CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMME

Approved by 40th Academic Council Meeting held on 23rd May 2025

Under Graduate Syllabus

Department of Botany
Nagaland University

2025

1. Minimum Credit Requirements to Award Degree under each Category

Sl. No.	Broad Category of Course	Minimum Credit Requirement	
		3-year UG	4-year UG
1	Major (Core)	60	80
2	Minor Stream	24	32
3	Multidisciplinary	09	09
4	Ability Enhancement Courses (AEC)	08	08
5	Skill Enhancement Courses (SEC)	09	09
6	Value Added Courses common for all UG	08	08
7	Summer Internship	02	02
8	Research Project/ Dissertation	-	12
	Total Credits	120	160

2. Course Structure for Curriculum and Credit Framework for UG Programme

Semester-Wise Course and Credit Distribution of UG Programme (FYUG)

Semester	Course Categories	Credits	Remark
I	2 Major Courses (4 + 4)	8	Core papers of one discipline will be the Minor papers of other discipline
	1 Minor Course	4	
	1 Multidisciplinary Course	3	
	1 Ability Enhancement Course	2	
	1 Skill Enhancement Course	3	
	Total	20	
Semester	**Course Categories**	**Credits**	**Remark**
II	2 Major Courses (4 credits each)	8	
	1 Minor Course	4	
	1 Multidisciplinary Course	3	
	1 Ability Enhancement Course	2	
	1 Common Value Added Course	3	
	Total	20	
Students exiting the programme after <u>securing 40 credits will be awarded UG Certificate</u> in the relevant Discipline / Subject provided they secure 4 credits in work based vocational courses offered during SUMMER TERM / Internship			
Semester	**Course Categories**	**Credits**	**Remark**
III	2 Major Courses	8	
	1 Minor Course	4	
	1 Multidisciplinary Course	3	
	1 Ability Enhancement Course	2	
	1 Skill Enhancement Course	3	
	Total	20	

Semester	Course Categories	Credits	Remark
IV	2 Major Courses	8	
	1 Minor Course	4	
	1 Ability Enhancement Course	2	
	1 Skill Enhancement Course	3	
	1 Common Value Added Course	3	
	Total	20	

Students exiting the programme after securing 80 credits will be awarded UG Diploma in the relevant Discipline / Subject provided they secure additional 4 credits in 'Skill based vocational courses offered' during first or second year SUMMER TERM.

Semester	Course Categories	Credits	Remark
V	3 Major Courses	12	
	1 Minor Course	4	
	1 Internship	2	
	1 Common Value Added Course	2	
	Total	20	
Semester	Course Categories	Credits	Remark
VI	4 Major Courses	16	
	1 Minor Course	4	
	Total	20	

Students who want to undertake 3-year UG programme will be awarded UG Degree in the relevant Discipline / Subject upon securing 120 Credits

Semester	Course Categories	Credits	Remark
VII	3 Major Courses (4 +4+4)	12	B.Sc. Hons
	1 Research Methodology Paper (4)	4	
	1 Minor Course (4)	4	
	Total	20	
Semester	Course Categories	Credits	Remark
VII	4 Major	16	B.Sc. Hons
	1 Minor Course	4	
	Total	20	
Semester	Course Categories	Credits	Remark
VIII	1 Major	4	B.Sc. Hons with Research
	1 Minor	4	
	Research Project	12	
	Total	20	

3. CREDIT DISTRIBUTION

Science	Remarks	Arts (Non-experimental)	Remarks
Total Credit 4	Theory 3 + Practical 1	Total Credit 4	Theory 3 + Tutorial 1

Botany Course Structure FYUG: Core Papers

Paper Code	Course Code	Title of the Paper	Total Credit
		SEMESTER - I	
C-1	**BCC-01**	Microbiology and Phycology	4
C-2	**BCC-02**	Biomolecules and Cell Biology	4
		SEMESTER - II	
C-3	**BCC-03**	Mycology and Phytopathology	4
C-4	**BCC-04**	Archegoniate (Bryophytes, Pteridophytes and Gymnosperms)	4
		SEMESTER - III	
C-5	**BCC - 05**	Morphology and Anatomy of Angiosperms	4
C-6	**BCC - 06**	Economic Botany	4
		SEMESTER - IV	
C-7	**BCC - 07**	Genetics	4
C-8	**BCC - 08**	Molecular Biology	4
		SEMESTER - V	
C- 9	**BCC - 09**	Plant Ecology and Phytogeography	4
C-10	**BCC - 10**	Plant Systematics	4
C-11	**BCC - 11**	Reproductive Biology of Angiosperms	4
		SEMESTER - VI	
C-12	**BCC - 12**	Plant Physiology	4
C-13	**BCC - 13**	Plant Metabolism	4
C-14	**BCC - 14**	Plant Biotechnology	4
C-15*	**BDSE – 01 A**	Plant Breeding	4
	BDSE – 01 B	Biostatistics	
		SEMESTER - VII	
C-16*	**BDSE – 02 A**	Analytical Techniques in Plant Sciences	4
	BDSE – 02 B	Bioinformatics	
C-17*	**BDSE – 03 A**	Natural Resource Management	4
	BDSE – 03 B	Horticultural Practices and Post-Harvest Technology	
C-18*	**BDSE – 04 A**	Industrial and Environmental Microbiology	4
	BDSE – 04 B	Advanced Molecular Biology	
C-19		Research Methodology	4
***Note: For C-15, C-16, C-17 and C-18 (BDSE papers) students can choose any paper from 'A or B'**			
		SEMESTER- VIII (For B.Sc. Honours)	
C-20	Agricultural Microbiology and Biosafety		4
C-21	Entrepreneurial Botany		4
C-22	Ethnobotany and Plant Biodiversity		4
C-23	Environmental Awareness and Ethics		4
		SEMESTER- VIII (For B.Sc. Honours with Research)	
C-20	Agricultural Microbiology and Biosafety		4
C-24	**Project For B.Sc. Hon & Research /Dissertation**		**12**

SKILL ENHANCEMENT COURSES Proposed (3 Credits Each)

Semester	Course Code	Title of the Paper	Department	Remark
I	**BSEC-01**	Biofertilizers	Botany	Students can select any one from the respective semester
	BSEC-02	Floriculture	Botany	
III	**BSEC-03**	Herbal Technology	Botany	
	BSEC-04	Nursery and Gardening	Botany	
IV	**BSEC-05**	Medicinal Botany	Botany	
	BSEC-06	Mushroom Culture Technology	Botany	

DETAILED SYLLABUS

CORE COURSES

Course Code: BCC-01: Microbiology and Phycology
(Credits: Theory-3; Practical-1)

Objectives: This course aims to introduce students to the microbial world and the phycological (algal) diversity, emphasizing their structural, functional, and ecological aspects. It covers the evolution and classification of microorganisms including viruses and bacteria, along with their nutritional and reproductive strategies. The course also explores various algal groups, their cellular components, methods of reproduction, and life cycles. Special focus is given to the ecological and economic significance of microbes and algae in diverse environments.

C-1 (T) BCC 01: THEORY (45 Lectures)

Unit 1: Introduction to Microbial World **(9 Lectures)**
General account of Darwin's theory of evolution; The evolution of population; Concept of species; Mechanism of speciation; Microbial nutrition, growth and metabolism.

Unit 2: Bacteria **(9 Lectures)**
Discovery of bacteria; General characteristics; Types-archaebacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Nutritional types; Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance of bacteria.

Unit 3: Virus **(9 Lectures)**
Discovery of viruses; General structure; Types of viruses- DNA virus (T-phage), RNA virus and Retrovirus; Virus replication (general account)- lytic (T4 phage) and lysogenic cycle (Lambda phage); Viroid and Prions.

Unit 4: Algae **(16 Lectures)**
General characteristics; Range of thallus organization; Cell structure and components- cell wall, pigment system, reserve food (of only groups represented in the syllabus) and flagella; Methods of reproduction; Classification system (Fritsch); Economic importance of algae.
General characters; Occurrence; Range of thallus organization; Reproduction and life cycle of Cyanophyta (*Nostoc)*, Xanthophyta (*Vaucheria),* Chlorophyta (*Oedogonium),* Charophyta (*Chara)*, Phaeophyta *(Ectocarpus*) and Rhodophyta (*Polysiphonia*).

C-1 (P) BCC 01: PRACTICAL (30 Hours)

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule.
3. Gram staining.
4. Study of Root nodules and its importance
5. Study of vegetative and reproductive structures of *Nostoc, Oedogonium, Chara, Vaucheria, Ectocarpus and Polysiphonia, Procholoron* through electron micrographs, temporary preparations and permanent slides.

Suggested Readings

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th edition. McGraw Hill International.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). Farming the Ocean: Seaweeds Cultivation and Utilization. Aravali International, New Delhi.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
6. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

Course Code: BCC-02: Biomolecules and Cell Biology
(Credits: Theory-3; Practical-1)

Objectives: This course provides a comprehensive understanding of the chemical foundation of biological systems and the structural and functional organization of cells. It introduces the nature and role of major biomolecules—carbohydrates, lipids, proteins, and nucleic acids—along with their biochemical properties and biological significance. The course also covers the principles of bioenergetics and enzyme kinetics, offering insight into metabolic energy flow and enzyme functionality. Additionally, it explores the cellular organization in prokaryotes and eukaryotes, cell cycle regulation, and the structure-function relationships of key cell organelles, with emphasis on molecular mechanisms governing cellular processes.

Unit 1: Biomolecules **(15 Lectures)**

Carbohydrates: Nomenclature and Classification- Monosaccharides, Disaccharides, Oligosaccharides and polysaccharides.

Lipids: Classification and structure of lipids. Fatty acids structure and functions; Fatty acids, saturated and unsaturated, triacylglycerols, phospholipids and sphingolipids

Proteins: Structure and classification of amino acids; Classification and structure of proteins; Properties of amino acids; Peptide bond formation; Protein denaturation

Nucleic Acids: Nucleosides and Nucleotides; Types of nucleic acids; Structure of DNA; Types of DNA; Types of RNA, Structure of tRNA; Phosphodiester and Hydrogen bonds; DNA denaturation.

Unit 2: Bioenergetics and Enzymes **(10 Lectures)**

Laws of thermodynamics; Concept of free energy; Endergonic and exergonic reactions; Redox reactions; ATP- structure & its role as an energy currency molecule.

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced-fit theory), Michaelis–Menten equation, Enzyme inhibition and factors affecting enzyme activity.

Unit 3: Cell Biology **(10 Lectures)**

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Structure and function of Plant cell wall; Structure and function of Cell membrane

Cell Organelles - Nucleus: Structure and function; Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament; Chloroplast, Mitochondria and Peroxisomes: Structure and Function; Endomembrane System: Endoplasmic Reticulum – Structure and types; Golgi Apparatus – organization and function; Lysosomes- Structure and function.

Unit 4: Cell Cycle **(10 Lectures)**

Basic features of the cell cycle; Process and phases of Mitosis and its significance; Process and phases of meiosis and its significance; Regulation of cell cycle- checkpoints; Role of protein kinases.

C-2 (P): Practical (30 Hours)

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo*/*Crinum*.
3. Study the phenomenon of plasmolysis and deplasmolysis.
4. Study of different stages of mitosis
5. Study of different stages of meiosis.

Suggested Readings

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning.
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone.
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman.
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company.
5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th edition., W.H. Freeman and Company.
6. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6thedition.
7. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8thedition.
8. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
9. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Course Code: BCC-03: Mycology and Phytopathology
(Credits: Theory-3, Practical-1)
Objectives: This course aims to provide students with a foundational understanding of fungi and their allied groups, including their classification, structure, reproduction, and ecological roles. It covers both free-living and symbiotic fungi, such as lichens and mycorrhizae, highlighting their biological significance. The course introduces key fungal divisions like Chytridiomycota, Zygomycota, Oomycota, Ascomycota, and Basidiomycota with representative life cycles. Emphasis is also placed on the practical applications of fungi in industry, agriculture, and medicine. In addition, students are introduced to the principles of plant pathology, including the nature of plant diseases, host-pathogen interactions, and strategies for disease prevention and control.

C-3 (T) BCC 03: THEORY (45 Lectures)

Unit 1: Introduction **(9 Lectures)**

True Fungi: General characteristic, origin, thallus organization, cell wall composition, nutrition and classification (Ainsworth system).

Allied Fungi: General characteristics, classification, status of Slime molds in taxonomy, Occurrence, Plasmodia; types of plasmodia and types of fruiting bodies.

Symbiotic Association: *Lichen*: Occurrence, General characteristics; Nature of associations of algal and fungal partners; Reproduction*; Mycorrhiza*: Ectomycorrhiza, Endomycorrhiza and their significance.

Unit 2: Chytridiomycota, Zygomycota and Oomycota **(10 Lectures)**

Chytridiomycota: Characteristic features; Thallus organization; Reproduction; Life cycle with reference to *Synchytrium.* **Zygomycota:** Characteristic features; Thallus organization; Reproduction; Life cycle with reference to *Rhizopus*. **Oomycota:** Characteristic features; thallus organization; Reproduction; Life cycle with reference to *Phytophthora.*

Unit 3: Ascomycota and Basidiomycota and applied Mycology **(16 Lectures)**

General characteristics (asexual and sexual fruiting bodies); Ecology, Heterokaryosis, parasexuality and Bioluminescence; Life cycle with reference to *Saccharomyces* and *Aspergillus;* Life cycle with reference to *Puccinia* and *Agaricus.*

Application of fungi in food industry (Flavour& texture, Fermentation, Baking, Organic acids, Enzymes; Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides).

Unit 4: Phytopathology **(10 Lectures)**

Terms and concepts; General symptoms, Host-Pathogen relationships, Disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine; Fungal diseases – White rust of crucifers, powdery mildew, damping off disease; Bacterial diseases – Citrus canker and bacterial leaf wilt of tomato; Viral diseases – Papaya Mosaic viruses, vein clearing.

C-3 (P) BCC 03: Practical (30 Hours)

1. *Rhizopus*: Study of asexual stage from temporary mounts and sexual structures through permanent slides.
2. *Aspergillus* and *Penicillium*: Study of asexual stage from temporary mounts. Study of sexual stage from permanent slides/photographs.
3. *Phytophthora:* Specimens/photographs and temporary mounts.
4. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
5. *Pleurotus*: Specimens of primordia and full-grown mushroom; sectioning of gills.
6. *Albugo:* Study of symptoms of plants infected with *Albugo*; asexual phase study through section/temporary mounts and sexual structures through permanent slides.
7. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs).
8. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; bacterial leaf wilt of tomato.
9. Viral diseases in the locality.

Suggested Readings

1. Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
3. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
4. Sethi, I.K. and Walia, S.K. (2011). Textbook of Fungi and Their Allies, Macmillan Publishers India Ltd.
5. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

Course Code: BCC-04: Archegoniate (Bryophytes, Pteridophytes and Gymnosperms) (Credits: Theory-3; Practical-1)

Objectives: This course introduces students to the diversity, structure, and evolutionary significance of archegoniate plants, encompassing Bryophytes, Pteridophytes, and Gymnosperms. It provides a comparative understanding of their classification, life cycles, morphology, and reproductive features, with representative type studies from each group. The course emphasizes key evolutionary developments such as heterospory, seed habit, telome theory, and stelar evolution. Additionally, it highlights the ecological and economic roles of these plant groups and explores the fundamentals of paleobotany, including fossil formation, geological time scales, and the significance of plant fossils in understanding Earth's vegetational history**.**

C-4 (T) BCC 04: THEORY (45 Lectures)

Unit 1: Introduction to Bryophytes and Pteridophytes (10 Lectures)

Unifying features of archegoniates; Alternation of generations; Bryophytes- General characteristics; Classification; Pteridophytes- General characteristics; Classification; Early land plants (*Rhynia*).

Unit 2: Type Studies- Bryophytes (10 Lectures)

Classification (up to family) (Proskauer, 1957); Morphology; anatomy; Reproduction and evolutionary trends of *Marchantia, Anthoceros and Sphagnum* (Developmental details not to be included); Ecological and economic importance of bryophytes with special reference to *Sphagnum*.

Unit 3: Type Studies- Pteridophytes (10 Lectures)

Classification (up to family); Morphology; Anatomy and reproduction of *Selaginella* and *Equisetum* (Developmental details not to be included); Ecological and economic importance; Heterospory and seed habit; Telome theory; Stelar evolution.

Unit 4: Gymnosperms and Paleobotany (15 Lectures)

General characteristics; classification (up to family); Morphology: Anatomy and reproduction of *Cycas* and *Pinus* (Developmental details not to be included). Ecological and Economic importance.

Geological time scale; Fossil types and their formation; General account of dominant fossil flora of different ages; Paleobotany in relation to exploration of fossil fuels.

C-4 (P) BCC 04: Practical **(30 Hours)**

1. ***Marchantia***- Morphology of thallus, whole mount of rhizoids & Scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides).
2. ***Anthoceros***- Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).
3. ***Selaginella***- Morphology, whole mount of leaf with ligule, transverse section of stem, wholemount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
4. ***Equisetum***- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
5. ***Cycas***- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll, transverse section of coralloid root, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).
6. ***Pinus***- Morphology (long and dwarf shoots, male and female cones), transverse section of Needle, transverse section of stem, longitudinal section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone, radial longitudinal sections stem (permanent slide).

Suggested Readings

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
3. Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot. Allahabad.
4. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
5. Vanderpoorten, A. & Goffinet, B. (2009) Introduction to Bryophytes. Cambridge University Press.

Course Code: BCC - 05: Morphology and Anatomy of Angiosperms
(Credits: Theory-3; Practical-1)

Objectives: This course aims to provide a comprehensive understanding of the external and internal structures of angiosperms. It explores the vegetative and floral morphology, highlighting structural modifications and their adaptive significance. Students will study various tissue types and their organization within plant organs, gaining insights into primary and secondary growth processes. The course also addresses developmental theories of apical organization and vascular cambium activity, alongside the anatomy of roots, shoots, and leaves. Emphasis is placed on functional and ecological aspects of plant structure, as well as wood formation and its applications in dendrochronology and plant taxonomy.

C-5 (T) BCC 05: THEORY (45 Lectures)

Unit 1: Vegetative Morphology (10 Lectures)

Root: Structures, types, with reference to modification. Stem: Habit, types, with reference to modification. Leaf: Structures, types, with reference to modification. Fruits: Structure, types and classification. Seeds: Structure and types. Fruit and seeds dispersal.

Unit 2: Floral Morphology (10 Lectures)

Detail structure of flower, floral parts, arrangement, relative position, numeric plan, cohesion and adhesion of floral parts. Types of aestivations, placentation, floral formulae and floral diagram. Types of inflorescences. Flower as a modified shoot.

Unit 3: Plant anatomy - Tissues (10 Lectures)

Classification and structure of tissue, types of cells and tissues; Simple tissue; structure, occurrence and function. Complex tissues; structure and function (Xylem, phloem). Secretory tissue (glands, glandular hairs, nectaries, hydathodes, schizogenous and lysigenous ducts, resin ducts, mucilage ducts, kinoveins, lacticifers). Vascular bundles: types (conjoint, collateral, bicollateral, open, closed, radial, concentric amphicribal and amphivasal). Protective Systems**:** Epidermis, cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and non-glandular).

Unit 4: Anatomy -Roots and Shoots, Cambium and wood (15 Lectures)

Shoots: theories on apical organisation (Apical cell theory, Histogen theory, Tunica-Corpus theory); Arrangement of primary tissues in the dicot and monocot stem and leaves; Roots: Organization of root apex (Apical cell theory, Korpe-kappe theory); Arrangement of primary tissues in dicot and monocot roots. Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. periderm, rhytidome and lenticels.

C-5 (P) BCC 05: Practical (30 Hours)

1. Study of root and its modifications.
2. Study of stem and its modifications.
3. Study of leaf and its modifications.
4. Study of floral morphology.
5. Study of fruits.
6. Study of anatomical details through permanent slides/temporary stain mounts/ macerations/museum specimens with the help of suitable examples.
7. Distribution and types of aerenchyma, parenchyma, collenchyma and sclerenchyma
8. Epidermal system: cell types; trichomes: non-glandular and glandular.
9. Root: monocot, dicot, secondary growth.
10. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.

Suggested Readings

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
4. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.
5. Bhattacharaya, K., Hait, G., Ghosh, A.K. (2008). A Textbook of Botany, Vol. 2, New Central Book Agency (P) Ltd. Kolkata.
6. Bhattacharaya, K., Ghosh, A.K., Hait, G. (2017). A Textbook of Botany, Vol. 4. New Central Book Agency (P) Ltd. Kolkata.
7. Pandey B.P. (2002). Plant Anatomy. S. Chand & Company Ltd., New Delhi.

Course Code: BCC - 06: Economic Botany
(Credits: Theory-3; Practical-1)
Objectives: This course provides an in-depth understanding of the external and internal morphology of angiosperms. It emphasizes the structure and modification of vegetative and floral organs, exploring their functional and adaptive significance. Students will examine the classification and organization of plant tissues, and gain insights into primary and secondary growth mechanisms. The course also covers theories of apical organization, the anatomy of roots, shoots, and leaves, and the structure and seasonal activity of vascular cambium. Additional focus is given to wood anatomy, including dendrochronology, and its relevance to ecological and taxonomic studies.

C-6 (T) BCC 06: THEORY (45 Lectures)
Unit 1: Origin of Cultivated Plants and Sources of Sugars and Starches (10 Lectures)
Concept of Centres of Origin, their importance with reference to Vavilov's work; Examples of major plant introductions; Crop domestication and loss of genetic diversity; Evolution of new crops/varieties; importance of germplasm diversity; Morphology and processing of sugarcane, products and by-products of sugarcane industry; Potato– morphology, propagation and uses.

Unit 2: Cereals, Legumes, Spices and Beverages (15 Lectures)
Cereals- Wheat and Rice (origin, morphology, processing and uses); Brief account of millets; Pulses- Origin, morphology and uses of soybean, chickpea, pigeon pea legumes. Listing of important spices, their family and parts used; Economic importance with special reference to ginger, cardamom, cinnamon, and black pepper; Tea, Coffee (morphology, processing and uses).

Unit 3: Natural Rubber and Sources of Oils and Fats. (10 Lectures)
Natural Rubber**:** Para-rubber: tapping, processing and uses.
Oils and Fats: General description; classification; extraction, their uses and health implications groundnut, sesame, coconut, linseed, mustard and coconut (Botanical name, family and uses).

Unit 4: Drug-yielding Plants, Timber Plant and Fibres (10 Lectures)
Therapeutic and habit-forming drugs with special reference to C*inchona, Digitalis, Papaver* and *Cannabis*; General account with special reference to teak and pine; Types based on the origin of fibres; Cotton and Jute (morphology, extraction and uses).

C-6 (P)BCC 06: Practical **(30 Hours)**

1. **Cereals**: Wheat (habit sketch, L. S/T.S. grain, starch grains), Rice (habit sketch, study of paddy and grain, starch grains).
2. **Legumes**: Groundnut, (habit, fruit, seed structure).
3. **Sources of sugars and starches**: Sugarcane (habit sketch), Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains)
4. **Spices:** Black pepper, ginger (habit and sections).
5. **Beverages**: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. **Sources of oils and fats**: Coconut, Mustard–plant specimen, seeds
7. **Essential oil-yielding plants**: Habit sketch of *Rosa*, *Vetiveria, Santalum* and *Eucalyptus* (specimens/photographs).
8. **Rubber**: specimen, photograph/model of tapping, samples of rubber products.
9. **Drug-yielding plants**: collection and herbarium.
10. **Fibre-yielding plants**: Cotton and jute: collection.

Suggested Readings

1. Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
2. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
3. Chrispeels, M.J. and Sadava, D.E. 1994. Plants, Genes and Agriculture. Jones & Bartlett Publishers.

Course Code: BCC - 07: Genetics
(Credits: Theory-3; Practical-1)
Objectives: This course aims to provide a foundational understanding of classical and molecular genetics. It introduces the principles of Mendelian inheritance and explores their extensions, including epistasis, polygenic traits, and penetrance. Students will examine extra-chromosomal inheritance patterns and maternal effects in model organisms. The course covers genetic linkage, recombination, and chromosome mapping, offering insights into the mechanisms of genetic transmission. A major focus is placed on chromosomal aberrations, gene mutations, and the molecular structure and function of genes, including mutagenesis and DNA repair. Concepts of population genetics and evolutionary forces such as natural selection and genetic drift are also addressed to explain genetic variation and speciation.

C-7 (T): THEORY (45 Lectures)
Unit 1: Mendelian Genetics and Its Extension (9 Lectures)
Mendelism: Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Polygenic inheritance, Penetrance and Expressivity.

Unit 2: Extra-chromosomal Inheritance, Linkage and Crossing over (15 Lectures)
Chloroplast mutation: Cytoplasmic inheritance in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in Paramecium.
Linkage and crossing over: Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Sex Linkage.

Unit 3: Chromosomal Aberrations and Structure of Gene (15 Lectures)
Mutation: Types; Point or gene mutation (base substitution), Chromosomal mutations/aberrations; Molecular basis of Mutations. Mutagens; physical and chemical mutagens; Role of Transposons in mutation; DNA repair mechanisms. Gene concept - Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism

Unit 4: Population and Evolutionary Genetics (6 Lectures)
Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

C-7 (P): Practical (30 Hours)

1. Meiosis through temporary squash preparation.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
3. Chromosome mapping using point test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1,9:3:4).
6. Blood Typing: ABO groups & Rh factor.
7. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
8. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

Course Code: BCC - 08: Molecular Biology
(Credits: Theory -3; Practical -1)
Objectives: This course is designed to provide students with an in-depth understanding of the molecular mechanisms governing the flow of genetic information. It covers the discovery and structural organization of nucleic acids and explores DNA and RNA as carriers of hereditary material. Emphasis is placed on the central dogma, including DNA replication, transcription, and translation, in both prokaryotic and eukaryotic systems. Students will examine the genetic code, gene regulation mechanisms such as the lac operon, and the intricacies of RNA processing, including splicing and RNA editing. The course also addresses protein synthesis, post-translational modifications, and the functional significance of these processes in cellular and molecular biology**.**

C-8 (T): THEORY **(45 Lectures)**

Unit 1: Nucleic Acids: Carriers of Genetic Information **(12 Lectures)**

DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty experiments). Types of genetic material; DNA Structure (Watson and Crick), Denaturation and Renaturation; Organization of DNA in Prokaryotes, Viruses & Eukaryotes; Structure of RNA; Mitochondria & Chloroplast DNA; Chromatin structure; Euchromatin & Heterochromatin

Unit 2: Genetic Code and Replication of DNA **(12 Lectures)**

The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features). Types of DNA replication; Replication of DNA in prokaryotes and eukaryotes; RNA priming

Unit 3: Transcription **(6 Lectures)**

Mechanism of Transcription in Prokaryotes and Eukaryotes; Regulation of gene expression in prokaryotes- lac operon and tryptophan synthesis in *E. coli*.

Unit 4: RNA Processing and Translation **(15 Lectures)**

RNA processing - Concept of introns and exons, removal of introns, splicing pathways, pre-mRNA Processing, spliceosome machinery, alternative splicing, RNA editing and mRNA transport. Translation- Various steps involved in translation/protein synthesis (aminoacylation of tRNA, translation, fidelity of translation); Inhibitors of protein synthesis; post-translational modifications of proteins.

C-8 (P): Practical **(30 hours)**

1. DNA isolation from any plant.
2. DNA estimation by diphenylamine reagent /UV- Spectrophotometry.
3. Study of DNA replication mechanisms through photographs.
4. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
5. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
6. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing

1. mechanism in group I & group II introns; Ribozyme and Alternative splicing.

Suggested Readings

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc.,U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

Course Code: BCC - 09: Plant Ecology and Phytogeography
(Credits: Theory-3; Practical-1)
Objectives: This course aims to provide students with a comprehensive understanding of the fundamental principles of plant ecology and phytogeography. It explores the inter-relationships between living organisms and their environment, focusing on the dynamic processes of ecosystems, including soil, water, light, temperature, and other environmental factors that shape plant life. Students will examine plant adaptation mechanisms, biotic interactions, and the concepts of population ecology and plant communities. The course also covers the structure and functional aspects of ecosystems, energy flow models, biogeochemical cycles, and the ecological dynamics of succession. Additionally, the principles of phytogeography are explored, with an emphasis on the distribution of plants across the globe, major biomes, and the phytogeographical divisions of India.

C-9 (T) BCC 09: THEORY (45 Lectures)

Unit 1: Introduction: Soil and Water (10 Lectures)

Basic concepts; Levels of organization; Inter-relationships between the living world and the environment, the components and dynamism; Homeostasis. Soil- Origin, Formation; Composition (Physical, Chemical and Biological components), Soil profile. Water- Importance, States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table.

Unit 2: Abiotic and Biotic Interaction, population ecology (15 Lectures)

Light; Temperature; Wind and Fire; Adaptation of plants to their variation.
Biotic interactions- Trophic organization; Basic source of energy: Autotrophy; Heterotrophy; symbiosis; commensalism; parasitism
Characteristics and Dynamics; Ecological Speciation; Plant communities; Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, Types; Climax concepts.

Unit 3: Ecosystem and functional aspects of ecosystem (10 Lectures)

Structure; Processes; Trophic organization; Food chains and Food webs; Ecological pyramids.
Functional aspects of ecosystem- Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Nitrogen and Phosphorus

Unit 4: Phytogeography (10 Lectures)

Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Local Vegetation.

C-9 (P) BCC 09: Practical (30 Hours)

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)
3. Determination of organic matter of different soil samples by titration method.
4. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
5. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
6. Study of morphological adaptations of hydrophytes and xerophytes.
7. Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*) Epiphytes, Predation (Insectivorous plants).
8. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and Comparison with Raunkiaer's frequency distribution law.
10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
11. Field visit to familiarise students with the ecology of different sites.

Suggested Readings

1. Odum, E.P. (2005). Fundamentals of Ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5thedition.
2. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
3. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
5. Kormondy, E.J. (1996). Concepts of Ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.

Course Code: BCC - 10: Plant Systematics
(Credits: Theory-3; Practical-1)
Objectives: This course aims to provide a comprehensive understanding of plant systematics, emphasizing the identification, classification, and evolutionary relationships of plants. It covers the foundational aspects of plant taxonomy, including the significance of herbarium collections, botanical gardens, and virtual herbaria in documenting plant diversity. Students will gain knowledge of key taxonomic methods such as flora, monographs, and taxonomical keys. The course explores the taxonomy of major angiosperm families, focusing on their economic importance, interrelationships, and evolutionary trends. Additionally, students will learn about taxonomic hierarchy, botanical nomenclature, and the systems of classification, including contributions by notable taxonomists. The course also delves into the phylogeny of angiosperms, helping students understand the evolution and relationships among plant groups.

C-10 (T) BCC 10: THEORY (Lectures: 45 Hours)

Unit 1: Significance of Plant Systematics (10 Lectures)
Introduction to plant systematics; Evidence from cytology; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; Documentation: Flora, Monographs, Taxonomical Keys: Single access and Multi-access.

Unit 2: Angiosperm Taxonomy (10 Lectures)
Critical study of the following families with emphasis on identification of local members using flora; economic importance; interrelationship and evolutionary trends- Dicots; Magnoliaceae, Brassicaceae, Ranunculaceae, Rutaceae, Fabaceae, Meliaceae, Lamiaceae, Euphorbiaceae, Solanaceae, Cucurbitaceae, Asteraceae. Monocots; Orchidaceae, Poaceae, Zingiberaceae

Unit 3: Taxonomic Hierarchy and Botanical Nomenclature (10 Lectures)
Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary); Principles and rules (ICN); Ranks and names of taxa; Typification; author citation; Effective & valid publication; Principle of priority and its limitations.

Unit 4: Systems of Classification and Phylogeny (15 Lectures)
Brief contributions of Linnaeus, Contribution of Hutchinson and Takhtajan in Taxonomy; Classification system of Bentham and Hooker (up to family); Brief reference of Angiosperm Phylogeny Group classification.
Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades); Origin and evolution of angiosperms.

C-10 (P) BCC 10: PRACTICAL (30 Hours)

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham and Hooker's system of classification):
   Ranunculaceae - *Ranunculus, Delphinium*
   Brassicaceae - *Brassica / Iberis*
   Asteraceae – *Bidens /Launaea, Vernonia/Ageratum, Eclipta/Tridax*
   Solanaceae - *Solanum nigrum/Withania*
   Lamiaceae - *Salvia/Ocimum*
   Euphorbiaceae - *Euphorbia hirta/E.milii/ Jatropha*
   Orchidaceae- *Dendrobium / Cymbidium*
   Liliaceae - *Asphodelus/Lilium/Allium*
2. Field visit (local) – Subject to grant of funds from the university.
3. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Suggested Readings

1. Singh, (2012). Plant Systematics: Theory and Practice Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
2. Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.
3. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics-A Phylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.
4. Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York.

Course Code: BCC - 11: Reproductive Biology of Angiosperms
(Credits: Theory-3; Practical-1)

Objectives: This course provides an in-depth exploration of the reproductive biology of angiosperms, covering both male and female reproductive structures and processes. It aims to equip students with a solid understanding of flower morphology, microsporogenesis, and microgametogenesis, as well as the structure and function of male reproductive organs, including pollen viability, storage, and germination. Students will study the structure of the carpel, ovule, and embryo sac, along with the processes of megasporogenesis and megagametogenesis. The course also covers pollination mechanisms, fertilization processes, and the development of endosperm, focusing on the significance of double fertilization. Post-fertilization topics include seed structure, types of endosperms, and mechanisms of seed dispersal, as well as the phenomenon of polyembryony and apomixis. Furthermore, students will examine self-incompatibility mechanisms, types of incompatibility, and modern reproductive technologies such as in vitro fertilization and cybrids.

C-11 (T) BCC 11: THEORY (45 Lectures)

Unit 1: Introduction to Reproductive Biology and Anther Biology (10 Lectures)

History and scope of embryology; Flower as a modified shoot; Structure of stamen; Microsporogenesis; Microgametogenesis; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia; Dehiscence

Unit 2: Ovule and Embryogeny (10 Lectures)

Structure of carpel; Types of Ovules; Megasporogenesis (monosporic, bisporic and tetrasporic types); Megagametogenesis; Structure of typical embryosac; Types of embryo sac (*Polygonum*, *Allium* and *Adoxa* type); Special structures– endothelium, obturator, aril, caruncle and hypostase

Unit 3: Pollination, Fertilization and Post-Fertilization (16 Lectures)

Pollination types and significance; Structure of stigma and style; Pollen tube entry; Double fertilization; Development of Endosperm.

Structure and types of endosperms; General pattern of development of dicot and monocot embryo and endosperm; Suspensor- structure and function; Embryo-endosperm relationship; Nutrition of embryo; Seed structure, importance and dispersal mechanisms; Polyembryony; Apomixis

Unit 4: Self-Incompatibility (9 Lectures)

Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Modification of stigma surface; Parasexual hybridization, cybrids, *in vitro* fertilization.

C-11 (P) BCC 11: PRACTICAL (30 HOURS)

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, pseudomonads, polyads, pollinia (slides/photographs, fresh material).
3. Pollen viability: Tetrazolium test, germination: Calculation of percentage germination in different media using hanging drop method.
4. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate.
5. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
6. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
7. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
2. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
3. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
4. Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

Course Code: BCC - 12: Plant Physiology
(Credits: Theory-3; Practical-1)
Objectives: This course aims to provide an understanding of plant physiology, focusing on water relations, mineral nutrition, nutrient uptake, and transport. Students will learn about water potential, transpiration, and the ascent of sap, along with nutrient absorption mechanisms and the roles of essential elements. The course also covers plant growth regulators, their physiological roles, and the processes of flowering, photoperiodism, and vernalization.

C-12 (T) BCC 12: THEORY (45 Lectures)

Unit 1: Plant-water Relations (12 Lectures)
Water Potential and its components; water absorption by roots; pathway of water movement-symplast, apoplast, transmembrane pathways, root pressure, guttation; Ascent of sap–cohesion-tension theory. Transpiration and factors affecting transpiration; anti-transpirants; mechanism of stomatal movement.

Unit 2: Mineral Nutrition (9 Lectures)
Essential and beneficial elements; macro and micronutrients; methods of study and use of nutrient solutions; criteria for essentiality; roles of essential elements; deficiency symptoms.

Unit 3: Nutrient Uptake and Translocation in the Phloem (12 Lectures)
Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.
Translocation in the phloem- Flow Model; Phloem loading and unloading; Source–sink relationship.

Unit 4: Plant Growth Regulators and Physiology of Flowering (12 Lectures)
Discovery; Physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, and Jasmonic acid. Photoperiodism; flowering stimulus; Florigen concept; Vernalization; Seed dormancy; Phytochrome; Cytochromes and Phototropins -Discovery, chemical nature, role in photomorphogenesis.

C-12 (P) BCC 12: Practical (30 Hours)

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the rate transpiration by Ganong's photometer.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of amesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in amesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory manual. Narosa Publishing House, New Delhi.

Course Code: BCC - 13: Plant Metabolism
(Credits: Theory-3; Practical-1)
Objectives: This course aims to explore the fundamental concepts of plant metabolism, covering both anabolic and catabolic pathways. Students will learn about carbohydrate metabolism, carbon assimilation processes like photosynthesis and photorespiration, and carbon oxidation pathways such as glycolysis and TCA cycle. The course also delves into ATP synthesis, mechanisms of signal transduction, lipid metabolism, and nitrogen metabolism, including nitrogen fixation and nitrate assimilation.

C-13 (T) BCC- 13: THEORY (45 Lectures)

Unit 1: Concept of Metabolism and Carbohydrate Metabolism (11 Lectures)
Introduction; Anabolic and catabolic pathways; Regulation of metabolism: Role of regulatory enzymes (allosteric, covalent modulation and isozymes); Carbohydrate Metabolism**;** Synthesis and catabolism of sucrose and starch.

Unit 2: Carbon Assimilation and Carbon oxidation (12 Lectures)
Photosynthetic pigments; Role of photosynthetic pigments: Antenna molecules and reaction centres; Photochemical reactions; Photosynthetic electron transport; Photorespiration; C4 pathways; Crassulacean acid metabolism; Factors affecting CO2 reduction.
Glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate; TCA cycle, mitochondrial electron transport, oxidative phosphorylation.

Unit 3: ATP-Synthesis and Mechanisms of Signal Transduction (11 Lectures)
Mechanism of ATP synthesis; Chemiosmotic mechanism (oxidative and photophosphorylation); ATP synthase; Receptor-ligand interactions; Second messenger concept; Calcium calmodulin.

Unit 4: Lipid and Nitrogen Metabolism (11 Lectures)
Synthesis and breakdown of triglycerides; β-oxidation and its role in mobilisation of lipids during seed germination. Nitrate assimilation, biological nitrogen fixation; Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

C-13 (P) BCC- 13: Practical (30 Hours)

1. Chemical separation of photosynthetic pigments.
2. To study the effect of light intensity on the rate of photosynthesis.
3. Effect of carbon dioxide on the rate of photosynthesis.
4. Demonstration of absorption spectrum of photosynthetic pigments.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.

Course Code: BCC-14: Plant Biotechnology
(Credits: Theory-3; Practical-1)

Objectives: This course aims to provide an understanding of plant biotechnology, including tissue culture, recombinant DNA technology, and gene cloning. Students will learn about protoplast isolation, cloning vectors, and various gene transfer methods such as Agrobacterium-mediated transfer and electroporation. The course also focuses on the applications of biotechnology in developing pest-resistant plants, improving crop quality, and bioremediation, while addressing biosafety concerns.

C-14 (T) BCC 14: THEORY (45 Lectures)

Unit 1: Plant Tissue Culture (11 Lectures)
Plant biotechnology; Composition of media; Nutrient and hormone requirements; Totipotency; Organogenesis; Embryogenesis- Protoplast isolation, culture and fusion; Tissue culture applications.

Unit 2: Recombinant DNA Technology (11 Lectures)
Restriction Endonucleases; Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic Vectors (pUC 18, pUC19, pBR322, Ti plasmid); Lambda phage, M13 phagemid, Shuttle vector; Eukaryotic Vectors-(YAC).

Unit 3: Gene Cloning (11 Lectures)
Recombinant DNA; Bacterial Transformation and selection of recombinant clones; PCR mediated gene cloning; Gene Construct; Construction of genomic and cDNA libraries; complementation; colony hybridization.

Unit 4: Methods of Gene Transfer and application of Biotechnology (12 Lectures)
Agrobacterium-mediated gene transfer; Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenic– selectable marker and reporter genes.
Pest and herbicide resistant plants; Transgenic crops with improved quality traits (FlavrSavr tomato, Golden rice); Improved horticultural varieties (Moon dust carnations); Role of transgenic in bioremediation (Superbug); Genetically Engineered Products; Biosafety concerns

C-14 (P) Practical (30 Hours)

1. (a) Preparation of MS medium.
   (b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants.
2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
3. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
4. Study of steps of genetic engineering for production of Bt cotton, Golden rice, FlavrSavr tomato through photographs.
5. Demonstration of PCR technique.

Suggested Readings:

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K.5th edition.
5. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.

Discipline Specific Elective Courses
Course Code: BDSE – 01: A. Analytical Techniques in Plant Sciences
(Credits: Theory-3; Practical-1)
Objectives: This course introduces students to various analytical techniques used in plant sciences, such as microscopy (light, fluorescence, and confocal), cell fractionation, and chromatography methods (including HPLC, TLC, and ion-exchange chromatography). Students will explore the use of radioisotopes and spectrophotometry in biological research, along with techniques for protein and nucleic acid characterization (e.g., mass spectrometry and X-ray crystallography). The course also covers essential biostatistics concepts, including measures of central tendency, dispersion, and the chi-square test.

C-15 (T) BDSE 01 A: THEORY (45 Lectures Hours)

Unit 1: Imaging and Related Techniques (11 Lectures)
Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS) (b): SEM and TEM; Chromosome banding, FISH.

Unit 2: Cell Fractionation and Chromatography (11 Lectures)
Centrifugation- Differential and density gradient centrifugation, sucrose density gradient, CsCl2gradient, analytical centrifugation, ultracentrifugation; marker enzymes.
Chromatography- Principle, Paper chromatography, Column chromatography, TLC, HPLC, Ion- exchange chromatography.

Unit 3: Radioisotopes, Spectrophotometry and Mass spectrometry (12 Lectures)
Use in biological research; auto-radiography; pulse chase experiment; Spectrophotometry- Principle and its application in biological research.
Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis.

Unit 4: Biostatistics (11 Lectures)
Statistics; Data, population; Samples; Parameters; Representation of data; Tabular, Graphical; Measures of central tendency- Arithmetic mean, mode, median; Measures of dispersion- Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

C-15 (P) BDSE – 01 A: Practical (30 Hours)

1. PCR (demonstration).
2. To separate sugars by thin layer chromatography.
3. To separate chloroplast pigments by column chromatography.
4. To estimate protein
5. Preparation of permanent slides (double staining).

Suggested Readings:

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

Course Code: BDSE – 01: B. Bioinformatics
(Credits: Theory-3; Practical-1)

Objectives: This course introduces students to bioinformatics, including its branches, research areas, and scope. It covers biological databases, database retrieval systems, and tools from major platforms such as NCBI, EMBL, DDBJ, and PIR. Students will learn how to retrieve and submit data to these databases and perform sequence alignment using tools like BLAST and CLUSTALW. The course also covers sequence analysis, scoring matrices, and molecular phylogeny methods, equipping students with skills to conduct phylogenetic analyses using various software.

C-15 (T) BDSE – 01 B : THEORY (45 Lectures)

Unit 1: Introduction to Bioinformatics and Databases in Bioinformatics (11 Lectures)

Introduction: Bioinformatics, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

Introduction to Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

Unit 2: Biological Sequence Databases I (11 Lectures)

National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database.

Unit 3: Biological Sequence Databases II (11 Lectures)

EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools. Introduction, Resources at DDBJ, Data Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR.

Unit 4: Sequence Alignments and Molecular Phylogeny (12 Lectures)

Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Blocks of Amino Acid Substitution Matrix (BLOSUM).

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

C-15 (P) BDSE – 01 B: Practical (30 Hours)

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.

Suggested Readings

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. - II Edition. Benjamin Cummings.

Course Code: BDSE – 02: A. Plant Breeding
(Credits: Theory-3; Practical-1)
Objectives: This course provides an understanding of plant breeding techniques, focusing on breeding systems and the modes of reproduction in crop plants. It discusses key achievements and challenges in plant breeding. Students will learn about methods of crop improvement, including acclimatization, selection methods for various types of plants, and hybridization procedures. The course covers the mechanisms of quantitative inheritance, inbreeding depression, and heterosis, along with their applications in plant breeding. The role of mutations, polyploidy, distant hybridization, and biotechnology in crop improvement will also be explored.

C-16 (T) BDSE – 02 A: THEORY (45 Lectures)

Unit 1: Plant Breeding (11 Lectures)
Introduction and objectives, Centres of origin and domestication of crop plants. Modes of reproduction in crop plants (Vegetative, Apomixes, and sexual). Breeding system: self-pollinated, cross-pollinated pollination control, Incompatibility and self-sterilization.

Unit 2: Breeding Methods of Crop Improvement (12 Lectures)
Introduction of plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross pollinated and vegetative propagated plants; Hybridization: For self, cross and vegetative propagated plants– Procedure, advantages and limitations.

Unit 3: Inheritance (11 Lectures)
Quantitative inheritance: mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings. Monogenic vs polygenic Inheritance. Genetic basis of Inbreeding depression.

Unit 4: Crop Improvement and Breeding (11 Lectures)
Role of mutations; Polyploidy; Heterosis and its applications, Hybrid seed production Distant hybridization and role of biotechnology in crop improvement.

C-16 (P) BDSE – 02 B PRACTICAL (30 Hours)
1. Perform hand pollination in some locally available flowers or vegetables. Note the detailed process and the results obtained.
2. Perform emasculation and cross pollination on some plants.
3. Visit agriculture research institutes/stations/centres, prepare a report on the accessions of vegetables/seeds/crops available.

Suggested Reading:

1. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7thedition.
2. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH.2nd edition.
3. Acquaah, G. (2007). Principles of Plant Genetics & Breeding. Blackwell Publishing.

Course Code: BDSE – 02: B. Biostatistics
(Credits: Theory-3; Practical-1)
Objectives: The course introduces students to the basics of biostatistics, including the statistical methods used in biological research. It covers the definition, principles, and functions of statistics. Students will learn various data collection techniques (primary and secondary data), their merits and demerits, as well as methods for classifying, tabulating, and presenting data. The course also addresses measures of central tendency (mean, median, mode, geometric mean) and measures of dispersion (range, standard deviation, quartile deviation, coefficient of variation), along with their respective merits and limitations. Additionally, students will explore correlation and regression methods, the differences between them, and how to apply them for prediction. Finally, the course covers statistical inference, including hypothesis testing, the student's t-test, and chi-square tests

C-16 (T) BDSE – 02 B.: THEORY (45 Lectures)

Unit 1: Biostatistics **(11 Lectures)**
Definition; Statistical methods; Basic principles; Variables- measurements, functions, limitations; Uses of statistics.

Unit 2: Collection of Data (Primary and Secondary) **(11 Lectures)**
Types and methods of data collection procedures; Merits and demerits; Classification; Tabulation; Presentation of data; Sampling methods.

Unit 3: Measures of Central Tendency **(11 Lectures)**
Mean, median, mode, geometric mean; Merits & demerits; Measures of dispersion - range, standard deviation, mean deviation, quartile deviation; Merits and demerits; Co- efficient of variations.

Unit 4: Correlation and Statistical Inference **(12 Lectures)**
Types and methods of correlation; regression; simple regression equation; fitting prediction; Similarities and dissimilarities of correlation and regression.
Hypothesis - simple hypothesis – student '*t*' test and *chi* square test.

C-16 (P) BDSE – 02 B: Practical (30 Hours)
1. Calculation of mean, standard deviation and standard error
2. Calculation of correlation coefficient values and finding out the probability
3. Calculation of 'F' value and finding out the probability value for the F value.

Suggested Readings

1. Danniel, W.W., 1987. Biostatistic, New York, John Wiley Sons.
2. Sundarrao, P.S.S and Richards, J. Christian. An introduction to Biostatistics, 3rd edition, Medical College, Vellore.
3. Selvin, S., 1991. Statistical Analysis of epidemiological data. New York University Press.
4. Boston, Bishop, O.N. Houghton, Statistics for Biology. Mifflin.
5. Freedman, P. New York, The Principles of Scientific research. Pergamon Press.
6. Campbell, R.C., 1998.Statistics for Biologists. Cambridge University Press.

Course Code: BDSE – 03: A. Natural Resource Management
(Credits: Theory-3; Practical-1)
Objective: The course aims to provide students with an understanding of natural resources, their types, and sustainable utilization practices. It covers the management of land, water, biodiversity, forests, and energy resources, focusing on ecological, economic, and socio-cultural approaches. Students will learn about the importance of resource conservation, the threats they face, and contemporary management practices such as Environmental Impact Assessment (EIA) and Geographic Information Systems (GIS).

C-17 (T) BDSE – 03 A: THEORY (45 Lectures)

Unit 1: Natural Resources, Biological resources &: Sustainable Utilization (15 Lectures)
Definition and types; Sustainable Utilization- Concept, approaches (economic, ecological and socio-cultural). Biodiversity- definition and types; Significance; Threats; Management strategies; Bio-prospecting; IPR; CBD; National Biodiversity Action Plan.

Unit 2: Land and Water (10 Lectures)
Utilization of land (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management. Water-Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies.

Unit 3: Forests and Energy (10 Lectures)
Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion; Management.
Energy- Renewable and non-renewable sources of energy.

Unit 4: Contemporary Practices in Resource Management (10 Lectures)
EIA, GIS, Ecological Footprint with emphasis on carbon footprint; Waste management. National and International Efforts in Resource Management and Conservation.

C-17 (P) BDSE-03 A: Practical (30 Hours)
1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
2. Collection of data on forest covers of specific areas.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Ecological modelling.
5. Field report

Suggested Readings

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.

Course Code: BDSE – 03: B. Horticultural Practices and Post-Harvest Technology (Credits: Theory-3; Practical-1)

Objective: The course provides an in-depth understanding of horticulture, landscaping, and garden design, highlighting their importance in food security, rural economy, and urban aesthetics. It covers ornamental plants, fruits, and vegetables, focusing on their identification, economic value, and distribution. Students will also learn various horticultural techniques such as irrigation methods, biofertilizers, and propagation methods. The course emphasizes post-harvest technology, floriculture, and strategies for disease and pest management, including integrated pest management (IPM) and quarantine practices, to ensure sustainable crop production and quality maintenance.

C-17 (T) BDSE-03 B: THEORY (45 Lectures)

Unit 1: Introduction to Horticulture, Landscaping and Garden Designs (11 Lectures)

Scope and importance; Branches of horticulture; Role in rural economy; Importance in food and nutritional security; Urban horticulture and ecotourism.

Landscaping and Garden Design- Planning and layout (parks and avenues); Gardening traditions - Ancient Indian, European, Mughal and Japanese Gardens; Urban forestry; policies and practices.

Unit 2: Ornamental Plants, Fruits and Vegetable (12 Lectures)

Types, classification (annuals, perennials, climbers and trees); Identification and salient features of some ornamental plants [rose, marigold, gladiolus, carnations, orchids and succulents (Opuntia and Agave)] Ornamental flowering trees (Gulmohar, Jacaranda, fishtail palm, coral tree).

Fruit and Vegetable Crops- Origin and distribution; Description of plants and their economic products; Identification of some fruits and vegetable varieties (citrus, banana, chillies and cucurbits).

Unit 3: Horticultural Techniques and Disease Control (11 Lectures)

Application of manure, fertilizers, nutrients and PGRs; Weed control; Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics.

Propagation Methods: asexual (grafting, cutting, layering, budding), Sexual (seed propagation). Identification of deficiency symptoms; common diseases and pests of ornamentals, fruits and vegetable crops, remedial measures and nutritional management practices; Crop sanitation; IPM strategies (genetic, biological and chemical methods for pest control) and Quarantine practices.

Unit 4: Post-harvest Technology and Floriculture (11 Lectures)

Importance of post-harvest technology in horticultural crops; Harvesting and handling of fruits, vegetables; Principles, methods of preservation and processing; Methods of minimizing loses during storage and transportation; Food irradiation - advantages and disadvantages; food safety.

Floriculture-Cut flowers, bonsai, Importance of flower shows, exhibitions and marketing

C-17 (P) BDSE-03 B: (Practical 60 Hours)

1. Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields or other suitable locations.
2. Propagation of horticultural crops and seeds
3. Preparation of potting mix for saplings
4. Grow some ornamental/horticultural plants in nurseries. Make a detailed report of the same.

Suggested Readings

1. Singh, D. & Manivannan, S. (2009). Genetic Resources of Horticultural Crops. Ridhi International, Delhi, India.
2. Swaminathan, M.S. and Kochhar, S.L. (2007). Groves of Beauty and Plenty: An Atlas of Major Flowering Trees in India. Macmillan Publishers, India.
3. NIIR Board (2005). Cultivation of Fruits, Vegetables and Floriculture. National Institute of Industrial Research Board, Delhi.
4. Kader, A.A. (2002). Post-Harvest Technology of Horticultural Crops. UCANR Publications, USA.
5. Capon, B. (2010). Botany for Gardeners. 3rd Edition. Timber Press, Portland, Oregon.

Course Code: BDSE – 04: A. Industrial and Environmental Microbiology
(Credits: Theory-3; Practical-1)

Objective: The course aims to provide knowledge of the industrial and environmental applications of microorganisms. Students will explore various fermentation processes, including solid-state and liquid-state fermentations, as well as bioreactors used in large-scale production. The course covers microbial production of industrial products such as enzymes and their downstream processing. It also discusses the importance of microbial enzymes in industry and the techniques of enzyme immobilization. Additionally, the course emphasizes the role of microbes in environmental quality, including water and soil pollution management, sewage treatment, and the use of microorganisms in agricultural and soil remediation practices.

C-18 (T): THEORY (45 Lectures)

Unit 1: Microbes and Fermentation Processes (13 Lectures)

Scope of Microbes in Industry and Environment; Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations; Types of bioreactors-laboratories, pilot scale and production; Fermenter- Constantly stirred tank Fermenter, tower Fermenter, fixed bed and fluidized bed bioreactors and air-lift Fermenter.

Unit 2: Microbial Production of Industrial Products (12 Lectures)

Microorganisms involved; Media; Fermentation conditions; Downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultra filtration, Lyophilization, Spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of enzyme- amylase or lipase activity.

Unit 3: Industrial Important Microbial Enzymes (13 Lectures)

Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase).

Unit 4: Microbes and Quality of Environment (12 Lectures)

Distribution of microbes in air; Isolation of microorganisms from soil, air and water.
Water pollution, role of microbes in sewage and domestic wastewater treatment systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and faecal coliform in water samples.

C-18 (P): (Practical 30 Hours)

1. Principles and functioning of instruments in microbiology laboratory.
2. Hands on sterilization techniques and preparation of culture media.
3. Isolation of root nodulating bacteria.
4. Arbuscular mycorrhizal colonization in plant roots.
5. Study of the methods for staining of microorganisms.

Suggested Readings

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application-based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.
3. Dubey R.C. & Maheshwari D.K. A textbook of Microbiology. S. Chand, New Delhi India.

Course code: BDSE-04. B: ADVANCED MOLECULAR BIOLOGY
(Credits: Theory -3, Practical-1)
Objective: The Advanced Molecular Biology option is designed to advance students' knowledge in molecular life sciences with its scope in contemporary biotechnology and molecular techniques. It aims to provide a deeper understanding of the mechanisms governing cellular processes, focusing on areas like cell division, genome integrity, and gene regulation. This subject is focus on the use of molecular techniques to study gene and protein functions in a range of organisms. It aims to provide students with an advanced understanding of the strategies and techniques used in molecular biology of relevance both to the biotechnology industry and to advanced molecular biology research.

C-18 (Theory) BDSE 04-B (45 lectures)

Unit 1: Introduction to Molecular Cloning (12 Lectures)
Vectors: Characteristics of cloning vectors, Plasmids (pBR322, pUC18/I9) and Ti plasmid. Shuttle vectors and Expression vectors: E. coli lac and T7 promoter-based vectors. Enzymes used in Molecular Cloning: Restriction enzymes. Types I, II and III, nomenclature, use of Type II restriction enzymes in cloning. Reverse transcriptase. Molecular probes: cDNA probes – RNA probes

Unit 2: PCR Techniques (11 Lectures)
Principle of Polymerase Chain Reaction, RT-PCR, Real-Time PCR and their applications.

Unit 3: Gene Expression (11 Lectures)
Regulation of gene expression in Prokaryotes: various models - operon - details of lac operon-negative and positive control lac operon. Regulation gene expression in eukaryotes: Regulation of transcription – regulation of RNA processing and translation. Microarray and gene expression analysis.

Unit 4: DNA Sequencing (11 Lectures)
DNA sequencing: Maxam Gilbert chemical method - Sanger's enzymatic chain termination method. Introduction to gene silencing (RNAi)/ post-transcriptional gene silencing (PTGS) and its mechanism. Introduction and Principle of genome editing.

C-18 BCC BDSE-04 -B (P) **(30 hours)**

1. Preparation and Use of cDNA/RNA Probes
2. Plasmid Isolation from E. coli
3. Basic PCR Amplification
4. Introduction to RT-PCR (Demonstration or Kit-based)
5. DNA Sequencing Interpretation (Paper or Software-based)
6. DNA Sequencing by Sanger Method (Hands-on or Simulation)

Suggested Readings:

1. Brown TA. (2010) Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
2. Primrose SB and Twyman RM. (2006) Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
3. Sambrook J and Russell D. (2001) Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.
4. Benjamin Lewin (2017) Genes 1X. Jones and Bartlett Publishers.
5. Hartwell L H *et al.* (2014), Genetics: From Genes to Genome. 5th Edition McGraw-Hill Education
6. Watson J D *et al* (2014). Molecular Biology of the Gene 7th Edition. The Benjamin-Cummings Pub Co.
7. Lodish H *et al.* (2016) Molecular Cell Biology 8th Edition. W.H. Freeman & Co Ltd
9. Adrin J Harwood (1996). Methods in Molecular Biology, Vol.58, Basic DNA and RNA protocols. Humana Press.
10. Cox *et al* (2015), Molecular Biology, Principles and Practice, 2nd Edition W H Freeman & Co.

COURSE CODE: BCC-19: RESEARCH METHODOLOGY
(Credits 4)

Objective: The objective of this course is to introduce students to the fundamentals of research methodology, emphasizing the processes, techniques, and tools required to conduct high-quality research. Students will learn about the various types of research, including qualitative, quantitative, and experimental approaches, and the importance of designing research with clear objectives, hypotheses, and problem statements. The course will cover the practical aspects of research design, data collection, and sampling techniques. Students will also explore the process of data analysis using statistical methods and software, along with ethical considerations and report writing standards, including the use of referencing styles and plagiarism detection tools.

C-19 (T) BCC 19: (Theory 60 lectures)

Unit 1: Research Methodology (15 Lectures)
Objectives and motivations in research; Characteristics and limitations of research; Components of research work; Criteria of good research, Research process; Types of Research; Fundamental, Pure or Theoretical Research, Applied Research, Descriptive Research, Evaluation Research, Experimental Research, Survey Research, Qualitative Research, Quantitative Research.

UNIT 2: Research Design Formulation (15 Lectures)
Research Design – definition – essentials and types of research design – errors and types of errors in research design. Research problem: Selecting and analyzing the research problem – problem statement formulation – formulation of hypothesis. Variables in Research – Measurement and scaling, Different scales, Construction of instrument, Validity and Reliability of instrument.

UNIT 3: Research Publication Ethics (15 Lectures)
Publication Ethics: Definition, Introduction and Importance, Conflicts of Interest, Best practices/standards initiatives, and guidelines: COPE, EAME, etc. Plagiarism, Self-Plagiarism, Software for detection of Plagiarism. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice-versa, types, complaints and appeals.

UNIT 4: Code of Ethics in Research (15 Lectures)
Ethical issues in research: Code of Ethics in Research, Violation of publication ethics, authorship and contributorship, Intellectual Property Rights, Ethics related to Participants and Researchers: Copyright; Royality, Patent Law, Citation, Acknowledgment. Predatory publishers and journals.

Suggested readings:

1. Cooper, D.R., Schindler, P.S. and Sun, J., 2006. *Business research methods* (Vol. 9). New York: McGraw-Hill Irwin.
2. Creswell, J.W. and Creswell, J.D., 2017. Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.
3. Kothari, C.R., 2004. Research methodology: Methods and techniques. New Age International.
4. Krishnaswamy, K.N., 2006. Management Research Methodology: Integration of Principles, Methods and Techniques. Pearson Education India.
5. Sekaran, U. and Bougie, R., 2016. Research methods for business: A skill building approach. John Wiley & Sons.
6. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
7. Danniel, W.W., (1987) Biostatistics, New York, John Wiley Sons.
8. Sundarrao, P.S.S and Richards, J. An introduction to Biostatistics, 3rd edition, Christian Medical College, Vellore
9. Campbell, R.C., (1998). *Statistics for Biologists*, Cambridge University Press.

Course Code: BCC-20: Agricultural Microbiology and Biosafety
(Credits: Theory -3, Practical-1)

Objective: This course introduces students to the application of plant microbiology for human welfare, focusing on the use of microbes in agriculture to promote plant growth, enhance productivity, and ensure safety. Students will learn about biofertilizers such as nitrogen fixers (e.g., Rhizobium, Azotobacter), phosphate solubilizers, and mycorrhizal biofertilizers, including their isolation, characterization, and field applications. The course also covers biopesticides like *Bacillus thuringiensis* and explores their benefits over synthetic pesticides. Additionally, students will gain practical knowledge of mushroom culture technology, including cultivation methods for species like *Pleurotus*, and *Agaricus*. The final unit also covers biosafety, focusing on safety protocols, regulatory compliance, and safe handling of toxic chemicals in microbiological settings.

C-20 (T) BCC 20: THEORY (45 Lectures)

Unit – 1: Biofertilizers (12 Lectures)

General account of biofertilizers; Nitrogen Cycle, General account of symbiotic & non symbiotic association, Symbiotic Nitrogen Fixers: *Rhizobium*- Isolation, characteristics, types, inoculum production and field application, legume/pulses plants; Non-Symbiotic Nitrogen fixers: Azotobacter, characteristics, production and field application

Phosphate Solubilizers: Phosphate solubilizing microbes. Mycorrhizal Biofertilizers- types of mycorrhizae and associated plants, field applications; Cyanobacteria, *Azolla*- Isolation, characterization, mass multiplication, field application.

Unit 2: Biopesticides (11 Lectures)

Bioinsecticide: General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, *Bacillus thuringiensis*, production, Field applications.

Pest Management: Pest Management Methods, Biological Control, Pest Control, Cultural Practices/Ecological Methods.

Unit 3: Mushroom culture technology (11 Lectures)

Structure and layout of mushroom growing room. Sterilization of substrates. Spawn production-preparation of culture media, pure culture isolation, mother spawn preparation, production of planting spawn, storage/transportation of spawn. Criteria for selection of good quality spawn. Cultivation of *Pleurotus* (Oyster mushroom) and *Agaricus* (white button mushroom).

Unit 4: Biosafety (11 Lectures)

Levels of Biosafety; Laboratory facilities and safety equipment; Disinfection, decontamination, and sterilization techniques; Regulatory compliance (laws and regulations); Current topics in biosafety; Chemical label; Common toxic chemicals and safety measures in handling.

C-20 (P) BCC 20: (PRACTICAL 30 hours)

1. Isolation of free-living Nitrogen fixing bacteria from soil.
2. Isolation of symbiotic nitrogen fixing bacteria.
3. Isolation of Cyanobacteria from soil.
4. Isolate and identification of mycorrhiza by wet sieving and decanting technique.
5. Exploration of mycorrhizal association in plant roots.
6. Isolation of mushroom pure culture and spawn production.
7. Cultivation of mushroom (Oyster / Paddy straw mushroom/ shitake).

Suggested Readings

1. Soil Microbiology Subha Rao, N.S. (2000), Oxford & IBH Publishers, New _Delhi.
2. Bio-fertilizers and organic Farming Vyas, S.C, Vyas, S. and Modi, H.A. (1998) Akta Prakashan, Nadiad
3. Biotechnology of Biofertilizers Kannaiyan, S., (2003), CHIPS, Texas.
4. Handbook of Microbial Biofertilizers Rai, M.K., (2005), The Haworth Press, Inc. New York
5. Experiments in Microbiology, Plant Pathology and Biotechnology by Aneja, K.R., New Age International
6. Microbiology A Laboratory Manual by J.G. Cappuccino, N. Sherman, Pearson
7. Mushrooms: A Manual for cultivation: Subrata Biswas, M. Datta, S.V. Ngachan. PHI Learning Private Limited, New Delhi.
8. Books: IPR, Biosafety and Bioethics" by Goel and Parashar
9. Biosafety and Bioethics" by Rajmohan Joshi
10. Bioethics and Biosafety in Biotechnology" by V Sree Krishna

Course Code: BCC 21: Entrepreneurial Botany
(Credits: Theory -3, Practicals-1)

Objective: This course aims to provide students with an understanding of the post-harvest technology of plant products, focusing on methods like drying, freezing, canning, and preservation. Students will also explore the role of antioxidants in food preservation and the significance of traditional preservation techniques such as pickling and sugar concentrates. The course introduces biotechnology's societal benefits, including genetically modified foods, recombinant therapeutics, and intellectual property rights in the biotechnology field. Additionally, it covers industries based on plant products, such as botanicals, nutraceuticals, enzymes, and biofuels, while also providing insight into market trends and entrepreneurship within the plant-based product sector, including demand management, branding, and marketing strategies.

C-21(T) BCC 21: THEORY (45 LECTURES)

Unit 1: Post-harvest technology (12 Lectures)

Storage of Plant Products- Introduction to storage of plant products, Types of Drying (Dehydration)- Natural conditions – Sun drying; Artificial drying- hot air drying, Vacuum drying, osmotically dried fruits, Crystallized or Candied fruits, Freeze Drying.

Freezing (Cold air blast system, Liquid immersion method, Plate freezers, Cryogenic Freezing, Dehydro freezing, Freeze drying), Canning, food preservation and role of antioxidants in preservation. Pickling (in brine, in vinegar, Indian pickles) Sugar concentrates (Jam, Jelly and Fruit juice)

Unit 2: Biotechnology and Society (11 Lectures)

Benefits of biotechnology, genetically modified (GM) foods and their safety, recombinant therapeutic products for human healthcare, and intellectual property rights; Patents in biotechnology inventions and plant-based businesses.

Unit 3: Industry Based on Plant Products (11 Lectures)

Botanicals and nutraceuticals, including *Spirulina*, Vanillin, *Garcinia indica*/*Garcinia cambogia*, and *Chlorella*. Enzyme industry (Source, properties, industrial & medicinal uses of - Cellulase, Protease (papaya & pineapple); Biofuel industry (scope of biofuels, merits and demerits)

Unit 4: Market and Entrepreneurship (11 Lectures)

Basics of market and entrepreneurship, market trends in plant-based products, demand and supply chain management, processing and packaging for marketability, branding and labeling strategies, marketing strategies for plant-based businesses.

C-21 (Practical) BCC 21 (30 hours)

1. Preparation of Squash/Jam
2. Extraction of essential oil
3. Study of transgenic plants -Bt Cotton, Bt Brinjal, Bt Tomato, Golden Rice.
4. Microbial analysis of pickled products
5. Market study and branding of a plant-based product
6. Demonstration of different drying techniques

Suggested Readings:

1. Industrial Microbiology Mac Millan Publications, New Delhi
2. Economic Botany by A F Hill, TATA McGraw-Hill Publishing Co. Ltd.
3. Post-Harvest Technology by Verma and Joshi, Indus Publication

COURSE CODE: BCC-22 ETHNOBOTANY AND PLANT BIODIVERSITY
(Credits: Theory- 3, Practical- 1)

Objective: The objective of this course is to introduce students to the interdisciplinary field of ethnobotany, focusing on the relationship between indigenous cultures and plant resources. Students will learn about the role of plants in the daily lives of ethnic groups for purposes such as food, medicine, and other utilities. The course emphasizes the application of ethnobotanical knowledge in modern medicine and its significance in conserving plant genetic resources. Additionally, students will explore the legal aspects surrounding ethnobotany, such as biopiracy and the protection of indigenous knowledge, and the broader context of plant biodiversity in India. Through this course, students will gain a deep understanding of the importance of plant diversity and its conservation for the sustainable use of resources.

Paper Code: C-22 (T) BCC 22 (Lectures: 45)

UNIT 1: Ethnobotany (11 Lectures)

Ethnobotany as an interdisciplinary science; The relevance of ethnobotany in the present context; Main world centers of Ethnobotanical studies; Traditional/Indigenous knowledge and its importance; Major and minor ethnic groups or Tribals of India; Role of ethnic groups in conservation of plant genetic resources.

Unit 2: Role of Ethnobotany in Modern Medicine (12 Lectures)

Medico-ethnobotanical sources in India; Significance of the following plants in ethnobotanical practices (along with their habitat and morphology): *Azadiractha indica, Ocimum sanctum*, *Emblica officinalis* (Amla) , *Aloe vera,* and *Cassia auriculata.* Role of ethnobotany in modern medicine with special example *Rauvolfia serpentina, Trichopus zeylanicus, Artemisia.*

Unit 3: Plant Biodiversity (11 Lectures)

Definition and diversity of flora in various forest types of India, levels of biodiversity (ecological, species, and genetic), keystone species, redundancy, mutualism and ecotones, importance and value of biodiversity. Hotspots of biodiversity, threats to biodiversity- habitat loss, pollution, overexploitation, global climate change and poaching of wildlife. Endangered and Endemic floral species of India.

Unit 4: Conservation of Biodiversity (11 lectures)

Strategies for conservation: Ex situ conservation-Managed ecosystems, biological resources and gene banks, botanical gardens, bio-parks, simulated ex situ conservation strategies, valuing biological resources, ecotourism. In situ conservation- Protected areas, biosphere reserves, Wildlife sanctuaries, National parks. Biodiversity legislation and convention, The Nagaland State Biological Diversity Rules, 2012.

C-22 (P) BCC 22: Practical (30 Hours)

1. Field trip to tribal settlement to survey, document and frame hypothesis on people-plant relationship.
2. Collection, processing and preservation of ethnobotanical specimens in the institutional repository.
3. Identify and document plant parts used in preparation of crude drugs/herbal formulations.
4. Field trip to any botanical garden / National Park.
5. Problems based on Simpson's diversity Index.

Suggested Readings:

1. S.K. Jain, Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.
2. S.K. Jain (ed.) Glimpses of Indian. Ethnobotany, Oxford and I B H, New Delhi1981
3. Lone et al. Palaeoethnobotany
4. S.K. Jain (ed.) 1989. Methods and approaches in ethnobotany. Society of ethnobotanists, Lucknow, India.
5. S.K. Jain, 1990. Contributions of Indian ethnobotany. Scientific publishers, Jodhpur.
6. Colton C.M. 1997. Ethnobotany -Principles and applications. John Wiley and sons Chichester
7. Rama Ro, N and A.N. Henry (1996). The Ethnobotany of Eastern Ghats in Andhra Pradesh, India. Botanical Survey of India. Howrah.
8. Rajiv K. Sinha – Ethnobotany the Renaissance of Traditional Herbal Medicine – INA – SHREE Publishers, Jaipur-1996
9. Faulks, P.J. 1958.An introduction to Ethnobotany, Moredale pub. Ltd.

Course Code: BCC: 23: Environmental Awareness and Ethics
(Credits: Theory -3, Practical- 1)

Objective: The objective of this course is to provide students with a comprehensive understanding of environmental awareness and the ethical considerations related to environmental protection and sustainability. Students will learn about the various types of pollution, waste management techniques, and the regulatory frameworks aimed at pollution control. The course also focuses on the concept of environmental auditing, sustainability practices, and the role of environmental ethics, including carbon credits and climate change mitigation. Additionally, students will explore the application of Geographic Information Systems (GIS) and remote sensing in environmental management and land use planning. Through this course, students will gain the knowledge required to address environmental challenges and contribute to sustainability efforts effectively.

C-23: THEORY BCC 23 (45 Lectures)

Unit 1: Pollution and Waste management (12 Lectures)

Environmental pollution, Environmental protection laws, Regulatory framework for pollution monitoring and control; Bioremediation, Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, neutralization reactor; ETP sludge management; digesters, bioscrubbers. Waste- Types, collection and disposal, Recycling of solid wastes (hazardous & non-hazardous) - classification, collection and segregation, Incineration, Pyrolysis and gasification, Sanitary landfilling; composting, Biogas production.

Unit 2: Environmental audit & Sustainability (10 Lectures)

Concept of environmental audit; Guidelines of environmental audit; Scheme of labelling of environment friendly products (Ecomark); Concept of energy and green audit, Sustainability indices; Concept of Sustainable Agriculture; India's environment action programme: issues, approaches and initiatives towards Sustainability; UN Sustainable Development Goals (SDG)

Unit 3: Environmental ethics, Carbon Credits (12 Lectures)

Carbon credit: concept, exchange of carbon credits. Carbon sequestration, importance, meaning and ways. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, Carrying capacity analysis; Concept of ecological footprints.

Unit 4: Role of GIS (11 Lectures)

Geographical Information Systems: definitions and components; spatial and non-spatial data; GIS software packages; GPS survey, data import, processing, and mapping. Applications and case studies of remote sensing and GIS in land use planning, forest resources & agriculture studies

C-23 (P) BCC 23: Practical (30 Hours)

1. Water Quality Assessment from adjacent water sources
2. Introductory GIS Practical: Basic Map Creation and Visualization
3. Pollution Mapping of water quality parameters (GIS-Based)
4. Carbon Footprint Calculation and Reduction Strategies

Suggested Readings:

1. Green Technology: An Approach for Sustainable Environment ISBN:9788177543438 Edition:01 Year: 2021 Author: Dr. Purohit SS Publisher: Agrobios (India).
2. Gillespie, A. 2006. Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries Policy and Science Considerations. Martinus Nijhoff Publishers.

Course Code: BCC- 24 Research project (12 credits)

Guidelines for Dissertation/Research Project (B.Sc. Hons with Research)

1. A dissertation/project work may be started from *seventh* semester itself.
2. A student needs to undertake the dissertation under the supervision of a teacher of the same department of the college.
3. The Dissertation can be Experimental, Theoretical or both.
4. A teacher can supervise more than one student/one group of students depending on the no. of students/no of teachers present in the department.
5. After completion of the dissertation, the report may be submitted to the department for evaluation. The Evaluation may be done internally by a committee constituted by the department under the chairmanship of Head of the Department. If any college wants, they can invite one external examiner from the neighboring colleges/Institute.
6. The Full marks for the Research Project paper is 100 (12 credit) and pass marks is 40. The Project evaluation may be made from 100 marks in the end semester examination. No midterm evaluation is required.

The evaluation will be made based on following points.

Activity	Marks allotted	Marks to be given by
Continuous Evaluation/students regularity	20 marks	Supervisor
Timely completion of work	10 marks	Supervisor
Presentation of the report	20 marks	Committee
Content of the report	30 marks	Committee
Viva-Voce	20 marks	Committee

ANNEURE- (i)

The report shall be prepared as per format given.

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Acknowledgements

Sample copy of Bonafide Certificate Name of the College Address and Pin Code

Department of …….

CERTIFICATE

This is to certify that the Dissertation/Project work entitled---------- carried out by ----------, Registration no……., Roll no ……., Year ……, for partial fulfillment for the award of B.Sc./B.A/B.Com (Hons with Research) degree of Nagaland University.

Name and Signature of the Supervisor
Date

Name and signature of the HoD
Date with Seal

DECLARATION

I hereby declare that Dissertation/Project work entitled---------- presented in this report has been carried by me under the supervision of ....., Department of ……..….,..... College.

Further, I declare that neither the whole nor a part of the report has previously been submitted to any university for any examination.

(Signature of the student)

Name of the Student
_ th Semester, B.Sc/B.Com (Hons/General)
Registration No: Year: Roll No.:

Date: Place:

References

1. UGC guidelines on curriculum and credit framework for Undergraduate programme, 2025.
2. CBCS guidelines of Nagaland University, 2025.