

DEPARTMENT OF BOTANY
KUMAUN UNIVERSITY, NAINITAL

'FINAL DRAFT SYLLABUS'
FOR
B.Sc. BOTANY

[AS PER NATIONAL EDUCATION POLICY-2020]

FACULTY OF SCIENCE

2022

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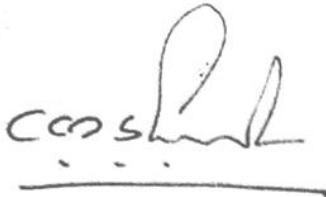
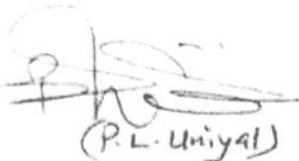



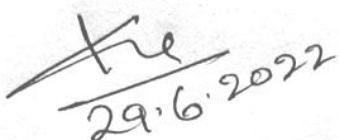
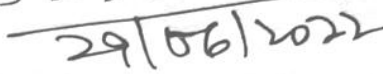
Dr. Prem Prakash

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Semester-wise Titles of the Papers in B. Sc (Botany)					
Year	Semester	Course Code	Paper title	Theory/ Practical	Credits
Certificate Course in Basic Botany					
First Year	I	BOT101T	Microbes, Algae, Fungi and Bryophytes	Theory	4
		BOT102P	Practical/Lab course	Practical	2
	II	BOT201T	Pteridophytes, Gymnosperms and Angiosperms	Theory	4
		BOT202P	Practical/Lab course	Practical	2
Diploma Course in Developmental Botany					
Second Year	III	BOT301T	Morphology, Anatomy and Embryology	Theory	4
		BOT302P	Practical/Lab course	Practical	2
	IV	BOT401T	Cytogenetics and Plant Breeding	Theory	4
		BOT402P	Practical/Lab course	Practical	2
Bachelor of Science					
Third Year	V	BOT501T	Molecular Biology and Plant Biotechnology	Theory	4
		BOT502T	Economic Botany	Theory	4
		BOT503 P	Practical/Lab course	Practical	2
		BOT504R	Project I-Local Plant Diversity	Practical	4
	VI	BOT 601T	Physiology and Biochemistry	Theory	4
		BOT602T	Ecology and Biostatistics	Theory	4
		BOT603P	Practical/Lab course	Practical	2
			Project II-Local Ecosystem Studies	Practical	4

Minor elective courses (4 credits)					
First Year	I/II	PSME01T	Plant Science 1	Theory	4
Second Year	III/IV	PSME02T	Plant Science 2	Theory	4

Vocational/ skill enhancement courses (3 credits)					
			Bio-fertilizers	Theory	3
			Herbal Technology	Theory	3
		BOT604R	Nursery and Gardening	Theory	3
			Floriculture	Theory	3
			Medicinal Botany	Theory	3
			Conservation and Natural Resource Management	Theory	3
			Ethnobotany	Theory	3
			Mushroom cultivation	Theory	3
			Intellectual Property Rights	Theory	3








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Year wise Structure of B.Sc. in Botany (Core/elective courses and Projects)

Subject: Botany											
Course/ Entry-Exit level	Year	Semester	Paper-1	Credits/hrs	Paper-2	Credits/ hrs	Paper-3	Credits/hrs	Research project	Credits /hrs	Total Credits/hrs
Certificate Course in Basic Botany	I	I	Microbes, Algae, Fungi and Bryophytes	4/60	Practical/ Lab course	2/60	-	-	-	-	6/120
		II	Pteridophytes, Gymnosperms and Angiosperms	4/60	Practical/ Lab course	2/60	-	-	-	-	6/120
Diploma Course in Developmental Botany	II	III	Morphology, Anatomy and Embryology	4/60	Practical/ Lab course	2/60	-	-	-	-	6/120
		IV	Cytogenetics and Plant Breeding	4/60	Practical/ Lab course	2/60	-	-	-	-	6/120
Bachelor of Science	III	V	Molecular Biology and Plant Biotechnology	4/60	Economic Botany	4/60	Practical /Lab course	2/60	Project-I	4/60	14/240
		VI	Physiology and Biochemistry	4/60	Ecology and Biostatistics	4/60	Practical /Lab course	2/60	Project-II	4/60	14/240

COURSE INTRODUCTION

The new curriculum of B.Sc. in Science (Botany) offers essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core, elective and vocational papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently being used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

B.Sc. Botany Programme covers academic activities within the classroom sessions along with practical concepts at laboratory sessions. Infield, outstation activities and projects would also be organized for real-life experience and learning. Candidates who have curiosity in plants kingdom, ecosystem, love exploring exotic places and wish to work as researchers or professions like Botanist, Conservationist, Ecologist, etc. can choose B.Sc. Botany course.

Programme outcomes (POs):

Transformed curriculum shall develop educated outcome-oriented candidature, fostered with discovery- learning, equipped with practice & skills to deal practical problems and versed with recent pedagogical trends in education including e-learning, flipped class and hybrid learning to develop into responsible citizen for nation-building and transforming the country towards the future with their knowledge gained in the field of plant science.

PO1	CBCS syllabus with a combination of general and specialized education shall introduce the concepts of breadth and depth in learning.
PO2	Shall produce competent plant biologists who can employ and implement their gained knowledge in basic and applied aspects that will profoundly influence the prevailing paradigm of agriculture, industry, healthcare and environment to provide sustainable development.
PO3	Will increase the ability of critical thinking, development of scientific attitude, handling of problems and generating solutions, improve practical skills, enhance communication skill, social interaction, and increase awareness in judicious use of plant resources by recognizing the ethical value system.
PO4	The training provided to the students will make them competent enough for doing jobs in Govt. and private sectors of academia, research and industry along with graduate preparation for national as well as international competitive examinations, especially UGC-CSIR NET, UPSC Civil Services Examination, IFS, NSC, FCI, BSI, FRI etc.

PO5	Certificate and diploma courses are framed to generate self- entrepreneurship and self- employability, if multi exit option is opted.
PO6	Lifelong learning is achieved by drawing attention to the vast world of knowledge of plants and their domestication.

Programme specific objectives (PSOs): B.Sc. I Year Certificate Course in Basic Botany

- This certificate course will provide knowledge on various fields of basic Botany.
- The syllabus is prepared to enable students for competitive exams in frontier areas of plant sciences.
- Students will be able to know about habit, habitat, morphology, anatomy and reproduction of various plant groups.

Programme specific outcomes (PSOs): B.Sc. II Year/ Diploma Course in Developmental Botany

- This programme will provide knowledge on plant morphogenesis, anatomy embryology and plant genetics.
- Laboratory sessions following theory will provide easy understanding of internal structure of various plant parts, structural organization, reproductive biology and genetics.
- This course will help students to become a plant morphologist.

Programme specific outcomes (PSOs): B.Sc. III Year/ Bachelor of Science

- The three year learning outcome of graduation will provide understanding of plant systematic, economic botany, developmental biology, ecology, statistics, physiology, biochemistry.
- It will provide expertise in conservation biology and reproduction biology.
- After completing this course successfully students will be able to contribute in the field of plant sciences. The research project will help to develop research aptitude for higher education and scientific research.

DETAILED SYLLABUS OF B.Sc. I YEAR FOR CERTIFICATE COURSE IN BASIC BOTANY

Course	Year	Semester
<i>Certificate Course in Basic Botany</i>	<i>B.Sc. I</i>	<i>I</i>

Paper 1: Microbes, Algae, Fungi and Bryophytes (Course code: BOT101T) Credit: 4

Course Outcome

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

1. Develop understanding about the classification and diversity of different microbes including viruses, Algae, Fungi & Lichens & their economic importance.
2. Develop conceptual skill about identifying microbes, pathogens, biofertilizers & lichens.
3. Gain knowledge about developing commercial enterprise of microbial products.
4. Learn host –pathogen relationship and disease management.
5. Gain Knowledge about uses of microbes in various fields.
6. Understand the structure and reproduction of certain selected bacteria algae, fungi and lichens
7. Develop critical understanding on morphology, anatomy and reproduction of Bryophytes.

Unit	Topic	No. of lectures/ hrs (60)
1	Microbes : Viruses-discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); economic importance; bacteria–discovery, general characteristics and cell structure; reproduction–vegetative, asexual and recombination (conjugation, transformation and transduction); economic importance.	15
2	Algae: General characteristics; Range of thallus organization and reproduction; classification of algae; morphology and life-cycles of: <i>Nostoc</i> , <i>Chlamydomonas</i> , <i>Oedogonium</i> , <i>Vaucheria</i> , <i>Sargassum</i> , <i>Polysiphonia</i> ; economic importance of algae.	15
3	Fungi : Introduction-general characteristics, ecology and significance, range of somatic thallus organization, cell wall composition, nutrition, reproduction and classification (G.C. Ainsworth); life cycle of <i>Stemonitis</i> (Myxomycota)	15

	<i>Rhizopus</i> (Zygomycota) <i>Penicillium</i> (Ascomycota), <i>Puccinia</i> , <i>Agaricus</i> (Basidiomycota); <i>Alternaria</i> (Deutromycota), Symbiotic associations: Lichens-General account, reproduction and significance; Mycorrhiza: ectomycorrhiza, endomycorrhiza and their significance.	
4	Bryophytes: General characteristics, adaptations to land habit, classification (up to family), morphology, anatomy and reproduction of <i>Marchantia</i> , <i>Anthoceros</i> and <i>Funaria</i> ; ecology and economic importance of bryophytes.	15

Suggested readings

- Barsanti, L. and Gualtieri, P. (2014). Algae: Anatomy, Biochemistry and Biotechnology, 2nd Edition. CRC/ Taylor & Francis, NY.
- Lee, R.E. (2018). Phycology, Fifth Edition. Cambridge University Press, Cambridge.
- Marjorie, Kelly and Cowan, Heidi Smith. (2017). Microbiology: A Systems Approach. McGraw Hill New York, 5th edition.
- Pandey, S.N and Trivedi, P.S. (2015). A text book of Botany Vol.I Vikas publishingHouse Pvt/ Ltd, New Delhi.
- Parihar, N.S. (1991). An Introduction to Embryophyta Vol. I Bryophyta. Central Book Depot, Allahabad.
- Mehrotra, R.S. and K.R. Aneja. (1999). An Introduction to Mycology. New Age International Publisher.
- Pelczar M.J., Chan E.C.S and Kreig N.R. (1997). Microbiology. Tata MacGraw Hill.
- Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGrawHill, Delhi, India.
- Robert Edward Lee. (2018). Phycology. Cambridge University Press, U.K. 5th edition.
- Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
- Sharma, O. P. (2011). Algae. Tata McGraw Hill Education Private Limited, U.K. 1st edition.
- Tortora, G.J., Funke, B.R., Case, C.L. (2011). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 13th edition.
- Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Bryophyta, S. Chand. Delhi, India.
- Webster, J. and Weber, R. (2007). Introduction to Fungi. Third Edition. Cambridge University Press. Cambridge and New York.
- Willey, J M., Sherwood, L.M. and Woolverton, C.J. (2017). Prescott's Microbiology, 11th Edition, McGraw-Hill, USA.

Paper 2: Practical/ Lab course (Course code: BOT102P)

Credit: 2

Course Outcome

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

1. Understand the instruments, techniques, lab etiquettes and practices for working in a microbiology laboratory.
2. Develop skills for identifying microbes and using them for Industrial, Agriculture and Environment purposes.

3. Practical skills in the field and laboratory experiments in Microbiology and Pathology.
4. Learn to identify algae, lichens and plant pathogens along with their symbiotic and parasitic associations.
5. Students would learn to create their small digital reports where they can capture the zoomed in and zoomed out pictures as well as videos in case they are able to find some rare structure or phenomenon related to Bryophytes.
6. Understand morphology, anatomy, reproduction and developmental changes therein through typological study and create a knowledge base in understanding diversity, economic values & taxonomy of bryophytes.

Unit	Topic	No. of Lectures/ hrs (60)
1	EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle. Types of Bacteria from temporary/permanent slides/photographs; EM of bacterium; Binary Fission; Conjugation; Structure of root nodule; Gram staining technique	15
2	Study of vegetative and reproductive structures of <i>Nostoc</i> , <i>Chlamydomonas</i> (electron micrographs), <i>Oedogonium</i> , <i>Vaucheria</i> , <i>Sargassum</i> and <i>Polysiphonia</i> through temporary preparations and permanent slides/specimens.	15
3	<i>Rhizopus and Penicillium</i> : Asexual stages from temporary mounts. <i>Alternaria</i> : Specimens/photographs and tease mounts. <i>Puccinia</i> : Herbarium specimens of Black Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on wheat and permanent slides of both the hosts. <i>Agaricus</i> : Specimens of button stage and full grown mushroom. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose). Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs).	15
4	<i>Riccia</i> , <i>Marchantia</i> and <i>Anthoceros</i> : Morphology of thallus, rhizoids and scales, V.S. thallus through gemma cup, gemmae whole mount (all temporary slides), V.S antheridiophore, archegoniophore, L.S. sporophyte (all permanent slides). <i>Funaria</i> - Morphology, whole mount leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, L.S capsule and protonema.	15

Suggested readings

- Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 1-3, Springer Verlag, New York, NY.
- Pandey, B.P. (2014). Modern Practical Botany Vol. I. S. Chand and Company Ltd. Ramnagar, New Delhi.
- Purohit, S.D., Kundra, G. K. and Singhvi, A. (2013). Practical Botany (part I). Apex Publishing House Durga Nursery Road Udaipur, Rajasthan.
- Sambamurty, A.V.S.S. (2006). A text book of Algae. I.K International Publishing House, Pvt. Ltd.

Course	Year	Semester
<i>Certificate Course in Basic Botany</i>	<i>B.Sc. I</i>	<i>II</i>

Paper 1: Pteridophytes, Gymnosperms and Angiosperms (BOT201T)

Credit 4 Course Outcome

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

1. Develop critical understanding on morphology, anatomy and reproduction of Pteridophytes, Gymnosperms and Angiosperms.
2. Understanding of plant evolution and their transition to land habitat.
3. To learn the major patterns of diversity among plants, and the characters and types of data used to classify plants.
4. To compare the different approaches to classification with regard to the analysis of data.
5. To become familiar with major taxa and their identifying characteristics, and to develop in depth knowledge of the current taxonomy of a major plant family.
6. To discover and use diverse taxonomic resources, reference materials, herbarium collections, publications.

Unit	Topic	No. of Lectures/ hrs (60)
1	Pteridophytes General characteristics, classification (up to family) including The Pteridophyte Phylogeny Group (PPG) classification, early land plants (<i>Rhynia</i>); morphology, anatomy and reproduction of <i>Selaginella</i> , <i>Equisetum</i> and <i>Pteris</i> ; heterospory and seed habit, stelar evolution; ecological and economic importance of Pteridophytes, Telome theory.	15

2	Gymnosperms General characteristics, classification (up to family), morphology, anatomy and reproduction of <i>Cycas</i> , <i>Pinus</i> and <i>Gnetum</i> ; ecological and economic importance.	15
3	Introduction to plant taxonomy Identification, classification, nomenclature, functions of herbarium, important herbaria and botanical gardens of the world and India. Important flora, botanical nomenclature (principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations). Classification: Types of classification-artificial, natural and phylogenetic Bentham and Hooker (upto series), Hutchinson classification and Angiosperm Phylogeny Group (APG IV) classification.	10
4	Taxonomy of plant families: Ranunculaceae, Malvaceae, Rutaceae, Fabaceae, Apiaceae, Asteraceae, Solanaceae, Lamiaceae, Euphorbiaceae, Orchidaceae and Poaceae.	20

Suggested readings

- Angiosperm Phylogeny Group (APG-2016). An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society 181: 1-20.
- Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
- Gangulee H.C., Kar, A.K. and Santra S.C. (2011). College Botany Vol II. 4th Edition New Central Book Agency.
- Pandey, B.P. (2010). College Botany Vol II. S. Chand and Company Ltd., New Delhi, India.
- Parihar, N.S. (1976). Biology and Morphology of Pteridophytes. Central Book Depot.
- Parihar, N.S. (1991). An Introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
- Sambamurty, A.V.S.S. (2010). Taxonomy of Angiosperms. I.K. International Pvt. Ltd.
- Saxena N.B. and Saxena S. (2012). Plant Taxonomy Pragati Prakashan.
- Sharma O.P. (2013). Plant Taxonomy. MC GRAW HILL INDIA.
- Sharma, O.P. (1990). Textbook of Pteridophyta. MacMillan India Ltd. Delhi.
- Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford and IBH Pvt. Ltd., New Delhi. 3rd edition.
- The Pteridophyte Phylogeny Group (PPG Classification) (2016): A community –derived classification for extant lycophytes and ferns. Journal of Systematics and Evolution. 54(6): 563-603. Doi:10.1111/jse.12229
- Vashishta, P.C., Sinha, A.K. and Kumar, A. (2010). Gymnosperms, S. Chand and Company Ltd., Ramnagar, New Delhi, India.

Course outcomes:

1. The students will be made aware of the group of plants that have given rise to land habit and the flowering plants. Through field study they will be able to see these plants growing in nature and become familiar with the biodiversity.
2. Develop an understanding by observation and table study of representative members of phylogenetically important groups to learn the process of evolution in a broad sense.
3. Understand morphology, reproduction and developmental changes therein through typological study and create a knowledge base in understanding the basis of plant diversity, economic values and taxonomy of plants.

Unit	Topic	No. of Lectures/ hrs (60)
1	<p><i>Selaginella</i>: Morphology, whole mount leaf with ligule, strobilus, microsporophyll and megasporophyll (temporary slides), T.S. stem, L.S. strobilus (permanent slide).</p> <p><i>Equisetum</i>: Morphology, T.S. internode, L.S. strobilus, T.S and L.S. Strobilus, whole mount sporangiophore, spores (wet and dry) (temporary slides); T.S. rhizome (permanent slide).</p> <p><i>Pteris</i>: Morphology, T.S rachis, V.S. sporophyll, whole mount sporangium and spores (temporary slides), T.S. rhizome, whole mount prothallus with sex organs and young sporophyte (permanent slide).</p>	15
2	<p><i>Cycas</i>: Morphology (coralloid roots, bulbil, leaf), T.S. coralloid root and rachis, V.S. leaflet and microsporophyll, whole mount spores (temporary slides), L.S. ovule, T.S. root (permanent slide).</p> <p><i>Pinus</i>: Morphology (long and dwarf shoots, male and female cones), T.S. needle and stem, L.S./T.S. male cone, whole mount microsporophyll and microspores (temporary slides), L.S. female cone, TLS and RLS stem (permanent slide).</p>	15
3	<p>Taxonomic Identification: Description of an angiospermic plant, study of vegetative and floral characters (description, V.S. flower, section of ovary, floral diagram/s, floral formula/e) and systematic position of the following families according to Bentham and Hooker's system of classification: Brassicaceae, Asteraceae, Solanaceae, Lamiaceae, and Liliaceae.</p>	20

4	Herbarium techniques: Plant collection, preservation and mounting of two properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book), digital/virtual herbarium.	10
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Suggested readings

- Pandey, B.P. (2014). Modern Practical Botany Vol. II. S. Chand and Company Ltd., NewDelhi.
- Bendre, A.M. and Kumar A. (2003). Manual of Practical Botany Vol. II. Rastogi Publications, Meerut.
- Santra S.C. and Chatterjee (2005). College Botany Practical Vol. II New Central Book Agency Pvt. Ltd.

DETAILED SYLLABUS OF B.Sc. II YEAR OR DIPLOMA COURSE IN DEVELOPMENTAL BOTANY

Course	Year	Semester
<i>Diploma Course in Developmental Botany</i>	<i>B.Sc. II</i>	<i>III</i>

Paper 1: Morphology, Anatomy and Embryology

(Course code: BOT301T) Credit: 4

Course outcomes:

1. Understand morphology, anatomy and Embryology.
2. Understand role of tissues in plant functions.
3. Understand the composition, modifications, internal structure & architecture of plants.
4. Understand reproduction and developmental changes in plants.

Unit	Topic	No. of Lectures/ hrs (60)
1	Meristematic and permanent tissues: Types of tissues, Root and shoot apical meristems, Theories related to apical meristem, simple, complex and secretory tissues. Organs: Structure of dicot and monocot root, stem and leaf, root stem transition.	15
4	Adaptive and protective systems: Epidermis, cuticle and stomata Secondary growth: Structure and function of Vascular cambium, secondary growth in stem and roots (Sunflower, Beet root), abnormal	15

	secondary growth (Monocot stem: <i>Dracaena</i> ; Dicot stem: <i>Achyranthes</i> , <i>Amaranthus</i> , <i>Bignonia</i> , <i>Boerhaavia</i> , <i>Bougainvillea</i> , <i>Chenopodium</i> , <i>Mirabilis</i> , <i>Nyctanthes</i> , <i>Salvadora</i>)	
5	Pollination and fertilization: Pollination mechanisms and adaptation, structure of anther and pollen, development of male and female gametophytes, double fertilization.	15
6	Embryo and endosperm: Types of ovules and embryo sacs; embryo and endosperm; types of endosperm; dicot and monocot embryo; apomixis and polyembryony.	15

Suggested readings

- Beck, C.B. (2010). An Introduction to Plant Structure and Development, II edition.
- Bhatnagar S.P, Dantu, P.K. Bhojwai S.S. (2018). The embryology of Angiosperms. Vikas Publ. House. New Delhi.
- Bhojwani, S.S. and Bhatnagar, S.P. (2010). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.
- Fosket, D.E. (1994). Plant, Growth and Development: A Molecular Approach, Academic Press.
- Hopkins, W.G. (2006). The Green World: Plant Development, Chelsea House Publication.
- Johri, B.M. (1984). Embryology of Angiosperms. Springer-Verlag, Berlin.
- Leins, P., Tucker, S.C. and Endress, P.K. (1988). Aspects of floral development. J. Cramer. Germany.
- Maheshwari, P. (1971). An Introduction to Embryology of Angiosperms. McGraw Hill Book Co. London.
- Pandey, B.P. (2001) Plant Anatomy. S. Chand and Company Ltd., New Delhi.
- Raghwan, (1997). Molecular embryology of flowering plants. Cambridge Univ. Press. Cambridge.
- Sharma, M.K. (2013) Plant Structures (An Introduction to Plant Anatomy). VayuEducation of India.
- Sharma, P.C. (2017). Text Book of Plant Anatomy. Arjun Publishing House.
- Shivanna, K.R. (2003). Pollen Biology and Biotechnology, Science Publishers. Verlag.

Course outcomes:

1. Understand cell structure in monocot and dicot plants.
2. Understand cell structure, secondary growth and adaptive anatomy in plants.
3. Understand the pollination and seed dispersal mechanism.
4. Study the structure of ovules and female gametophytes.

Unit	Topic	No. of Lectures (60 hrs)
1	Study of meristems through permanent slides and photographs. Tissues (parenchyma, collenchyma and sclerenchyma), complex and secretory tissues. Anatomy of monocot and dicot Stem; monocot and dicot leaf; monocot and dicot root	15
2	Adaptive anatomy: Xerophytes, Hydrophytes, Epiphytes Normal and abnormal secondary growth in different plants	15
3	Pollination types and seed dispersal mechanisms (photographs and specimens)	15
4	Structure of anther (young and mature). Types of ovules: anatropous, orthotropous, circumtropous, amphitropous, campylotropous. Female gametophyte: <i>Polygonum</i> (monosporic) type of embryo sac development (permanent slides/photographs) Ultrastructure of mature egg apparatus cells through electron micrographs (permanent slides/photographs)	15

Suggested readings

- Pandey, B.P. (2014). Modern Practical Botany Vol. II. S. Chand and Company Ltd. Ramnagar, New Delhi.
- Pandey, B.P. (2001). Plant Anatomy. S. Chand and Company Ltd., Ram Nagar, New Delhi.
- Sundara, R.S. (2002). Practical Manual Anatomy and Embryology. Anmol Publisher, New Delhi.

Course	Year	Semester
<i>Diploma Course in Developmental Botany</i>	<i>B.Sc. II</i>	<i>IV</i>

Paper 1: Cytogenetics and Plant Breeding (course code: BOT401 T)

Credit 4 Course outcomes:

1. Understand the structure and chemical composition of chromatin and concept of cell division.
2. Interpret the Mendel's principles; acquire knowledge on cytoplasmic inheritance and sex-linked inheritance.
3. Understand the plant breeding systems and heterosis and mutation in plant breeding.

Unit	Topic	No. of Lectures (60 hrs)
1	Heredity: (Pre-mendelian genetics, brief life history of Mendel, laws of Inheritance, modified mendelian ratios, lethal genes, co-dominance, incomplete dominance, chi square, pedigree analysis, multiple allelism, chromosome theory of inheritance, sex-determination and sex-linked inheritance, cytoplasmic inheritance Linkage and crossing over: Linkage: concept and history, complete and incomplete linkage, bridges experiment, coupling and repulsion, recombination frequency, linkage maps based on two and three factor crosses.	15
2	Crossing over: Concept and significance, cytological proof of crossing over; mutations and chromosomal aberrations (types of mutations, effects of physical and chemical mutagens, numerical chromosomal changes: euploidy, polyploidy and aneuploidy; structural chromosomal changes: deletions, duplications, inversions and translocations).	15
3	Plant breeding: introduction and objectives; breeding systems, important achievements and undesirable consequences of plant breeding); methods of crop improvement; centres of origin and domestication of crop plants, plant genetic resources; acclimatization; selection methods.	15
4	Hybridization: for self, cross and vegetatively propagated plants – procedure, advantages and limitations; inbreeding depression and heterosis (history, genetic basis of inbreeding depression and heterosis; applications); crop improvement and breeding (role of mutations; polyploidy; distant hybridization and role of biotechnology in crop improvement).	15

Suggested readings

- Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2014). Molecular Biology of the Cell. Garland Publishing Inc., New York. 6th edition.
- Gardner, E.J., Simmons, M.J. and Snustad, D.P. (1991). Principles of Genetics, John Wiley & Sons.
- Hartwell, L.H., Hood, L., Goldberg, M.L., Reynolds, A.E., Silver, L.M., Veres, R.C. (2006). Genetics-From Genes to Genomes, McGraw Hill
- Lewin, B. (2008). Genes IX, Jones and Barlett Publishers.
- Lodish, H., Berk, A., Zipursky, S.L., Maztsudaira, P., Baltimore, Dand Darnell, I. (2016). Molecular Cell Biology (8th Edition). W.H. Freeman and Co., New York, USA.
- Rastogi, V.B. (2019). Genetics. 4th Edition. MEDTECH: A Division of Scientific International.
- Russel P. J. (2010). Genetics-A Molecular Approach, Pearson Education Inc.
- Singh R. J. (2002). Plant Cytogenetics, CRC Press.
- Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7th edition.
- Strickberger M.W. (2008). Genetics, Pearson (Prentice Hall).
- Watson, J.D. (2013). Molecular Biology of the Genes, Benjamin. 7th Edition.

Paper 2: Practical/Lab Course (Course code: BOT402 P)

Credit 4: Course outcomes

1. Interpret the Mendel's principles; and understand the monohybrid and dihybrid crosses and their ratio and chromosomal changes.
2. Learn the basic structure and function of cells and instruments used in molecular biology.

Unit	Topic	No. of Lectures (60 hrs)
1	Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square. Monohybrid cross (dominance and incomplete dominance) Dihybrid cross and gene interactions. Pedigree analysis for dominant and recessive autosomal and sex linked traits. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4). Contribution of Mendel.	15

2	Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes through photographs. Photographs/permanent slides showing translocation ring, laggards and inversion bridge.	15
3	Hybridization techniques - Emasculation, Bagging (For demonstration only). Induction of polyploidy in plants (For demonstration only).	15
4	Techniques used for Crop Improvement. Contribution of Dr. M.S. Swaminathen, T.S. Venkataraman, B.P. Pal, Dharampal Singh, V. Santhanam in plant breeding.	15

Suggested readings

- Singh, R.J. (2021). Practical Manual on Plant Cytogenetics. CRC Press, Taylor and Francis Group, Routledge.

DETAILED SYLLABUS OF B. Sc III YEAR OR BACHELOR OF SCIENCE

Course	Year	Semester
<i>Bachelor of Science</i>	<i>B.Sc. III</i>	<i>V</i>

Paper 1: Cell and Molecular Biology, and Biotechnology (Course code: BOT501T)

Credit 4

Course outcomes:

1. Understand cell structure, nucleic acids, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.
2. Know about processing and modification of RNA and translation process, function and regulation of expression.
3. Understand the basic tools and techniques used in Plant tissue culture.

Unit	Topic	No. of Lectures (60 hrs)
1	Cell Biology: The cell theories, prokaryotic and eukaryotic cells, cell organelles (Mitochondria, Chloroplast, ER, golgi body, lysosomes, peroxisomes, glyoxisomes, nucleus, chromatin; DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure), cell membrane and cell wall; models of membrane structure, cell cycle (overview of cell cycle, mitosis and meiosis, molecular controls).	18

2	Molecular Biology: Genetic material (DNA: Miescher to Watson and Crick- historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase bacteriophage experiment, DNA structure, types of DNA, types of genetic material); DNA replication (Prokaryotes); Transcription (Prokaryotes) Types of structures of RNA (mRNA, tRNA, rRNA); Translation (Prokaryotes), Regulation of gene expression (Prokaryotes: Lac operon and Tryptophan operon).	18
3	Plant tissue culture: Culture types on the basis of explants and media composition, General lab setup and instrumentation, micropropagation, brief account of protoplast culture, somatic embryogenesis with their applications.	12
4	Recombinant DNA techniques: Blotting techniques: Northern, Southern and Western Blotting, Molecular DNA markers i.e. RAPD, RFLP, SNPs, PCR, hybridoma and monoclonal antibodies, ELISA and Immunodetection.	12

Suggested readings:

- Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M. and Roberts, K. (2014). Molecular Biology of the Cell. CRC Press, Taylor & Francis Group, USA.; 1464 pages
- Berk, A., Kaiser, C.A., Lodish, H., Amon, A., Ploegh, H, Bretscher (Author), Monty Krieger, A., Martin, K.C. (Eds). (2016) Molecular Cell Biology. Freeman & Co., USA.
- Brown, T. A. (2017). Genomes 4. CRC Press, Taylor & Francis Group, USA.
- Buchanan, B.B., Gruissem, W. and Jones, R.L (2015). Biochemistry and molecular biology of plants. Wiley Publisher; pages: 1264p
- Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley and Sons. Inc.

Paper 2: Economic Botany (Course code: BOT502T) Credit: 4

Course outcomes

1. Know about the importance of medicinal plants and its useful parts, economically important plants in our daily life and also about the traditional medicines and herbs, and its relevance in modern times.

Unit	Topic	No. of Lectures (60 hrs)
1	Origin of cultivated plants (concept of centres of origin, their importance with reference to Vavilov's work)	15
2	A brief knowledge of botany and commercial utilization and uses of the following plants: Cereals and millets- Wheat, Rice and Maize, Ragi, Pearl millet. Sugar yielding plants- Sugarcane and Sugar beet. Fruits- Mango, Apple, Banana, Citrus and Litchi. Fibers- Cotton, Jute, Hemp, Coir, Agave and Semal. Vegetables- Root vegetables stem vegetables and fruit vegetables. Timbers- Teak, Shisham, Sal, Chir and Deodar.	15
3	Oils, Beverages, Fumitories, masticatories, Spices and Condiments Medicinal plants- <i>Aconitum</i> , <i>Atropa</i> , <i>Cinchona</i> , <i>Rauwolfia</i> , <i>Ephedra</i> , <i>Withania</i> , and <i>Alovera</i> . Bioprospects of medicinal plants.	15
4	Lesser known plants of Uttarakhand and their economic importance (Jhangora- Barnyard Millet, Koni- Foxtail millet, Jakhya, Bhangjeera, Tarur.) Wild edible plants of Uttarakhand: Kilmora, Hisalu, Ghigaru, Kafal, Timla, Bedu, Jamun, Lingura, Kachnar, Bichhu-Ghas. Conservation of traditional crops: Role of organizations (NBPGR, CIMAP, ICAR, VPKAS, GBPUAT)	15

Suggested readings

- Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
- Kochhar, S.L. (2016). Economic Botany: A comprehensive study, Fifth edition, Cambridge University Press, NY.
- Pandey, B.P. (1999). Economic Botany. S. Chand, New Delhi.
- Singh, H.B. and R.K. Arora. (1978). Wild edible plants of India (1st ed.). ICAR Publication, New Delhi.
- Wickens, G.E. (2004). Economic Botany: Principles and Practices, Springer, ISBN 978-0- 7923-6781-9.

Course outcomes

1. Know about the commercial products produced from plants.
2. Understand about the ethno-botanical details of plants.
3. Learn about the chemistry of plants and herbal preparations.

Unit	Topic	No. of Lectures (60 hrs)
1	<p>Structure of prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light and electron micrographs.</p> <p>Study of the photomicrographs of cell organelles, structure of plant cell through temporary mounts.</p> <p>Study of mitosis and meiosis (temporary mounts and permanent slides).</p> <p>Demonstration of the effect of temperature, organic solvent on semi permeable membrane.</p> <p>Study of plasmolysis, deplasmolysis, Endo- and Exo-osmosis.</p>	15
2	<p>Instruments and equipments used in molecular biology</p> <p>The cell size measurements (either length or breadth/diameter) by micrometry.</p> <p>Study the structure of nuclear pore complex by photograph (from Gerald Karp) Study of special chromosomes (polytene and lampbrush) either by slides or photographs.</p> <p>Study DNA packaging by micrographs.</p> <p>Preparation of the karyotype and ideogram from given photograph of somatic metaphase chromosome.</p>	15
3	<p>Study of economically important plants:</p> <p>Cereals: Wheat, Rice, Maize</p> <p>Millet: Finger millet, Foxtail, Ragi</p> <p>Pulses: Gram, Green gram, Pea, Pigeon pea, Soyabean, Chick pea</p> <p>Timbers: Shisam, Sal, Teak, Deodar, Pine</p> <p>Medicinal plants: Dhatura, Berginia, Hedychium, Poppy, Basil, Barberry</p> <p>Beverages: Tea, Coffee</p> <p>Oils: Mustard, Seseame, Coconut, Linseed, Groundnut, Castor, Laung, Sandal wood, Mentha</p> <p>Spices: Coriander, Cardmum, Curcuma, Cinamom, Laung, Cumin, Thyme, Nigella, Cinamom leaf.</p> <p>Fibers: Jute, Coconut, Hemp, Urtica, Cotton</p> <p>Wild edible plants:</p> <p>Sugars and starch yielding plants: Sugarcane, Potato, Beet root</p> <p>Fruits and vegetables cultivated in the area.</p> <p>Gums and Resins.</p>	15

Suggested readings

- Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
- Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
- Kochhar, S.L. (2016). Economic Botany: A comprehensive study, Fifth edition, Cambridge University Press, NY.
- Pandey, B.P. (1999). Economic Botany. S. Chand, New Delhi.
- Wickens, G.E. (2004). Economic Botany: Principles and Practices, Springer, ISBN 978-0- 7923-6781-9.

Paper 4: Project in Botany for Pre-graduation (Course code: BOT504R) Credit: 4

(Based on Local Plant Diversity)

Course	Year	Semester
<i>Bachelor of Science</i>	<i>B.Sc. III</i>	<i>VI</i>

Paper 1: Plant Physiology and Biochemistry (BOT601T) Credit: 4

Course outcome

1. Understand the role of physiological and metabolic processes for plant growth and development.
2. Learn the symptoms of mineral deficiency in crops and their management.
3. Assimilate knowledge about Biochemical constitution of plant diversity.
4. Know the role of plants in development of natural products, nutraceuticals, dietary supplements, antioxidants.

5.

Unit	Topic	No. of Lectures (60 hrs)
1	<p>Plant-water relations: Importance of water, water potential and its components; transpiration and its significance; factors affecting transpiration; root pressure and guttation.</p> <p>Mineral nutrition: Essential elements, macro and micronutrients; criteria of essentiality of elements; role of essential elements; transport of ions across cell membrane, active and passive transport, carriers, channels and Pumps.</p>	18

2	<p>Photosynthesis: (photosynthetic Pigments (Chl a, b, xanthophylls, carotene); photosystem I and II, electron transport and mechanism of ATP synthesis; C₃, C₄ and CAM pathways of carbon fixation; photorespiration).</p> <p>Respiration (glycolysis, anaerobic respiration, TCA cycle; oxidative phosphorylation, glyoxylate cycle).</p>	18
3	<p>Nitrogen metabolism: Biological nitrogen fixation; nitrate and ammonia assimilation.</p> <p>Plant growth regulators: Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.</p>	12
4	<p>Biochemistry: General introduction to carbohydrates, lipids and proteins. Enzymes (structure and properties; mechanism of enzyme catalysis and enzyme inhibition, factors affecting enzyme action).</p>	12

Suggested readings

- Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.
- Buchanan, B., Gruissem, G. and Jones, R. (2000). Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA.
- Davies P J. (2004). Plant Hormones: Biosynthesis, Signal Transduction, Action. 3rd Edition, Kluwer Academic Publisher, Dordrecht, The Netherlands.
- Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley and Sons, U.S.A. 4th Edition.
- Nelson, D.L., and Cox, M.M. (2008). *Lehninger Principles of Biochemistry* (5th ed.). W.H. Freeman & Co., New York.
- Taiz, L., Zeiger, E., (2014). Plant Physiology. Sinauer Associates Inc., U.S.A. 6th Edition.

Paper 2: Ecology and Biostatistics (Course code: BOT602T) Credit: 4

Course outcome

1. Acquaint the students with complex interrelationship between organisms and environment;
2. Make them understand methods for studying vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography.
3. Understanding the strategies for sustainable natural resource management and biodiversity conservation.
4. Practical knowledge of the different statistics tools and techniques.

Unit	Topic	No. of Lectures (60 hrs)
1	Ecological factors: Soil (Origin, formation, composition, soil profile) Plant adaptation in relation to water (Hydrophytes and xerophytes), light (Sciophytes and heliophytes) and temperature Pollution: Water, Soil and Radioactive.	12
2	Ecosystem: Types, structure, energy flow, trophic organization, food chains and food webs, ecological pyramids. Biogeochemical cycles: Cycling of carbon, nitrogen and phosphorous. Population: Characteristics, Growth curves, Ecotypes and Ecads Plant communities: Characteristics, plant succession, Biological spectrum Biodiversity conservation	18
3	Biostatistics: Definition and scope of statistics, sampling techniques, representation of data: tabular, graphical etc Measures of central tendency: Arithmetic mean, mode, median.	18
4	Measures of dispersion: range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit Regression analysis	12

Suggested readings

- Banerjee, P.K. (2006). Introduction to Biostatistics. S. Chand and Company Ltd., Ram Nagar, New Delhi.
- Chapman, J.L. and Reiss, M.J. (2003). Ecology: Principles and Applications. Second Edition. Cambridge University Press, UK. ISBN 0 521 58802 2. 335 pages.
- Odum, E.P. (2011). Fundamental of Ecology. 5th Edition. Saunders. ISBN 9780030584145. 613 pages.
- Rastogi, V.B. (2015). Biostatistics. Medtech, 3rd Edition.
- Real, L.A. and Brown, J.H. (Eds.) (1991). Foundations of Ecology: Classic Papers with Commentaries. The University of Chicago Press. ISBN-10 0-226-70594-3. 904 pages.
- Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
- Shukla, R.S. and Chandel P.S. (2005). A text book of Plant Ecology. S. Chand and Company Ltd., Ram Nagar, New Delhi.
- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.

Course outcome

1. Understand the role of different physiological and metabolic processes of plants.
2. Gaining practical knowledge implemented in the biodiversity assessment and conservation.
3. Practical knowledge of the different statistics tools and techniques.

Unit	Topic	No. of Lectures (60 hrs)
1	Demonstration of process of diffusion, osmosis and plasmolysis Demonstration of transpiration in dorsiventral leaf by four leaf and cobalt chloride method. Determination of rate of transpiration by Ganong's/Farm potometer.	18
	Demonstration of the effect of light intensity and bicarbonate concentration on O ₂ evolution in photosynthesis by Wilmott's bublar Determination of R.Q of different respiratory substrates by Ganong's respirometer Demonstration of anaerobic respiration in germinating seeds.	
2	Test of carbohydrates, proteins and fats.	12
3	Observation and study of different ecosystems mentioned in the syllabus. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, rain gauge and lux meter. Determination of pH, and analysis of soil samples for soil moisture, organic carbon, nitrogen and phosphorus. Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats. Study of ecological adaptations in hydrophytes and xerophytes. Study of biotic interactions of stem parasite (<i>Cuscuta</i>), root parasite (<i>Orobanche</i>), epiphytes, predation (insectivorous plants) through specimen or diagrams. Determination of minimum quadrat size for the study of herbaceous vegetation by species area curve method (species to be listed). Quantitative analysis of herbaceous vegetation in the college campus for frequency, density, abundance and A/F ratio. Population structure study of dominant tree species of the locality.	18

4	Analysis of statistical data: mean, median and mode by analyzing the given data of individual, discrete and continuous series, standard error and deviation Numerical based on correlation coefficient Numerical based on chi square value Representation of data by making graphs and diagrams etc. Comment upon given graphs, diagrams etc.	12
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Suggested readings

- Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.
- Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.

Paper 4: Project in Botany for Pre-graduation (Course code: BOT604R) Credits: 04

(Based on Local Ecosystem studies)

Minor Elective Courses in Botany

Paper 1: Plant Science 1 (Course code: PSME01T) Credit: 4

Course Outcome

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

1. Develop understanding about the classification and diversity of different microbes including viruses, Algae, Fungi & Lichens & their economic importance.
2. Gain knowledge about uses of microbes in various fields.
3. Understand the structure and reproduction of certain selected bacteria algae, fungi and lichens
4. Develop critical understanding on morphology, anatomy and reproduction of Bryophytes, Pteridophytes and Gymnosperms.
5. Understand the basic concepts of plant taxonomy
6. Understand morphology, anatomy and embryology.

Unit	Topic	Credits
1	Microbes: General characteristics and economic importance of bacteria and viruses. Algae: General characteristics; range of thallus, reproduction and economic importance Fungi: General characteristics, reproduction, ecology and significance.	1
2	Bryophytes: General characteristics, adaptations to land habit, reproduction and economic importance of bryophytes. Pteridophytes: General characteristics, ecological and economic importance of Pteridophytes.	1
3	Gymnosperms: General characteristics, ecological and economic importance. Introduction to plant taxonomy: Identification, classification, nomenclature, functions of herbarium, important herbaria and botanical gardens of the world and India.	1
4	Plant Embryology: Embryo, Types of ovules and embryo sacs; endosperm; types of endosperm; dicot and monocot embryo, pollination, fertilization. Plant Anatomy: Types of tissues, Root and shoot apical meristems, simple, complex and secretory tissues, structure of dicot and monocot root, stem and leaf.	1

Paper 2: Plant Science II (Course code: PSME02T)

Credit: 4

Course Outcome

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

1. Understand the basic biochemical and physiological process in plants.
2. Understand the basic of plant tissue culture techniques used in molecular biology.
3. Understand the concept of biodiversity and its conservation and global warming.
4. Learn the concepts of mendelian genetics, plant breeding methods, crop evolution and uses of plants.

S.No.	Topics	Credit
1	Plant Physiology and Biochemistry: Photosynthesis, respiration, nitrogen fixation, carbohydrates, proteins, lipids and secondary metabolites.	1
2	Plant Biotechnology: Plant tissue culture, recombinant DNA technology and techniques used in molecular biology.	1

3	Biodiversity and Conservation: Species, population, species interaction, ecosystem, ecological succession, environment pollution, biodiversity, In situ and ex situ conservation, International Union for Conservation of Nature (IUCN), and Climate change and its consequence.	1
4	Plant Breeding and Utilization: Mendelian principles, plant breeding methods, and evolution of major crop plants, economics and utilization of plant resources.	1

Vocational/Skill Enhancement Courses in Botany

i) Bio-fertilizers

Credit: 3

Course outcome

1. Develop conceptual skill about identifying microbes, and bio-fertilizers.
2. Gain knowledge about developing commercial enterprise of bio-fertilizers.

Unit	Topic	No. of lecturers/ hrs (45)
1	General account about the microbes used as biofertilizer – <i>Rhizobium</i> – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.	10
2	<i>Azospirillum</i> : isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. <i>Azotobacter</i> : classification, characteristics – crop response to <i>Azotobacter</i> inoculum, maintenance and mass multiplication Cyanobacteria (blue green algae), <i>Azolla</i> and <i>Anabaena azollae</i> association, nitrogen fixation, factors affecting growth, blue green algae and <i>Azolla</i> in rice cultivation	15
3	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	10

4	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.	10
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Suggested readings

- Dubey, R.C. (2005). A Text Book of Biotechnology. S.Chand and Co, New Delhi.
- John Jothi Prakash, E. (2004). Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
- Kumaresan, V. (2005). Biotechnology, Saras Publications, New Delhi.
- Sathe, T.V. (2004). Vermiculture and Organic Farming. Daya Publishers.
- Subha Rao, N.S. (2000). Soil Microbiology, Oxford and IBH Publishers, New Delhi.
- Vayas, S.C, Vayas, S. and Modi, H.A. (1998). Bio-fertilizers and organic Farming. Akta Prakashan, Nadiad.

ii) Herbal Technology Credit: 3

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	Topic	No. of lecturers/ hrs (45)
1	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.	10
2	Pharmacognosy - systematic position medicinal uses of the following herbs in curing various ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka. Phytochemistry - active principles and methods of their testing - identification and utilization of the medicinal herbs; <i>Catharanthus roseus</i> (cardiotonic), <i>Withania somnifera</i> (drugs acting on nervous system), <i>Clerodendron phlomoides</i> (anti-rheumatic) and <i>Centella asiatica</i> (memory booster).	15

3	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).	10
4	Medicinal plant banks micro propagation of important species (ashwagandha, neem and tulsi- Herbal foods-future of pharmacognosy). National and state institutes related to the activity.	10

Suggested readings

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

iii) Nursery and Gardening

Credit: 3

Course outcome

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

Unit	Topic	No. of lecturers/ hrs (45)
1	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	15
2	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	10

3	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.	10
4	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. National and state institutes related to the activity.	10

Suggested readings

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

iv) Floriculture

Credit: 3

Course outcome

1. Develop conceptual skill about floriculture.
2. Gain knowledge about developing commercial enterprise of commercial floriculture.

Unit	Topic	No. of lecturers/ hrs (45)
1	Introduction: History of gardening; Importance and scope of floriculture. Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Role of plant growth regulators.	15
2	Ornamental Plants: Flowering annuals; Herbaceous perennials; Shade and ornamental trees; Cacti and succulents; Palms and Cycads; Ferns; Cultivation of plants in pots; Indoor gardening; Bonsai.	10

3	Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India.	10
4	Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold, Rose, Lilium, Orchids). Diseases and Pests of Ornamental Plants. National and state institutes related to the activity.	10

Suggested readings

- Randhawa, G.S. and Mukhopadhyay, A. (1986). Floriculture in India. Allied Publishers.

v) Medicinal Botany

Credit: 3

Course outcome

1. Understand the traditional Indian medicinal systems and their importance.
2. To learn the strategies for the conservation of medicinal plants.
3. Gain knowledge about developing commercial enterprise of herbal medicines.

Unit	Topic	No. of lecturers/ hrs (45)
1	History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences; Definition and Scope-Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants used in ayurvedic treatments, Siddha	10
2	Origin of Siddha medicinal systems, Basis of Siddha system, plants used in Siddha medicine. Unani: History, concept: Umooor-e- tabiya, tumors treatments/ therapy, polyherbal formulations.	10

3	Conservation of endangered and endemic medicinal plants. Definition: endemic and endangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacred groves, National Parks; Ex situ conservation: Botanical Gardens, Ethnomedicinal plant Gardens. Propagation of Medicinal Plants: Objectives of the nursery, its classification, important components of a nursery, sowing, pricking, use of green house for nursery production, propagation through cuttings, layering, grafting and budding	15
4	Ethno-botany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. folkmedicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases. National and state institutes related to the activity.	10

Suggested readings

- Jain, S.K. (1989). Method of Approaches in Ethnobotany. Lucknow.
- Jain, S.K. (2010). A Manual of Ethnobotany. Scientific Publishers.
- Jain, S.K. and Mudgal, V. (1999). A handbook of Ethnobotany. Dehradun.
- Krattigar, F. Anatole (1994). Widening Perspectives on Biodiversity. Dehradun.
- Martin, G.J. (1994). Ethnobotany: A Method Manual. London.
- Pande, P.C., Pokharia D.S. and Bhatt J.C. (1999 Ed.). Ethnobotany of Kumaun Himalaya. Jodhpur.
- Purohit, S.S. and Vyas, S.P. (2008). Medicinal Plant Cultivation: A Scientific Approach, 2nd edn. Agrobios, India.
- Trivedi, P.C. (2006). Medicinal Plants: Ethnobotanical Approach, Agrobios, India.
- Wariko, K. (1995). Society and culture in the Himalaya. New Delhi.
- Yamin, F. (1995). The Biodiversity Conservation and Intellectual Property Rights. Switzerland.

vi) Conservation and Management of biodiversity (Conservation and Natural Resource Management) Credit: 3

Course outcome

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

Unit	Topic	No. of lecturers/ hrs (45)
1	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	10
2	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.	15
3	Conservation of Biodiversity: Conservation of genetic diversity, species diversity and ecosystem diversity, <i>In situ</i> and <i>ex situ</i> conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development	10
4	Role of plants in relation to Human Welfare a) Importance of forestry their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d) Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses. National and state institutes related to the activity.	10

Suggested readings

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

Course outcomes

1. To learn the proper documentation and presentation of traditional knowledge about plants.
2. To use important plants by the tribal communities for various purposes.
3. To learn the conservation of wild growing plants and their socioeconomic impacts.

Unit	Topic	No. of lecturers/ hrs (45)
1	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	10
2	Methodology of Ethnobotanical studies a) Field work b) Herbarium c) Ancient Literature d) Temples and sacred places e) Indigenous knowledge system	10
3	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) <i>Azadirachta indica</i> b) <i>Ocimum sanctum</i> c) <i>Vitex negundo</i> d) <i>Gloriosa superba</i> e) <i>Tribulus terrestris</i> f) <i>Pongamia pinnata</i> g) <i>Cassia fistula</i> h) <i>Indigofera tinctoria</i> . Role of ethnobotany in modern medicine with special example <i>Rauvolfia serpentina</i> , <i>Trichopus zeylanicus</i> , <i>Artemisia</i> , <i>Withania</i> . Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).	15
4	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. National and state institutes related to the activity.	10

Suggested readings

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

viii) Mushroom Cultivation

Credit: 3

Course outcome

1. Understand the economic importance of mushroom cultivation.
2. To learn the basic tools and techniques used in mushroom cultivation.
3. To learn the skills for developing commercial enterprise of mushroom cultivation.

Unit	Topic	No. of lecturers/ hrs (45)
1	Introduction, history. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India- <i>Volvariella volvacea</i> , <i>Pleurotus citrinopileatus</i> , <i>Agaricus bisporus</i> .	10
2	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	15
3	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.	10
4	Food preparation: Delicacies of mushroom and its value addition, Research Centres - National level and Regional level. Cost benefit	10

	ratio - Marketing in India and abroad, Export Value. National and state institutes related to the activity.	
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Suggested readings

- Bahl, N. (2000). Hand book of Mushrooms. Oxford & Ibh Publishing Co. Pvt Ltd.
- Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R. (1991). Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
- Swaminathan, M. (1990). Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
- Tewari, P. and Kapoor, S.C. (1988). Mushroom cultivation, Mittal Publications, Delhi.

ix) Intellectual Property Rights

Credit: 3

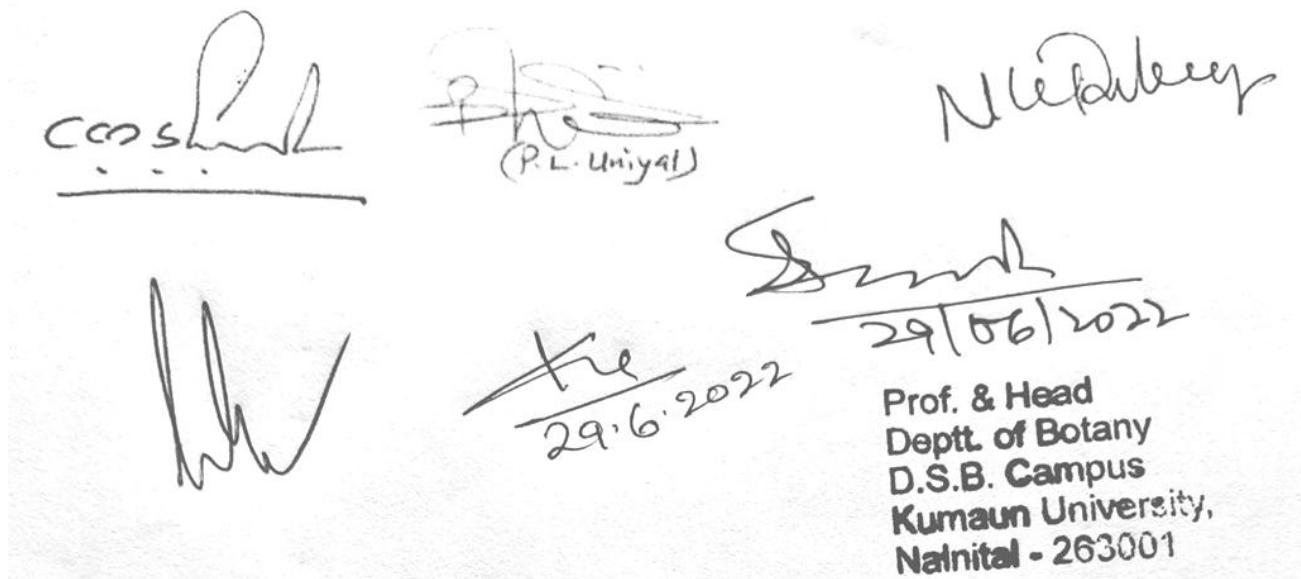
1. Understand the basic concepts of intellectual property rights.
2. To learn the procedure for obtaining the intellectual property rights.

Unit	Topic	No. of lecturers/ hrs (45)
1	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.	10

<p>2</p>	<p>Patents Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents, Infringement.</p> <p>Copyrights Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement.</p> <p>Trademarks Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defenses, Domain name.</p> <p>Geographical Indications Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position.</p>	<p>10</p>
<p>3</p>	<p>Protection of Traditional Knowledge Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level</p>	<p>10</p>
	<p>Traditional Knowledge Digital Library.</p> <p>Industrial Designs Objectives, Rights, Assignments, Infringements, Defenses of Design Infringement</p>	
<p>4</p>	<p>Protection of Plant Varieties Plant Varieties Protection-Objectives, Justification, International Position, Plant varieties protection in India. Rights of farmers, Breeders and Researchers. National gene bank, Benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001.</p> <p>Information Technology Related Intellectual Property Rights Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection.</p> <p>Biotechnology and Intellectual Property Rights. Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues in Patenting Biotechnological inventions.</p>	<p>15</p>

Suggested readings

- Acharya N.K. (2001). Textbook on intellectual property rights, Asia Law House.
- Ganguli P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill.
- Guru M. and Rao M.B. (2003). Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications.
- Miller, A.R. and Davis M.H. (2000). Intellectual Property: Patents, Trademarks and Copyright in Nutshell, West Group Publishers.
- Watal, J. (2003) Intellectual property rights in the WTO and developing countries, Oxford University Press, Oxford.



The image shows a document with several handwritten signatures and dates. The signatures are: 'coshank' (underlined), 'P.L. Uniyal' (with 'P.L. Uniyal' written below), 'N. K. Acharya', 'S. K. Singh' (with '29/06/2022' written below), and 'H. K. Singh' (with '29.6.2022' written below). The text 'Prof. & Head Deptt. of Botany D.S.B. Campus Kumaun University, Nainital - 263001' is printed at the bottom right of the document.