of horticulture: Theory and practice. Cambridge University Press.
5. The Practical Gardener (1994). Reader's Digest Special Volume.

SECBOT304. Plant Aromatics and Perfumery

(30 hours)

Unit I

Classification of essential oils on the basis of chemical composition, aroma and extraction methods. Principles, processing and techniques of extraction of essential oils. Cultivation practices of the common aromatic crops (any five) - Rose, Lavender, Peppermint, Spearmint, Basil, Citronella, Vetiver, Palmrosa, Lemongrass. Extraction process of essential oil from fruit/ fruit peel by steam distillation (e.g. orange, lemon).

Unit II

Extraction of essential oil from bark by steam distillation (e.g. cinnamon). Extraction of essential oils from flower by steam distillation (e.g. clove, rose, jasmine, lavender, rosemary). Extraction of essential oil from leaves and stems by steam distillation (e.g. lemongrass, eucalyptus, citronella, bottlebrush). Extraction of essential oil from seeds by steam distillation (e.g. fennel, nutmeg). Extraction of essential oil from root (e.g. vetiver) and rhizome (e.g. ginger, curcuma) by steam distillation

Unit III

Determination of oil content in aromatic crop/material by Clevenger's method. Quality assessment of essential oils through sensory evaluation (odour, colour), physical tests (specific gravity, refractive index, optical rotation, solubility), chemical tests (determination of acid value, ester value). Demonstration/Illustration of Instruments and techniques quality assessment of Gas chromatography (GC) and Thin layer chromatography (TLC). Field Visit to essential oils and perfumery Institute/Industry.

Practical Exercise

1. Cultivation practices of the common aromatic crops (any five) - Rose, Lavender, Peppermint, Spearmint, Basil, Citronella, Vetiver, Palmrosa, Lemongrass
2. Extraction of essential oil from bark by steam distillation (e.g. cinnamon)
3. Extraction of essential oil from seeds by steam distillation (e.g. fennel, nutmeg)
4. Assessment of essential oils through chemical tests (determination of acid value, ester value)
5. Demonstration/Illustration of Instruments and techniques quality assessment of Gas chromatography (GC) and Thin layer chromatography (TLC)

Essential Readings:

1. EIRI BOARD. (2008). Handbook of Essential Oils Manufacturing and Aromatic Plants5/E edition, Engineers India Research Institute (India), New Delhi.

2. Kochhar, S.L. (2016). Economic Botany – A Comprehensive Study, 5th Edition. New Delhi, India: Cambridge University Press.

Suggestive Readings:

1. Başer, K.H.C., Buchbauer, G. (2020). Handbook of Essential Oils: Science, Technology, and Applications, 3rd edition, CRC Press.

SECBOT305. Floriculture

(30 hours)

Unit I

Introduction to floriculture, tools and equipment's. Study of diversity in shape, size, and colour of flowers (including basic botany, nomenclature, common name and general uses). Identification and preparation of an inventory of herbaceous flowering plants, climbers, shrubs, and trees around the campus. Study the various physico-chemical soil properties for understanding different soils/soil-types. Methods of preparation of floral beds, soil preparation, greenhouse design and fumigation methods.

Unit II

Methods of seed sowing and raising flowering plants through seeds, bulbs and through vegetative methods in planters, containers and in outdoor environments. Role of light, plant growth regulators and nutrients in blooming and flowering. Bacterial and fungal diseases and pests of ornamental flowers and their management. Interior decoration methods, flower arrangements (Japanese, Western and Indian).

Unit III

Harvesting, methods to increase the shelf life of flowers, post-harvest care and marketing platforms for the floriculture industry. Field visit to nearby nursery/garden to understand basic aspects of Garden design. Commercially growing flowering plants, their share in the global market, methods used for selling the products and importance of the floriculture industry.

Practical Exercise

1. Study of diversity in shape, size, and colour of flowers (including basic botany, nomenclature, common name and general uses
2. To demonstrate the methods of seed sowing and raising flowering plants through seeds, bulbs
3. To study the bacterial and fungal diseases and pests of ornamental flowers and their management
4. To study the interior decoration methods by flowering plant
5. Field visit to nearby nursery/garden to understand basic aspects of Garden design
6. Project Report on any five flowering plants that are grown commercially, their share in the global market

Essential Readings:

1. Randhawa, G.S., Mukhopadhyay, A. (1986). Floriculture in India. New York, NY: Allied Publishers.

2. Larson, R. A. (Ed.). (2012). Introduction to floriculture. Elsevier.

Suggestive Readings:

1. Pal, S. L. (2019). Role of plant growth regulators in floriculture: An overview. J. Pharmacogn. Phytochem, 8, 789-796.

SECBOT306. Green Belt Development for Smart Cities

(30 hours)

Unit I

Methods of vegetation sampling and calculation of importance value index. Measuring Tree Basal Area, Height and Canopy Cover to estimate green cover of an area. Understanding of Instruments for measuring microclimatic variables viz., light, wind, temperature, humidity and precipitation.

Unit II

Estimation of Total Carbon stock of an area. Understanding methods for selection of plants according to pollutant load of both air and water (includes field survey). Assessing air pollution tolerance of plant species using APTI (Air pollution tolerance index).

Unit III

Use Open Source Softwares for mapping the GPS points and generating a cover map. Measurement of Dissolved Oxygen (DO) from treated wastewater. Measurement of BOD and TDS from tank and treated pond. Determination of total dissolved and suspended solids in water. Practical exercises

1. Methods of vegetation sampling and calculation of importance value index.
2. To estimate the Basal Area, Height and Canopy Cover to estimate green cover of an area
3. Use Open Source Softwares for mapping the GPS points and generating a cover map
4. Measurement of Dissolved Oxygen (DO) from treated wastewater
5. Measurement of BOD and TDS from tank and treated pond

Essential Readings:

1. Bell, J. R., Wheater, C. P., Cook, P. A., Bell, J. R., Wheater, C. P., Cook, P. A. (2011). Practical Field Ecology: A Project Guide. United Kingdom: Wiley.

2. Singh J.S., Singh S.P. & Gupta S.R. · 2014. Ecology, Environmental Science & Conservation. (2014). India: S. Chand Pvt. Limited.

3. Measurements for Estimation of Carbon Stocksin Afforestation and Reforestation Project Activities under the Clean Development Mechanism, Afield Manual UNFCCC.

4. Slingsby, D., Cook, C., Slingsby, D., Cook, C. (2016). Practical Ecology. United Kingdom: Macmillan Education UK.

5. Mukerji, K. G. (2013). Laboratory Manual of Food Microbiology. India: I.K. International Publishing House Pvt. Limited.

SEMESTER- VI

DSEBOT7201T. Biochemistry and plant metabolism

(60 hours)

Learning objective:

The learning objectives of this course are as follows:

- To introduce the basic principles of plant structure and function and its application in related fields.
- to understand the fundamental concepts of plant physiology and metabolism.
- to identify the role of water, minerals, hormones, and light in plant growth and development.
- to understand the basic biochemical mechanisms and mineral nutrition of plants.
- to identify the criteria for the essentiality of elements.
- to understand the role of hormones in plant growth and development.
- to examine the commercial applications of growth regulators.
- to understand the physiology of flowering and senescence.
- to understand the mechanisms of photosynthesis and respiration.
- to examine the biological nitrogen fixation in plants.

Learning outcomes: On completion of the course the students will be able to:

- understand the structure and function of plants
- comprehend and compare various tissue systems in plants and their role
- realize the importance of water, soil and atmosphere in the life of organisms
- appreciate the ability of plants to sense the environment and adapt
- interpret and evaluate the significance of regulator molecules in controlling life forms
- apply the principles of plant physiology to solve problems in related fields

Unit I

Plant-water relations: Water potential and its components, water absorption by roots, water movement via symplast, apoplast and aquaporins, root pressure, guttation, ascent of sap, cohesion-tension theory, transpiration, factors affecting transpiration, anti-transpirants.

Mineral nutrition: Essential and beneficial elements, macro- and micro-elements, criteria for essentiality, roles of essential elements, chelating agents, phytosiderophores, mineral nutrition in hydroponics and aeroponics.

Unit II

Nutrient uptake: Transport of ions across cell membrane, passive absorption, simple and facilitated diffusion (carrier and channel proteins), Fick's law, active absorption, proton ATPase pump, electrochemical gradient, ion flux, uniport, co-transport (symport, antiport).

Translocation in the phloem: Composition of phloem sap, phloem loading and unloading, Pressure-Flow Model, source sink relationship

Classification, Structure and properties, mechanism of enzyme catalysis and enzyme inhibition.

Unit III

Carbon Oxidation: Krebs cycle, Glycolysis, Fermentation, oxidative pentose phosphate pathway, Regulation of Krebs cycle, Oxidative phosphorylation, ATP-Synthetase, Chemiosmotic mechanism, factors affecting respiration.

Photosynthesis: Pigments, Cyclic and non-cyclic light reaction, C3, C4 and CAM- carbon fixation and Significance

Nitrogen Metabolism: Nitrate assimilation, biological nitrogen fixation, Physiology and biochemistry of nitrogen fixation, Ammonia assimilation (GS-GOGAT);

Unit IV

Lipid Metabolism: Synthesis and breakdown of triglycerides, -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination

Plant growth regulators: Chemical nature (basic structure, precursor), physiological roles, bioassays and applications of Auxins, Gibberellins, Cytokinins, Abscisic Acid, Ethylene; Other growth regulators - Jasmonic Acid, Brassinosteroids, Nitric Oxide. Mechanism of action of Auxin. Introduction to interactions among plant growth regulators.

Unit V

Physiology of photo-sensory molecules: Discovery, chemical nature, mode of action and role of phytochrome, cryptochrome and phototropin in photomorphogenesis Physiology of flowering: Concept of florigen, photoperiodism, CO-FT Model of flowering, vernalization. Seed dormancy: Seed dormancy -causes and methods to induce and/or overcome dormancy.

DCCBOT7201P Practical for Biochemistry and plant metabolism

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of potato tuber cells by weight method.
3. Determination of water potential of potato tuber cells by falling drop method.
4. Study of effect of light on the rate of transpiration in excised leafy twig.
5. Calculation of stomatal index and stomatal frequency from the lower surface of leaves of a mesophyte and a xerophyte.
6. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and a xerophyte (lower surface).
7. To study the effect of different concentrations of ABA on stomatal closure.
8. To study the effect of light and dark on seed germination.
9. To study induction of amylase activity in germinating barley grains.
10. To study the effect of ethylene on fruit ripening.
11. To study the effect of auxin on rooting.
12. To study the effect of the environmental factor light on transpiration by excised twig.
13. To study the activity of catalase and study the effect of pH on the activity of enzyme.
14. To study the effect of light intensity on O2 evolution in photosynthesis.
15. Comparison of the rate of respiration in any two parts of a plant.
16. To separate photosynthetic pigments by paper chromatography.
17. Bolting / Effect of auxins on rooting.
18. To demonstrate the delay of senescence by cytokinins/ effect of ethylene on fruit ripening
19. To study the phenomenon of seed germination (effect of light and darkness).
20. To demonstrate Respiratory Quotient (RQ)

Suggested Readings:

1. Hopkins, W. G., Huner, N. P. A. (2009). Introduction to Plant Physiology, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.
2. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
3. Kochhar, S.L., Gujral, S.K. (2020). Plant Physiology: Theory and Applications. New Delhi, Delhi: Foundation Books, 2ndEdn. Cambridge University Press India Pvt, Ltd.

Additional Resources:

1. Bajracharya, D. (1999). Experiments in Plant Physiology: A Laboratory Manual. New Delhi, Delhi: Narosa Publishing House.
2. Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.

DSEBOT7202T. Plant Molecular Biology

(60 hours)

Learning Objectives:

- To understand basic concept of molecular biology.
- To understand basic tools and techniques of molecular biology.
- To understand various means of isolation and separation of DNA, protein and RNA
- To understand gene manipulation in plants

Learning Outcomes: At the end of this course students would be able to:

- Students will be able to use various tools and techniques of molecular biology.
- They will be able to isolate and separate DNA, protein and RNA.
- They will be able to clone genes.
- They will be able to manipulate genes of plants.

Unit I

Central dogma of molecular biology: transcription and translation. Genetic recombination in bacteria. Structure of prokaryotic and eukaryotic gene. Gene expression in prokaryote and eukaryote.

Unit II

Tools and techniques in molecular biology: Centrifugation, PAGE and agarose electrophoresis, PCR, DNA sequencing and mass spectrometry. Chromatography.

Unit III

Isolation, purification and separation of DNA, RNA and Protein. Isolation of genes. Vectors for gene cloning: ColE1, pSC101 (natural cloning vectors), p-BR322, pUC8, PAC, YAC and BAC. Detection and screening of recombinant DNA

Unit IV

Recombinant DNA technology: Molecular biology of *A. tumefaciens* and its use in gene transfer. Molecluar biology of restriction enzymes and their use in gene manipulation. Vector mediated and other means of gene transfer methods in plants.

Unit V

Applications of molecular biology: Molecular biotechnology and its applications. Pharmacogenomics. Molecular mechanism of genetically modified plants and its applications: Bt cotton and golden rice as a model system in genetic engineering.

DSEBOT7202P. Plant Molecular Biology

(60 hours)

1. Extract DNA from given plant sample (Cauliflower/Onion) by Rapid Method.
2. Confirmative test of DNA using diphenyl amine (DPA).
3. Preparation of PAGE
4. Preparation of agarose gel
5. Loading of DNA, RNA and protein on gel
6. To study the various technique Chromatography, PCR, Electrophoreses, Mass spectrometry
7. To study the various Restriction enzymes
8. To study various Cloning vectors: Ti plasmid, pUC8, ColE1, pSC101, p-BR322, PAC, YAC and BAC.
9. To study the *A. tumefaciens*

10. to study the GM Crops (Golden rice, Bt cotton)

Suggested Readings

Primrose S, Twyman R, Old B Principles of Gene Manipulation, Black well Scientific Publications, Oxford, U.K., 2001.

Glick, B.R. and Thompson, J.E. Methods in Plant Molecular Biology and Biotechnology, CRC Press, Boxa Raton, Florida, 1993 Roberts, J. and Tucker, G.A. (eds.) Plant Hormone Protocols Humana Press, New Jersey, USA 2000.

Brown, T. A. (2020) Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.

Primrose, S. B. & Twyman, R.M. (2006). Principles of Gene Manipulation and Genomics. 7thedn. Victoria, Australia: Blackwell Publishing.

DSEBOT7203T. Genetic Engineering Technologies & Applications

(60 hours)

Learning Objectives:

- To illustrate the use of modern techniques for the manipulation and analysis of DNA
- sequences
- To understand the applications of recombinant DNA technology for the generation of
- commercial biotechnological products of diverse usage.
- To gain knowledge about biosafety and ethical concerns associated with recombinant
- DNA technology.
- To train students in strategizing research topics employing genetic engineering
- techniques.

Learning Outcomes: At the end of this course students would be able to:

- understand methods and techniques involved in manipulation and analysis of nucleic acids, gene cloning and creation of genetically modified organisms (GMOs).
- understand the commercial application of rDNA technology in research, agriculture and human health
- comprehend biosafety and ethical issues associated with rDNA technology

Unit I

Introduction to rDNA technology and gene cloning. Enzymes and Vectors in genetic engineering: Restriction endonucleases, exonucleases, polymerases, RNAses, kinases, ligases; Plasmids (pBR322, pUC18, pUC19); Lambda based vectors and derivatives (Insertion vectors, replacement vectors, cosmids, phagemids); Artificial Chromosomes (YACs, BACs); Bacterial transformation, strategies for selection and screening (α complementation, antibiotic resistance);

Unit II

Plant Transformation vectors (Ti plasmid), Protein Expression Vectors for use in E. coli; introduction to marker and reporter genes (GUS, GFP).

Gene transfer methods: Agrobacterium mediated transformation, Electroporation, Microinjection, Particle Bombardment, PEG mediated

Unit III

DNA libraries construction and screening: Procedures for construction of genomic and cDNA libraries, screening methods for locating the desired gene (Replica plating, Complementation screening, heterologous gene probe-based hybridizations)

Unit IV

PCR, nucleic acid hybridization and DNA sequencing: PCR technique and its applications, RT-PCR, qPCR, Hybridization based assays (Southern and Northern blotting), Sanger's di-deoxy chain termination method of sequencing – gel-based electrophoresis (semi-automated) and capillary-based gel electrophoresis (automated sequencing).

Unit V

Applications of rDNA technology: Applications in basic research (identify, map, clone, and sequence genes and to determine their functions); applications in agriculture; applications in human health and therapeutics. Human genome project and sequencing of plant genomes by taking Arabidopsis genome as an example. Safety and Ethical Issues related to rDNA research.

DSEBOT7203P. Practical for Genetic Engineering Technologies & Applications
(60 hours)

1. Isolation of genomic/plasmid DNA from bacteria.
2. Quantification of extracted DNA by DPA (Diphenylamine) method.
3. Restriction digestion and AGE (Agarose gel electrophoresis) of DNA.
4. Restricting Mapping of linear and circular DNA.
5. Study of direct and indirect gene transfer methods by photographs: Electroporation, Microinjection and Particle Bombardment, Ti-plasmid mediated gene transfer.
6. Demonstration of techniques by photographs: PCR, RT-PCR, qPCR, Southern and Northern blotting and hybridization.
7. Study of applications of rDNA technology by photographs: recombinant insulin, interferon and human growth hormone, Bt Cotton, Golden rice, and Flavr Savr tomato.
8. Demonstration of working of equipment's used in rDNA technology: Thermocycler, Laminar air flow cabinet, Autoclave, Incubator shaker, Refrigerated centrifuge.

Suggested Readings:

1. M. R. Green, J. Sambrook. Molecular Cloning: A Laboratory Manual (Cold Spring Harbor, ed. 4, 2012).
2. M. Wink. An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology (Wiley, ed. 2, 2011).
3. Glick, B.R., & Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6thedn. Washington, U.S.: ASM Press.
4. Snustad, D.P.,Simmons, M.J. (2019). Principles of Genetics, 7th edition. Chichester, England: John Wiley and Sons.
5. Brown, T. A. 2020. Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.
6. Primrose, S. B., Twyman, R. (2009). Principles of gene manipulation and genomics. Wiley. com.
7. Howe, C. J. (2007). Gene cloning and manipulation. Cambridge University Press.

Additional Resources:

1. M. M. Burell. (1993) Enzymes of Molecular Biology, Humana Press.
2. H.M. Eun. (1996) Enzymology: Primer for Recombinant DNA Technology, Academic Press.
3. S. B. Primrose, R. Twyman. (2006) Principles of Gene Manipulation and Genomics (Wiley-Blackwell, ed. 7).

DSEBOT7204T. Genomics, Proteomics and Metabolomics

(60 hours)

Learning Objectives:

- Build the concepts of genomics, proteomics and metabolomics.
- Understand the role of model organisms in genomics studies
- Familiarization of tools used in genomics and proteomics.

Learning Outcomes: At the end of this course, students will be able to:

1. understand the implications of genomic, transcriptomic, proteomic and metabolomic studies in an organism.
2. assimilate logic and reasoning behind choice of model organisms for genomics study.

Unit I

Genomics: Recapitulating basics of prokaryotic and eukaryotic genomes; basic concept of structural and functional genomics.

Model organisms in genomics: Features of important model organisms used in genomics study (*Escherichia coli, Saccharomyces cerevisiae, Caenorhabditis elegans, Arabidopsis thaliana*)

Unit II

Sequencing strategies: Sequencing: basic principle-Sanger's method; classical approaches for sequencing large genomes (whole genome shot gun method viz. WGS, clone by clone sequencing); Next generation sequencing (NGS); Concept of third generation sequencing; Genome sequencing Projects: Human genome project (brief history and significance); Arabidopsis genome project; rice genome project; applications of genomics in agriculture and human health

Unit III

Transcriptomics: Concept: EST sequencing; Gene expression studies by Microarrays and RNAseq. Proteomics: Proteins as structural and functional unit of life; basics concept of protein structure (primary, secondary, tertiary, and quaternary), peptide bonds; brief introduction of major post-translational modifications (phosphorylation, glycosylation); introduction to enzymes; introduction to proteomics and its applications.

Unit IV

Tools for proteome analysis: Separation and isolation of proteins from plant tissue; purification of proteins by chromatographic techniques (column chromatography, ion exchange and affinity chromatography); separation of total cellular proteins by electrophoresis: SDS-PAGE, western blotting and ELISA.

Unit V

Metabolomics: Concept of metabolomics; classes of metabolites (primary and secondary metabolites in plants); Experimental methods and instruments used in metabolomics- HPLC, GC; applications of metabolomics.

DSEBOT7204P. Practical for Genomics, Proteomics and Metabolomics

(60 hours)

1. Genomic DNA extraction from cauliflower heads
2. Select 10 different organisms (5 prokaryotic and 5 eukaryotic) whose genomes have been completely sequenced and categorize them based on taxonomy, find their genome size and locate the database where their genome sequence is hosted.
3. Demonstration of gene expression studies through photographs: microarrays and RNA seq.
4. Demonstration of Sanger's DNA sequencing principle.
5. Interpretation and reading of DNA sequence chromatograms.
6. Experiment to demonstrate activity of Amylase.
7. Estimation of protein concentration through Lowry's methods/Bradford assay.
8. Demonstration of separation of proteins using SDS-PAGE (demonstration).
9. Study of proteins by Western blotting technique (digital resources/demonstration).
10. Demonstration of ELISA through kit.

Suggested readings:

1. Brown, T. A. (2020). Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.
2. Glick, B.R., Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6thedn. Washington, U.S.: ASM Press.
3. Griffiths, A.J.F., Doebley, J., Peichel, C, Wassarman D. (2020). Introduction to Genetic Analysis, 12th edition. New York, NY: W.H. Freeman and Co.
4. Liebler, D.C. (2002). Introduction to Proteomics: Tools for New Biology, Humana Press.
5. Primrose, S. B. Twyman, R.M. (2006). Principles of Gene Manipulation and Genomics. 7thedn. Victoria, Australia: Blackwell Publishing.
6. Twyman R. (2013) Principles of Proteomics, Taylor & Francis Books.
7. Watson J.D. (2017) Molecular Biology of the Gene. Pearson publishers.
8. Westermeier, R., Naven, T., Hopker, H.R. (2008). Proteomics in Practice: A guide to successful experimental design, 2nd edition, Wiley Blackwell.
9. Wood, P.L., (2021) Metabolomics. Springer Protocols.

Additional resources:

1. Banks, K (2022) Introduction to Proteomics. Larsen & Keller Education
2. Campbell, A.M. and Heyer, L.J (2006). Discovering Genomics, Proteomics and Bioinformatics, Pearson publishers.
3. Bhattacharya, S.K. (2019) Metabolomics: Methods & Protocols. Springer Protocols/Humana Press

DSEBOT7205T. Advances in plant molecular Biology

(60 hours)

Learning Objective:

● To gain comprehensive knowledge about of genetic material, central dogma, genetic code, DNA replication, transcription, modification of transcript, translation and regulation of gene expression.

Learning Outcomes: At the end of this course the student will understand:

1. structure and function of nucleic acids at molecular level.
2. the concept of central dogma and genetic code.
3. molecular details of DNA replication and its types.
4. cellular processes of transcription and translation including modification of transcripts and polypeptides/proteins
5. mechanisms regulating gene expression.

Unit I

Discovery of nucleic acids, Experiments that established nucleic acids (DNA & RNA) as the carrier of genetic information: Griffith's, Hershey & Chase, Avery, McLeod & McCarty, and Fraenkel-Conrat's experiment.

DNA double helix structure (Chargaff's rule; Watson and Crick model); salient features of DNA double helix. Types of DNA: A, B & Z conformations, denaturation and renaturation (only melting profile- Tm), types of RNA (mRNA, rRNA, tRNA, small RNAs). split genes (Phillip Sharp)

Unit II

Beadle and Tatum's one gene one enzyme hypothesis; The Central Dogma, Genetic code and its salient features, Experiments for deciphering Genetic code (Experiments by Nirenberg &Matthaei, and Har Gobind Khorana). Adaptor hypothesis by Crick; Baltimore and Temin's discovery of reverse transcription;

Delbruck's Dispersive mechanism model; Bloch and Butler's conservative replication model; Messelson and Stahl's semi-conservative replication model; Mechanism - initiation, elongation and termination; Enzymes and other proteins involved in DNA replication;

Unit III

General principles – bidirectional, semiconservative and semi-discontinuous replication (Replisome), RNA priming (Primase & Primosome); Various modes of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear dsDNA. Replication of the 5'end of linear chromosome (end-replication problem & Telomerase).

Transcription process in prokaryotes (Initiation, Elongation and Termination); structure and function of RNA polymerase enzyme; concept of promoters and transcription factors; comparison between prokaryotic and eukaryotic transcription;

Unit IV

Concept of post-transcriptional modifications (introduction to eukaryotic mRNA processing: 5' capping; Splicing and alternative splicing; 3' poly A tailing).

Translation in prokaryotes: Initiation, Elongation and Termination; concept of charging of tRNA and role of aminoacyl synthetases; ribosome structure and assembly (prokaryotes and eukaryotes); comparison between prokaryotic and eukaryotic translation; post-translational modifications (phosphorylation, glycosylation).

Unit V

Gene regulation in prokaryotes: Operon concept; inducible & repressible systems; regulation of lactose metabolism in E. coli (inducible system, positive & negative control); regulation of tryptophan synthesis (Repression-De-repression and concept of Attenuation) in E. coli. Gene regulation in eukaryotes: concept of gene silencing by DNA methylation and RNA interference.

DSEBOT7205P. Practical for Advances in plant molecular Biology

(60 hours)

1. Isolation of plasmid and genomic DNA from E. coli and quantification using agarose gel electrophoresis
2. Isolation of genomic DNA from plant samples (atleast two different genera / species) using CTAB method and quantification using agarose gel electrophoresis
3. Quantification of unknown DNA by diphenylamine reagent (colorimetry).
4. To estimate the generation time of Escherichia coli (prokaryote) and budding yeast (eukaryote) by spectrophotometric measurement and plotting growth curve as an indirect method to study DNA replication
5. To study control of replication in budding yeast with the help of specific inhibitors (beta-lactams:-Clavulanic acid, Ceftazidime, Piperacillin, Ceftriaxone etc) and studying budding frequency.
6. To study control of transcription in Escherichia coli with the help of prokaryotic (Rifampicin) and eukaryotic (Actinomycin-D) transcription inhibitors and plotting growth curve
7. To study control of translation in Escherichia coli with the help of prokaryotic (Kanamycin / Streptomycin) inhibitors using an IPTG-inducible system.
8. To understand the regulation of lactose (lac) operon (positive & negative regulation) and tryptophan (trp) operon (Repression and De-repression & Attenuation) through digital resources/data sets.

Suggestive readings:

1. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino, & Darrell Killian (2019). Concepts of Genetics. Pearson; 12th edition.
2. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
3. Snustad, D.P. and Simmons, M.J. (2019). Principles of Genetics. John Wiley, 7th edition.
4. Russell, P. J. (2010). iGenetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.

Additional Resources:

1. Griffiths, A.J.F., John Doebley J., Peichel, C., Wassarman D.A. (2020). Introduction to Genetic Analysis. W H Freeman & Co; 12th edition
2. Micklos D A., Freyer G.A. (2003) DNA Science: A First Course (2nd Edition), Cold Spring Harbor Laboratory; Greg A., CSHL Press, USA

DSEBOT7206T. Plant Ecology and soil biology

(60 hours)

Learning Objectives:

● To introduce the students with environmental factors affecting the plants, the basic principles of ecology and phytogeography.
● To make them understand community patterns and processes, and ecosystem functioning.

Learning Outcomes:

At the end of this course, students will be able to understand:
● the interrelationship between organisms and environment.
● methods to study vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography.
● evolving strategies for sustainable natural resource management and biodiversity conservation.

Unit I

Basic concepts, Interrelationships between the living world and the environment; Abiotic interactions: Abiotic factors and plant adaptations, variations in light, temperature & wind conditions.

Unit II

Biotic interactions: Definition; types of positive and negative biotic inter actions. Ecosystems: Types, components, trophic organisation; food chain & food webs, ecological pyramids. models of energy flow; production and productivity; a brief outline of biogeochemical cycles (Carbon and Nitrogen)

Unit III

Population ecology: Characteristics of populations; population growth models and introduction to population regulation (density-dependent and independent); ecotypes; metapopulation (history, concept and applications to conservation)

Unit IV

Plant Communities: Community characters (General account of analytical and synthetic characters); Ecotone; Succession: processes, types (Lithosere, Hydrosere, Xerosere, Psammosere)

Unit V

Soil: Origin & Formation; physical, chemical and organic components; soil profile; forms of water in soil; Water: Importance; States of water in the environment; Atmospheric moisture; Water table

Phytogeography: Principles; Continental drift; Theory of tolerance; Endemism; Phytogeographical division of India

DSEBOT7206P. Practical for Plant Ecology and soil biology

(60 hours)

1. Principle and operation of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH and detection of carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from atleast two soil samples by rapid field tests.
3. Determination of pH & dissolved oxygen from polluted and unpolluted water samples.
4. Determination of soil organic carbon and organic matter of different soil samples by Walkley & Black rapid titration method.
5. Study of ecological adaptations of hydrophytes and xerophytes (four each).
6. Study of biotic interactions of the following: Stem parasite (Cuscuta), Root parasite (Orobanche), Epiphytes, Predation (Insectivorous plants).
7. Determination of minimal quadrat size and number for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
8. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
9. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
10. Species distribution pattern based on A/F ratio (regular, random, clumped).
11. Field visit to familiarize students with ecology/conservation of different sites.

Suggested Readings:

1. Daubenmire, R.F. (1975). Plant and Environment.London: J. Wiley and Sons Inc.
2. Kormondy, E.J. (1996). Concepts of Ecology. New Delhi, India: PHI Learning Pvt. Ltd. 4th edition.
3. Odum, E.P. (2005). Fundamentals of Ecology. New Delhi, India: Cengage Learning India Pvt. Ltd., 5th edition.
4. Sharma, P.D. (2010). Ecology and Environment. Meerut, India: Rastogi Publications. 8th edition.
5. Singh, J.S., Singh, S.P., Gupta, S.R. (2014). Ecology, Environmental Science and Conservation. New Delhi, India: S. Chand.

Additional Resources:

1. Ambasht, R.S. and Ambasht, N.K. (2008). A text book of Plant Ecology, CBS Publishers & Distributors PVT. LTD.
2. Majumdar, R and Kashyap, R (2019). Practical Manual of Ecology and Environmental Science, New Delhi, India: Prestige Publishers
3. Singh, J.S., Singh, S.P., Gupta, S. R. (2006). Ecology, Environment and Resource Conservation. New Delhi, India: Anamaya Publications.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology. USA: An Earth Systems Approach. Oxford University Press.
5. Hanski, I.A., & Gilpin, M.E. (1997). Metapopulation biology: Ecology, genetics, and evolution. Academic Press.

DSEBOT7207T. Environmental Monitoring and Ecosystem Restoration

(60 hours)

Learning Objectives:

- The course will train students on methods for conducting environmental monitoring protocols.
- It will provide experiential learning in conducting quality check experiments on soil, water and air.
- The course will develop understanding on different aspects of ecosystem restoration and processes through monitoring system.

Learning Outcomes:

At the end of this course, students will be able to:

- understand the problem of environmental degradation
- assessment of quantitative and qualitative parameters used in environmental monitoring of air, soil and water.
- understand the strategies and methods for ecosystem restoration, including physicochemical and biological indicators.
- understand degraded and restored sites through field visits.

Unit I

Ecosystem degradation, Magnitude/ Scale of degradation (National and Global Scenario); influence of climate change in Ecosystem degradation (extreme and erratic natural events)

Unit II

Factors of environmental degradation: Factors responsible for degradation of soil, water, air and loss of biodiversity; natural and anthropogenic-forest fires, landslides, floods, deforestation, overgrazing, soil erosion, mining, landfills, etc.

Unit III

Ecosystem Restoration: Definition; UN decade on Ecosystem Restoration; Bradshaw's Concept: Restoration, Rehabilitation and Reclamation (replacement); Role of Sustainable Development Goals (SDGs)., REDD+, Joint Forest Management; Relevance for people, nature and climate.

Unit IV

Environment Monitoring: Indicators of land degradation: Soil- alkalinity, salinity, organic carbon and soil health; Water- pH, Hardness, BOD, COD and Heavy metals content; Air- PM 10 , PM 2.5 , SO2 , NOx, ozone), Air Quality Index (AQI); Bioindicators/ Biomonitors (plants, animals and microbes).

Unit V

Role of Plants and Microbes in Ecosystem Restoration: Brief account of remediation technologies: bioremediation, phytoremediation (phytoextraction, rhizofiltration, phytovolatilization, phytostabilization etc); Role of associations of Grasses-AMF, Legumes-Rhizobium in restoring degraded land/ mined out areas; Role of macrophytes in wetland restoration; Role of green spaces including parklands and avenue plantations in amelioration of air quality.

DSEBOT7207P. Practical for Environmental Monitoring and Ecosystem Restoration (60 hours)

1. Field visit to degraded ecosystem/ natural ecosystem/restored ecosystem.
2. Analyze the soil and water samples from polluted and unpolluted sites for their pH
3. Analyze carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field tests in soil samples from degraded and healthy sites.
4. Determine the organic matter in soil samples by Walkley and Black's rapid titration method.
5. Determine the dissolved oxygen of water samples of polluted and nonpolluted sites by Winkler's method.
6. Determine the BOD and COD content of water samples of polluted and nonpolluted sites.
7. To collect, collate and analyze Air Quality Index (AQI) data, Water Quality data of various locations from DPCC/CPCB website collected from real-time monitoring stations.
8. Study of bioindicators (plant, animal and microbes).

Suggested Readings:

1. Bagyaraj, D.J. and Jamaluddin (2016) Microbes for Restoration of Degraded Ecosystems, New India Publishing Agency
2. Majumdar R., Kashyap R (2020). Practical Manual of Ecology and Environmental Science, Prestige
3. Ricklefs, R. E., Miller, G. L., (2000). Ecology, 4th edition W.H. Freeman.
4. Sharma, P. D. (2017). Ecology and Environment, 13th Edition. Meerut: Rastogi Publications.
5. Smith, T. M., Smith, R. L. (2012). Elements of Ecology 8th Edition. Pearson.

Additional Resources:

1. Central Pollution Control Board (CPCB) Air and Water: https://cpcb.nic.in/real-time-data/
2. Managing Ecosystems in The Context of Climate Change Mitigation: A review of current knowledge and recommendations to support ecosystem-based mitigation actions that look beyond terrestrial forests https://www.cbd.int/doc/publications/cbd-ts-86-en.pdf
3. National Clean Air Programme (NCAP) 2018. https://moef.gov.in/wp-content/uploads/2019/05/NCAP_Report.pdf
4. Real Time Ambient Air Quality Data (DPCC). https://www.dpccairdata.com/dpccairdata/display/index.php
5. Restoration for People, Nature and Climate, https://wedocs.unep.org/bitstream/handle/20.500.11822/36251/ERPNC.pdf
6. Champion, H. G., and S. K. Seth. A revised classification of forest types of India. Manager Publication, Government of India, Delhi (1968).

DSEBOT7208T. Plant Pathology

Learning Objectives:

- To introduce students with the phytopathology, its concepts and principles
- To acquaint with various plant diseases, causal organisms and their control

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

- Understand the economic and pathological importance of fungi, bacteria and viruses
- Identify common plant diseases and their control measures

Unit I

Introduction: Definition of disease and its components (disease pyramid); Classification of diseases (on the basis of pathogens; geographical distribution; extent of occurrence); History and significance of Phytopathology (with special reference to India); Eminent plant pathologists and their contributions.

Unit II

Basic concepts of Plant Pathology: Definitions (Pathogenesis; Pathogen; symptoms; etiology); Types of pathogens and their Symptoms (Fungus, Oomycetes, Bacteria, Virus, Nematode, Phytoplasma); Koch's Postulates; Disease cycle (Components) - Epidemiology and forecasting of Plant diseases.

Host- Pathogen relationship: How pathogens attack plants (brief concept on mode of penetration; post-penetration and colonization). Plant defence mechanisms (Constitutive and induced, structural and
biochemical).

Unit III

Fungal diseases: Causal Organism, Symptoms, Disease Cycle and control: Powdery mildew of Pea; Ergot of Rye; Apple scab, Early blight of potato, red rot of sugarcane, Black, Yellow and Brown rust of Wheat; Smut of Barley (Loose and Covered Smut).

Oomycete Diseases: Causal organism, symptoms, disease cycle and control: Late Blight of Potato; White Rust of Crucifers; Downy mildew of Grapes.

Bacterial Diseases: General symptoms; Disease cycle and Control measures - Citrus canker; Angular leaf spot of Cotton.

Unit IV

Viral Diseases: General symptoms; Mode of transmission and Control measures-Tobacco mosaic disease; Vein Clearing of Bhindi

Nematode Diseases: General symptoms, Disease cycle and Control measures-Root knot disease of Brinjal.

Plant Disease Control: Plant quarantine and its significance; Methods of disease control: Physical; Chemical methods. Types of fungicides – Inorganic, Organic; Systemic fungicides and their mode of action.

Unit V

Cultural practices (Host eradication, sanitation, crop rotation, Polythene traps, Mulches) Biological Control (Antibiosis, hyper - parasitism, Hypovirulence, Predation, Induced systemic Resistance).

Plant Disease Control: Quarantine, Cultural practices, Physical methods, Chemical methods, biological control of plant diseases.

DSE-BOT7208P. Practical for Plant Pathology

(60 hours)

1. Study of Late blight of Potato through specimens, temporary mounts (V.S. of leaf showing infection) and permanent slides.
2. Study of Black stem Rust of Wheat: Symptoms on wheat and barberry. Observe uredospores and teleutospores on V.S. wheat leaf/ to study stem spore stages of *Puccinia graministritici* with the help of temporary tease/section mount of wheat. Permanent slides of somatic and reproductive phases on both the hosts.
3. Study of smut of barley, symptoms of loose and covered smut and temporary spore mount.
4. Study of Powdery mildew of pea, Symptoms with the help of live or preserved specimens. Study of Erysiphe asexual and sexual stages with the help of temporary tease/section mount/ permanent slides.
5. Study of symptoms of Red rot of sugarcane, W.M. of conidia through temporary tease mount.
6. Study symptoms of bacterial diseases: Citrus canker, Angular leaf spot of Cotton.
7. Study symptoms of viral diseases: Tobacco mosaic Disease, Vein clearing of Abelmoschus esculentus/Ageratum sp.
8. Study of nematode diseases: Root knot disease of Brinjal.
9. Isolation of seed borne mycoflora by moist chamber method technique.
10. Study of biocontrol agents: Nematophagous fungi; Trichoderma sp.
11. The students should submit specimens of any two plant diseases studied by them.

Suggested Readings:

1. Agrios, G.N. (2005) Plant Pathology 5 th edition: Elsevier Academic Press, Amesterdam.
2. Sharma, P.D. (2014) Plant Pathology Rastogi Publications, Meerut, U.P.
3. Singh, R.S. (2018) Plant Diseases. 10th Edition Medtech, New Delhi.

Additional Readings:

1. Ownley, Bonnie and Trigiano, Robert N. (2017). Plant Pathology: Concepts and Laboratory Exercises, 3rd Edition, CRC Press.

DSEBOT7209T. Crop Genetics and Plant Breeding

(60 hours)

Learning Objectives:

The Learning Objectives of this course are as follows:

- to develop an understanding of the concepts of plant breeding and its applications.
- to provide adequate knowledge on the natural breeding systems of different agriculturally important plant and strategies employed for crop improvement.
- to impart skills on plant genome analysis and gene mapping using DNA markers and their use in increasing efficiency of plant breeding.
- to understand the genetic basis of hybrid vigour and development of hybrid varieties.
- to make students familiar with the concept of varietal release and rights of a farmer and plant breeder.

Learning Outcome:

By studying this course, the students will be able to:

- gain knowledge on the importance of plant breeding for developing new cultivars and use of breeding strategies for improvement of crop plants.
- understand the concept of gene pool and germplasm resources that are fundamental to crop improvement.
- explicate the breeding methods for commercially important crop plants.

Unit I

Plant Breeding: introduction, importance of plant breeding and its history; Breeding systems in crop plants; Self-incompatibility, male sterility and apomixis, Important achievements in plant breeding.

Unit II

Sources of Variation: Plant genetic resources- their management and conservation, utilization of gene pools in breeding programs. Chromosome manipulation- induced mutations, haploidy, polyploidy, somatic hybridization, somaclonal variation.

Unit III

Conventional Breeding Methods: Selection methods for self-pollinated, cross-pollinated and vegetatively propagated crop plants; Hybridization for self-pollinated, cross-pollinated and vegetatively propagated crop plants-procedure, advantage and limitations.

Heterosis Breeding: Genetic and molecular basis of heterosis (hybrid vigour); Development of hybrid varieties through exploitation of hybrid vigour. Inbreeding depression.

Unit IV

Molecular Genetics and Plant Breeding: Molecular markers as tools in plant breeding; Principle of genetic linkage; Concept of genetic distance; Development and choice of mapping populations (F2, NILs, RILs, BC etc); Linkage map construction; Quantitative traits - Principles and methods of QTL mapping, QTL Introgression; Marker-assisted breeding- Gene tagging; Marker-aided selection (foreground and background selection); Elimination of linkage drags; Marker assisted recurrent selection (MARS). Novel Plant Breeding Tools (TALEN's, CRISPR-Cas9, Base editing).

Unit V

Intellectual Property Rights and Varietal Release: IPR, Patenting; Breeder's Right; Release of New Varities-Trials & their evaluation, Prerelease, Notification and its Release; Plant variety protection; Farmer's Right.

DSEBOT7209P. Practical for Crop Genetics and Plant Breeding

(60 hours)

1. Introduction to open/controlled pollinations in field and laboratory (Breeders kit; temporal details of anthesis, anther dehiscence, CMS, stigma receptivity, emasculation, bagging). 24
2. Analysis of the breeding system of chosen crop species by calculating pollen: ovule ratio.
3. Calculation of Index of self-incompatibility (ISI).
4. Study of dominant/ codominant nature of different molecular markers.
5. Assessment of phenotypic diversity in different accessions of given plant material using morphological markers.
6. Assessment of genetic diversity and construction of dendrogram using molecular markers.
7. Phenotypic screening of a mapping population/ land races for biotic stress resistance and calculating the log of percentage severity and symptom score.
8. Study of floral biology, emasculation and hybridization techniques in self-pollinated and cross-pollinated crops.
9. Estimation of heterosis, inbreeding depression and heritability.
10. Project: Case study based on gene mapping.
11. Field trip to plant breeding station.

Essential/recommended readings

1. Acquaah, G. (2012). Principles of Plant Genetics & Breeding. 2nd edition. Hoboken, NJ, Wiley.
2. Allard, R.W. (1999). Principles of Plant Breeding. John Wiley, New York.
3. Singh, B.D. (2022). Plant Breeding: Principles and Methods, 12th edition. New Delhi, Delhi: Kalyani Publishers.
4. Frey, K. J. (1982). Plant Breeding II. Kalyani Publishers, New Delhi.

Suggestive readings:

1. Chopra, V.L. (2023). Plant Breeding: Theory and Practice 2nd Restructured Edition, New India Publishing Agency, New Delhi.
2. Poehlman J. M. and Sleper D. A. (1995). Breeding Field Crops, 4th Ed. Panima Publishing Corporation, New Delhi.
3. Welsh, J. R. (1981). Fundamentals of Plant Genetics and Breeding. John Wiley and Sons, New York.

DSEBOT7210T. Advanced tools & Analytical Techniques in Plant Biology

(60 hours)

Learning Objectives:

• To gain the knowledge on various techniques and instruments used for the study of plant biology

Learning Outcomes: At the end of this course, students will be:

● competent in the basic principles of major techniques used in study of plants

● understand principles and uses of light, confocal, transmission and electron microscopy, centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques

Unit I

Imaging and related techniques: Electron microscopy: Transmission and Scanning electron microscopy, cryofixation, negative staining, shadow casting, freeze-fracture, freeze-etching; Chromosome banding, FISH, GISH, chromosome painting.

Centrifugation: types of rotors, differential and density gradient centrifugation, sucrose density gradient, ultracentrifugation, caesium chloride gradient; marker enzymes for analysis of cellular fractions.

Unit II

Radioisotopes: Types of radioisotopes; types of emissions (alpha, beta, gamma radiations); half-life; use of radioisotopes in biological research; auto-radiography; pulse-chase experiment; Biosafety measures and disposal of radioactive material

Unit III

Spectrophotometry: Principles and applications of UV, Visible and IR spectrophotometry, Mass spectrometry; X-ray diffraction; X-ray crystallography; Electrophoresis: AGE, PAGE, SDS-PAGE

Unit IV

Chromatography: Principles and applications of Paper chromatography, Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography, Molecular sieve chromatography, Affinity chromatography.

Unit V

Techniques for detection and analysis of nucleic acids and proteins: PCR – design of PCR primers, enzymes used for PCR, cloning of PCR products; DNA polymorphism and its applications (RFLP, AFLP, SSR, SNPs); RNA isolation and analysis, cDNA synthesis and qRT-PCR; Extraction of proteins, PAGE (Native and denaturing); Blotting and hybridization techniques: Southern (Radioactive and Non-radioactive), Northern and Western; DNA sequencing – Sanger's dideoxy sequencing; ELISA.

DSE-BOT7210P. Practical for Advanced tools & Analytical Techniques in Plant Biology
(60 hours)

1. Study of microscopic techniques using digital resources (freeze-fracture, freeze-etching, negative staining, FISH, chromosome banding).
2. Isolation of chloroplasts by differential centrifugation.
3. Separation of nitrogenous bases by paper chromatography.
4. Separation of sugars by thin layer chromatography
5. Separation of chloroplast pigments by column chromatography (demonstration)
6. Amplification of DNA by PCR and visualization of PCR products.
7. Detection of DNA polymorphism (SSR based DNA fingerprinting).
8. Gel based and capillary based DNA sequence data analysis.
9. Estimation of protein concentration by Bradford method.
10. PAGE to study overexpression of proteins/ Separation of proteins by PAGE.
11. Blotting techniques: Southern, Northern and Western using digital resources.

Suggested Reading:

1.Hofmann, A., &Clokie, S. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology (8th ed.). Cambridge University Press.
2. Gerald Karp, Janet Iwasa, Wallace Marshall (2019). Karp's Cell and Molecular Biology, 9th Edition: Wiley
3. O' Brien, T.P. and Cully M.E (1981). The Study of Plant Structure. Principles and selected Methods, Termarcarphi Pty. Ltd., Melbourne.

Additional Resources:

1. Cooper, G.M., Hausman, R .E. (2009). The Cell: A Molecular Approach, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA.

SECBOT401. Biofertilizers

(30 hours)

Unit I

General account about the microbes used as biofertilizer –Rhizobium – isolation, identification, mass multiplication, carrier-based inoculants, Actinorrhizal symbiosis.

Unit II

Azospirillum: isolation and mass multiplication – carrier-based inoculant, associative effect of different microorganisms. Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation

Unit III

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop Plants

Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application. National and state institutes related to the activity.

Laboratory Exercise

1. identification and characterization of rhizobium
2. Preparation of temporary slides of rhizobium
3. perform the technique for isolation and mass multiplication of Azospirillum
4. Study the various cyanobacteria for nitrogen fixation
5. perform the technique for mass multiplication of Azolla
6. preform the preparation of green manure and vermicomposting
7. Study the VAM

Essential Readings:

1. Kumaresan, V. (2005). *Biotechnology.* New Delhi, Delhi: Saras Publication.
2. Sathe, T.V. (2004). *Vermiculture and Organic Farming.* New Delhi, Delhi: Daya publishers.
3. Subha Rao, N.S. (2000). *Soil Microbiology.* New Delhi, Delhi: Oxford & IBH Publishers.
4. Khosla, R. (2017). Biofertilizers and Biocontrol Agents for Organic Farming Kojo Press.

Suggestive Readings:

1. Azotobacter - Isolation and characterization -- https://youtu.be/1Z1VhgJ2h6U
2. Rhizobium -- Identification and characterization - https://youtu.be/jELlo-pMvc4.
3. 3-Days Online Workshop On Arbuscular Mycorrhizal Fungi_ Biodiversity, Taxonomy and Propagation 19-2 (2022-01-20 at 02_27 GMT-8) – https://youtu.be/LKzK4IuSRc4
4. Vayas,S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming. Nadiad, Gujarat: Akta Prakashan.

SECBOT402. Bioinoculants for Agriculture and Sustainable Development

(30 hours)

Unit I

Biofertilizers: success story – biofertilizer production under ICAR - How Biofertilizers for Corn Went Commercial. Biopesticides: success story of using biopesticides for nematode management in horticultural crops.

Bioinoculants as a solution to the problem of parali (stubble) burning: case study of "PUSA Decomposer". Bioinoculants for reforestation. Bioinoculants for the reclamation of waste lands having alkaline, acidic, heavy metal-contaminated soils.

Bioinoculants for clearance of oil spills. Mycorrhizal inoculants. Some important commercially available bioinoculants.

Unit II

Isolation of phosphate solubilizers, free-living nitrogen fixers, heavy metal-accumulating microbes, alkalophiles, acidophiles from suitable soil samples. Observation of colony morphology and microscopic structure of selected microbes and preservation of these cultures in slants and glycerol stocks.

Unit III

Culturing of selected microbes from those isolated, and formulating them into a bioinoculant. Preparation of workflow for evaluating efficacy in potted plants and in fields, for determining shelf life, and stability.

Laboratory/project exercises

1. Study the Biopesticides
2. Case study of PUSA Decomposer
3. Case study the bioinoculant in waste lands having alkaline, acidic and heavy metal-contaminant soil
4. Isolation of free-living nitrogen fixers
5. Observation of colony morphology and microscopic structure of selected microbes
6. Isolation and culturing of selected microbes used for formulating into a bioinoculant.
7. Preparation of workflow model to evaluating efficacy in potted plant and in field plant and also submit the final report

Essential/Recommended readings

1. Microbiology: A Lab Manual by J. G. Cappuccino and C. T. Welson. 12th edition.
2. Bio-inoculants as prospective inputs for achieving sustainability: Indian Story by C. Gupta et al. Economic Affairs. Vol. 65, No. 1, pp. 31-41. 2020.
3. Bioinoculants for bioremediation applications and disease resistance: Innovative Perspectives by T. Chaudhary and P. Shukla. Indian J Microbiol. 59 (2): 129–136. 2019.
4. Remediation of metalliferous soils through the heavy metal resistant plant growth promoting bacteria: paradigms and prospects by M. Ahemad. Arabian Journal of Chemistry, 12 (7);1365-1377. 2019.
5. Laboratory manual of Microbiology and Biotechnology by K.R. Aneja. 2nd edition. Scientific International Pvt. Ltd., Delhi. 2018.
6. Online resource: https://www.jaivikkheti.in/DMS/Waste-Decomposer%20Book-Eng.pdf

7. Online resource: https://www.iihr.res.in/success-story-using-biopesticides-nematodemanagement-horticultural-crops.
8. Biofertilizer Production under ICAR All India Network Project on Soil Biodiversity Biofertilizers DOI: 10.13140/RG.2.2.26840.42244
9. Online resource: https://blog.teamtrade.cz/the-story-of-how-biofertilizers-for-cornwent-commercial-part-one/
10. Online resource: https://en.wikipedia.org/wiki/Microbial_inoculant

Examination scheme and mode:

Evaluation scheme and mode will be as per the guidelines notified by the University of Delhi.

SECBOT403. Fruits and Vegetable Processing

(30 hours)

Unit I

Preparation of canned fruits /vegetables. Preparation of chips from potato/bittergourd/apples etc. In bottle pasteurization of fruit juices, nectars, purees etc.

Unit II

Preparation of fruit squashes. Preparation of fruit cordials. Preparation of fruit jams/jellies. Preparation of fruit nectars. Preparation of mango/chilli/ lime pickle.

Unit III

Preparation of Tomato puree & product. How to plan a startup, budgeting, marketing / case study/ entrepreneur (anyone of the above). To study the Regulation, Licensing & registration of particular

Laboratory exercise

1. Preparation of canned fruits/vegetables juice
2. Preparation of chips from potato/apples
3. To perform the pasteurization of fruit juices, nectars
4. To perform the preparation of fruit jams/jelles
5. To prepare a plan a startup, budgeting, marketing/case study for fruit and vegetable processing

Essential Readings

1. Girdharilal., Siddappaa, G.S and Tandon, G.L.(2009). Preservation of fruits & vegetables. ICAR, New Delhi.
2. Thompson, A.K., (2003). Fruits and vegetables; Harvesting, handling and storage. Blackwell Publishing.

Suggested Readings:

1. Crusess, W.B. (2004). Commercial Unit and Vegetable Products. W.V. Special Indian Edition. Agrobios India.
2. Manay, S. and Shadaksharaswami, M. (2004). Foods: Facts and Principles. New Age Publishers.
3. Ranganna S.(2007). Handbook of analysis and quality control for fruits and vegetable products. Tata Mc Graw-Hill publishing company limited, Second edition.
4. Srivastava, R.P. and Kumar, S. (2006). Fruits and Vegetables Preservation- Principles and Practices. 3rd Ed. International Book Distributing Co.
5. Somogyi, L.P., Ramaswamy, H.S. and Hui, Y.H. (1996). Biology, Principles and Applications. Volume 1. Technomic Publishing Company, Inc.

SECBOT404. Food Waste and By-Product Utilization

(30 hours)

Unit I

Identification of waste from agriculture and food processing (Dairy/ Meat/ Fruits Vegetables / Alcoholic beverages/ cereals). Study and layout of waste water treatment system (ETP). Identification of co-products from F&V industry, estimation and utilization to develop value added products (pectin, banana fibre, lycopene from tomato waste, watermelon/pumpkin rind).

Unit II

Identification of waste from animal industry and utilisation to develop value added products (gelatin, egg shell). Identification of various co-products from dairy industry, estimation and utilization to develop value added products (utilisation of ghee residue, buttermilk beverage, whey).

Unit III

Identification of co-products from cereal industry, estimation and utilization to develop value added products (cereal husk, wheat fibre). Determination of physico-chemical properties of wastewater. Production of alcohol/ acetic acid from waste material.

Laboratory exercises

1. Study and layout of waste water treatment system and prepare a model for waste water treatment system
2. to estimation and utilization to develop value added products (pectin, banana fibre, lycopene from tomato waste)
3. to perform the formation of bulttermilk beverage
4. to estimation and utilization to develop value added products from cereal industry
5. to give model for production of alcohol/acetic from waste material

Essential readings

1. Marriott, N. G., Gravani, R. B., & Schilling, M. W. (2006). Principles of food sanitation (Vol. 22). New York: Springer.
2. Sadasivam, A, & Manickam, A. (2021). Biochemical Methods. New Age InternationalPublishers.
3. Green, J. H., & Kramer, A. (1979). Food Processing. Waste Management. Avi PublishingCompany, 629.
4. Herzka, A. and Booth, R.G. Food Industry and Trade: Recycling Waste. Applied SciencePublishers, 1981.
5. Tegge, G., Green, J. H., and A. Kramer. Food Processing Waste Management; AVI Publishing, 1979
6. Marriott, N. G., Gravani, R. B., & Schilling, M. W. (2006). Principles of food sanitation (Vol. 22). New York: Springer.
7. Sadasivam, A, & Manickam, A. (2021). Biochemical Methods. New Age InternationalPublishers.
8. Green, J. H., & Kramer, A. (1979). Food Processing. Waste Management. Avi PublishingCompany, 629.
9. Herzka, A. and Booth, R.G. Food Industry and Trade: Recycling Waste. Applied SciencePublishers, 1981.
10. Tegge, G., Green, J. H., and A. Kramer. Food Processing Waste Management; AVIPublishing, 1979