

Department of Botany

B.Sc. BOTANY

Four-Year Undergraduate Program

FYUP (Eight-Semester Course) As per NEP

Course Contents & Syllabus

(For students enrolled in 2025-26 academic session)



Hemvati Nandan Bahuguna Garhwal University

(A Central University)

Srinagar Garhwal-246174 (Uttarakhand)

Course Structure and Credit Allocation

First Year (NHEQF Level-4.5)									
Course Category	Semester-I					Semester-II			
	Subject	Paper	Credits			Subject	Paper	Credits	
			T	P				T	P
Discipline Specific Core	DSC-1 (Major)	Microbiology & Plant Pathology	3	1		DSC –II (Major)	Diversity of Cryptogams	3	1
	DSC-1 (Minor)	General Microbiology & Plant Pathology	3	1		DSC –II (Minor)	Study of Cryptogams	3	1
MD/ID (Minor)-Subject-1	MD/ID (M)-1	Microbial Techniques	3	1		MD/ID(M) -2	Herbarium Methodology & Plant Nomenclature	3	1
MD/ID (General)	MD/ID (G)-I		3	--		MD/ID (G)-II		3	--
AEC/AMSC	AEC-Communication Skills or AMSC	Mushroom Cultivation Technology	3	--		AMSC/Field Work/SEC Or Field work/ SEC/Communication Skills	Floriculture	3	--
VAC	Understanding and Connecting with Environment Or Life Skills & Personality development	Understanding and Connecting with Environment	2	--		Understanding and Connecting with Environment Or Life Skills & Personality Development	Life Skills & Personality Development	2	--
Total			17	3				17	3
NHEQF Level-4.5	<i>Student on exit after successfully completing first year (i.e., securing minimum required 40 credits + 4 Credits in one vocational course/skills-enhancement course of 4 credits) will be awarded “Undergraduate Certificate” of one year, in related field/discipline/subject</i>								
<i>The student may opt for Communication Skills in one semester, and any one course from Additional Multidisciplinary skill Course (SEC--AMSC) in the other semester.</i>									
AMSC- Additional Multidisciplinary Skill Course (is offered as SEC)									
List of Additional Multidisciplinary Skill course (SEC-AMSC) courses:									
Following are the courses which will be offered by the University under AMSC under the 4-year U.G. program. University may add new courses under AMSC in future along with the following courses:									
- Plant Nursery Development and Management - Physical Education and Sports Management - Indian traditional music - Basic Yoga practices - Regional Folklores and their cultural context - Tour and travel Operations									
Communication Skills- AEC: ‘Communication Skills’ course will be offered in Hindi, English and Sanskrit Languages, student may opt any one language for studying the course									
Life Skill & Personality Development – VAC					Understanding and connecting with environment- VAC				

Note: Student can opt Botany subject as either Discipline Specific Major or Discipline Specific Minor or as Multidisciplinary/Interdisciplinary (MD/ID) Subject.

Second Year – NHEQF Level- 5									
Course Category	Semester-III					Semester-IV			
	Subject/Title	Paper	Credits			Subject /Title	Paper	Credits	
			T	P				T	P
Major-I (One Subject) Major	DSC (Major)-III	Plant physiology and biochemistry	4	1		DSC (Major)-IV	Taxonomy and Reproductive Biology of Plants	4	1
Minor-I (One Subject)	DSC (Minor)-III	Introductory Plant Physiology and Biochemistry	3	1		DSC (Minor)-IV	Taxonomy and Embryology of plants	3	1
M.D/I.D (Minor)	M.D/I.D (M)-III	Bioinformatics	3	1		M.D/I.D (M)-IV	Environmental Pollution and Management	3	1
SEC	SEC (Major)-III	Medicinal plants and natural products	3	-		SEC (Major)-IV	Nursery and Gardening Techniques	3	-
AEC (Language based courses)	Indian, Modern, Regional Language-I	1	2	-		Indian, Modern, Regional Language-II	1	2	-
VAC/AEC	AEC-Indian Knowledge System Or VAC-Culture, traditions and moral values	1	2			AEC-Indian Knowledge System Or VAC-Culture, traditions and moral values	1	2	-
Total		6	17	3			6	17	3
NHEQF Level 5	<i>Student on exit after successfully completing Second year (i.e., securing minimum required 80 credits + 4 Credits in one vocational course/skills-enhancement course of 4 credits) will be awarded “Undergraduate Diploma” of two year, in related field/discipline/subject.</i>								
IKS- Indian Knowledge System- AEC									
Culture, Traditions and Moral Values- VAC									
Students are required to study both courses — <i>Indian Knowledge System (IKS)</i> and <i>Culture, traditions and moral values</i> — during the 3rd and 4th semesters. However, they will have the flexibility to study one course in each semester.									
IMR Language- ‘Indian, Modern, Regional Language’- Hindi, Sanskrit and English (Student have to study 2 different languages in the second year with one language in one semester and other language in another semester). One additional course titled “Heritage of Indian Languages” shall be offered, which students may opt for in lieu of any one prescribed language course, subject to the applicable regulations of the programme.									
*The department will offer a 3-credit SEC-Major course in a fully theory-based module.									
<i>Note: Student will continue with the same Discipline specific major & Minor in the second year (III & IV Semester) as studied in the first year (I & II semester) of the FYUP.</i>									

FOUR-YEAR BACHELOR'S DEGREE PROGRAMME WITH HONOURS/RESEARCH
(B.Sc. Botany)
SYLLABUS (w.e.f. 2025-26)

B. Sc. First Year (I Semester)

DSC-1 MAJOR/CORE BOTANY
(Theory: 3 Credits; Practical: 1 Credit)

SOLS/BOT/DSC (Major)-1 Microbiology and Plant Pathology	3 Credits [30 hours]
--	-----------------------------

Unit I **[8 hours]**

History and scope of Microbiology

General account, distribution and classification of microorganisms.

Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance

Unit II **[8 hours]**

Introduction to the *Archaea*, Archaeal Cell Wall, Archaeal Lipid and Membranes, Major Archaeal Groups

Bacteria – Discovery, General characteristics and cell structure; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

Unit III **[7 hours]**

Microalgae- Distribution, Classification, Ultrastructure of algal cell, nutrition, reproduction, and economic

importance. Fungi-General characteristics, nutrition, Cell wall composition, ultrastructure of Fungal Cell, life cycle, Slime molds and water Molds, Economic importance of Fungi.

Unit IV **[7 hours]**

History of Plant Pathology. Modes of Infection and general symptoms, physiology of parasitism, defense mechanism in plants, role of environment in disease development, Disease resistance in plants.

Causal organisms, symptoms, disease cycle and control of the following plant diseases: Citrus canker, TMV, wilt of tomato, bacterial blight of rice, mosaic of sugarcane and little leaf of brinjal. Late blight of potato, Wilt of Arahara, Loose smut of Wheat, Covered smut of Barley, Green ear disease of bajra, downy mildew of crucifers, rusts of pea and linseed, smut of bajra.

Suggested Readings

1. Brock Biology of Microorganisms, 13th edition (2012)
2. Van Den Hoek et al. Algae: An Introduction to Phycology, Cambridge University Press, Cambridge (1997)
3. Webster, J. 1985. Introduction to Fungi. Cambridge University Press.
4. Stainier, R.Y. General Microbiology 5th edition (2009) Mc Millan Press Ltd., Hound Mills
5. Talaro, K.P., Chess, B., 2011. Foundation in Microbiology. 8th edition. McGraw-Hill
6. Willey JM, Sherwood L, Woolverton CJ (2013) Prescott's Microbiology, 9th edition, McGraw-Hill, New York
7. Agrios, G.N., 1988. Plant Pathology, Academic Press, London.
8. Lucas, John, A., 1998. Plant Pathology and Plant Pathogens, Wiley-Blackwell, CRC Press.
9. Singh, R.S. Plant diseases, 9th edition (2009). Oxford and IBH Pub. Co. Pvt. Ltd., New Delhi

MINOR/CORE BOTANY
(Theory: 3 Credits; Practical: 1 Credit)
[For students with Major Subjects other than BOTANY]

SOLS/BOT/DSC (Minor)-I General Microbiology and Plant Pathology

3 Credits [30 Hours]

Unit I

[8 hours]

History and scope of Microbiology

General account, distribution and classification of microorganisms.

Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance

Unit II

[8 hours]

Introduction to the *Archaea*, Archaeal Cell Wall, Archaeal Lipid and Membranes, Major Archaeal Groups

Bacteria – Discovery, General characteristics and cell structure; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

Unit III

[7 hours]

Microalgae- Distribution, Classification, Ultrastructure of algal cell, nutrition, reproduction, and economic

importance. Fungi-General characteristics, nutrition, Cell wall composition, ultrastructure of Fungal Cell, life cycle,

Slime molds and water Molds, Economic importance of Fungi.

Unit IV

[7 hours]

History of Plant Pathology. Modes of Infection and general symptoms, physiology of parasitism, defense mechanism in plants, role of environment in disease development, Disease resistance in plants.

Causal organisms, symptoms, disease cycle and control of the following plant diseases: Citrus canker, TMV, wilt of tomato, bacterial blight of rice, mosaic of sugarcane and little leaf of brinjal. Late blight of potato, Wilt of Arahara, Loose smut of Wheat, Covered smut of Barley, Green ear disease of bajra, downy mildew of crucifers, rusts of pea and linseed, smut of bajra.

Suggested Readings

1. Brock Biology of Microorganisms, 13th edition (2012)
2. Van Den Hoek et al. Algae: An Introduction to Phycology, Cambridge University Press, Cambridge (1997)
3. Webster, J. 1985. Introduction to Fungi. Cambridge University Press.
4. Stainier, R.Y. General Microbiology 5th edition (2009) Mc Millan Press Ltd., Hound Mills
5. Talaro, K.P., Chess, B., 2011. Foundation in Microbiology. 8th edition. McGraw-Hill
6. Willey JM, Sherwood L, Woolverton CJ (2013) Prescott's Microbiology, 9th edition, McGraw-Hill, New York
7. Agrios, G.N., 1988. Plant Pathology, Academic Press, London.
8. Lucas, John, A., 1998. Plant Pathology and Plant Pathogens, Wiley-Blackwell, CRC Press.
9. Singh, R.S. Plant diseases, 9th edition (2009). Oxford and IBH Pub. Co. Pvt. Ltd., New Delhi

SOLS/BOT/DSC (Major)-1(P) Microbiology and Plant Pathology (Practical)	1 Credits
SOLS/BOT/DSC (Minor)-1 (P) General Microbiology and Plant Pathology (Practical)	1 Credits

1. Laboratory safety and good laboratory practices
2. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
3. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.
4. Staining method of microorganisms
5. Study of *Nostoc*, *Chlamydomonas*, *Chlorella* and Diatoms
6. Study of *Rhizopus*, *Penicillium*, *Aspergillus*, *Alternaria*, *Ustilago* and *Puccinia* (Asexual stage from temporary mounts and sexual structures through permanent slides).
7. Study of plant diseases with the help of infected plant specimens - TMV, citrus canker, little leaf of brinjal, loose smut of wheat, downy mildew of crucifers, rust of pea, smut of bajra

MULTIDISCIPLINARY/INTERDISCIPLINARY COURSE
(Theory: 3 Credits; Practical: 1 Credits)

SOLS/BOT/MD/ID- 1 Microbial Techniques	3 Credits [30 Hours]
---	-----------------------------

Unit I **[7 Hours]**

Microscopy and specimen preparation

Principles of bright-field and fluorescence microscopy, Preparation and Staining of Specimens, Scanning and Transmission Electron Microscopy: Basics and preparation of specimens, Introduction to Confocal Microscopy and Scanning Probe.

Unit II **[7 Hours]**

Culture techniques and measurement of microbial growth

Culture media for bacteria, microalgae and Fungi. Sterilisation process, Principles and applications of autoclave, biosafety cabinets and Incubators, Batch and Continuous Cultures, Growth Curve, Microbial growth behaviour in batch system, Influence of environmental factors on growth.

Unit III **[8 Hours]**

Spectrophotometry and Centrifugation

UV-Visible and Fluorescence Spectrophotometry and its applications in microbial research, Differential and Density gradient centrifugation, Ultracentrifugation.

Unit IV **[8 Hours]**

Chromatography and other techniques

Paper Chromatography, Column Chromatography, TLC, HPLC and Ion-exchange chromatography. X-ray crystallography, PCR, AGE, PAGE and SDS-PAGE, Isolation and purification of genomic DNA, plasmid and proteins.

Suggested readings:

1. Dubey RC (2013) A Text Book of Biotechnology, 4th edition, S Chand & Co Ltd, New Delhi.
2. Green MR, Sambrook J (2000) Molecular Cloning: A Laboratory Manual, 4th edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor.
3. Dubey RC, Maheshwari DK (2016) A Text Book of Microbiology, S Chand & Co Ltd, New Delhi.
4. Brown TA (2007) Gemones-3, 3rd edition, Garland Sci Publishing, New York.
5. Willey JM, Sherwood LM, Woolverton CJ (2014) Prescott's Microbiology, 9th edition, MacGraw Hill International, New York.

SOLS/BOT/MD/ID-1 (P) Microbial Techniques (Practical)	1 Credits [30Hours]
--	----------------------------

1. Laboratory safety and good laboratory practices, Cleaning and Sterilisation of Glassware
2. Preparation of media- Nutrient Agar and Broth
3. Inoculation and culturing of bacteria/microalgae in Nutrient agar and nutrient broth, Serial dilution
4. Study and enumeration of soil bacteria/microflora using MPN
5. Preparation of agar slant, stab, agar plate
6. Isolation and pure culture techniques
7. Isolation of lactic acid bacteria from curd.
8. Isolation of nitrogen-fixing bacteria from root nodules of legumes.
9. Study of natural microalgal community
10. Study of growth of unicellular microorganism by cell counting/turbidometry
11. Pathological specimens of Loose smut of wheat, Late blight of potato, White rust of crucifer, Stem gall of Coriander, Red rot of sugarcane; Slides of uredial, telial, pycnial & aecial stages of *Puccinia*, Few viral and bacterial plant diseases.

SOLS/BOT/SEC- I Mushroom Cultivation Technology	3 Credits [30 Hours]
--	-----------------------------

Unit I **[7 hours]**
 Introduction, history. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India - *Volvariella volvacea*, *Pleurotus ostreatus*, *Agaricus bisporus*.

Unit II **[10 hours]**
 Cultivation Technology: 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 **[7 hours]**
 Storage and nutrition: Short-term storage (Refrigeration – up to 24 hours) Long term Storage (canning, pickles, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fiber content - Vitamins.

Unit IV **[6 hours]**
 Food Preparation_: Types of foods prepared from mushroom. Research Centres - National level and regional level. Cost benefit ratio - Marketing in India and abroad, Export Value.

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
3. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol. II.

Unit I [8 hours]

General characteristics; Classification of algae; Morphology and life-cycles of the following: *Oscillatoria*, *Scytonema*, *Volvox*, *Ulva*, *Vaucheria*, *Fucus* and *Polysiphonia*. Economic importance of algae

Unit II [8 hours]

True Fungi- General characteristics, Comparative account of Ascomycetes, Basidiomycetes and deuteromycetes, Life cycle of *Puccinia* and *Agaricus* (Basidiomycota);

Symbiotic Associations- **Lichens**: General account, reproduction and significance; **Mycorrhiza**: ectomycorrhiza and endomycorrhiza and their significance

Unit III [7 hours]

Bryophytes: General characteristics, adaptations to land habit, Classification, Range of thallus organisation. Classification, morphology, anatomy and reproduction of *Riccia*, *Anthoceros*, *Marchantia* and *Funaria*. (Developmental details not to be included). Ecology and economic importance of bryophytes

Unit IV [8 hours]

Pteridophytes: General characteristics, classification, Early land plants (*Cooksonia* and *Rhynia*). Classification, morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris*. (Developmental details not to be included). Heterospory and seed habit, stelar evolution. Ecological and economical importance of Pteridophytes.

Suggested Readings

1. Gangulee HC, Kar AK (2011) College Botany Vol II (Algae, Fungi, Bryophyta, Pteridophyta), New Central Book Agency, Kolkata.
2. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
3. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
4. Dubey HC (2009) An Introduction to Fungi, 3rd edition, Vikash Publication House Pvt Ltd, Noida.
5. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
6. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad

Unit I

[8 hours]

General characteristics; Classification of algae; Morphology and life-cycles of the following: *Oscillatoria*, *Scytonema*, *Volvox*, *Ulva*, *Vaucheria*, *Fucus* and *Polysiphonia*. Economic importance of algae

Unit II

[8 hours]

True Fungi- General characteristics, Comparative account of Ascomycetes, Basidiomycetes and deuteromycetes, Life cycle of *Puccinia* and *Agaricus* (Basidiomycota);

Symbiotic Associations- Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance

Unit III

[7 hours]

Bryophytes: General characteristics, adaptations to land habit, Classification, Range of thallus organisation.

Classification, morphology, anatomy and reproduction of *Riccia*, *Anthoceros*, *Marchantia* and *Funaria*.

(Developmental details not to be included). Ecology and economic importance of bryophytes

Unit IV

[8 hours]

Pteridophytes: General characteristics, classification, Early land plants (*Cooksonia* and *Rhynia*). Classification, morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris*. (Developmental details not to be included). Heterospory and seed habit, stelar evolution. Ecological and economic importance of Pteridophytes.

Suggested Readings

1. Gangulee HC, Kar AK (2011) College Botany Vol II (Algae, Fungi, Bryophyta, Pteridophyta), New Central Book Agency, Kolkata.
2. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
3. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
4. Dubey HC (2009) An Introduction to Fungi, 3rd edition, Vikash Publication House Pvt Ltd, Noida.
5. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
6. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad

SOLS/BOT/DSC (Major)-2 (P) Diversity of Cryptogams (Practical)	1 Credits
SOLS/BOT/DSC (Minor)-2 (P) Study of Cryptogams (Practical)	1 Credits

1. Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas* (electron micrographs), *Oedogonium*, *Vaucheria*, *Fucus** and *Polysiphonia* through temporary preparations and permanent slides. (* *Fucus* - Specimen and permanent slides),
2. *Agaricus*: Specimens of button stage and full-grown mushroom
3. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
4. Mycorrhiza: Ecto-mycorrhiza and endo mycorrhiza (Photographs)
5. *Marchantia* and *Riccia*- morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
Funaria- morphology, w.m. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, l.s. capsule and protonema.
6. *Selaginella*- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus, w.m. microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
7. *Equisetum*- morphology, t.s. internode, l.s. strobilus, t.s. strobilus, w.m. sporangiophore, w.m. spores (wet and dry)(temporary slides); t.s rhizome (permanent slide).
8. *Pteris*- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores (temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).

Unit I**[7 hours]**

Introduction: History of herbarium, Types and thematic herbaria, Virtual herbarium, Functions of herbarium, Roles of herbarium in conservation and taxonomic research, Acronyms, Famous herbaria of the world and India.

Unit II**[8 hours]**

Herbarium methodology: General concept of herbarium specimen's preservation and preparation, Types of preservation techniques, herbarium slips, scaling and colour coding, herbarium techniques for Algae (Macro-algae), Lichens, Fungi (Mushrooms), Bryophytes, Ferns and Fern allies, Gymnosperms and Angiosperms, Carpological collections, Equipment and chemicals, Precautions, Maintenance and Digitization of herbarium specimens.

Unit III**[6 hours]**

Plant Nomenclature: Introduction, concept, and history of plant nomenclature; International Code of Nomenclature for Algae, Fungi, and Plants (ICN): Division-I. Principles; Division-II. Rules and Recommendations; Division-III. Provisions for governance.

Unit IV**[9 hours]**

Articles: I). Nomenclature type, type concept, typification; II). Rules of Priority; III). Rules of Effective Publication; IV). Rules of Valid publication of names; V). Citation; VI). Different types of names in code. General concept of PhyloCode and BioCode.

Suggested Readings:

1. Naik, V.N. (1991). *Taxonomy of Angiosperms*. Tata McGraw-Hill Publishing Company Limited, New Delhi.
2. Brummitt, R. K. & Powell, C. E. (1992). *Authors of Plant Names*. Kew: Royal Botanic Gardens.
3. Jain, S.K. & Rao, R.R. (1976). *A Hand Book of Field and Herbarium Methods*. Today and Tomorrow's Printers and Publishers, New Delhi.
4. Thiers, B (2025). Index Herbariorum: A Global Directory of Public Herbaria and Associated Staff. New York Botanical Garden's Virtual. Herbarium.
5. Turland, N. J., Wiersema, J. H., Barrie, F. R., Greuter, W., Hawksworth, D. L., Herendeen, P. S., Knapp, S., Kusber, W.-H., Li, D.-Z., Marhold, K., May, T. W., McNeill, J., Monro, A. M., Prado, J., Price, M. J. & Smith, G. F. (eds) (2018). International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. *Regnum Vegetabilis* 159. Koeltz Botanical Books, Glashütten.
6. Pandey, A.K. & Kasana, S. (2021). *Plant Systematics*. Jaya Publishing House, New Delhi.

1. Preparation of a minimum of 10 herbarium specimens of different plant groups.
2. Write a report on a visit to any nearby herbarium/museum.
3. Discuss: Heterotypic and Homotypic synonyms; Replacement name and Replaced name;
4. Protologue citation (journals, authored book, edited book with standard abbreviated form) and Author citation (standard abbreviation of author names).
5. Important websites for taxonomic literature and virtual herbaria.
6. Preparation of the dissection of fragile flowers/illustrations.

Unit I**[8 hours]**

Introduction: History of gardening; Importance and scope of floriculture and landscape gardening.
Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators.

Unit II**[7 hours]**

Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai.

Unit III**[8 hours]**

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. Landscaping Places of Public Importance: Landscaping highways and educational institutions.

Unit IV**[7 hours]**

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.

Suggested Readings

1. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied Publishers.
2. Laurie, A., & Ries, V. H. (2020). Floriculture: Fundamentals and Practices. Jodhpur: Agrobios/Indian Books & Periodicals. ISBN: 9788177540925.
3. Singh, A. K., & Sisodia, A. (2020). Textbook of Floriculture and Landscaping. New Delhi: New India Publishing Agency. ISBN: 9789386546005.
4. Datta, S. K., & Gupta, Y. C. (Eds.). (2022). Floriculture and Ornamental Plants. Singapore: Springer Nature. ISBN: 9789811535185.
5. Dirr, M. A. (2009). Manual of Woody Landscape Plants (6th ed.). Champaign: Stipes Publishing.

MAJOR/CORE BOTANY
(Theory: 4 Credits; Practical: 1 Credits)

SOLS/BOT/Major-3 Plant Physiology and Biochemistry

4 Credits [60 hours]

Unit 1: Plant-Water Relations

Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.

Unit 2: Mineral Nutrition

Essential elements, macro and micronutrients; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels, and pumps. Sugar translocation.

Unit 3: Photosynthesis

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4, and CAM pathways of carbon fixation; Photorespiration.

Unit 4: Respiration

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate cycle, Oxidative Pentose Phosphate Pathway.

Unit 5: Plant Growth Regulators

Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, and ethylene. Plant response to light and temperature. Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red-light responses on photomorphogenesis; Vernalization.

Unit 6:

Biologically important molecules: Carbohydrates, Amino acids, Proteins, and Lipids. Enzymes: Structure and properties; Mechanism of enzyme action, coenzymes, allosteric enzymes, isozymes, enzyme inhibition.

Suggested Readings

1. Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007) Biochemistry (Sixth Edition) W.H. Freeman & Company, New York.
5. Cox, M.M. and Nelson DL (2004) Lehninger Principle of Biochemistry (Third Edition) MacMillan Worth Publishers.
6. Dennis, D.T. & Turpin, D.H. (1993) Plant Physiology, Biochemistry and Molecular Biology. Longman Scientific & Technical, England.

MINOR/CORE BOTANY
(Theory: 3 Credits; Practical: 1 Credits)

SOLS/BOT/Minor-3: Introductory Plant Physiology and Biochemistry

3 Credits [45 hours]

Unit 1: Plant-water relations

Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation. (7 Lectures)

Unit 2: Mineral nutrition

Essential elements, macro and micronutrients; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels, and pumps. Sugar translocation (7 Lectures)

Unit 3: Photosynthesis

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4, and CAM pathways of carbon fixation; Photorespiration. (8 Lectures)

Unit 4: Respiration

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate Cycle, Oxidative Pentose Phosphate Pathway. (7 Lectures)

Unit 5: Plant growth regulators

Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, and ethylene. Plant response to light and temperature, Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), Vernalization. (8 Lectures)

Unit 6:

Biologically important molecules: Carbohydrates, Amino acids, Proteins, and Lipids. Enzymes: Structure and properties; Mechanism of enzyme action, coenzymes, allosteric enzymes, isozymes, enzyme inhibition. (8 Lectures)

Suggested Readings

1. Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007) Biochemistry (Sixth Edition) W.H. Freeman & Company, New York.
5. Cox, M.M. and Nelson DL (2004) Lehninger Principle of Biochemistry (Third Edition) MacMillan Worth Publishers.
6. Dennis, D.T. & Turpin, D.H. (1993) Plant Physiology, Biochemistry and Molecular Biology. Longman Scientific & Technical, England.

SOLS/BOT/DSC (Major)-3(P) Plant physiology and Biochemistry (Practical)

1 Credits [hours]

SOLS/BOT/DSC (Minor)-3(P) Introductory Plant Physiology and Bio-chemistry (Practical)

1 Credits [hours]

1. Determination of osmotic potential of plant cell sap by the plasmolytic method.
2. To study the effect of two environmental factors (light and wind) on transpiration by an excised twig.
3. Estimation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. Demonstration of the Hill reaction.
5. To study the effect of light intensity and bicarbonate concentration on O₂ evolution in photosynthesis.
6. Demonstration experiments
 - (i) Bolting.
 - (ii) Effect of auxins on rooting.
 - (iii) Suction due to transpiration.
 - (iv) R.Q.

MULTIDISCIPLINARY/INTERDISCIPLINARY COURSE
(Theory: 3 Credits; Practical: 1 Credits)

SOLS/BOT/MD/ID- 3 Bioinformatics

3 Credits [30 Hours]

Unit-1: Introduction

Introduction to Bioinformatics - History, scope of bioinformatics in research, business and employment opportunities. Role of bioinformatics in Human Genome Project. Bioinformatics in India - current status and future implication. Bioinformatics and its relation with molecular biology.

Unit – 2: Types of Databases

NCBI – GenBank and DDBJ, Nucleotide Database - Ensembl, Gene expression database – Omnibus, Pathway and Molecular interaction databases - KEGG, Protein Database – InterPro, SWISS Prot and UniProt, Protein structure Database - RCSB-PDB, EMBL-EBI structure database, Alphafold protein structure database. Pubmed and secondary databases of proteins. Specialized Genome databases: (SGD, TIGR, and ACeDB). Structure databases (CATH, SCOP and PDBsum).

Unit-3: Data Storage and Retrieval and Online tools

Data submission and retrieval with: Entrez, DBGET/LinkDB, and SRS. Sequence alignment and analysis. Examples of related Tools (FASTA, BLAST, BLAT, RASMOL), nucleotide composition, GC percentile in nucleic acids, generation of complementary and reverse complement sequences, restriction mapping via NEB cutter 3.0, melting temperature identification, , translation of mRNA, codon usage analysis.

Unit- 4: Sequence alignments and visualization

Introduction to sequences, Importance of nucleotide and protein sequence alignment tools. Local alignment and global sequence alignments. Pairwise alignment (BLAST and FASTA Algorithm) and multiple sequence alignment (ClustalW, MAFFT, T-COFFEE, CLUSTAL Omega, COBALT tools). Methods for presenting large quantities of biological data: sequence viewers (Artemis, SeqVISTA, Jalview), 3D structure viewers (Rasmol, Swiss-Pdb viewer, Chimera protein viewer, Cn3D, PyMol). Next generation sequencing and Data analysis – Illumina sequencing and Nanopore sequencing.

Suggested Readings

1. Jonathan Pevsner, Bioinformatics and functional genomics, 2015, Wiley Blackwell Publications.
2. Bryan Bergeron, Bioinformatics Computing, 2002, Prentice Hall PTR publishers.
3. Andreas D. Baxevanis, B. F. Francis Ouellette, 2001, Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins, 2nd Edition, A John Wiley & Sons, Inc., Publication.
4. Francisco Azuaje, Joaquín Dopazo, 2005, Data Analysis and Visualization, in Genomics and Proteomics John Wiley & Sons Ltd.

SOLS/BOT/MD/ID-3 (P) Bioinformatics (Practical)

1 Credits [30Hours]

1. Study of NCBI database and retrieval of nucleotide sequences from GenBank.
2. Retrieval of protein sequences from UniProt and SWISS-Prot databases.
3. Searching literature using PubMed database.
4. Study of KEGG pathway database and metabolic pathway identification.
5. Retrieval and visualization of protein structures from RCSB-PDB database.
6. Study of Ensembl genome browser and gene annotation tools.

Unit I [8 hours]

History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences and Scope, Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants, used in ayurvedic treatments, Siddha: Origin of Siddha medicinal systems, Basis of Siddha system, plants used in Siddha medicine. Unani: History, concept: Umoor-e- tabiya, tumors treatments/ therapy, polyherbal formulations

Unit II [5 hours]

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: Botanic Gardens, Ethnomedicinal plant Gardens.

Unit III [5 hours]

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.

Unit IV [10 hours]

Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases.

Suggested Readings

1. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied Publishers.
2. Biren Shah & A.K. Seth. Textbook of Pharmacognosy and Phytochemistry. 2nd Edition, Elsevier, 2010.
3. B.P. Pandey. Economic Botany. 6th Edition, S. Chand Publishing, 2014. Relevant pages: pp. 190–275 (Medicinal plants and plant products).
4. Hans Wagner & Sabine Bladt. Plant Drug Analysis: A Thin Layer Chromatography Atlas. 2nd Edition, Springer, 2009.

MAJOR/CORE BOTANY

(Theory: 4 Credits; Practical: 1 Credits)

SOLS/BOT/Major-4: Taxonomy and Reproductive Biology of Plants
--

4 Credits [hours]

TAXONOMY

Unit 1: Introduction to plant taxonomy

Taxonomy: Identification, Classification, Nomenclature. Taxonomic hierarchy, Ranks, Categories, and taxonomic groups Identification. Herbarium and Botanic Gardens: Functions of Herbaria and Botanic gardens; important herbaria and botanic gardens of the world and India. Taxonomic literature: Flora, Revisions, Monographs, Checklist.

(8 Lectures)

Unit 2: Plant classifications

Classifications: Types of classification-artificial, natural, and phylogenetic. Bentham and Hooker (up to series), Engler and Prantl (up to series).

(8 Lectures)

Unit 3: Taxonomy, important distinguishing characters, classification, and economic importance of the following families: Ranunculaceae, Papaveraceae, Malvaceae, Brassicaceae, Rutaceae, Fabaceae, Apiaceae, Asteraceae, Solanaceae, Apocyanaceae, Asclepiadaceae, Acanthaceae, Lamiaceae, Euphorbiaceae, Orchidaceae, Poaceae.

(10 Lectures)

EMBRYOLOGY

Unit 4: Structural Organization of Flower

Structure of anther and pollen grains, Types of ovules, Microsporogenesis and Megasporogenesis, Types of embryo sacs, Pollination and double fertilization.

(8 Lectures)

Unit 5: Embryo and Endosperm

Types and functions of endosperm, Development of dicot and monocot embryo, Polyembryony and Apomixis, Male sterility and self-incompatibility.

(8 Lectures)

Suggested Readings

1. Singh, G. (2021). Plant Systematics: Theory and Practice (4th ed.). CRC Press, Boca Raton.
2. Sharma, O. P. (2017). Plant Taxonomy (2nd ed.). McGraw Hill Education, New Delhi.
3. Singh, V., & Jain, D. K. (2014). Taxonomy of Angiosperms. Rastogi Publications, Meerut. An Introduction to Taxonomy
4. Subrahmanyam, N. S. (2016). An Introduction to Taxonomy. Vikas Publishing House, New Delhi.
5. Bhojwani, S. S., & Bhatnagar, S. P. (2015). The Embryology of Angiosperms (5th ed.). Vikas Publishing House, New Delhi.
6. Maheshwari, P. (2012 reprint). An Introduction to the Embryology of Angiosperms. McGraw Hill Education, New Delhi.
7. Tiagi, Y. D. (2018). Embryology of Angiosperms. Kalyani Publishers, Ludhiana.
8. Pandey, B. P. (2020). A Textbook of Botany: Angiosperms, Taxonomy, Anatomy, Embryology. S. Chand Publishing, New Delhi.

MINOR/CORE BOTANY
(Theory: 3 Credits; Practical: 1 Credits)

SOLS/BOT/Minor-4: Taxonomy and Embryology of Plants	3 Credits [hours]
--	---------------------------

TAXONOMY

Unit 1: Introduction to plant taxonomy (8 Lectures)

Taxonomy: Identification, Classification, Nomenclature. Taxonomic hierarchy, Ranks, Categories, and taxonomic groups Identification. Herbarium and Botanic Gardens: Functions of Herbaria and Botanic gardens; important herbaria and botanic gardens of the world and India. Taxonomic literature: Flora, Revisions, Monographs, Checklist.

Unit 2: Plant classifications (8 Lectures)

Classifications: Types of classification-artificial, natural, and phylogenetic. Bentham and Hooker (up to series), Engler and Prantl (up to series).

Unit 3: Taxonomy, important distinguishing characters, classification, and economic importance of the following families: (10 Lectures)

Ranunculaceae, Papaveraceae, Malvaceae, Brassicaceae, Rutaceae, Asteraceae, Solanaceae, Asclepiadaceae, Acanthaceae, Lamiaceae, Euphorbiaceae, Orchidaceae, Poaceae.

EMBRYOLOGY

Unit 4: Structural Organization of Flower

Structure of anther and pollen grains, Types of ovules, Microsporogenesis and Megasporogenesis, Types of embryo sacs, Pollination and double fertilization.

Unit 5: Embryo and Endosperm

Types and functions of endosperm, Development of dicot and monocot embryo, Polyembryony and Apomixis, Male sterility and self-incompatibility.

Suggested Readings

1. Singh, G. (2021). Plant Systematics: Theory and Practice (4th ed.). CRC Press, Boca Raton.
2. Sharma, O. P. (2017). Plant Taxonomy (2nd ed.). McGraw Hill Education, New Delhi.
3. Singh, V., & Jain, D. K. (2014). Taxonomy of Angiosperms. Rastogi Publications, Meerut. An Introduction to Taxonomy
4. Subrahmanyam, N. S. (2016). An Introduction to Taxonomy. Vikas Publishing House, New Delhi.
5. Bhojwani, S. S., & Bhatnagar, S. P. (2015). The Embryology of Angiosperms (5th ed.). Vikas Publishing House, New Delhi.
6. Maheshwari, P. (2012 reprint). An Introduction to the Embryology of Angiosperms. McGraw Hill Education, New Delhi.

SOLS/BOT/DSC (Major)-4 (P) Taxonomy and Reproductive Biology of Plants (Practical)	1 Credits [hours]
SOLS/BOT/DSC (Minor)-4 (P) Taxonomy and Embryology of Plants (Practical)	1 Credits [hours]

1. Study of vegetative and floral characters of the following families according to Bentham & Hooker's system of classification: *Brassicaceae, Asteraceae, Solanaceae, Acanthaceae, Lamiaceae, Poaceae.*
2. Preparation of twenty (min. 20) properly dried and pressed herbarium specimens of any wild plants of your area in the form of a well-arranged herbarium file.
3. Study of taxonomic terminology.
4. Study of different types of ovules and embryo sacs using permanent slides.
5. Study of dicot and monocot embryo development through prepared slides and diagrams.

Unit 1 Air Pollution

1. Introduction and types of air pollutants
2. Natural and human-made sources of air pollution
3. Greenhouse gases, global warming, acid rain and ozone depletion

Unit 2 Water Pollution

- i). Sources and causes of water pollution
- ii). Water quality parameters
- iii). Eutrophication and biomagnification
- iv). Industrial and domestic wastewater
- v). Water treatment and quality assessment methods

Unit 3 Soil, Noise and Radioactive Pollution

- i). Soil pollution and remediation methods
- ii). Pesticide and heavy metal contamination
- iii). Noise pollution: sources, effects and control
- iv). Radioactive pollution and environmental hazards

Unit 4 Solid Waste Management

- i). Types of solid waste
- ii). Municipal, biomedical and hazardous waste
- iii). Waste collection, segregation and disposal
- iv). Recycling, composting, landfill and incineration

Suggested Readings

1. Benny Joseph (2017). Environmental Science and Engineering. 3rd Edition. New Delhi: Tata McGraw-Hill Education Pvt. Ltd.
2. Anubha Kaushik & C. P. Kaushik (2022). Perspectives in Environmental Studies. 7th Edition. New Delhi: New Age International Publishers.
3. Gilbert M. Masters & Wendell P. Ela (2018). Introduction to Environmental Engineering and Science. 4th Edition. Pearson Education.
4. Howard S. Peavy, Donald R. Rowe & George Tchobanoglous (2017 reprint). Environmental Engineering. New Delhi: McGraw-Hill Education.
5. S. K. Garg (2019). Sewage Disposal and Air Pollution Engineering. New Delhi: Khanna Publishers.

1. Measurement of pH, turbidity and dissolved oxygen of water
2. Estimation of BOD and COD
3. Determination of particulate matter in air
4. Soil texture and soil moisture analysis
5. Noise level monitoring
6. Solid waste characterization
7. Visit to wastewater treatment plant / polluted site
8. Preparation of environmental impact report

Unit 1:**[4 Lectures]**

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

Unit 2:**[6 Lectures]**

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 3:**[6 Lectures]**

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 4:**[8 Lectures]**

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.

Unit 5:**[6 Lectures]**

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.

Suggested Readings

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