MAHARAJA SURAJMAL BRIJ UNIVERSITY
BHARATPUR, RAJASTHAN
MASTERS IN BOTANY
(TWO YEARS)
PROGRAM BROCHURE

SYLLABUS
M.Sc. (BOTANY)
(Semester Scheme)

Proposed to be implemented from
Academic Session: 2025–2026
Syllabus based on NEP 2020 Frame Work For the
I & II Semester Examination 2025-26

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I. Introduction to NEP 2020

National Education Policy (NEP) 2020

The courses have been designed to promote curricular flexibility, research-oriented education, and interdisciplinary learning. The updated design places a strong emphasis on experiential learning, critical thinking, and skill development, guaranteeing compliance with both new industrial expectations and international academic standards. It incorporates cutting-edge teaching strategies with online learning resources while encouraging academic mobility and lifelong learning. This reform aims to improve students' employability, capacity for innovation, and comprehensive grasp of the subject in accordance with the National Education Policy (NEP) 2020.

Definitions:

(i) **'Academic Programme'** refers to a complete course of study that includes its structure, course information, assessment methods, etc., which is intended to be delivered and assessed in a teaching Department or collaboratively across several such Departments.

(ii) **'Course'** refers to a component of a topic that is included in an Academic Programme.

(iii) **'Programme Structure'** refers to a compilation of courses (Core, Elective, Skill-based Course, etc.) that constitute an academic program, detailing the syllabus, credits, teaching hours, evaluation methods, examination processes, and the minimum credits necessary for successful program completion, all in line with University regulations and admission eligibility requirements.

(iv) **"Core Course"** refers to a course that a student enrolled in a specific program is required to successfully finish in order to obtain the degree, and it cannot be replaced by any other course.

(v) **'Elective Course'** refers to a course that a student may choose from the courses available in their own or any other Department.

(vi) PG **'General Elective'** refers to an elective course accessible to students from all programs except for those within the same department. Students from other Departments may choose these courses if they meet the eligibility criteria established by the Department providing the course.

(vii) **'Credit'** refers to the value allocated to a course that signifies the degree of instruction; One hour of lecture each week equals 1 credit, while 2 hours of practical class each week also equals 1 credit. Credit for a practical may be suggested as a component of a course or as an independent practical course.

(viii) **'SGPA'** refers to the Semester Grade Point Average computed for each semester.

(ix) **"CGPA"** refers to the Cumulative Grade Points Average calculated for every course finished by students at any given moment. CGPA is computed annually by combining both semesters.

(x) **'Grand CGPA'** is determined in the final year of the two-year program by combining the CGPA from both years, which consists of four semesters. This cumulative grade point average, displayed as a Transcript, thoroughly represents the student's academic achievements during the program. To assist the student, a formula for translating the Grand CGPA into percentage marks is included in the Transcript, supporting their future academic and career endeavours.

Programme Objectives (POs)

The **M.Sc. Botany** programme aims to provide an in-depth and interdisciplinary understanding of plant life, integrating classical Botanical principles with modern scientific approaches. The programme is designed to:

- **Establish Firm Foundations**: Offer thorough understanding of plant structure, function, diversity, evolution, and classification via essential readings like Cell and Molecular Biology and Principles of Plant Pathology and Microbiology.
- **Encourage Research and Analytical Abilities**: Cultivate a scientific mindset, critical reasoning, and problem-solving skills by engaging in experimental design, data analysis, and the interpretation of biological systems at cellular, molecular, and pathological stages.
- **Promote Interdisciplinary Education:** Combine conventional botanical wisdom with contemporary fields like Molecular Genetics, Genomics, Biotechnology, Bioinformatics, and seed science and technology, enhancing comprehension of modern developments in life sciences.
- **Encourage Practical Training and Technical Skills:** Facilitate hands-on expertise via rigorous lab activities, field experiences, and internships, offering familiarity with modern tools and methods in biological and ecological studies.
- **Foster Ethical and Environmental Accountability:** Promote ethical principles, sustainability consciousness, and social responsibility in tackling matters concerning plants, biodiversity preservation, and environmental stewardship.
- **Prepare for Professional and Academic Careers:** Provide students with knowledge and abilities for various career avenues in research, biotechnology, pathology, environmental consulting, plant physiology, and applied microbiology.
- **Foster Continuous Learning and Innovation:** Cultivate curiosity, creativity, and a mindset for ongoing education, motivating students to engage in scientific discovery, innovation, and societal improvement.

Programme Specific Outcomes (PSOs)

Upon successful completion of the **M.Sc. Botany** programme, students will be able to:

Show Expertise: Display comprehensive knowledge of plant physiology, molecular and cellular mechanisms, genetics, practical microbiology, plant diseases, and ecological systems.
Utilize Molecular and Analytical Approaches: Proficiently conduct and analyse laboratory experiments that include microscopy, molecular markers, genetic modification, and bioinformatics resources.
Combine Interdisciplinary Ideas: Utilize combined expertise from biochemistry, genetics, molecular biology, biotechnology, and ecology to tackle actual biological and environmental issues.
Examine and Interpret Biological Data: Assess biological events critically with quantitative and qualitative analysis techniques and convey scientific findings effectively through written and spoken presentations.
Carry Out Autonomous and Ethical Investigations: Plan, implement, and present scientific studies while complying with ethical guidelines and biosafety rules, showcasing skill in project management and research documentation.
Tackle Emerging Global Issues: Apply knowledge from elective specializations (such as cell biology and evolution, applied phycology and mycology, seed pathology, advanced

biosystematics, seed science and technology, angiosperm morphology, environmental biology, biotechnology, and bioinformatics and biostatistics) to aid in plant systems and sustainable development.

Enhance Professional Skills: Utilize botanical expertise in professional settings, including education, laboratory studies, biodiversity conservation, biotechnology sectors, and policy development.

Participate in Continuous Learning and Innovation: Keep enhancing abilities via research, education, and cross-disciplinary cooperation, aiding scientific advancements and social development.

Criteria for Admissions in M.Sc. Botany programme:

This course is available to students who have taken Botany or Plant Sciences in their B.Sc. and are seeking admission to the M.Sc. The Botany program will be regulated by the guidelines established by the Commissionerate of College Education (CCE), Rajasthan, Jaipur, and Maharaja Surajmal Brij University, Bharatpur. Only candidates meeting the minimum eligibility criteria set by the University will be considered for admission.

Assessment of Students' Performance and Scheme of Examination:

1. Examination Schedule

Examinations will be carried out at the conclusion of every semester in accordance with the Academic Calendar issued by Maharaja Surajmal Brij University (MSBU), Bharatpur.

2. General Structure of Examination (NEP-2020 Aligned)

A. Continuous Assessment (CA)

- Each semester shall include **continuous assessment** for both **theoretical** and **practical** components.
- The evaluation will include **internal tests, seminars, assignments, oral/viva-voce examinations** and assessment of **class participation and regularity**.
- To qualify in each paper, a candidate must secure the **minimum prescribed grade** separately in **CA** and **End of Semester Examination (EoSE).**

B. End of Semester Examination (EoSE)

- Each **theory paper** shall carry **100 marks**, with **20% weightage** from CA and **80% weightage** from the EoSE.
- The **EoSE** shall be of **3 hours duration**.
- The question paper shall consist of **five questions** in total:
  - **Part A:** Eight short-answer questions (2 marks each) covering the entire syllabus to assess conceptual comprehension and application.
  - **Part B:** Four descriptive questions (16 marks each), one from each unit, with **internal choice**.

C. Laboratory Examination

- Each practical examination shall be of 5 **hours duration**, comprising **laboratory experiments/exercises, record evaluation and viva-voce**.
- Evaluation shall be conducted in a **1:1 ratio** between **experimental work** and **viva-voce/record assessment**.
- Practical assessments shall be carried out by a **Board of Examiners** consisting of **one Internal Examiner** (appointed by the Head of Department) and **one External Examiner** (appointed by the University).

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D. Medium of Instruction

- The **medium of instruction and examination** shall be **English only**.

E. Selection of Elective Courses:

- Each elective course will have a limited number of seats, and this will be announced prior to the start of the course each year. The choice of elective courses in the 1st and 2nd Semesters will be determined by merit criteria set forth by the Department's Academic committee

Examination Scheme: As NEP 2020

M.Sc. Botany

1. **Credit Structure:**
   - Each paper of 100 marks carries **4 credits**.
   - The *M.Sc. Botany* programme comprises **100 credits** in total.
     - **Semester I – IV:** 24 credits each (Total = 96 credits)
     - **Internship/Project:** 4 credits (4–6 weeks; minimum 120 hours)
2. **Assessment Components:**
   - Continuous Assessment (CA): **20% weightage**
   - End of Semester Examination (EoSE): **80% weightage**
3. **Attendance Requirement:**
   - A minimum of **75% attendance** in each course is mandatory for appearing in the EoSE.
4. **Minimum Grade Requirement:**
   - To qualify in any course, a student must secure at least a **'C' grade** in both **CA** and **EoSE** separately.
   - Credit points will be awarded only after earning the minimum qualifying grade in each component.
5. **Non-Collegiate Students:**
   - Non-collegiate students shall not be eligible for continuous assessment.
   - They must secure a minimum of a **'C' grade** in the EoSE to earn credits.
6. **Credit Hours:**
   - **Theory Courses:** 1 credit = 15 hours of teaching.
   - **Practical Courses:** 1 credit = 30 hours of laboratory work.
   - A 4-credit practical course = 120 hours of laboratory work per semester.
7. **Question Paper Pattern (Theory):**
   - **Maximum Marks:** 80 (EoSE)
   - **Duration:** 3 hours
     - **Part A:** 8 very short answer questions × 2 marks = 16 marks (covering entire syllabus)
     - **Part B:** 4 descriptive questions (one per unit) × 16 marks = 64 marks (each with internal choice)
8. **Practical Examination:**
   - Duration: 5 hours
   - Components: Experimental work, Record evaluation and Viva-voce
   - Total Marks: 100 (Internal + External)
9. **Internship / Project Work:**

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- A mandatory internship or project of **4–6 weeks** duration (minimum 120 hours) carrying **4 credits** will be completed during the final semester.
- The internship aims to provide practical exposure, research experience, or field engagement as per NEP-2020 guidelines.

10. Total Credit Summary (as per NEP-2020)

Component	Credit Distribution
Semester I	24
Semester II	24
Semester III	24
Semester IV	24
Internship / Project	**4**
Grand Total	**100 Credits**

I. Programme Structure:

The M.Sc. in Botany program spans two years, consisting of four semesters, with each semester lasting six months. Students could choose to leave after completing the first year of the program successfully, receiving a **Master's Diploma Degree in Botany**. To obtain a Diploma Degree, a student must successfully finish **52 credits**, which include 48 credits from the First Year (two semesters) of the Programme and 4 credits from an internship or project. The 2-year full-time **Master's degree in Botany**, requiring 100 credits, will be the preferred choice as it encompasses comprehensive subject education, including Internship and Master's Thesis.

Year	Semester	Semester	Credits
First Year	Semester I	Semester II	
Optional Exit point 1 with a Diploma Degree in Botany			**24+24+4*=52**
Second Year	Semester III	Semester IV	
Preferred and Final Exit point 2 with a Masters' Degree in Botany			**100**

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Course Credit Scheme:

Year Wise	Particular Course Discipline	Course Type	Credit Details		Total (I + II)
			Semester (I) Odd	Semester (II) Even	
I Year	Centric Core Paper-I	Major	4	4	8
	Centric Core Paper-II	Major	4	4	8
	Centric Core Elective Paper -III	Major	4	4	8
	Centric Core **Elective** Paper -IV	Major	4	----	4
	Practical Paper	Major	4	4	8
	Introduction to Research	Major	----	4	4
	Skill Enhancement Course (SEC)	Major/Minor	4	----	4
	Interdisciplinary Elective Course	Major/Minor	----	4	4
Total Semester Wise Credit			**24**	**24**	**48**
Year Wise	**Particular Course Discipline**	**Course Type**	**Credit Details**		**Total (III + IV)**
			Semester (III) Odd	**Semester (IV) Even**	
II Year	Centric Core Paper -I	Major	4	4	8
	Centric Core Paper -II	Major	4	4	8
	Centric Core **Elective** Paper -III	Major	4	----	4
	Centric Core **Elective** Paper -IV	Major	4	----	4
	Practical Paper	Major	4	4	8
	Skill Enhancement Course (SEC)	Major/Minor	4	----	4
	Interdisciplinary Elective Course	Major/Minor	----	4	4
	Dissertation/ Fieldwork / Project / Seminar & Term Paper	Major	----	8	8
Total Semester Wise Credit			**24**	**24**	**48**

Total Credit= (48+48+4*=100); *Internship: It must be **4-6 Weeks (120 Hours)** During Summer Vacation 04 Credit

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III. Semester wise Details of M.Sc. in Botany Course:

The course structure of **TWO YEARS Master in Botany programme** shall be as under:

Semester wise Details of M.Sc. Botany Course

Course Code.	Course Title	Course type	Credit
	Semester I		
BOT-20101-T	**Cell and Molecular Biology**	Core Course	04
BOT-20102-T	**Algae , Fungi and Bryophytes**	Core Course	04
BOT-20103-P	Lab based on BOTCC 101-102	Core Course	02
BOT-20104-T	Applied Phycology and Mycology	Elective Course	04
BOT-20105-T	Seed Pathology		
BOT-20106-T	Biosystematics of Angiosperms &reproductive		
BOT-20107-T	Microbiology and Microbial Technology		
BOT-20108-T	Genetics and cytogenetics		
BOT-20109-T	Stress Physiology		
BOT-20110-T	Phytochemistry and herbal medicines	Elective Course	04
BOT-20111-T	Environmental pollution and management		
BOT-20112-T	Microbial technology		
BOT-20113-T	Advanced genetic engineering &molecular		
BOT-20114-T	Methods in plant sciences		
BOT-20115-T	Environmental pollution & management		
BOT-20116-P	Lab based on BOTEL-104A	Elective Course	01
BOT-20117-P	Lab based on BOTEL-104B		
BOT-20118-P	Lab based on BOTEL-104C		
BOT-20119-P	Lab based on BOTEL-104D		
BOT-20120-P	Lab based on BOTEL-104E		
BOT-20121-P	Lab based on BOTEL-104F		
BOT-20122-P	Lab based on BOTEL-105A	Elective Course	01
BOT-20123-P	Lab based on BOTEL-105B		
BOT-20124-P	Lab based on BOTEL-105C		
BOT-20125-P	Lab based on BOTEL-105D		
BOT-20126-P	Lab based on BOTEL-105E		
BOT-20127-P	Lab based on BOTEL-105F		
SEC-	Skill Enhancement Course (**SEC**)	SEC Course	04
	Semester Total		**24**
	Semester II		
BOT-20201-T	**Biosystematics of Angiosperms**	Core Course	04
BOT-20202-T	**Pteridophytes, Gymnosperms and**	Core Course	04
BOT-20203-P	Lab based on BOTCC 201, 202, BOTEL204		04
IRM-20204-T	Introduction to Research Methodology		03
BOT-20205-T	Developmental biology of plants	Elective Course	04
BOT-20206-T	Physiology, biochemistry and biostatistics		
BOT-20207-T	Genetic engineering and r DNA technology		
BOT-20208-T	Principles of Plant Breeding		
BOT-20209-T	Genomics and proteomics		
BOT-20210-T	Angiosperm plant Biosystematics		
BOT-20211-P	Lab based on BOTEL-205A	Elective Course	01
BOT-20212-P	Lab based on BOTEL-205B		

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BOT-20213-P	Lab based on BOTEL-205C		
BOT-20214-P	Lab based on BOTEL-205D		
BOT-20215-P	Lab based on BOTEL-205E		
BOT-20216-P	Lab based on BOTEL-205F		
IEC-20217-T	Interdisciplinary Elective Course (IEC)		4
	Semester Total		**24**
	Semester III		
BOT-20301-T	**Plant physiology and Metabolism**	Core Course	04
BOT-20302-T	**Molecular Biology**	Core Course	04
BOT-20303-P	Lab based on BOTCC301 and 302	Core Course	02
	Elective Papers for Specializations		
	Group A: Advanced Plant Pathology		
BOT-20304-T	Advanced Plant Pathology 1	Elective Course	04
BOT-20305-T	Advanced Plant Pathology II	Elective Course	04
BOT-20306-P	Lab based on BOTCC304A and 304B	Elective Course	02
	Group B: Plant Ecology		
BOT-20307-T	Environmental Biology	Elective Course	04
BOT-20308-T	Ecosystem Ecology	Elective Course	04
BOT-20309-P	Lab based on BOTCC305A and 305B	Elective Course	02
	Group C: Cell and Molecular Biology		
BOT-20310-T	Molecular Cell Organization and Function	Elective Course	04
BOT-20311-T	Gene Regulation, Cell Signalling and Molecular Interactions	Elective Course	04
BOT-20312-P	Lab based on BOTCC306A and 306B	Elective Course	02
	Group D: Plant Physiology		
BOT-20313-T	Advanced Plant Physiology	Elective Course	04
BOT-20314-T	Plant Biochemistry and Metabolism	Elective Course	04
BOT-20315-P	Lab based on BOTCC307A and 307B	Elective Course	02
	Group E: Biosystematics of Angiosperms		
BOT-20316-T	Advanced Biosystematics of Angiosperms	Elective Course	04
BOT-20317-T	Angiosperm Plant Biosystematics	Elective Course	04
BOT-20318-P	Lab based on BOTCC308A and 308B	Elective Course	02
	Group F: Biotechnology		

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BOT-20319-T	Recombinant DNA Technology and Genetic Engineering	Elective Course	04
BOT-20320-T	Plant Biotechnology and Tissue Culture	Elective Course	04
BOT-20321-P	Lab based on BOTCC309A and 309B	Elective Course	02
	Group G: Advanced Plant Morphology and Embryology		
BOT-20322T	Angiosperm Morphology and Morphogenesis	Elective Course	04
BOT-20323T	Morphogenesis and Experimental Biology	Elective Course	04
BOT-20324P	Lab based on BOTCC310A and 310B	Elective Course	02
	Group H: Seed Pathology		
BOT20325T	Seed Pathology	Elective Course	04
BOT-20326-T	Seed Science and Technology	Elective Course	04
BOT-20327-T	Lab based on BOTCC311A and 311B	Elective Course	02
	Skill Enhancement Course (SEC)	SEC Course	04
	Semester IV		
BOT-20401-T	**Plant Reproductive Biology**	Core Course	04
BOT-20402-T	**Plant Tissue Culture and Genetic Engineering**	Core Course	04
BOT-20403-P	Lab based on BOTCC401 and 402	Elective Course	04
BOT-20404-T	Interdisciplinary Elective Course **(IEC)**		04
BOT-20405-D/F	Dissertation/ Fieldwork / Project / Seminar &		08

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M.Sc. Botany (Semester–I)

Core Course (BOT- 20101-T)

Course Title: Cell and Molecular Biology

Credits: 04 **Total Hours:** 60 (Theory)

Course Overview

This course provides a foundational yet advanced exploration of cell and molecular biology, covering their cellular structure and functions, molecular mechanisms, cell signalling and regulation and apply to real world problems. Under NEP-2020 alignment, the course is structured to build competencies in critical thinking, and hands-on identification skills.

Learning Objectives

By the end of the course, students will be able to:

- Understand the structure, function and dynamics of prokaryotic and eukaryotic cells.
- Explain principles of genome organization, DNA–RNA biology and gene regulation.
- Analyze molecular mechanisms of replication, transcription, translation and epigenetic regulation.
- Describe cell communication, signal transduction pathways and cellular responses.
- Apply advanced molecular techniques used in genomics, proteomics and cell biology.

Detailed Course Content

Unit I: Structural organisation of plant cell *(15 Hours)*

- Specialized plant cell types, chemical foundation, biochemical energetics.
- Cell wall: biochemistry and molecular biology of cell wall
- Plasma membrane, structure, models and functions
- Plasmodesmata: composition and structure, signalling and movement of molecules and macromolecules, gap junctions
- Plant vacuole: tonoplast membrane, transporters and storage organelles
- Chloroplast: structure, genome organizations, gene expression
- Mitochondria: structure, genome organizations and biogenesis
- Cell shape and motility, microtubules and microfilaments Other cell organelles: golgi apparatus, lysosomes, peroxisomes, endoplasmic reticulum

UNIT II: Endomembrane System, Intracellular Transport & Cellular Communication

Endomembrane System & Trafficking *(15 Hours)*

- Compartmentalization in eukaryotic cells
- Gated transport between nucleus and cytosol
- Nuclear pore complex: structure and transport mechanisms
- Signal sequences and sorting receptors
- Role of monomeric GTPases in protein sorting
- Protein targeting to ER and mitochondria
- Vesicular trafficking, secretory pathways, receptor-mediated endocytosis

Cellular Communication & Signal Transduction

- General principles of cell communication
- Extracellular matrix and cell adhesion mechanisms
- Signalling molecules and cell-surface receptors: GPCRs, Ion-channel linked receptors, Enzyme-linked receptors
- Second messengers
- Regulation of signaling pathways: **JAK–STAT pathway** and **MAP Kinase pathway**

Cell Cycle and Cell Division

- **Overview and regulation** of the cell cycle
- Cell-cycle checkpoints
- Regulation of mitosis and meiosis

UNIT III: DNA Structure, Replication & Gene Expression (Transcription) *(15 Hours)*

DNA Replication

- Enzymes of replication: DNA polymerases and accessory factors
- Origin of replication, formation of primosome
- Unit of replication, replication fork, replisome
- Fidelity and proofreading mechanisms
- Termination of replication

Transcription (Prokaryotes & Eukaryotes)

- Fine structure of gene, transcription unit
- RNA polymerases
- General transcription factors & transcription machinery
- Steps: initiation, elongation, termination
- Differences between prokaryotic & eukaryotic transcription

UNIT IV – Translation, Gene Regulation & Post-Transcriptional/Translational Control

Translation (Prokaryotes & Eukaryotes) *(15 Hours)*

- tRNA aminoacylation
- tRNA identity and aminoacyl-tRNA synthetases
- Initiation, elongation & termination of translation

Regulation of Gene Expression

- Transcriptional regulation: lac operon and trp operon
- Role of chromatin remodeling in gene expression

RNA Processing & Post-Transcriptional Control

- Capping, splicing, polyadenylation
- RNA editing
- Gene silencing and RNA interference (RNAi)

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Post-Translational Events

Protein folding and molecular chaperones

Suggested Laboratory Exercises:

- EM study of cell organelles
- Fluorescence staining with FDA for cell viability.
- Cell wall staining with Calcifluor white
- Study of stages in cell cycle
- Mitosis and Meiosis
- Histochemical localization of protein, carbohydrate, fats, starch, lignin, nucleic acids
- Isolation of mitochondria and the activity of its marker enzyme, succinate dehydrogenase(SDH).
- Isolation of chloroplast and study of its percentage intactness
- Isolation of chloroplast and study of light reaction system.
- Demonstration of SEM and TEM.
- Hardy-Weinberg numerical
- Any other practical based on theory syllabus.
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- Intracellular protein degradation (ubiquitin–proteasome pathway)

Suggested Readings:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. **Molecular Biology of the Cell.** Garland Science.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M., Scott, M., Bretscher, A., Ploegh, H., & Matsudaira, P. **Molecular Cell Biology.** W.H. Freeman.
3. Karp, G. **Cell and Molecular Biology: Concepts and Experiments.** Wiley.
4. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R. **Molecular Biology of the Gene.** Benjamin Cummings.
5. Becker, W.M., Kleinsmith, L.J., Hardin, J., & Bertoni, G. **The World of the Cell.** Pearson.
6. Nelson, D.L., & Cox, M.M. **Lehninger Principles of Biochemistry.** W.H. Freeman.
7. Lewin, B. **Genes XII.** Jones & Bartlett Learning.
8. Berg, J.M., Tymoczko, J.L., & Stryer, L. **Biochemistry.** W.H. Freeman.
9. Gupta, P.K. **Cell and Molecular Biology.** Rastogi Publications.
10. Sambrook, J., & Russell, D.W. **Molecular Cloning: A Laboratory Manual.** Cold Spring Harbor Laboratory Press.

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M.Sc. Botany (Semester–I)

Core Course (BOT- 20102-T)

Algae, Fungi and Bryophytes

Credits: 04 **Total Hours:** 60 (Theory)

Objectives of the Course

- This course is designed to provide fundamental and advance knowledge about the various algae, Fungi and Bryophytes.

Course Learning Objectives:

After completion of this course, students will be able to

- Learn criteria of classification, diversity, life form, reproduction, phylogeny, nutritional and economic importance of the Algae, Fungi & Bryophytes.
- Develop critical understanding on morphology, anatomy and reproduction.
- Develop proficiency in the experimental technique and methods of appropriate analysis of plant ofthese groups.
- Explore many unexplored plants for the economic benefits of human like medicine, biofertilizers andother uses because Rajasthan have diversified climatic condition.
- Understand plant origin, evolution and their transition to land habitat because algae, Fungi and bryophytes are one of the basics of botany.

- **Detailed Course Content**

Unit I

15Hrs

- **Phycology:** Algae in diversified habitats (terrestrial, freshwater and marine), thallus organization, cell ultra-structure, reproduction (vegetative, asexual and sexual) classification of algae (F.E. Fritch and G.M. Smith), cell wall composition, reserved food material and flagellation. Salient features of Cyanophyta, Chlorophyta, Bacillariophyta, Xanthophyta, Pyrrophyta, Phaeophyta and Rhodophyta with special reference to Oedogonium, *Spirulina, Acetabularia, Dunaliella, Pinnularia, Gonyaulax, Polysiphonia, Laminaria,* and *Batrachospermum.*
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Unit II 15Hrs

- **Economic importance of Algae**: specially in industries, food, fodder, biofertilizers, Biofuels and algal bloom, isolation and culture of algae.
- **Mycology:** General characters of Fungi, substrate relationship, cell ultra-structure, thallus organization, cell wall composition, nutrition (saprobic, biotropic and symbiotic), reproduction (asexual and sexual).
- Heterothallism, heterokaryosis, Brachymeosis, parasexuality, sex hormones and recent trends in classification of fungi, phylogeny of fungi.

Unit III 15Hrs

- **General accounts:** Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina with special reference to *Rhizopus*, *Peronospora Neurospora*, *Polyporus*, *Drechslera* and *Colletotrichum.*
- **Economic importance of fungi:** specially in industries, medicines and as food, fungi as biocontrol agents, poisonous fungi, mycorhizae.
- **Bryology:** Distribution, Classification of Morphology, structure, reproduction of bryophytes.

Unit IV 15Hrs

- **General accounts:** Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Funariales and Polytrichales with special reference to *Plagiochasma, Notothylus, Sphagnum, Physcomitrella patens* and *Polytrichum.*
- Fossil Bryophytes, evolutionary trends in Bryophytes.
- Economic importance of Bryophyta
- Role of Bryophytes in plant succession.

Suggested Laboratory Exercises:

Morphological study of representative members of algae, fungi and bryophytes present in your locality in their natural habitat with special reference to:

- **Phycology:** *Microcystis*, *Spirullina*, *Scytonema*, *Rivularia*, *Dunaliella*, *Aulosira*, *Spirogyra*, *Pediastrum*, *Hydrodictyon*, *Ulva*, *Pithophora*, *Stigeoclonium*, *Gelidium* and *Batrachospermum*: Isolation and culture of algae.
- **Mycology:** *Stemonites, Peronospora, Pythium, Albugo, Rhizopus,*

Pilobolus, Yeast, *Emeri cella, Chaetomium, Pleospora, Morchella, Melamsora, Phallus, Polyporus, Drechslera, Curvularia, Phoma, Penicillium. Aspergillus, Colletotricum, Fusarium* and *Alternaria*:

- Isolation and culture of fungi using moistened blotters, PDA and Sabouraud's Dextrose Agar media.
- **Bryology:** *Plagiochasma, Pogonatum, Pellia, Notothylus, Andreaea* and *Polytric hum*

Suggested Readings:

1. Alexopoulus, C.J., Mims, C.W. and Blackwel, M. (1996). Introductory Mycology, John Wiley & Sons ind.
2. Anderson, R.A. (2005) Algal Culturing Techniques. Physiological Society of America. Elsevier Academic Press, USA.
3. Fritsch, F.E. (1993, 1945). The structure and Reproduction of Algae Vol. I, II. Cambridge University Press, Cambridge, UK.
4. Kashyap, S.R. (1932) Liverworts of Western Himalayas and Punjab Plains (VII. I & II) Reserch co. Publications, New Delhi.
5. Richardson, D.H.S. Biology of Mosses. (1981). Blackwell Scientific Publications, Oxford.
6. Bold, H. C., Alexopoulus, C.J. and Delevoryas. T. (1980): Morphology of plant and fungi (4th Ed.) Harper & Foul Co., New Work.
7. Ghemawat, M.S., Kapoor J.N., and Narayana, H.S. (1976): A text book of Algae. Ramesh Book Depot, Jaipur.
8. Gilbert, M Smith. Cryptogamic Botany, Vol. I & II (2nd Ed.) (1985). Tata McGraw Hill. Publishing Co. Ltd., New Delhi.
9. Puri, V. Bryophytes. (1985). Atmaram& sons. Delhi, Lucknow.
10. Sharma, P.D. (1996). Introduction to Bryophytes. Ramesh Book Depot, Jaipur.

M.Sc. Botany (Semester–I)

Core Course (B0T- 20103-P)

Laboratory Course

Credits: 04 **Total Hours:** 05

Scheme of Practical Examination

Laboratory Course Based on BOTCC101 & BOTCC102

S. No.	Particulars	Marks
1	Exercise based on BOT**CC101: Cell and Molecular Biology**	12
2	Exercise based on BOT**CC102: Algae, Fungi &Bryophytes**	12
3	Exercise based on BOTEL 104	12
4	Exercise based on BOTEL105	12
5	**Spotting** *(8 specimens × 3 marks each)*	24
5	**Seminar / Presentation**	15
6	**Viva Voce**	07
7	**Practical Record / Journal**	06
	Total Marks	**100**

Guidelines for Practical Examination

- Each exercise should test applied and conceptual understanding aligned with NEP–2020 learning outcomes.
- Spotting should include museum specimens, permanent slides, diagrams, or photographs from all three core courses.
- Seminar presentation will assess analytical thinking, data interpretation and communication skills.
- Viva voce will evaluate practical knowledge, integration of theory with experiment and contemporary understanding.
- Practical records should be neat, properly labelled and duly certified by the course instructor.

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M.Sc. Botany (Semester–I)

Elective Course (BOT-20104-T)

Applied Phycology and Mycology

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives

This course covers the applications of algae and fungi, focusing on their roles in food production, biofertilizers, and soil remediation. Students will explore algae's use in producing substances like alginic acid and fungi's contributions to food, fermentation, and pharmaceuticals. The course also addresses algae's role in reducing chemical fertilizers and fungi's impact on soil cleanup and pest control, with a focus on mushroom cultivation for economic development and sustainability.

Course Learning Outcomes

Upon completing the course, students will be able to:

- Learn how algae are utilized as food, fodder, and in the production of acids such as alginic acid, agar, and carrageenan.
- Explore the use of algae as biofertilizers to reduce chemical fertilizer dependence in agriculture.
- Examine the role of fungi in food production, fermentation, baking, and the production of organic acids, enzymes, and pharmaceuticals.
- Study how fungi contribute to soil remediation and serve as biological control agents, including mycoinsecticides and myconematicides.
- Understand the impact of mushroom cultivation on providing employment opportunities and improving the lives of rural populations.

UNIT-I

15 Hrs

Applied Phycology: Use of algae as food, fodder and industrial applications of algae (Alginic acid, Agar, Carrageenan), Algal Biofertilizers with special reference to Cyanobacteria. Algal blooms and Water Pollution, Toxic Algae,Biofouling and Control.Algal biofuels – algal biodiesel, bio-ethanol and biological hydrogen production.Algae in global warming – carbon capture by algae.

Isolation, Purification and Culture of algae; Mass cultivation of microalgae with special reference to *Spirullina* and *Dunaliella* and their applications in human welfare. Cryopreservation, aquaculture (micro and macro algae cultivation).

UNIT-II

15 Hrs

Importance of algae in production of algal pigments, important bioactive molecules, role of algae in sustainable environmenrole of algae in bioremediation, recent

developments and future of algal biotechnology.

Applied Mycology: Application of fungi in food industry (Flavour& texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Fungi in agriculture (biofertilizer) and remediation of contaminated soils.Mycotoxins; Fungalendophytes of plants and their applications: Endophytic fungi, colonization and adaptation of endophytes. Endophytes as latent pathogens and biocontrol agents.

UNIT-III 15Hrs

Fungi as Biological control agents (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides). Fungi in plant disease control- Selection, production and formulation of fungal biopesticides and commercial use of biocontrol agents.Introduction and importance of Keratinophilic fungi.

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield. Biology of vesicular arbuscular mycorrhizal (VAM) fungi: signaling, penetration and colonization inside roots, isolation and inoculum production of VAM, and its influence on growth and yield of crop plants and in forestry, recent advances in the field of mycorrhiza. A general account of Phosphate solubilizing fungi (PSF). Overview of Lichens.

UNIT-IV 15Hrs

Mushroom cultivation- General account of Oyster, white button, paddy straw, Morels, Truffles & Poisonous mushrooms. Cultivation of mushrooms (*Agaricusbisporus, Pleurotus* and *Volvoriella)*, Medicinal and nutritional value of edible mushrooms, Effect of

environmental, nutritional and chemical factors on mushroom cultivation (intensive and extensive cultivation methods).

Suggested Laboratory Exercises:-

- Isolation and culture of algae.
- Identification of Algal biofertilizers.
- Identification of toxic algae.
- Identification of bloom forming algae.
- Making an algal bloom.
- Phytoplankton identification from local water bodies.
- Isolation, culture and identification of fungi using moistened blotters, PDA and Sabouraud's Dextrose Agar media
- Cultivation of *Spirullina* and *Dunaliella*.
- Estimation of pigments in microalgae.
- Study of Mushroom specimens
- Mushroom cultivation.
- Demonstration of antagonistic fungi a) Antibiosis b) Competition c) Mycoparasitism
- Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs)
- Study of Mycorrhizal colonization in roots of *Parthenium* and *Tagetus*.
- Isolation and identification of AM Fungi and estimation of root colonization.

Suggested Readings:-

1. Kumar, H.D. Introductory Phycology , Affiliated East West Pvt. Ltd. , New Delhi
2. Fritsch, F.E (1945). The structure and Reproduction of Algae Vols. I & II. Cambridge University Press, UK

3. Anderson, R.A. (2005) Algal Culturing Techniques. Physiological Society of America. Elesvier Academic Press, USA.

4. Ghemawat, M.S., Kapoor J.N., and Narayan,H.S. (1976) : A text book of Algae. Ramesh book Depot, Jaipur.

5. Alexopoulus, C.J., Mims, C.W. and Blackwel, M. (1996). Introductory Mycology, John Wiley & Sons ind.

6. Verma, A & Hock, B. 1999. Mycorrhizae. Springer Publishers

7. Powel, C and D. J. Bagyaraj - V.A. Mycorhizae

8. Change. S.T. and P.G. Miles - Edible mushrooms and their cultivation

9. Handbook of Industrial mycology. Edited by Zhiqiang An, CRC Press.

10. Mycotechnology: Present status and future prospects. Edited by MahendraRai. I.K., International Publishing House Pvt. Ltd.; 2007.

11. Agrios, G.N. 1999. Plant Pathology. Academic Press

12. Mehrotra, R.S. 1991. Plant Pathology. Tata Mcgraw – Hill Publishing Company Ltd

A Singh

M.Sc. Botany (Semester–I)

Elective Course (BOT-20105-T)

Seed Pathology

Credits: 04 **Total Hours:** 60 (Theory)

Objectives of the Course

- This course is designed to provide fundamental and advance knowledge about the Seed pathology.

Course Learning Objectives:

After completion of this course, students will be able to

- Understand the basic knowledge about history and introduction of seed pathology.
- Develop a good knowledge about pathogen detection methods & mechanism of infection.
- Develop a knowledge about disease transmission & various control methods
- Develop practical skill to perform basic & advanced experiments in seed pathology.

Unit -I

15Hrs

- **General Introduction & History: -** Introduction and importance of Seed Pathology in modern agriculture. History of Seed Pathology.
- **Methods for pathogen Detection & Mechanism of seed infection: -** Various methods for testing seed borne fungi, bacteria and viruses (Dry seed examination, seed washing test, incubation methods, cultural, biochemical, serological, nucleic acid-based methods). Mechanism of seed infection and its types, environment influencing seed infection, infected/contaminated part of seed, morphology and anatomy of seeds in relation to invasion, location of inoculum of the pathogen in seed- seed coat and pericarp, endosperm and perisperm and embryo.

Unit -II

15Hrs

- **Seed-borne diseases: -** Seed-borne diseases of some important crops with particular reference to the state of Rajasthan and India.

Typical case of infection by: fungi (wheat- smuts and bunts, Sesame- charcoal rot; bacteria (Brassicas- black rot, cluster bean- bacterial blight); viruses (tomato mosaic virus, pea seed borne mosaic virus,) and nematodes (wheat- ear cockle, rice- whitetip).

Unit -III

15Hrs

- **Inoculum:** - Seed-borne inoculum, inoculum density and assessment of seed borne inoculum in relation to plant infection, epiphytotics due to seed borne inoculum, disease forecast based on infected seed samples, tolerance limits of seed borne pathogens

- **Disease Transmission:** - Transmission of seed borne disease: Systemic and non- systemic seed transmission, types of disease transmission, mode of establishment and course of disease from seed to seedling and plant, factors affecting seed transmission.

Unit -IV

15Hrs

- **Disease Management**: - Management of seed-borne disease, principles of control, seed treatments (physical, chemical and biological), mechanism of action of seed treatments, major seed treatments for important seed borne pathogens and their methods of application.

Suggested Laboratory Exercises:

- Dry seed examination of seed lots.
- Isolation and identification of seed-borne mycoflora by standard blotter method.
- Preparation of culture media (PDA and NA).
- Plating seeds on PDA/NA for identification of seed borne fungi and bacteria.
- Other methods of plating e.g. deep freezing; 2,4D- blotter method.
- Water agar test tube seedling symptom test.
- Study of any seed borne nematode disease.
- Detection of bacterial and viral pathogens in seeds.
- LOPAT tests for detection of seed- borne bacteria.
- Nucleic acid based detection of seed borne pathogens.
- Histopathology of infected seed samples.
- Physical control of seed-borne pathogens.
- Antibiotic/fungicidal assay against seed-borne pathogens
- Biological control of seed borne pathogens.
- Field visits: Crop fields, FCI, NSC, Seed testing Labs., quarantine station (e.g. NBPGR)

etc.

Suggested Readings:

1. Agarwal, P. C., Mortensen, C. N. and Mathur, S. B. (1989). Seed-borne diseases and seed health testing of rice. Technical Bull. No.3, Danish government institute of seed Pathology for Developing Countries (DGISP), Copenhagen and CAB International Mycological Institute, (CMI) UK.
2. Agarwal, V.K. (2006). Seed Health. International Book Distributing Company. Charbagh, Lucknow, India.
3. Agarwal, V.K. and Sinclair, J.B. (1987). Principles of Seed-pathology, II edition CRC Lewis Publishers, Boca Raton, New York, London.
4. Agrawal, R.L. (1980). Seed Technology. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
5. Agrios, G.N. (2005). Plant Pathology. Academic Press, London., New York
6. Anonymous (1985, 2014). International rules for seed testing. International Seed Testing Association (ISTA). http://www.seedtest.org/en/home.html; http://www.seedtest.org/en/international-rules-_content---1--1083.html
7. Cliffton, A. (1958). Introduction to the Bacteria. McGraw Hill Book Co., New York.
8. Khare, D. and Bhale, M.S. (2014). Seed Technology. Scientific Publishers (India),Jodhpur. Revised 2nd Ed.
9. Mandahar, C.L. (1978). Introduction to plant viruses. S. Chand & Co. Ltd., Delhi.
10. Mathur, S.B. and Cunfer, B.M. (1993). Seed-borne diseases and Seed health Testingof Wheat. Danish Government Institute of Seed Pathology for Developing Countries. Hellerup, Denmark.
11. Neergaard, P. (1977). Seed Pathology. Vol. I & II. The Mac Millan Press Ltd., London.
12. Rangaswamy, G. & Mahadevan, A. (1999). Diseases of crop plants in India (4th edition). Prentice Hill of India, Pvt. New Delhi.
13. Richardson, M. J. (1990). An annotated list of seed borne diseases 4th edn. Proc. Int Seed Test Assoc. Zurich, Switzerland.
14. Schaad, N. W. (1980). Laboratory guide for identification of plant pathogenic bacteria (edt.). Bacteriology Committee of American Phytopathological Society, St. Paul, Minnesota.
15. Schaad, N. W. (1988). Laboratory guide for identification of plant pathogenic bacteria (2nd eds.). APS Press (The American Phytopathological Society), St. Paul, Minnesota.
16. Singh, D. and Mathur, S. B. (2004). Histopathology of seed-borne infections. CRC Press, Boca Raton, London, New York, Washington DC.pp 296.

17. Singh, K.G. and Manalo, P.L. (1986). Plant Quarantine and Phytosanitary Barriers inthe Asean. Asean Plant Quarantine Centre and Training Institute, Malays

M.Sc. Botany (Semester–I)
Elective Course (BOT- 20106-T)

BIOSYSTEMATICS OF ANGIOSPERMS & REPRODUCTIVE BIOLOGY

Credits: 04 **Total Hours:** 60 (Theory)

UNIT-I
15 Hrs

Principle and Methods of Taxonomy: Taxonomic Hierarchy, Species, Genus, Family and other categories. Salient features of International Code of Botanical Nomenclature.

Taxonomic Tools: Herbarium, Flora, Botanical Gardens, biochemical and molecular techniques, computers and GIS (Geo Information Systems). Cladistics in taxonomy. Numerical taxonomy and Sero taxonomy.

Taxonomic evidences: Palynology, Embryology, Cytology, Phytochemistry and Genome analysis.

Classification: Artificial system (Linnaeus), Natural system (Bentham and Hooker), and Phylogenetic (APG system) with merits and demerits of these systems.

UNIT-II
15 hrs

Taxonomic Studies: Ranunculaceae, Pappaveraceae, Capparidaceae, Caryophyllaceae, Leguminosae, Cucurbitaceae, Apiaceae, Rubiaceae, Asteraceae, Asclepiadaceae, Apocynaceae, Convolvulaceae, Solanaceae, Acanthaceae, Bignoniaceae, Lamiaceae, Chenopodiaceae, Euphorbiaceae, Liliaceae, and Poaceae. Phylogeny of Angiosperm: Origin and evolution of Angiosperms. Fossil Angiosperms.

UNIT-III

15 hrs

Embryology: Introduction, History. Male gametophyte: Microsporogenesis, Tapetum; types and functions, Sporopollenin, Pollen structure, pollen Allergy.

Female gametophyte: Brief Introduction to Embryo sac development (No type studies). Organization of Mature Embryo sac, Ultra Structure of Egg apparatus, Nutrition of Embryo sac.

UNIT-IV

15 hrs

Pollination: Brief account, Structure, Histo-chemical details of style and Stigma, Pollen germination, pollen embryo sac. Self incompatibility Fertilization: Path of entry of pollen tube, Site of pollen discharge. Double fertilization.

Endosperm: Types of endosperm development, Endosperm haustoria, Endosperm culture & function. Embryogenesis: Monocot and dicot embryo development; Physiology and genetics of Embryo development, Somatic embryogenesis.

Suggested Practical exercises

Study of vegetative and floral characters of specimens from representative, locally available families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula and systematic position according to Bentham & Hooker's system of classification):

Ranunculaceae Ranunculus, Delphinium

Brassicaceae Brassica, Coronopus, Iberis

Pappaveraceae: Argemone

Capparidaceae: Capparis, Cleome

Malvaceae: Hibiscus, Abutilon, Sida, Malvastrum

Pedaliaceae: Pedalium murex

Leguminosae: Acacia, Bauhinia, Cassia, Crotalaria, Pea

Caryophyllaceae: Dianthus, Spergula, Stellaria

Cucurbitaceae: Coccinia, Luffa, Momordica

Rubiaceae: Haemalia, Ixora

Asclepiadaceae: Calotropis, Cryptostegia

Apocyanaceae: Nerium, Catharanthus, Tabernaemontana

Convolvulaceae: Ipomoea, Convolvulus

Solanaceae Datura, Withania, Petunia, Solanum

Acanthaceae: Adhatoda, Barleria

Bignoniaceae: Tecomella, Tecoma

Labiatae Salvia, Ocimum, Majorana

Nyctaginaceae: Bauganvillea

Chenopodiaceae: Chenopodium

Umbelliferae: Coriandrum, Foeniculum

Asteraceae: Sonchus, Launaca, Vernonia, Ageratum, Eclipta, Tridax

Euphorbiaceae - Ricinus, Euphorbia, Jatropha

Liliaceae Asphodelus, Lilium, Alium

Poaceae Triticum, Hordeum, Avena

Construction of taxonomic keys and Nomenclature exercise.

Training in using floras and herbarium for identification of specimens described in the class.

Study of anther and ovule using permanent slides/photographs.

Field study of several types of flowers with different pollination mechanisms.

Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, Cannabis sativa, Crotoloria, Tradescantia, Brassica, Petunia, Solanum melongena, etc.)

Tests for pollen viability using stains and in vitro germination.

Emasculation, bagging and hand pollination to study pollen germination.

Study of nuclear and cellular endosperm through dissections and staining.

Dissection and observation of Embryo sac haustoria in Santalum or Argemone.

Structure of endosperm (nuclear and cellular) using permanent slides/Photographs.

Dissection and observation of Endosperm haustoria in Crotalaria or Coccinia.

Developmental stages of dicot and monocot embryos using permanent slides/photographs.

Field trips within and nearby areas in the university/college campus, compilation of field notes and preparation of herbarium sheets of such plants wild or cultivated that are abundant. Photography of the collected specimens and their habitat (if applicable).

Submission: Record book, Tour report and Herbarium specimens of at least 50 properly dried and pressed wild or cultivated plants from your locality.

Suggested Readings

Davis, P.H. and V.H. Heywood. 1991. Principles of Angiosperm Taxonomy. Today and Tomorrow Publications, New Delhi

Heywood - Plant taxonomy - Edward Arnold London.

Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.

Judd, W.S, Christopher S. Campbell, Elizabeth A. Kellogg, Peter F. Stevens, and Michael J. Approach, 4rd ed. Sinauer

Lawrence - Taxonomy of Vascular Plants - Oxford & IBH, New Delhi.

Datta S C, Systematic Botany, 4th Ed, Wiley Eastern Ltd., New Delhi, 1988.

Mondal AK. 2011. Advanced Plant Taxonomy. New Central Book Agency Pvt. Ltd., Kolkata.

Naik V.N., Taxonomy of Angiosperms, 1991. Tata Mcgraw-Hill Pub. Co. Ltd., New Delhi.

Pandey, B.P. 2007. Taxonomy of Angiosperms. S. Chand and Company Limited. New Delhi.

Pandey, S. N, and S.P. Misra (2008)-Taxonomy of Angiosperms- Ane Books India, New Delhi.

Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York.

Sharma, O.P. 2009. Plant Taxonomy. Tata McGraw-Hill. Mumbai.

Simpson MG, 2006. Plant Systematics. Elsevier Academic Press, California, USA.

Singh, G. (2012). Plant Systematics: Theory and Practice (3 edition). Oxford & IBH Pvt. Ltd., New Delhi.

Singh V. & Jain - Taxonomy of Angiosperms - Rastogi Publications, Meerut.

APG III (2009) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Bot. J. Linnaean Soc. 161: 105-121.

Bhojwani S. S. and Bhatnagar S. P. (2000). The embryology of Angiosperms (4th revised and enlarged edition) Vikas Publishing house, New Delhi.

Johri, B.M. (2011) Embryology of Angiosperms. Springer-Verlag, Berlin.

Maheswari, P. (1971). An Introduction to Embryology of Angiosperms. McGraw Hill- Book Co., London.

Pandey, A. K. (2000) Introduction to Embryology of Angiosperms. CBS Publishers- & Distributors Pvt. Ltd., New Delhi

Any local/state/regional flora published by BSI or any other agency.

Reference and Reading Books:

1. Raghavan V. (1997). Molecular embryology of flowering plants. Cambridge University press, Cambridge.

2. Raghavan V. (1986). Embryogenesis in angiosperms- A developmental and experimental studies. Cambridge University Press New York USA.

3. Shivanna K. R. and Sawhney V. K. (eds) 1997. Pollen Biotechnology for crop production and improvement. Cambridge University, Cambridge.

4. Hans Mohr & P. Schopfer (2006) Plant Physiology, Springer (India) Pvt. Ltd., New Delhi

5. Verma, SK. A Textbook of Plant Physiology, Biochemistry & Biotechnology. S. Chand & Co.

M.Sc. Botany (Semester–I)

Elective Course (BOT–20107-T)

Microbiology and Microbial Technology

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives

- To introduce microbial diversity, structure, physiology and classification.
- To understand microbial growth, metabolism, genetics and host–microbe interactions.
- To expose students to applied microbiology including industrial, medical, agricultural and environmental uses.
- To provide knowledge of microbial technology, bioprocessing, fermentation and product development.

Course Outcomes

Learners will be able to:

- Identify and classify microorganisms based on structure and characteristics.
- Understand microbial growth, metabolism, genetics and pathogenesis.
- Explain industrial fermentation processes and microbial products.
- Apply knowledge of microbes in healthcare, agriculture and biotechnology.

UNIT I: Microbial Diversity, Structure & Physiology **(15 Hours)**

1. Introduction to Microbiology
   - Scope, history and significance of microbiology
   - Major groups of microorganisms: bacteria, archaea, cyanobacteria, fungi, protozoa, viruses
2. Microbial Systematics and Classification
   - Principles of microbial taxonomy
   - Bergey's Manual classification
   - Molecular phylogeny (16S rRNA, DNA–DNA hybridization, ANI)
3. Microbial Cell Structure
   - Prokaryotic cell structure: cell wall, capsule, pili, flagella, endospores
   - Eukaryotic microbial cell structure: fungal and protozoan cells
   - Viral structure and classification
4. Microbial Physiology
   - Nutritional types of microbes
   - Microbial growth kinetics and growth curves
   - Factors influencing growth: temperature, pH, water activity, radiation, oxygen
   - Biofilms and quorum sensing

UNIT II: Microbial Genetics, Pathogenicity & Immunology (15 Hours)

1. Microbial Genetics
   - DNA replication, transcription, translation in prokaryotes

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- Gene regulation: operon models
- Mutation and mutagenesis
- Horizontal gene transfer: transformation, transduction, conjugation
- Plasmids, transposons, integrons

2. Microbial Pathogenicity
   - Mechanisms of microbial virulence
   - Host–pathogen interactions
   - Bacterial toxins (exotoxins, endotoxins)
   - Principles of infection and disease transmission
3. Basics of Immunology
   - Innate and adaptive immunity
   - Antigens, antibodies and antigen–antibody interactions
   - Vaccines: types and principles (live, killed, recombinant, mRNA)
   - Diagnostic immunology: ELISA, agglutination, immunofluorescence

UNIT III: Industrial & Fermentation Microbiology (15 Hours)

1. Fermentation Technology
   - Types of fermentation: submerged, solid-state, batch, fed-batch, continuous
   - Bioreactors: types, components, design considerations
   - Sterilization, inoculum development, media optimization
2. Industrial Microbial Products
   - Microbial production of antibiotics, enzymes, organic acids, alcohol, vitamins
   - Microbial polysaccharides and bioplastics
   - Microbial biomass and single-cell protein
3. Food & Dairy Microbiology
   - Microbial spoilage of food
   - Food preservation techniques
   - Fermented foods: cheese, yogurt, beverages, pickles
   - Probiotics and prebiotics

UNIT IV: Environmental, Agricultural & Applied Microbial Technology (15 Hours)

1. Environmental Microbiology
   - Microbial role in biogeochemical cycles: nitrogen, carbon, sulfur
   - Biodegradation, bioremediation and biosensors
   - Wastewater microbiology
2. Agricultural Microbiology
   - Rhizosphere and soil microbes
   - Nitrogen-fixing organisms
   - Mycorrhizae and plant growth–promoting microbes
   - Biofertilizers, biopesticides
3. Applied Microbial Technology
   - Microbial biotechnology in aquaculture
   - Microorganisms in animal health and probiotics
   - Microbial biotechnology in pharmaceuticals
   - Intellectual Property Rights: patents for microbial innovations

Recommended Books

- Prescott, Harley & Klein – *Microbiology*
- Pelczar, Chan & Krieg – *Microbiology*

- Tortora – *Microbiology: An Introduction*
- Stanbury, Whitaker & Hall – *Principles of Fermentation Technology*
- Madigan & Martinko – *Brock Biology of Microorganisms*

Practical Syllabus

1. Basic Microbiological Techniques
   - Laboratory safety, aseptic techniques.
   - Cleaning and sterilization of glassware (autoclave, hot air oven).
2. Culture Media Preparation
   - Preparation of nutrient agar and broth.
   - Pour plate or streak plate for isolation of bacteria.
3. Microscopy & Staining
   - Use of compound microscope.
   - Simple staining and Gram staining of bacteria.
4. Microbial Count
   - Serial dilution and total viable count (TVC) of bacteria.
5. Applied Microbiology
   - Antibiotic sensitivity test (disc diffusion).
   - Demonstration: MPN test for water quality **or** fermentation process.
6. Record & Viva
   - Practical record submission and viva-voce.

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M.Sc. Botany (Semester–I)

Elective Course (BOT- 20108.T)

Genetics & Cytogenetics

Credits: 04 **Total Hours:** 60 (Theory)

Objectives of the Course

- This course is designed to provide the advance theoretical as well as practical knowledge of Genetics.

Course Learning Objectives

After completion of this course, students will be able to

- To develop conceptual understanding of chromosomes, law of inheritance, genetic basis of loci, alleles and their linkage.
- Comprehend the effect of chromosomal abnormalities in numerical as well as structural changes leading to genetic disorders and study of chromosomal basis of inheritance.
- Develop conceptual understanding of Mutation.
- Learning the practical methods of genetics.

Unit -I

15Hrs

- **Inheritance and allelism**: Chromosome theory of inheritance; Mendelian laws; Organelle inheritance: mitochondrial, chloroplast genome: Evolution, structure and organization.
- **Cytogenetics:** Chromosome: Structure and nomenclature, centromere and telomere; Sex determination: mechanisms, sex chromosomes.

Unit -II

15Hrs

- **Chromosomal aberrations:** Duplications, deficiencies/deletions, inversions, interchanges/translocations; Role of chromosomal aberrations in crop evolution; Ploidy changes: Haploids, polyploids and aneuploids.
- **Gene:** Fine structure of gene, concept, cis-trans test. Gene interactions: complementary, supplementary, epistasis, duplicate genes.

Unit -III

15Hrs

- **Mutation and mutagenesis**: Spontaneous and induced mutations, physical and chemical mutagens, types of mutations; Molecular basis of mutations; Transposons and their use in mutagenesis and site directed mutagenesis; Behavioral genetics; Population genetics and Quantitative genetics.

Unit -IV

15Hrs

- **Chromosome mapping:** Linkage and crossing over: basic concepts, linkage maps, correlation of genetic and physical maps, molecular markers and construction of linkage maps; Molecular mechanism of recombination.
- **Molecular Cytogenetics:** C value paradox, cot curve and its significance, multigene families and their evolution, in situ hybridization- concept and technique, flow cytometry.

Suggested Laboratory Exercises:

- Problems related to linkage, crossing over and gene interaction
- Problems related to gene mapping
- Construction of restriction map
- Linear differentiation in Chromosome through banding technique
- Isolation of chlorophyll mutants following irradiation and treatment with chemicalmutagen
- Quantitative estimation of DNA by diphenyamine method
- Karyotype analysis
- Induction of polyploidy
- To study the application of colchicines treatment.
- Selfing and crossing technique
- Demonstration of flow cytometery and confocal microscopy
- Presentation of chart and models related to syllabus
- Any other exercise based on theory syllabus

Suggested Reading:

1. Benjamin Lewin (2000). Genes VII. Oxford university press.
2. Gardner E J, Simmons M J, Snustad D P (1991). Principles of Genetics (III Edn). John Wiley and Sons Inc.
3. Snustad D P, Simmons M J (2000). Principles of Genetics (III Edn). John Wiley andSons.
4. Strickberger (2005). Genetics (III Edn). Prentice Hall of India Pvt. Ltd.
5. William S Klug, Michael R Cummings (1994). Concepts of Genetics. Prentice Hall.

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6. Robert J Brooker (2009). Genetics: Analysis and principles (III Edn). McGraw Hill.
7. Daniel L Hartl, Elizabeth W Jones (2009). Genetics: Analysis of genes and genomes (VII Edn). Jones and Bartlett publishers.
8. D Peter Snustad, Michael J Simmons (2010). Principles of genetics (V Edn). JohnWiley and Sons.
9. Acquaah G (2007). Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd. USA.
10. Hartl DL and Jones EW (2007). Genetics – Analysis of Genes and Genomes, 7th edition, Jones and Barlett publishers.
11. Hartwell LH, Hood L, Goldberg ML, Reynolds AE, Silver LM, Veres RC (2006).Genetics – From Genes to Genomes, 3rd edition, McGraw Hill.
12. Lewin B (2008). Genes IX, Jones and Barlett Publishers.
13. Singh RJ (2002). Plant Cytogenetics, 2nd edition, CRC Press.
14. Strickberger MW (2008). Genetics, 3rd Edition, Pearson (Prentice Hall).
15. Weising K, Nybom H, Wolff K and Kahl G (2005) DNA Fingerprinting in Plants

M.Sc. Botany (Semester–I)
Elective Course (BOT–20109-T)
: Stress Physiology

Credits: 04 **Total Hours:** 60 (Theory)

UNIT-I 15 hrs

Environmental stresses: Introduction, significance, types

Water deficit stress: Effects on physiological processes, Physiological responses to water deficit stress, Various strategies of drought resistance in plants, Mechanism of stomatal action, Antitranspirants, ABA as stress hormone, ABA dependent and ABA independent pathways, LEA proteins

Flooding stress (anoxia): Nature of waterlogging stress, Effects of flooding stress on physiological processes in plants, Wetland and non-wetland species, Mechanism of waterlogging tolerance

UNIT-II 15 hrs

Salinity stress: Definition of saline soil, Causes of soil salinization, A brief outline of salt affected soils in India. Salinity stress- combination of osmotic stress and ionic stress, Physiological responses of plants to salinity stress, mechanism of salinity tolerance in higher plants, Signaling under salinity stress- Salt Overly Sensitive (SOS) Pathway, Compatible osmolytes- role in osmotic adjustment

Heavy metal stress: Effect of ion toxicity (iron, zinc), heavy metals toxicity and aluminum toxicity in plants, Mechanism of aluminum tolerance, Phytoremediation

UNIT-III 15 hrs

Thermal stresses: Effects of high and low temperatures on plant, Physiological responses of plants to high and low temperatures, Mechanisms of high and low temperatures tolerance, Role of Heat Shock Proteins (HSPs) , calcium, calmodulin and C-repeat binding factors (CBFs)

Oxidative stress: Influence of high light intensity on photosynthesis,

Generation of reactive oxygen species (ROS), Effects of ROS, Photoprotection and ROS detoxification mechanisms in plants

UNIT-IV **15 hrs**

Biotic stresses: Responses of plants towards biotic stresses, plant defense system, genetic basis, understanding of R genes, Systemic acquired resistance

Biotic stress signaling (plant defense): Elicitors and plant defense: Plant responses to elicitors and their role in crop improvement, Plant defense priming, Role of Jasmonic acid, salicylic acid, ethylene and nitric oxide signaling in plant defense.

Suggested Laboratory Exercises:

- Measurement of RWC under stress.
- Leaf disc assays under various abiotic stresses.
- Determination of chlorophyll content under stress.
- Determination of electrolyte leakage under stress.
- Estimation of sodium, potassium, chlorides in different plant leaves.
- Estimation of free amino acids content in the given sample
- Study of effect of fungal infection on peroxidase activity.
- Study of phenolics in scales of onion varieties differing in disease resistance.
- Study of free radicals scavenging enzymes, catalase and super oxide dismutase.
- Estimation of proline content in given water stressed samples
- Study of seed germination under stress condition.
- Estimation of betaine content in salt stressed samples.
- Determination of ascorbic content in temperature (low and high) and salt stressed samples.
- Determination of the concentration of polyamines in the given stressed samples.
- Effect of stress on the activity of following scavenging enzymes:
- superoxide dismutase, (b) catalase, (c) peroxidase, (d) ascorbate peroxidase.
- Visualization of stress proteins by SDS-gel electrophoresis.
- Effect of stress on membrane damage in relation to lipid peroxidation.
- Effect of water stress and Hyperthermia on the activity of nitrate reductase.

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Suggested Readings:

1. Plant Physiology (3rd edition), Lincoln Taiz and Eduardo Zeiger (2002), Sinauer Associates
2. Biochemistry and molecular biology of plants: Buchanan et al 2000, American Society of Plant Biologists, USA
3. Abiotic stress adaptation in plants: Pareek et al (2010), Springer
4. Plant Responses to Abiotic Stress: Hirt and Shinozaki: (Online) Springer
5. Plant Responses to environmental stress: Smallwood et al BIOS Scientific Publishers
6. Plant, Genes and Crop Biotechnology, Maarten J. Chrispeels& David E. Sadava, 2002, American Society of Plant Biologists, USA
7. Handbook of Plant and Crop Physiology: Pessarakli et al 2002, Marcel Dekker Inc. USA
8. Plant Ecophysiology: Prasad MNV 1997, John Wiley & Sons, Inc, USA
9. Introduction to Plant Physiology. Second Edition, Hopkins, William G. John Willey & Sons, Inc.
10. Oxidative stress and the molecular biology of antioxidant defenses. Scandolios, J. 1997. New York: Cold Spring Harbor Laboratory Press.

M.Sc. Botany (Semester–I)

Elective Course (BOT-20110-T)

: Phytochemistry and Herbal Medicines

Credits: 04 **Total Hours:** 60 (Theory)

UNIT-I 15 hrs

Historical background & Present status- Scope of Medicinal Botany, Indigenous medical system, Bioprospecting, Indigenous Knowledge system, Ayurveda, Siddha, Unani, Homeopathy and Folklore system of medicine. Related terminology.

Phytochemical screening of crude drugs: Crude Drugs: Scope & Importance, Classification (Taxonomical, Morphological Chemical, Pharmacological); Cultivation, Collection & Processing of Crude Drugs.

UNIT-II 15 hrs

Extraction and Characterization of Phytochemicals: General methods and Extraction, Biological sources, chemistry and uses of Resins, Tannins, Volatile oils, alkaloids, flavonoids, saponin, terpenoids and glycosides.

UNIT-III 15 hrs

Analysis of Phytochemicals: Standardization of phytopharmaceuticals by UV, IR, HPLC and HPTLC, GCMS techniques. Preliminary Screening. Methods of Drug Evaluation (Morphological, Microscopic, Physical & Chemical); Processing, Drug Adulteration –Types of Adulterants.

UNIT-IV 15 hrs

Indian Trade in Medicinal and Aromatic plants: Export potential of Indian medicinal herbs. Indian medicinal plants used in cosmetics and aromatherapy. Spices and their uses. List of medicinal plants cultivated in India. Patents: Indian and international patent laws.

Suggested Laboratory Exercises:

- Crude drug preparation methods.
- Demonstration of Soxhlet extraction method.
- Solvent Screening for various phytochemical extractions.
- Extraction methods of Phytochemicals (alkaloids, tannins, glycosides, Flavonoids)
- Reagent test of alkaloids determination in plants (Dragendorff's reagent, Meyer's reagent, Hager's reagent, Wagner's Test).
- Phytochemical screening and detection of carbohydrates (Molisch's Test, Benedict's test, Fehling's Test)
- Phytochemical screening and detection of phytochemicals from plant samples
- Demonstration of counter current extraction, microwave-assisted extraction, ultrasound extraction (sonication), supercritical fluid extraction, and distillation techniques (water distillation, steam distillation, phytonic extraction (with hydro fluorocarbon solvents).

Text /References Books:

1. Pharmacognosy, C. K. Kokate, A. P. Purohit& S. B. Gokhale (1996), Nirali Prakashan, 4th ed.
2. Natural Products In Medicine: A Biosynthetic Approach (1997), Wiley.
3. Melmon, K.L., and Morelli; Clinical Pharmacology: Basic Principle of Therapeutics, McMillan, New York
4. Craig, C.R. and Stitzel, B.E.; Modern Pharmacology, Little Brown and Co, Boston
5. Drill, V.A.; Pharmacology in Medicine, McGraw Hill, New York
6. Goodman and Gilman; Pharmacological Basis of Therapeutics, McGraw Hill
7. Trease and Evans, Pharmacognosy, Saunders Company, London.
8. Wallis T. E., Text Book of Pharmacognosy, CBS publishers & distribution, Delhi.
9. Textbook of Industrial Pharmacognosy, by A. N. Kalia, CBS Publishers and Distributors. New Delhi

10. Chaudhari R D, Herbal Drug Industry, Eastern publication.
11. Chadwick,D.J. & Marsh, J.:Bioactive compounds from plants.
12. J.C. Willis: Pharmacognosy
13. C.K. Kokate: Pharmacognosy
14. Trease, G.E and Evans, W.C.: Pharmacogonosy, Saunders, 1996.
15. Natesh, S. 2001. The changing scenario of herbal drugs: Role of Botanists. Phytomorphology. (Golden Jubilee Issue)., Pp.75-97.
16. JonneBernes – Herbal Medicines, Pharmaceutical Press, London 3rd ed.2007
17. Cutler, S.J. and Cutler, S.H.G. 2000. Biologically active natural Products – Pharmaceuticals. CRC Press, USA.
18. Herbal Cosmetics - H.Pande, Asia Pacific Business press, New Delhi.
19. Homeopathic Pharmacy An introduction & Hand book by Steven B. Kayne.
20. Indian Herbal Pharmacopoeia, Vol.1&2, RRL, 1DMA, 1998, 2000.
21. Ayurvedic system of medicine, 2nd edition, Kaviraj, NagendranathSengupata, vol. I &II.
22. Kumar, N.C. (1993). An Introduction to Medical botany and Pharmacognosy. Emkay Publications, New Delhi.
23. JonneBernes – Herbal Medicines, Pharmaceutical Press, London.
24. Siddha Pharmacopoeia by Dr.S. Chidambarathanupillai, Ist edition.
25. Unani Pharmacopoeia.

M.Sc. Botany (Semester–I)

Elective Course (BOT- 2011-T

: Environmental Pollution and Management

Credits: 04 **Total Hours:** 60 (Theory)

COURSE OBJECTIVES:

- To understand major types, sources and impacts of environmental pollutants.
- To study ecological, physiological and toxicological effects of pollution on organisms.
- To learn monitoring methods, environmental standards and analytical techniques.
- To develop knowledge of pollution control, mitigation and sustainable management strategies.
- To promote skills for environmental assessment, conservation and policy awareness.

LEARNING Objectives:

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

1. Identify major pollutants, their sources and their ecological and health impacts.
2. Explain toxicological mechanisms and evaluate pollutant effects using biological indicators.
3. Perform basic environmental sampling and interpret pollution-related data.
4. Understand pollution control technologies, waste management and mitigation strategies.
5. Apply environmental principles in conservation, sustainability and policy contexts.

UNIT I: Fundamentals of Environmental Pollution (15 hrs)

- Concept of pollution: definitions, sources, pathways, biomonitoring.
- **Air pollution:** primary & secondary pollutants, smog, particulates, greenhouse gases.
- Air quality standards, AQI, dispersion models.
- **Water pollution:** physical, chemical, biological pollutants; eutrophication.
- **Soil pollution:** agrochemicals, heavy metals, plastics, industrial waste.
- Bioaccumulation, biomagnification & biotransformation of pollutants.

UNIT II: Toxicology & Biological Effects of Pollutants (15 hrs)

- Introduction to environmental toxicology: dose–response, LD50, NOAEL.
- Mechanisms of toxicity: oxidative stress, endocrine disruption, neurotoxicity.
- Heavy metals (Hg, Pb, Cd, As) – sources & impacts.
- Pesticides, PAHs, microplastics & emerging contaminants (pharmaceuticals, nanoparticles).
- Effects on wildlife: behavioural, reproductive, developmental and genetic impacts.

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- Environmental health issues: air pollution diseases, waterborne pathogens.

UNIT III: Environmental Monitoring & Assessment (15 hrs)

- Sampling methods: water, air, soil, biological samples.
- **Analytical techniques:** spectrophotometry, chromatography (GC, HPLC), AAS, biosensors.
- Biomarkers & bioindicators: algae, invertebrates, fish.
- Ecotoxicological tests: LC50, toxicity bioassays, micronucleus test.
- Environmental Impact Assessment (EIA): principles & process.
- Environmental legislation: EPA (India), Wildlife Protection Act, Water & Air Acts, CPCB/PCB norms.

UNIT IV: Pollution Control, Mitigation & Management (15 hrs)

- **Air pollution control:** filters, scrubbers, catalytic converters, green technologies.
- **Water treatment:** primary–secondary–tertiary treatments, bioremediation, phytoremediation.
- **Solid waste management:** composting, vermitechnology, waste-to-energy, plastic alternatives.
- Climate change mitigation: carbon sequestration, renewable energy, adaptation strategies.
- Biodiversity conservation & habitat restoration.
- Sustainable development: SDGs, circular economy & environmental ethics.

Suggested Readings

1. **Connell, D. W., & Miller, G. J. (2012).** *Chemistry and Ecotoxicology of Pollution*. **Wiley-Blackwell.**
2. **Waisberg, M., Joseph, P., Hale, B., & Beyersmann, D. (2003). "Molecular and cellular mechanisms of cadmium carcinogenesis."** *Toxicology*, **192(2–3), 95–117.**
3. **Alloway, B. J. (2013).** *Heavy Metals in Soils: Trace Metals and Metalloids in Soils and Their Bioavailability* **(3rd ed.). Springer.**
4. **Manahan, S. E. (2017).** *Environmental Chemistry* **(10th ed.). CRC Press.**
5. **Nathanson, J. A., & Schneider, D. (2021).** *Basic Environmental Technology: Water Supply, Waste Management and Pollution Control* **(7th ed.). Pearson.**
6. **Walker, C. H., Sibly, R., Hopkin, S., & Peakall, D. (2012).** *Principles of Ecotoxicology* **(4th ed.). CRC Press.**
7. **Connell, D. W. (2009).** *Bioaccumulation of Xenobiotic Compounds*. **CRC Press.**
8. **Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017).** *Principles of Instrumental Analysis* **(7th ed.). Cengage.**
9. **Friedman, M. S., et al. (2001). "Impact of changes in transport and commuting behaviors during the Olympic Games on air pollution and health."** *JAMA*, **285(7), 897–905.**
10. **Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (2013).** *Environmental Engineering*. **McGraw-Hill.**

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11. **Goel, P. K. (2017).** *Water Pollution: Causes, Effects and Control* **(New Age International).**
12. **Rao, M. N., & Datta, A. K. (2017).** *Wastewater Treatment*. **Oxford & IBH.**
13. **UNEP. (2019).** *Global Environment Outlook 6 (GEO-6): Healthy Planet, Healthy People*. **United Nations Environment Programme.**
14. **IPCC. (2021).** *Climate Change 2021: The Physical Science Basis*. **Cambridge University Press.**
15. **Rockström, J., et al. (2009). "Planetary boundaries: Exploring the safe operating space for humanity."** *Ecology and Society*, **14(2).**
16. **MoEFCC. (2006).** *National Environmental Policy (NEP), Government of India*.
17. **Central Pollution Control Board (CPCB). (2022).** *National Air Quality Status & Trends Report*.
18. **Sharma, B. K. (2019).** *Environmental Chemistry* **(16th ed.). Goel Publishing House, India.**

PRACTICAL SYLLABUS

1. Water quality analysis (pH, DO, BOD, hardness – basic parameters).
2. Air quality monitoring: particulate matter, dust fall (demonstration/field).
3. Soil analysis: texture & organic matter.
4. Identification of bioindicator species (algae, insects, fish).
5. Study of EIA format and environmental regulation case study.
6. Demonstration of bioremediation/ phytoremediation models.
7. Toxicity test (LC50) – demonstration/problem-solving.
8. Field visit report (STP, solid waste plant, polluted habitat, etc.).

M.Sc. Botany (Semester–I)
Elective Course (BOT-20112-T
LC-103C: Microbial Technology

Credits: 04 **Total Hours:** 60 (Theory)

UNIT-I 15 hrs

Pre-requisite of industrial microorganisms; Strategies for screening, selection and improvement of industrial strains; Methods of preservation & maintenance of microbial strains & their stability; Formulation of fermentation media; methods of sterilization; culturing techniques of microbial strains; inoculum preparation and inoculum development. Overview of upstream and Downstream processing, *In situ* recovery of products.

Microbial Fermentations :Metabolic pathways and metabolic control mechanisms, industrial production of citric acid, lactic acid, enzymes (alpha-amylase, lipase, xylase, pectinases, proteases), acetone- butanol, Amino acid (lysine and glutamic acid), Vitamins (Riboflavin, cyanocobalamine).

UNIT-II 15 hrs

Microbial Production of Therapeutic and Pharmaceutical Compounds: Microbial production of therapeutic compounds (β lactam, aminoglycosides, Ansamycins (Rifamycin), peptide antibiotics Quinolinones), biotransformation of steroids, Fermentative production of antibiotics (penicillins, erythromycins); Vaccines, recombinant vaccines.

UNIT-III 15 hrs

Biofuels: Useful features of bio-fuels, The substrate digester and the microorganisms in the process of biogas production (biomethanation), Production of bioethanol from sugar, molasses, starch and cellulosic materials. Ethanol recovery, Microbial production of hydrogen gas, biodiesel from hydrocarbons.

Modern trends in Microbial Production: microbial production of bioplastics (PHB, PHA), bioinsectices (thuricide), biopolymer (dextran, alginate, xanthan, pullulan), Biofertilizers (Rhizobia, BGA, Azotobacter, Phosphate solubilizing microorganisms), Single Cell Protein and production of biological weapons

with reference to anthrax.

UNIT-IV **15 hrs**

Advances in Microbial Technology: Recombinant fermentations, strategies for fermentation with recombinant organisms and stability issues of recombinants; Applications of immobilized/co-immobilized cells/enzymes in fermentation industry; Overview of nanomaterials and biosynthesis of silver and gold nanomaterials from microbes.

Suggested Laboratory Exercise:

- Screening of industrial microbes
- Collection and identification of important bacterial/fungal strains of industrial importance
- Determination of specific cell growth rate.
- Production and characterization of citric acid using A. niger.
- Microbial production of glutamic acid.
- Production of rifamycin using Nocardia strain.
- Comparison of ethanol production using various Organic wastes /raw Material [Free cells/ immobilized cells].
- Laboratory scale production of Biofertilizers [Nitrogen fixer/Phosphate Solubilizers].
- Microbial production of dextran by Leuconostocmesenteroides
- Microbial production of hydrogen gas by algae/bacteria
- Laboratory production of vinegar.
- Demonstration & operation of ultrasonicator
- Enzymatic production of high fructose syrup from inulin
- Production of alkaline phosphatase in lab scale Fermenter

- Biochemical tests for identification of bacteria.
- Synthesis of nanoparticles using microbes

Recommended Readings:

1. Biotechnology: A Textbook of Industrial Microbiology by W. Crueger, A. Crueger and T.D. Brock, Sinauer Associates Inc., USA (1991). 24
2. Industrial Microbiology: An Introduction by M.M.J. Waites, N.L. Morgan, J.S. Rockey and G. Higton, John Wiley & Sons, USA (2010).
3. Manual of Industrial Microbiology and Biotechnology by R.H. Baltz, J.E. Davies and

   A.L. Demain, ASM Press, USA (2010).
4. Microbial Biotechnology, Fundamentals of Applied Microbiology by A.N. Glazer and

   H. Nikaido, Cambridge University Press, UK (2007).
5. Microbial Biotechnology: Principles and Applications by Y.K. Lee, World Scientific Publs, Singapore (2006).
6. Microorganisms and Biotechnology by J. Taylor, N. Thornes, UK (2001).
7. Modern Industrial Microbiology and Biotechnology by N. Okafor, Science Publishers, USA (2007).
8. Prescott and Dunn's Industrial Microbiology by G. Reed, CBS Publishers and Distributors, India (2004).
9. Microbiology: A Laboratory Manual, J.G. Cappuccino and N. Sherman, 2002. Addison-Wesley.
10. Laboratory Manual of Experimental Microbiology, R.M. Atlas, A.E. Brown and L.C. Parks, 1995. Mosby, St. Louis.
11. Laboratory Manual in General Microbiology, N. Kannan, 2002. Panima Publishers.

12. Bergey's Manual of Determinative Bacteriology. Ninth edition J.G.Holt, N.R.Krieg, Lippincott Williams, 2000. Wilkin Publishers.

13. Pharmaceutical Microbiology SS Purohit, AK Saluja and HN Kakrani, 2012

M.Sc. Botany (Semester–I)
Elective Course (BOT-2013-T)

Advance Genetic Engineering and Molecular Pharming

Credits: 04 **Total Hours:** 60 (Theory)

UNIT-I 15 hrs

Enzymes used in genetic engineering: Restriction nucleases: exo&endo nucleases, DNA modifying enzymes and their mechanisms of action: DNA polymerases, DNaes, RNaes, Reverse transcriptase, Polynucleotide phosphorylase, Polynucleotide kinase, Alkaline phosphatase, Ligase.
Cloning and expression hosts: Characteristics of cloning and expression host, bacterial, yeast, plant and mammalian host systems for cloning and expression of genes.

UNIT-II 15 hrs

Vectors for plant transformation: Basic features of vectors (Promoters, terminators & sequences influencing gene expression, selectable markers & reporter genes, origin of replication), Vectors for cloning - Plasmids, Bacteriophage λ vectors, Cosmids, BAC and YAC vectors, Shuttle vectors, Expression vectors, Co-integrative and binary vectors for plant transformation
Heterologous gene expression in plants and **Genetic manipulation** of plants for Herbicide tolerance (Roundup ready Soybean), Insect resistance (Bt Cotton), stress tolerance, disease resistance, Improvement of crop yield and quality (Post-harvest loses, longer shelf-life of fruits (flavrsavr tomato), color manipulation of flowers (Blue rose), Making of Golden Rice

UNIT-III 15 hrs

Genome editing (TALEN & CRISPR) and its applications in crop improvement. Applications of DNA based molecular markers (RFLP, RAPD and AFLP) in plant biotechnology.
Science and society: Public acceptance of genetically modified crops (Public concerns, current status of transgenic crops, regulation of GM crops, Cisgenic crops, and products), Introduction to Intellectual property, Biosafety guidelines, Environmental release of GMO's, Risk analysis, Risk Assessment and Risk management.

UNIT-IV

15 hrs

Molecular Pharming in Plants

Introduction and brief history of plant molecular farming; Unique properties of host species for molecular farming (tobacco, alfalfa, white clover, lettuce, spinach, dry seed crops, oil crops, fruit and vegetable crops); Types of plant expression systems for molecular pharming (Stable nuclear transformation, plastid transformation system, virus-infected plants, transiently transformed leaves, hydroponic cultures, hairy roots, shooty teratomas, suspension cell cultures, Oleosin system); Comparison, advantage and disadvantages of production system of molecular pharming (bacteria, yeast, transgenic animal, plant cell culture and transgenic plants).

Plant Made Pharmaceuticals (PMPs)

(1) Plant Made Pharmaceutical and Therapeutic proteins (Human Serum Albumin, Human Insulin-like Growth Factors, Human Interferon, Anti-Microbial Peptides, Therapeutic Enzymes, Lactoferrins) (2) Industrial proteins (3) Monoclonal recombinant antibodies (4) Antigens(Edible vaccines- Rabies, Hepatitis B, Respiratory Syncytial Virus, Enterotoxic *E.coli* and *Vibrio cholerae*). Detailed account of Biopharmaceuticals already in market and close to market.

Suggested Laboratory Exercises:

Aseptic culture techniques for establishment and maintenance of cultures for genetic engineering.

- Preparation of suitable media to grow transformed *E. coli* cells.
- Activity assay of various enzymes involved in genetic engineering.
- Analysis of different Plant DNA samples by molecular markers.
- *Agrobacterium* culture, selection of transformants, reporter gene (GUS) assays.
- Isolation of plant DNA using CTAB method.
- PCR and Gel electrophoresis for gene cloning.
- Demonstration of GLPs and Biosafety in research labs.
- Preparation of Competent cells of *E.coli* for harvesting plant transformation vector.
- Transformation of competent cells of *E coli* with plant transformation vector.
- Mobilization of Ti plasmid from common laboratory host (*E. coli*) to an
- *Agrobacterium tumefaciens* strain
- Development technique for production for transgenic plant (*Agrobacterium tumefaciens* mediated plant transformation).

- Assignments on topics such as GMO, genome editing, PCR, gene cloning and molecular farming etc.

Suggested Readings:

1. Molecular Farming: Plant-Made Pharmaceuticals and Technical Proteins by Rainer Fischer and Stefan Schillberg, Wiley-Blackwell publisher, 2005.
2. Plant tissue culture by Bhojwani SS and Razdan MK. Elsevier, 2004.
3. Molecular Farming in Plants: Recent Advances and Future Prospects by Aiming Wang (Editor), Shengwu Ma (Editor), Springer, 2011.
4. Plant Genetic Engineering: by Jaiwal P K, Vol 8-9, Metabolic Engineering and Molecular Farming (2005), Studium Press. USA.
5. J.Hammond,P. McGarvey and V. Yusibov (Eds.): Plant Biotechnology. Springer Verlag, 2000.
6. T-J.Fu,G. Singh,and W.R. Curtis(Eds):Plant Cell and Tissue Culture for the Production of Food ingredients. Kluwer Academic/Plenum Press.1999.
7. H.S.Chawla:Biotechnology in Crop improvement. International Book Distributing Company,1998.
8. P.K.Gupta:Plant Biotechnology. Rastogi and Co.Meerut,2010
9. Slater A, Scott N, Fowler M: Plant biotechnology: the genetic manipulation of plants. Oxford: Oxford University Press.2010.
10. Metabolic Engineering: *Stephanopoulos, Aristidou, A. A. and Nielsen J.*, Academic Press.
11. Basic Biotechnology-Ratledge C, Kristainsen B, Cambridge Publication.
12. Principles of Crop Improvement by Simmonds N.W. , Longman, London and New York. 1979.

M.Sc. Botany (Semester–I)
Elective Course (BOT–20114-T
: Methods in Plant Sciences

Credits: 04 **Total Hours:** 60 (Theory)

UNIT-I 15 hrs

Microscopic techniques: Visualization of cells and sub cellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes (SEM, TEM), different fixation and staining techniques for EM, image processing methods in microscopy.

Centrifugation: Principle, Types & Applications.

UNIT-II 15 hrs

Spectroscopy: concept of spectroscopy, laws of photometry. Beer Lambert's law, principles and applications of colorimetry. Visible and UV spectroscopy, X ray diffraction, NMR, Mass spectrometry.

Immunotechniques: Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH. 10 hrs

UNIT-III 15 hrs

Electrophoresis: Theory and application PAGE (Native & SDS), 2D Electrophoresis.

Radiolabeling techniques: Detection and measurement of different types of radioisotopes normally used in biology, , Autoradiography-Principle, method, use in gene probe molecules, safety guidelines.

UNIT-IV 15 hrs

Statisitcal Methods: Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Levels of significance; Regression and Correlation; t-test; F-test Analysis of variance; X2 test.

Bioinformatics (Definition, history, applications & scope): Biological databases and Sequence analysis, BLAST and FASTA, Multiple sequence alignment, phylogenetic analysis and Bioinformatics in Drug Discovery.

Suggested Laboratory Exercises:

- Instrumentation in Lab.
- Microscopy- SEM, TEM, Florescence, Staining & fixation procedures
- Centrifugation technique for isolation of cell organelles
- Separation of biomolecules by Column/TLC/partition chromatography.
- Measurement of cell size using stage micrometer and ocular micrometer.
- Quantification of DNA by UV-Visible spectrophotometer.
- Quantification of RNA by UV-Visible spectrophotometer
- NMR spectroscopy technique.
- IR spectroscopy technique.
- Numericals related to biostatistics
- ELISA, RIA, Flow Cytometry
- BLAST and FASTA
- Phylogenetic analysis
- Any other Exercise within scope of the syllabus

Suggested Readings:

1. Keith Wilson and John Walker (2005). Principles and Techniques of Biochemistry and Molecular Biology, 6th edition ,Cambridge University Press.
2. K.L.Ghatak,2011.Techniques and Methods in Biology,PHL learning Private Limited, New Delhi.
3. Upadhyay, Upadhyay and Nath,(2014).Biophysical Chemistry-Principles and Techniques,4th Edition,Himalaya Publishing House Pvt.Ltd.
4. Hammes GD (2005) Spectroscopy for the Biological Sciences; Wiley Interscience, USA.
5. Vinay Sharma. (2008).Text Book of Bioinformatics. Rastogi Publications.
6. Pranav Kumar (2016).Fundamentals and Techniques of Biophysics and Molecular Biology Paperback.Pathfinder Publication.
7. Rosener.(2010).Fundamentals of Biostatistics . Cengage Learning, Inc.

M.Sc. Botany (Semester–I)

Elective Course (BOT-20115-T

: Environmental Pollution and Management

Credits: 04 **Total Hours:** 60 (Theory)

COURSE OBJECTIVES

- To understand major types, sources and impacts of environmental pollutants.
- To study ecological, physiological and toxicological effects of pollution on organisms.
- To learn monitoring methods, environmental standards and analytical techniques.
- To develop knowledge of pollution control, mitigation and sustainable management strategies.
- To promote skills for environmental assessment, conservation and policy awareness.

LEARNING OBJECTIVES

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

6. Identify major pollutants, their sources and their ecological and health impacts.
7. Explain toxicological mechanisms and evaluate pollutant effects using biological indicators.
8. Perform basic environmental sampling and interpret pollution-related data.
9. Understand pollution control technologies, waste management and mitigation strategies.
10. Apply environmental principles in conservation, sustainability and policy contexts.

UNIT I: Fundamentals of Environmental Pollution (15 hrs)

- Concept of pollution: definitions, sources, pathways, biomonitoring.
- **Air pollution:** primary & secondary pollutants, smog, particulates, greenhouse gases.
- Air quality standards, AQI, dispersion models.
- **Water pollution:** physical, chemical, biological pollutants; eutrophication.
- **Soil pollution:** agrochemicals, heavy metals, plastics, industrial waste.
- Bioaccumulation, biomagnification & biotransformation of pollutants.

UNIT II: Toxicology & Biological Effects of Pollutants (15 hrs)

- Introduction to environmental toxicology: dose–response, LD50, NOAEL.
- Mechanisms of toxicity: oxidative stress, endocrine disruption, neurotoxicity.
- Heavy metals (Hg, Pb, Cd, As) – sources & impacts.

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- Pesticides, PAHs, microplastics & emerging contaminants (pharmaceuticals, nanoparticles).
- Effects on wildlife: behavioural, reproductive, developmental and genetic impacts.
- Environmental health issues: air pollution diseases, waterborne pathogens.

UNIT III: Environmental Monitoring & Assessment (15 hrs)

- Sampling methods: water, air, soil, biological samples.
- **Analytical techniques:** spectrophotometry, chromatography (GC, HPLC), AAS, biosensors.
- Biomarkers & bioindicators: algae, invertebrates, fish.
- Ecotoxicological tests: LC50, toxicity bioassays, micronucleus test.
- Environmental Impact Assessment (EIA): principles & process.
- Environmental legislation: EPA (India), Wildlife Protection Act, Water & Air Acts, CPCB/PCB norms.

UNIT IV: Pollution Control, Mitigation & Management (15 hrs)

- **Air pollution control:** filters, scrubbers, catalytic converters, green technologies.
- **Water treatment:** primary–secondary–tertiary treatments, bioremediation, phytoremediation.
- **Solid waste management:** composting, vermitechnology, waste-to-energy, plastic alternatives.
- Climate change mitigation: carbon sequestration, renewable energy, adaptation strategies.
- Biodiversity conservation & habitat restoration.
- Sustainable development: SDGs, circular economy & environmental ethics.

Suggested Readings

Connell, D. W., & Miller, G. J. (2012). *Chemistry and Ecotoxicology of Pollution*. **Wiley-Blackwell.**

- **Waisberg, M., Joseph, P., Hale, B., & Beyersmann, D. (2003). "Molecular and cellular mechanisms of cadmium carcinogenesis."** *Toxicology*, **192(2–3), 95–117.**
- **Alloway, B. J. (2013).** *Heavy Metals in Soils: Trace Metals and Metalloids in Soils and Their Bioavailability* **(3rd ed.). Springer.**
- **Manahan, S. E. (2017).** *Environmental Chemistry* **(10th ed.). CRC Press.**
- **Nathanson, J. A., & Schneider, D. (2021).** *Basic Environmental Technology: Water Supply, Waste Management and Pollution Control* **(7th ed.). Pearson.**
- **Walker, C. H., Sibly, R., Hopkin, S., & Peakall, D. (2012).** *Principles of Ecotoxicology* **(4th ed.). CRC Press.**
- **Connell, D. W. (2009).** *Bioaccumulation of Xenobiotic Compounds*. **CRC Press.**
- **Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017).** *Principles of Instrumental Analysis* **(7th ed.). Cengage.**

- **Friedman, M. S., et al. (2001). "Impact of changes in transport and commuting behaviors during the Olympic Games on air pollution and health."** *JAMA*, **285(7), 897–905.**
- **Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (2013).** *Environmental Engineering*. **McGraw-Hill.**
- **Goel, P. K. (2017).** *Water Pollution: Causes, Effects and Control* **(New Age International).**
- **Rao, M. N., & Datta, A. K. (2017).** *Wastewater Treatment*. **Oxford & IBH.**
- **UNEP. (2019).** *Global Environment Outlook 6 (GEO-6): Healthy Planet, Healthy People*. **United Nations Environment Programme.**
- **IPCC. (2021).** *Climate Change 2021: The Physical Science Basis*. **Cambridge University Press.**
- **Rockström, J., et al. (2009). "Planetary boundaries: Exploring the safe operating space for humanity."** *Ecology and Society*, **14(2).**
- **MoEFCC. (2006).** *National Environmental Policy (NEP), Government of India*.
- **Central Pollution Control Board (CPCB). (2022).** *National Air Quality Status & Trends Report*.
- **Sharma, B. K. (2019).** *Environmental Chemistry* **(16th ed.). Goel Publishing House, India.**

PRACTICAL SYLLABUS

1. Water quality analysis (pH, DO, BOD, hardness – basic parameters).
- Air quality monitoring: particulate matter, dust fall (demonstration/field).
- Soil analysis: texture & organic matter.
- Identification of bioindicator species (algae, insects, fish).
- Study of EIA format and environmental regulation case study.
- Demonstration of bioremediation/ phytoremediation models.
- Toxicity test (LC50) – demonstration/problem-solving.
- Field visit report (STP, solid waste plant, polluted habitat, etc.).

M.Sc. Botany (Semester–II)
Core Course (BOT- 20201-T)
Biosystematics of Angiosperms &Reproductive Biology

Credits: 04 **Total Hours:** 60 (Theory)

UNIT-I 15 Hrs

Principle and Methods of Taxonomy: Taxonomic Hierarchy, Species, Genus, Family and other categories. Salient features of International Code of Botanical Nomenclature.

Taxonomic Tools: Herbarium, Flora, Botanical Gardens, biochemical and molecular techniques, computers and GIS (Geo Information Systems). Cladistics in taxonomy. Numerical taxonomy and Sero taxonomy.

Taxonomic evidences: Palynology, Embryology, Cytology, Phytochemistry and Genome analysis.

Classification: Artificial system (Linnaeus), Natural system (Bentham and Hooker), and Phylogenetic (APG system) with merits and demerits of these systems.

UNIT-II 15 hrs

Taxonomic Studies: Ranunculaceae, Pappaveraceae, Capparidaceae, Caryophyllaceae, Leguminosae, Cucurbitaceae, Apiaceae, Rubiaceae, Asteraceae, Asclepiadaceae, Apocynaceae, Convolvulaceae, Solanaceae, Acanthaceae, Bignoniaceae, Lamiaceae, Chenopodiaceae, Euphorbiaceae, Liliaceae, and Poaceae. Phylogeny of Angiosperm: Origin and evolution of Angiosperms. Fossil Angiosperms.

UNIT-III 15 hrs

Embryology: Introduction, History. Male gametophyte: Microsporogenesis, Tapetum; types and functions, Sporopollenin, Pollen structure, pollen Allergy.

Female gametophyte: Brief Introduction to Embryo sac development (No type studies). Organization of Mature Embryo sac, Ultra Structure of Egg apparatus, Nutrition of Embryo sac.

UNIT-IV

15 hrs

Pollination: Brief account, Structure, Histo-chemical details of style and Stigma, Pollen germination, pollen embryo sac. Self incompatibility Fertilization: Path of entry of pollen tube, Site of pollen discharge. Double fertilization.

Endosperm: Types of endosperm development, Endosperm haustoria, Endosperm culture & function. Embryogenesis: Monocot and dicot embryo development; Physiology and genetics of Embryo development, Somatic embryogenesis.

Suggested Practical exercises

Study of vegetative and floral characters of specimens from representative, locally available families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula and systematic position according to Bentham & Hooker's system of classification):

Ranunculaceae Ranunculus, Delphinium

Brassicaceae Brassica, Coronopus, Iberis

Pappaveraceae: Argemone

Capparidaceae: Capparis, Cleome

Malvaceae: Hibiscus, Abutilon, Sida, Malvastrum

Pedaliaceae: Pedalium murex

Leguminosae: Acacia, Bauhinia, Cassia, Crotalaria, Pea

Caryophyllaceae: Dianthus, Spergula, Stellaria

Cucurbitaceae: Coccinia, Luffa, Momordica

Rubiaceae: Haemalia, Ixora

Asclepiadaceae: Calotropis, Cryptostegia

Apocyanaceae: Nerium, Catharanthus, Tabernaemontana

Convolvulaceae: Ipomoea, Convolvulus

Solanaceae Datura, Withania, Petunia, Solanum

Acanthaceae: Adhatoda, Barleria

Bignoniaceae: Tecomella, Tecoma

Labiatae Salvia, Ocimum, Majorana

Nyctaginaceae: Bauganvillea

Chenopodiaceae: Chenopodium

Umbelliferae: Coriandrum, Foeniculum

Asteraceae: Sonchus, Launaca, Vernonia, Ageratum, Eclipta, Tridax

Euphorbiaceae - Ricinus, Euphorbia, Jatropha

Liliaceae Asphodelus, Lilium, Alium

Poaceae Triticum, Hordeum, Avena

Construction of taxonomic keys and Nomenclature exercise.

Training in using floras and herbarium for identification of specimens described in the class.

Study of anther and ovule using permanent slides/photographs.

Field study of several types of flowers with different pollination mechanisms.

Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, Cannabis sativa, Crotoloria, Tradescantia, Brassica, Petunia, Solanum melongena, etc.)

Tests for pollen viability using stains and in vitro germination.

Emasculation, bagging and hand pollination to study pollen germination.

Study of nuclear and cellular endosperm through dissections and staining.

Dissection and observation of Embryo sac haustoria in Santalum or Argemone.

Structure of endosperm (nuclear and cellular) using permanent slides/Photographs.

Dissection and observation of Endosperm haustoria in Crotalaria or Coccinia.

Developmental stages of dicot and monocot embryos using permanent slides/photographs.

Field trips within and nearby areas in the university/college campus, compilation of field notes and preparation of herbarium sheets of such plants wild or cultivated that are abundant. Photography of the collected specimens and their habitat (if applicable).

Submission: Record book, Tour report and Herbarium specimens of at least 50 properly dried and pressed wild or cultivated plants from your locality.

Suggested Readings

Davis, P.H. and V.H. Heywood. 1991. Principles of Angiosperm Taxonomy. Today and Tomorrow Publications, New Delhi

Heywood - Plant taxonomy - Edward Arnold London.

Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.

Judd, W.S, Christopher S. Campbell, Elizabeth A. Kellogg, Peter F. Stevens, and Michael J. Approach, 4rd ed. Sinauer

Lawrence - Taxonomy of Vascular Plants - Oxford & IBH, New Delhi.

Datta S C, Systematic Botany, 4th Ed, Wiley Eastern Ltd., New Delhi, 1988.

Mondal AK. 2011. Advanced Plant Taxonomy. New Central Book Agency Pvt. Ltd., Kolkata.

Naik V.N., Taxonomy of Angiosperms, 1991. Tata Mcgraw-Hill Pub. Co. Ltd., New Delhi.

Pandey, B.P. 2007. Taxonomy of Angiosperms. S. Chand and Company Limited. New Delhi.

Pandey, S. N, and S.P. Misra (2008)-Taxonomy of Angiosperms- Ane Books India, New Delhi.

Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York.

Sharma, O.P. 2009. Plant Taxonomy. Tata McGraw-Hill. Mumbai.

Simpson MG, 2006. Plant Systematics. Elsevier Academic Press, California, USA.

Singh, G. (2012). Plant Systematics: Theory and Practice (3 edition). Oxford & IBH Pvt. Ltd., New Delhi.

Singh V. & Jain - Taxonomy of Angiosperms - Rastogi Publications, Meerut.

APG III (2009) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Bot. J. Linnaean Soc. 161: 105-121.

Bhojwani S. S. and Bhatnagar S. P. (2000). The embryology of Angiosperms (4th revised and enlarged edition) Vikas Publishing house, New Delhi.

Johri, B.M. (2011) Embryology of Angiosperms. Springer-Verlag, Berlin.

Maheswari, P. (1971). An Introduction to Embryology of Angiosperms. McGraw Hill- Book Co., London.

Pandey, A. K. (2000) Introduction to Embryology of Angiosperms. CBS Publishers- & Distributors Pvt. Ltd., New Delhi

Any local/state/regional flora published by BSI or any other agency.

Reference and Reading Books:

1. Raghavan V. (1997). Molecular embryology of flowering plants. Cambridge University press, Cambridge.

2. Raghavan V. (1986). Embryogenesis in angiosperms- A developmental and experimental studies. Cambridge University Press New York USA.

3. Shivanna K. R. and Sawhney V. K. (eds) 1997. Pollen Biotechnology for crop production and improvement. Cambridge University, Cambridge.

4. Hans Mohr & P. Schopfer (2006) Plant Physiology, Springer (India) Pvt. Ltd., New Delhi

5. Verma, SK. A Textbook of Plant Physiology, Biochemistry & Biotechnology. S. Chand & Co.

M.Sc. Botany (Semester–II)
Core Course (BOT- 20202-T)
Pteridophytes, Gymnosperm and Paleobotany

Credits: 04 **Total Hours:** 60 (Theory)

COURSE OBJECTIVES (COs):

Objectives of the Course

- This course is designed to provide fundamental and advance knowledge about the Pteridophytes, Gymnosperms and Palaeobotany.

Course Learning Objectives

After completion of this course, students will be able to

- Understand about the evolution of stellar system and heterospory.
- Gain knowledge about the general character and classification of pteridophytes.
- Understand about the general character of gymnosperms.
- Learn about evolutionary relationship of Cycadopsida, Coniferopsida, Gnetopsida, Coniferales etc.
- Understand about the basic principle of paleobotany and know about prominent scientist.

Unit -I

15Hrs

- **Pteridophytes:** Distribution, classification by International Committee of Botanical Nomenclature (ICBN), Economic importance of Pteridophytes.
- General account of fossil Pteridophytes, Psilopsida, Lycopsida, Sphenopsida and Pteropsida classes.
- Morphology, anatomy, reproduction, classification, life history of: *Tmesipteris, Lycopodium, Gleichenia, Isoetes, Ophioglossum* and *Azolla.*

Unit -II

15Hrs

- **Gymnosperms:** Distribution, morphology, anatomy, reproduction; classification, life history and evolution. Cycadales (*Zamia*), Ginkgoales (*Ginkgo*), Coniferales (*Pinus, Taxus, Araucaria* and *Biota*), Welwitschiales (*Welwitschia*), Gnetales (*Gnetum*).

Unit -III

15Hrs

- **Paleobotany:** History of paleobotany, formation and types of fossils, techniques of study of fossils, Geological time scale. Brief account of Pteridospermales (*Lygenopteris, Medullosa, Caytonia* and *Glossopteris*).

Unit -IV 15 hrs

- Brief account of Cycadeoidales (Cycadeoidea), Cordaitales (Cordaites).
- Paloeobotany and the evolution of vascular plants.
- Origin and evolution of stele, heterospory and seed habit.
- Applied aspects of paleobotany, use in coal and petroleum exploration

Suggested Laboratory Exercises:

- Morphological and anatomical study of representative members of Pteridophytes and Gymnosperms in their natural habitat found in your locality with special reference to, *Lycopodium, Isoetes, Gleichenia, Ophioglossum* and *Azolla* in Pteridophytes.
- *Zamia, Ginkgo, Pinus, Taxus, Araucaria, Biota* and *Gnetum* in Gymnosperms. Collection and study of fossils.

Suggested Readings:

1. Parihar, N.S. 1996. Biology & Morphology of Pteridophytes. Central Book Depot, Allahabad.
2. Sporne, K.K. 1991. The Morphology of Pteridophytes.B.I. Publishing Pvt. Ltd.,Bombay.
3. Stewart, W.N. and Rathwell, G.W. 1993. Paleobotany and the Evolution of

A Singh

Plants.Cambridge University Press, UK.
4. Bhatnagar, S.P. and Moitra, A. 1996. Gymnosperms. New Age International Pvt. Ltd., New Delhi.
5. Singh, H. 1978, Embryology of Gymnosperms, Encyclopaedia of Plant Anatomy X. Gebruder Bortraeger, Berlin, Germany.
6. Smith, G.M. 1955. Cryptogamic Botany Vol II Tata McGraw Hill Book Co, NY.
7. Pandey, B.P.1993. College Botany. Vol. II. S. Chand and Company Ltd., New Delhi.
8. Arnold, Chester, A. 2000. An Introduction to Paleobotany. Agrobios, (India).
9. Rashid.A.2001.An introduction to Pteridophyta(II edition). Vikas publishing house, Pvt. Ltd., New Delhi.
10. Sunderrajan,S (2007), Introduction to Pteridophyta, New Age International Publishers, New Delhi.

M.Sc. Botany (Semester–II)
Core Course (IRM-2020AT)
Introduction to Research Methodology

Credits: 04 **Total Hours:** 60 (Theory)

1. Course Objectives (COs)

The course aims to:

1. Develop understanding of scientific research principles, ethics and methodologies.
2. Equip students with skills to formulate hypotheses, research questions and experimental designs.
3. Train students in data collection, statistical analysis and scientific writing.
4. Develop competence in handling research tools: referencing, plagiarism checks and data presentation.
5. Prepare students for dissertation/project work using modern research practices.

2. Learning Outcomes (LOs)

After successful completion, students will be able to:

1. Explain concepts, types and approaches of biological research.
2. Formulate research problems, hypotheses and suitable methodologies.
3. Apply statistical tools for data analysis and interpretation.
4. Prepare scientific reports, theses and research articles using standard formats.
5. Demonstrate ethical and responsible conduct in research and publication.

UNIT I: Foundations of Research (15 hours)

1. **Introduction to Research**
   - Meaning, nature, scope and significance of research
   - Types of research: basic, applied, qualitative, quantitative, interdisciplinary
   - Scientific temper and scientific method
2. **Research Problem & Hypothesis**
   - Identification of research problem
   - Criteria of good research problem
   - Types of hypotheses, characteristics, formulation
3. **Research Design**
   - Experimental, descriptive, exploratory, diagnostic, cross-sectional & longitudinal designs
   - Variables: independent, dependent, controlled, confounding
4. **Sampling Methods**
   - Probability & non-probability sampling
   - Sample size determination
   - Errors in sampling
5. **Laboratory and Field Research in Zoology**
   - Experimental setups, field surveys, population studies
   - Safety, ethics, biosafety levels, permits

UNIT II: Data Collection & Analysis (15 hours)

1. **Data Collection Techniques**
   - Primary and secondary data

- Questionnaires, interviews, surveys
- Observational methods
- Experimental data acquisition

2. **Measurement & Scaling Techniques**
   - Nominal, ordinal, interval, ratio scales
   - Reliability and validity
3. **Introduction to Biostatistics**
   - Types of data, sampling distribution
   - Measures of central tendency (mean, median, mode)
   - Measures of dispersion (SD, variance, SE)
4. **Statistical Tests**
   - t-test, chi-square test, ANOVA (conceptual understanding)
   - Correlation & regression
   - Non-parametric tests (Mann–Whitney, Kruskal–Wallis)
5. **Data Representation**
   - Tables, graphs, charts
   - Histogram, polygon, scatter plot

UNIT III: Research Tools & Scientific Writing (15 hours)

1. **Research Tools & ICT in Research**
   - Reference management tools: Zotero, Mendeley
   - Plagiarism detection tools: Turnitin, iThenticate
   - Data analysis software: Excel, SPSS/R (conceptual)
2. **Scientific Writing**
   - Structure of thesis & dissertation
   - Writing research papers: IMRAD format
   - Abstract, introduction, methods, results, discussion formatting
3. **Referencing Styles**
   - APA, MLA, Chicago, Vancouver
   - Citation rules, bibliography preparation
4. **Presentation Skills**
   - Seminar and conference presentation
   - Poster presentation techniques
5. **Communication Skills in Research**
   - Technical reports
   - Review articles, short communications

UNIT IV: Research Ethics, Intellectual Property & Project Management (15 hours)

1. **Research Ethics**
   - Ethical principles in biological sciences
   - Animal ethics: CPCSEA guidelines
   - Human ethics: Informed consent, confidentiality
2. **Plagiarism & Academic Integrity**
   - Types of plagiarism
   - Preventive strategies
   - Ethical authorship and contribution
3. **Intellectual Property Rights (IPR)**
   - Patents, copyrights, trademarks
   - Patent filing basics
   - Biological materials & patent issues
4. **Funding & Research Project Management**

- Grant writing
- Funding agencies (DST, DBT, CSIR, UGC, SERB, ICAR)
- Budgeting, timeline development
- Maintaining lab records, research notebooks

5. **Research Dissemination**
   - Peer review process
   - Journal selection, impact factor, h-index
   - Open access, predatory journals

Suggestive Readings:

1. **Kothari, C.R. & Garg, G. (2019).** ***Research Methodology: Methods and Techniques.*** **New Age International Publishers.**
2. **Creswell, J.W. & Creswell, J.D. (2017).** ***Research Design: Qualitative, Quantitative and Mixed Methods Approaches.*** **Sage Publications.**
3. **Sokal, R.R. & Rohlf, F.J. (2012).** ***Biometry: The Principles and Practice of Statistics in Biological Research.*** **W.H. Freeman & Co.**
4. **Wayne W. Daniel & Chad L. Cross. (2018).** ***Biostatistics: A Foundation for Analysis in the Health Sciences.*** **Wiley.**
5. **Day, R. & Gastel, B. (2012).** ***How to Write and Publish a Scientific Paper.*** **Cambridge University Press.**
6. **Laurel D. Hansen & Mark VanBaalen. (2015).** ***Research Methods in Biology.*** **Cambridge Scholars Publishing.**
7. **Graf, J. (2004).** ***Introduction to Research Methods: A Hands-On Approach.*** **Sage Publications.**
8. **Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA). Guidelines for Laboratory Animal Facility (Latest Edition).**
9. **Open-access Manuals:**
   - *UGC Research and Publication Ethics (RPE) Guidelines*
   - *DBT/ICMR Ethical Guidelines for Biomedical Research*

M.Sc. Botany (Semester–II)
Laboratory Course – BOT-20203-P

Credits: 04 **Total Hours:** 05

Scheme of Practical Examination

Laboratory Course Based on BOTCC201, 202 BOTEL203,205

S. No.	Particulars	Marks
1	Exercise based on BOTCC201	12
2	Exercise based on BOTCC202	12
3.	Exercise based on BOTEL203	12
4	Exercise based on BOTEL205	12
4	**Spotting** *(8 specimens × 3 marks each)*	24
5	**Seminar / Presentation**	15
6	**Viva Voce**	07
7	**Practical Record / Journal**	06
	Total Marks	**100**

Guidelines for Practical Examination

- Each exercise should test applied and conceptual understanding aligned with NEP–2020 learning outcomes.
- Spotting should include museum specimens, permanent slides, diagrams, or photographs from all three core courses.
- Seminar presentation will assess analytical thinking, data interpretation and communication skills.
- Viva voce will evaluate practical knowledge, integration of theory with experiment and contemporary understanding.
- Practical records should be neat, properly labelled and duly certified by the course instructor.

M.Sc. Botany (Semester–II)
Elective Course (BOT-20205-T)
Developmental Biology of Plants

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives :

Unlike animals, plants are modular and characterized by developmental reiteration of organs in their body plan. In order to understand this complexity, one has to look into the various aspects of growth, development and reproduction. This course aims at making the students acquainted with the fundamentals, and current understanding of the mechanisms associated with specification, development and differentiation of various plant organs.

Course Learning Outcomes

The students will be learning the following main aspects.

1. The aspects of growth in plants different types of networks that regulate growth and development.

2. The main growing regions of the plant and maintenance of their meristematic identity while forming cells that are determined and undergo differentiation.

3. Different organs or tissues with specific structures and functions are formed in the plant body and what are the key mechanisms that regulate their development.

4. Formation of three-dimensional structures in plants and the mechanisms that are responsible for the diversity observed in their architecture.

5. Transformation of shoot apical meristem into an inflorescence and floral meristem, and their development.

6. Establishment of male and female germ lines, and coordination of a variety of tissues coordinate to form gametes.

Unit I — 15 hours

Key concepts in growth and development, plant growth vs animal growth, positive and negative regulatory networks; coordination of growth, isotropic and anisotropic growth, polarity, proliferation and termination of growth, growth and development of three-dimensional structures, developmental plasticity; Meristems, different types, RAM, SAM, Cell fate determination, lineage decisions, developmental patterning.

Unit II — 15 hours

Differentiation of cells: stomata, trichomes, tracheary elements etc.; development of organs, key regulatory mechanisms for organ identity, shape and size of specific organs such as leaf, stem, root; plant architecture, growth of main stem and lateral organs, determinate and indeterminate growth, branching pattern and apical dominance, root and shoot architecture, phyllotaxy.

Unit III — 15 hours

Transition to flowering; Inflorescence and floral meristems; maintenance of inflorescence and floral domains; Floral homeotic mutations in *Arabidopsis*, *Antirrhinum* and *Petunia*; Regulation of

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anther and ovule development, Microsporogenesis and microgametogenesis, Megasporogenesis and megagametogenesis, Domains of pollen-wall; Pollen embryogenesis, Male sterility.

Unit IV **15 hours**

Pollination; Progamic phase; *In vitro* pollen germination; Pollen tube growth and guidance; Double-fertilization; Self-incompatibility; Polarity during embryogenesis; Maternal to zygotic transition; Embryo pattern mutants, *In vitro* fertilization, endosperm development, Apomixis, Polyembryony, Somatic embryogenesis.

Lab based exercises:

1. Study of surface structures in plants-I Stomata
2. Study of surface structures in plants-II Trichomes
3. Study of planar structures in plants
4. Study of complex tissues xylem and phloem
5. Study of stem development in dicots and monocots
6. Study of root development in dicots and monocots
7.. Assessment of pollen fertility and viability.
8.. Comparative assessment of viability, germinability and vigour of pollen.
9. Role of transcriptional and translational inhibitors on pollen germinability and tube growth.
10. Assessment of stigma-receptivity by localising non-specific esterases, phosphatases and peroxidases.
11. Study of megasporogenesis, megagametogenesis and mature female gametophyte with the help of permanent slides and electron micrographs.
12. Study of the stages of pollen and ovule development in the wild and mutant plants using permanent slides, electron micrographs and available phenotypes.
13. Study of types and structures of stigma and style through sections in selected taxa.
14.. Study of the embryo, endosperm and haustorium in selected taxa through dissections.

Suggested Readings

1. Beck, C.B. (2010). An Introduction to Plant Structure and Development, II edition
2. Howell, S.H. (1998). Molecular Genetics of Plant Development, Cambridge University Press.
3. Wolpert, L., Jessell, T., Meyerowitz, E., Robertson, E. and Smith, J. (2007). Principles of Development; Oxford, Oxford University Press.
4. Raghavan, V. (1997). Molecular Embryology of Flowering Plants. Cambridge. University Press.
5. Shivanna, K.R. (2003). Pollen Biology and Biotechnology, Science Publishers.
6. Shivanna, K.R. and Rangaswamy, N.S. (1992). Pollen Biology A Laboratory Manual, Springer.

Additional Reading

1. Pua, E-C. and Davey, M.R. (2010). Plant Developmental Biology-Biotechnological perspectives.
2. Fosket, D.E. (1994). Plant, Growth and Development A Molecular Approach, Academic Press.
3. Hopkins, W.G. (2006). The Green World Plant Development, Chelsea House Publication.
4. Leyser, O. and Day, S. (2003). Mechanism of Plant Development, Blackwell Press, 241p.
5. Raghavan, V. (2000). Developmental Biology of Flowering Plants, Springer, Netherlands
6. Bhojwani, S.S., and Razdan, M.K. (1996). Plant Tissue Culture Theory and Practice, Elsevier
7. Whitelam, G.C. and Halliday, K.J. (2007). Light and plant development; Blackwell Publishing.

M.Sc. Botany (Semester–II)
Elective Course (BOT-20206-T)
Physiology, Biochemistry& Biostatistics

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

This course aims to educate student on concepts of proteins, enzymes, basic plant signaling mechanisms, sensory photobiology. The course further deals with physiology of nutrient uptake mechanism, phytohormones signaling, and basics of flower evocation. Develop conceptual understanding of statistical principles applied to biological sciences and Train students to analyze biological data using descriptive and inferential statistics.

Course Learning Outcomes

1. Students will be learning about proteins, folding into specific structures, post translational modifications and degradation mechanisms. The course will also teach about catalytic mechanism of enzymes, its inhibitors and regulation.

2. The students will be learning about the various signal transduction mechanisms in plants. The concept of second messengers, calcium signaling, kinases/phosphatases in plant signaling would be delineated to enhance their grasping power for understanding of different signaling pathways operative in plants. Two component signaling concepts would be introduced and extended to plant hormone signaling. Quorum sensing and its potential biotechnological applications should be clear to students after these classes.

3. During the course students will gain knowledge about various mechanisms such as channel or transport proteins involved in nutrient uptake in plants. Further the course will deal with various phytohormones and their role in physiology of growth and development.

4. This course will introduce students to physiological advances in sensory photobiology. Students will gain the knowledge on physiology of flowering, molecular basis of light mediation of flowering mechanism. Apply appropriate statistical tools to analyze biological data. Interpret hypothesis-testing results and perform probability-based analyses.

Detailed Syllabus

Unit I **15 hours**

Protein structure, Enzymes and Signal Transduction

Hierarchical structure of proteins; folding; ticketing; degradation; molecular motors and pumps. Enzymes and regulation of enzymatic activity. Overview of signal transduction, second messengers, receptors, phospholipid signaling, calcium-calmodulin cascade, specific signaling

mechanisms and their regulation, e.g. simple and hybrid type of two-component sensor-regulator system in bacteria and plants, quorum sensing.

Unit II — 15 hours

Nutrient Uptake
Apoplastic and symplastic transport mechanisms, role of aquaporins and transporter proteins, structure-function relationship of inward and outward ion channels, dual action of ATPases/pumps and modulation of their activity.

Phytohormones Biosynthesis, Signaling and Stress Responses
Concept of phytohormones as chemical messengers, techniques for detection and quantification of phytohormones, classical approaches and use of mutants in understanding phytohormones actions, phytohormones under biotic and abiotic stresses, synthetic regulatory compounds and their diverse uses.

Unit III — 15 hours

Physiology of photomorphogenesis and flowering
Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; scotomorphogenesis and photomorphogenesis. Flowering as a multi-organ function, floral induction, evocation and development. Regulation of flowering by light and temperature and role of circadian rhythm.
Fundamentals of Biostatistics

- **Introduction to Biostatistics:** Types of biological data; variables; scales of measurement.
- **Data Presentation:** Frequency distribution, tabulation, graphical representation (histograms, bar diagrams, pie charts, box plots).
- **Measures of Central Tendency:** Mean, median, mode, geometric and harmonic mean.
- **Measures of Dispersion:** Range, variance, standard deviation, coefficient of variation, standard error.

Unit IV — 15hours

- **Probability and Distribution:** Basic probability rules; binomial, Poisson and normal distribution.
- **Correlation and Regression:** Pearson and Spearman correlation; linear regression.

Inferential Statistics

- **Sampling Methods:** Random sampling techniques; sampling errors; sample size determination.
- **Hypothesis Testing:** Null and alternate hypotheses, p-values, levels of significance.
- **Parametric Tests:** t-test (one sample, two sample, paired), Z-test, F-test, ANOVA (one-way and two-way).
- **Non-Parametric Tests:** Chi-square test; Mann–Whitney U test; Kruskal–Wallis test.
- **Statistical Software:** Introduction to SPSS/R; analysis and interpretation of biological datasets.

Lab based Exercises:

Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below

1. Comparative assessment of methods for protein quantitation.
2. Study of enzyme kinetics for determination of Km value, nature of inhibition – competitive/non-competitive.
3. Study of enzyme kinetics for effect of time/ enzyme concentration/ pH.
4. Extraction of proteins from root and shoot of Brassica seedlings and comparative quantitative estimation of proteins by Bradford's method.
5. Qualitative comparison of root and shoot protein profile on SDS PAGE
6. To determine molecular weight of polypeptides from root/ shoot samples from CBB stained SDS PAGE gel
7. To study the lipid peroxidation under salinity stress in Indian mustard leaf samples by estimating the malondialdehyde (MDA) content
8. To study the role of compatible osmolyte for salinity tolerance in Indian mustard by estimating the proline content in leaf samples
9. Analysis of total nitrogen and ammonium contents in leaves using Nessler's and other associated reagents to get an insight of N-metabolism in plants.
10. In vivo assay for nitrate reductase in leaf tissues.
11. Qualitative and quantitative analysis of photosynthetic pigments and anthocyanins by spectrophotometric and chromatographic techniques.

Suggested Readings:

1. Buchanan, B., Gruissem, G. and Jones, R. (2015). Biochemistry and Molecular Biology of Plants. 2nd Edition, American Society of Plant Physiologists, USA.

2. Davies P J. (2010). Plant Hormones Biosynthesis, Signal Transduction, Action. 3rd Edition, Kluwer Academic Publisher, Dordrecht, The Netherlands.

3. Jordan, B.R. (2006). The Molecular Biology and Biotechnology of Flowering, 2nd Edition, CAB International, U.K.

4. Nelson, D.L., and Cox, M.M. (2021). Lehninger Principles of Biochemistry (8th edition). W.H. Freeman & Co., New York.

5. Taiz, L. and Zeiger, E., Møller, I.M., Murphy, A. (2023) Plant Physiology and Development.. 7th Edition. Sinauer Associates, USA.

Biostatistics

1. Zar, J.H. *Biostatistical Analysis*. 5th Ed., Pearson Education, 2010.
2. Sokal, R.R., & Rohlf, F.J. *Biometry: The Principles and Practice of Statistics in Biological Research*. 4th Ed., W.H. Freeman, 2012.
3. Prasad, S. *Elements of Biostatistics*. Rastogi Publications, 2015.
4. Khan, I.A., & Khanum, A. *Fundamentals of Biostatistics*. Ukaaz Publications, 2014.

Additional Readings:

1. Heldt, H-W. and Piechulla, B. (2024). Plant Biochemistry, 6th Edition. Academic Press, NY.

2. Bhatla, S.C., Lal, M.A. (2024). Plant Physiology, Development and Metabolism. 2nd Edition. Springer Nature, Singapore.

M.Sc. Botany (Semester–II)
Elective Course (BOT-20207-T)
: Genetic Engineering and r DNA Technology

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

1. Provide conceptual understanding of principles and tools used in genetic engineering.
2. Develop proficiency in DNA/RNA manipulation, gene cloning and expression systems.
3. Introduce modern genome-editing technologies and their applications.
4. Train students in methodological approaches like PCR, vectors, blotting, sequencing and rDNA construction.
5. Enable understanding of biosafety, ethical issues and regulatory frameworks related to genetic engineering.

Learning Outcomes (LOs):

After completing the course, students will be able to:

1. Explain molecular tools and methodologies used in genetic manipulation.
2. Perform and interpret gene cloning, vector design and expression strategies.
3. Evaluate genome editing technologies like CRISPR-Cas, ZFN and TALENs.
4. Apply techniques such as PCR, hybridization, sequencing and DNA–protein interactions.
5. Understand biosafety, risk assessment and ethical considerations in rDNA technology.

UNIT–I: Tools & Techniques of Genetic Engineering (15Hours)

1. DNA Manipulating Enzymes

- Restriction endonucleases: Types, sequence recognition, cleavage patterns
- DNA ligase, alkaline phosphatase, polynucleotide kinase
- Exonucleases, endonucleases, topoisomerases
- Reverse transcriptase, RNase H
- DNA polymerases (Taq, Pfu, Vent), RNA polymerases

2. DNA Separation & Analysis

- Agarose gel electrophoresis
- PAGE (native & denaturing)
- Pulsed-field gel electrophoresis
- Southern, Northern and Western blotting
- Hybridization techniques

3. DNA Amplification

- PCR: Principles, types (RT-PCR, qPCR, nested PCR, multiplex PCR, touchdown PCR)
- Primer design
- PCR troubleshooting and optimization

UNIT–II: Vectors, Gene Cloning & Gene Expression Systems (15Hours)

1. Cloning Vectors

- Plasmid vectors: pBR322, pUC
- Phage vectors: λ phage, M13
- Cosmids, phagemids
- BAC, YAC, PAC vectors
- Shuttle vectors
- Expression vectors (bacterial, yeast, insect, mammalian)

2. Gene Cloning Strategies

- Construction of recombinant DNA
- Linkers, adapters, homopolymer tailing
- Selection and screening: blue–white screening, reporter genes, selectable markers
- Genomic and cDNA libraries: construction, screening, applications

3. Gene Expression Systems

- Prokaryotic & eukaryotic expression systems
- Inducible vs. constitutive promoters
- Recombinant protein production and purification
- Fusion proteins, His-tag purification, GST-tag purification

UNIT–III: Genome Editing, Gene Silencing & Advanced Molecular Tools (15Hours)

1. Genome Editing Technologies

- CRISPR-Cas9: mechanism, gRNA design, PAM specificity
- Base editing & prime editing
- TALENs, ZFNs
- Applications in medicine, agriculture, biotechnology

2. Gene Silencing Approaches

- RNA interference (RNAi): siRNA, miRNA
- Antisense technology
- ribozymes

3. Molecular Interaction & DNA Sequencing Technologies

- DNA–protein interactions (EMSA, ChIP, footprinting assays)
- Sanger sequencing
- Next-generation sequencing (NGS) platforms
- Applications of genomics and transcriptomics

UNIT–IV: Applications, Biosafety, Regulations & Ethical Issues

Total Hours: 15

1. Applications of Genetic Engineering

- Transgenic plants, animals and microbes
- Gene therapy (in vivo and ex vivo)
- Pharmaceutical products: insulin, growth hormone, vaccines
- GMOs: detection and molecular characterization
- Industrial and environmental applications

2. Biosafety & Bioethics

- Biosafety levels (BSL-I, II, III, IV)
- Risk assessment of GMOs
- Containment strategies
- Laboratory safety guidelines for rDNA research

3. Regulatory Framework

- International guidelines: NIH, WHO, OECD
- Indian regulations: DBT, RCGM, GEAC
- Cartagena Protocol on Biosafety
- IPR in biotechnology
- Patenting of biological materials and genes

Suggested Readings:

1. **Brown, T. A. (2020). *Gene Cloning and DNA Analysis*. Wiley.**
2. **Primrose, S. B., Twyman, R., & Old, R. (2019). *Principles of Gene Manipulation and Genomics*. Wiley-Blackwell.**
3. **Watson, J. et al. (2018). *Recombinant DNA: Genes and Genomes*. W.H. Freeman.**
4. **Glick, B. R., & Pasternak, J. J. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. ASM Press.**
5. **Lodish et al. (2021). *Molecular Cell Biology*. W. H. Freeman.**
6. **Sambrook & Russell (2012). *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor Laboratory Press.**
7. **Campbell & Farrell (2021). *Biochemistry*. Cengage Learning.**
8. **Griffiths et al. (2020). *Modern Genetic Analysis*. W. H. Freeman.**

M.Sc. Botany (Semester–II)
Elective Course (BOT-20208-T
Principles of Plant Breeding

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

- This course is designed to provide the advance theoretical knowledge of principles of plant breeding.

Course Learning Outcomes

After completion of this course, students will be able to

- To develop conceptual understanding of plant breeding.
- Develop conceptual understanding of plant genetic resources, plant breeding, gene bank and gene pool.
- Learning the methods of crop improvement through plant breeding
- Leaning the practical methods of plant breeding.

Unit -I

15Hrs

- **Overview & Historical perspectives:** History of Plant Breeding-the pioneers, their theories and plant breeding techniques.
- **Population and quantitative Genetic principles:** Concept of Population, gene pool, gene frequency and inbreeding and its implications in breeding, Qualitative genetics versus Quantitative genetics, the concept of Population Improvement.
- **Reproductive systems:** Importance of Mode of Reproduction, Types of Reproduction, Autogamy, Haploids and double haploids: their application in plant breeding, Allogamy, Inbreeding depression, hybrid vigour, Hybridization, wide crosses, clonal propagation and *In vitro* culture.

Unit -II

15Hrs

- **Germplasm for Breeding:** Variation-Types, origin and scale, Plant Domestication- Centres & Models, Plant Genetic Resources-Importance & Sources of Germplasm, Concept of Gene pools, Crop vulnerability, Germplasm conservation: *In situ*& *Ex situ,* Types of Germplasm collection, Germplasm storage technologies, Plant explorations & Introductions & their impact on agriculture.

Unit -III

15Hrs

- **Breeding Objectives:** Yield and morphological trait- Yield potential, Harvest Index, breeding for lodging resistance, shattering resistance, plant stature & early maturity; Quality traits- breeding for improved protein content, improved fatty acid content, seedlessness in fruits,

  elayed ripening & novel traits, Breeding for resistance to disease & insect pests – Resistance Breeding strategies; Abiotic Stresses –Breeding for drought resistance, cold tolerance, salt tolerance, heat stress, aluminium toxicity, oxidative stress, resistance to water logging.

Unit -IV

15Hrs

- **Selection Methods:** Breeding -self-pollinated species- Mass selection, pure line selection, Pedigree selection & Bulk population; cross pollinated species - hybrid cultivars and clonally propagated species.
- **Molecular Breeding:** Molecular markers- classification, Mapping of Genes-gene maps & QTL mapping, Marker assisted selection, Mutagenesis and Polyploidy in Plant Breeding
- **Marketing and Societal issues in Breeding:** Performance and Evaluation for crop cultivar release, Seed certification and commercial seed release, Regulatory and Legal issues, Value driven concepts and social concerns, International Plant breeding Efforts. Plant cultivar protection, legislation, patenting and transgenics.

Suggested Laboratory Exercises:

- Vegetative propagation methods of important crops of the locality.
- Emasculation, selfing and crossing techniques.
- Floral biology in self pollinated species.
- Floral biology in cross pollinated species.
- Floral biology in self pollinated species.
- Selection methods in segregating populations and evaluation of breeding material.
- Germplasm conservation methods- In situ & Ex situ methods.
- Haploid production.
- In situ & ex situ conservation methods
- Analysis of variance (ANOVA).
- Maintenance of experimental records
- Field inspection at different growth stages to study various breeding objectives.

Suggested Readings:

1. George Acquaah, (2012) Principles of Plant Genetics and Breeding.Wiley-Blackwell.
2. B.D.Singh and A.K.Singh, (2015).Marker Assisted Plant Breeding, Springer.
3. B.D.Singh, (2015). Plant Breeding principles & Methods, Kalyani Publishers.
4. Jack Brown, Peter Caligari and Hugo campos, (2014). An Introduction to Plant Breeding, Wiley.
5. Brown and Caligari, (2008). An Introduction to Plant Breeding, Blackwell Publishing.
6. Chopra VL. (2001). Breeding Field Crops. Oxford & IBH.
7. Chopra VL. (2004). Plant Breeding. Oxford & IBH.
8. Gupta SK. (2005). Practical Plant Breeding. Agribios. Jodhpur.
9. Roy D. (2003). Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ.House.
10. Sharma JR. (2001). Principles and Practice of Plant Breeding. Tata McGraw-Hill.
11. Simmonds NW. (1990). Principles of Crop Improvement. English Language BookSociety.
12. Dana, Sukumar. (2001). Plant Breeding. Naya Udyog, Colcutta. 700 006.
13. Kucku, Kobabe and Wenzel, (1995). Fundamentals of Plant Breeding. Narosa Publishing House.
14. Singh BD. (2006). Plant Breeding. Kalyani.
15. Singh P. (2002). Objective Genetics and Plant Breeding. Kalyani.
16. Singh P. (2006). Essentials of Plant Breeding. Kalyani.
17. Singh S & Pawar IS. (2006). Genetic Bases and Methods of Plant Breeding. CBS.
18. Stoskopf, N C, Tomes, D T and Christie, (1993). Plant breeding: theory and Practice.Scientific Publishers (India) Jodhpur.

M.Sc. Botany (Semester–II)

Elective Course (BOT – 20209-T

Genomics and Proteomics

Credits: 04 **Total Hours:** 60 (Theory)

UNIT-I

Genomic analysis: Introduction to gemone and genomics, Structural & functional Genomics, Structure & Organization of Prokaryotic (*E.coli*) & Eukaryotic genome (Yeast), Genome and Gene databases, Brief Outlook of Various Plant Genome Projects and their Outcome (Arabidopsis, Tomato, Potato, Rice), Human Genome Project. Genome sequencing strategies, new technologies for high throughput sequencing, Various Approaches in sequencing genome; shotgun, directed short gun & Clone Contig Approach, Primer Walking, Chromosome Walking, Chromosome Jumping, Contig Assembly, methods for sequence alignment and gene annotation.

UNIT-II

Approaches to analyze differential expression of genes - ESTs, SAGE, microarrays and their applications, gene tagging, gene and promoter trapping; knockout and knock-down mutants. Transcriptome, Transcriptomics, RNA interference and gene silencing, genome imprinting, small RNAs-biogenesis and functions, role of small RNAs in heterochromatin formation and gene silencing, tools to study methylome and histone modifications.

UNIT-III

Proteomics: Introduction to Proteome, Sequence & Structural Proteomics, Interaction & Functional Proteomics

Tools andtechniques of proteome analysis: 1-D and 2-D gel electrophoresis, DIGE (Differential In Gel Electrophoresis), Image analysis of 2D and DIGE gels: spot detection & quantitation, gel matching, data analysis and presentation,Liquid Chromatography and Multidimensional Chromatography; Protein Identification by Mass Spectroscopy (MALDI/TOF), LC/MS-MS for identification of proteins, Peptide Mass Fingerprinting, Protein *de novo* sequencing.

UNIT-IV

Analysis of proteins by different biochemical and biophysical procedures: CD (Circular Dichroism), NMR, Analysis of post-translational modifications

and protein-protein interactions; protein chips and arrays, Proteome Databases: Protein Sequence Database, SWISS-PROT, PROSITE, PDB etc. other protein related bioinformatics tools (ExPASy, PFAM). Applications of proteomics in medicine, toxicology and Pharmaceuticals.

Suggested Practical Exercises:

- Demonstration and listing of sequence retrieval online tools.
- Demonstration and listing of sequence submission online tools.
- Listing and demonstration of Protein and DNA Sequence Databases and their utilities.
- Demonstration of DNA and Protein Array Technology and applications.
- Reverse transcription-PCR to examine gene expression.
- Real-time PCR to quantify gene expression.
- Northern and Western Blotting analysis.
- Demonstration of Instrumentation (MALDI/TOF, LC-MS-MS, 2DGE) by visit or audio-visual medium.
- Protein separation techniques (Chromatography-Ion-Exchange, Gel Filtration, Affinity; Ultrafiltration, Recombinant protein separation techniques).
- Comparison of Next-generation sequencing methods (by Chart/ poster preparation).
- Any other exercises designed by course teacher as per the syllabus.

Suggested readings:

1. Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Campbell AM &Heyer LJ, Benjamin Cummings 2007; CSH Press, NY. ISBN-10: 8131715590
2. Principles of Proteomics. R.M Twyman (2004). (BIOS Scientific publishers). ISBN-10: 1859962734
3. Principles of Gene Manipulation and Genomics- Primrose S &Twyman R, 7th Edition, Blackwell, 2006. ISBN-10: 1405135441
4. Principles of Genome Analysis and Genomics. Primrose SB &Twyman RM. 2007. Blackwell. ISBN-10: 1405101202.

5. Introduction to Genomics. A.M Lesk, Oxford University press, 2007. ISBN-10: 0199557489 .
6. A Primer of Genome Science. Greg Gibson and Spencer V. Muse. 2nd ed. 2004. SINAUER Associates Inc. ISBN-10: 0878932364.
7. Genome III – T.A. Brown Garland Science Publ. June 08, 2006. ISBN-10: 0815341385.
8. Introduction to Proteomics: Tools for the New Biology. Daniel C. Liebler, Humana Press Inc., 2002. ISBN-10: 0896039919.
9. Bioinformatics – Sequence and Genome Analysis – David W. Mount –Cold Spring Harbor Laboratory Press, U.S.; 2nd Revised edition, 2004. ISBN-10: 9746520709.
10. Lieber DC (2006) Introduction to Proteomics: Tools for New Biology; Humana Press, NJ.
11. Pennington SR, Dunn MJ (Eds.) (2002) Proteomics: From Protein Sequence to Function, BIOS Scientific Publishers, United Kingdom.
12. Sambrook J and Russell DW (2001). Molecular Cloning – A Laboratory Manual, Vols I – III, Cold Spring Harbor Laboratory, USA.

M.Sc. Botany (Semester–II)

Elective Course (BOT-202107

Angiosperm Plant Biosystematics

Credits: 04 **Total Hours:** 60 (Theory)

UNIT-I

Herbarium methods- Plant exploration, plant collection, pressing and drying, mounting, maintenance and importance of herbarium; Important national, international herbaria, concept of digital herbaria.

Concept of Species- speciation; Gradual and additive mechanism; species classification.

UNIT-II

Concept of characters: analytic versus synthetic character, qualitative verses quantitative characters, good and bad characters.

Concept of population – its significance, types of variation (developmental, environmental and genetical), variance analysis, isolating mechanism.

UNIT-III

Ecotypes- Origin and differentiation, taxonomic significance of ecotypes, vicarians.

Experimental taxonomy and hybridization- Role of hybridization in evolution, amphidiploidy, breeding barriers, epistasis and pleiotropy.

UNIT-IV

Biochemical systematic- Methods and principles, systematic markers, PCR analysis, chemotaxonomy, technique of protein electrophoresis, chemical protein analysis procedures, genome analysis and nucleic acid hybridization.

Suggested Laboratory Exercises:

- Flora writing
- Synonymy
- Taximetrics and cladistics
- Molecular taxonomy

Suggested Readings:

1. Cole, A.J. 1989. Numerical Taxonomy, Academic Press, London.
2. Davis, P.H. and Heywood, V.H. 1973, Principles of Angiosperms Taxonomy, Robert E. Kreiger Pub. Co., New York.
3. Grant, V. 1971. Plant Speciation. Columbia University Press, New York.
4. Grant W.E. 1984. Plant Biosystematics Academic Press London.
5. Harrison H.J. 1971. New Concepts in Flowering Plant Taxonomy, Rieman Educational Book Ltd. London.
6. Heslop-Harrison, J. 1967. Plant Taxonomy - English Language Book Soc. & Edward Arnold Pub. Ltd. U.K.
7. Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press London.
8. Jones, A.D. and wilbins, a.d. 1971. Variations and Applications in Plant Species. Hiemand & Co. Educational Books Ltd. London.
9. Jones, S.B. Jr. and Luchsinger, A.E. 1986. Plant Systematic (2nd edition). Mcgraw-Hill Book co., New York.
10. Nordenstam, B., El Gazaly, G. and Kassas, M. 2000. Plant Systematic for 21st century, Portland press Ltd. London.
11. Radford, A.E. 1986. Fundamentals of Plant Systematic. Harper & Row Publications, USA.
12. Singh, H. 1978. Embryology of Gymnosperms, Encyclopaedia of Plant Anatomy X. Gebruder Bortaeger, Berlin.
13. Solbrig, O.T. and Solbrig, D.J. 1979. Population Biology and Evolution, Addison-Weslley Publicating Co. Ind USA.
14. Solbrig, O.T. 1970. Principles and Metods of Plant Biosystematics. The Macmillan Cocollier- Macmillan Ltd. London.
15. Stabbings, G.L. 1974. Flowering Plant- Evolution above Species Level. Edward Arnold Ltd. London.
16. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd edition) Edward Arnold Ltd. London.
17. Takhtajan, A.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
18. Woodland, D.W. 1991. Contemporary Plant Systematic. Prentice Hall. New Jersey.

IEC-2021.T

: Interdisciplinary Course in Botany

Course Name: Indian Knowledge System and Botany

Course details

Unit- I

Microbiology in Indian Vedic Knowledge: Sukshmjeevanu in Vedas (The concept of microbes by Rishi Kanva; discoveries of Rishi Kanva and his descendants Atri, Yamadagnni, and Agasti against microbial infection are in Atharvaveda).

Unit- II

Indian Knowledge System on Concept of origin of life: Ancient Science of India 10: Primary Concept on Origin of Life: Origin of Life-concept in Manusmriti

Unit- III

Indian Knowledge System on Plant Morphology of Plants: Description of plant morphology in Samhita - Charak (1st Century AD); Susruta (600 BC); Parasar (1st Century BC or AD); Study of plants in Nighantu Period in India (In Rajanighantu, In Dhanvantarinighantu, In Nighantushesha, In Bhavprakashnighantu); Indian Traditional Ayurvedic System of Medicine and Nutritional Supplementation:

Unit- IV

Indian Knowledge System on medicinal plants before Theophrastus: Ancient Indian rishi's (Sages) knowledge of botany and medicinal plants since Vedic period: Study of plants in Vedic period (2500 BC to 600 BC) in India; study of plants in Samhita period (900 – 600 BC) in India (The Charaka Samhita, The Sushruta Samhita)

References

1. Kuhad U, Goel G, Maurya, PK, Ramesh Kuhad C. 2021. Sukshmjeevanu in Vedas: The Forgotten Past of Microbiology in Indian Vedic Knowledge, Indian journal of Microbiology, 61: 108-110.
2. Padhy S 1999. Ancient Science of India 10: Primary Concept on Origin of Life-A Review, Anthropologist, 54(1-3): 1-6 (2023)
3. Balkrishna A, Mishra R.K, Srivastava A, Joshi B, Marde R and Prajapati UP. 2019. Ancient Indian rishi's (Sages) knowledge of botany and medicinal plants since Vedic period was much older than the period of Theophrastus, A case study-who was the actual father of botany? International Journal of Unani and Integrative Medicine 3(3): 40-44.
4. Pandey M. M., Rastogi S, and Rawat A. K. S. 2013. Indian Traditional Ayurvedic System of Medicine and Nutritional Supplementation. Evid Based Complement Alternate Med.: 376327.

IEC-2021&T

:Interdisciplinary Course in Botany
Course Name: Organic Farming

Course details

Unit- I

Introduction to Organic Farming: Introduction; Need of Organic Farming; Benefits of Organic Farming; Social aspects of Organic Farming; Market aspects of Organic Farming

Unit- II

Organic Fertilizers: Need of Organic Fertilizer; Benefits of Organic Fertilizer; Preparation of Organic Fertilizer; Demonstration & land preparation. Plant Nutrients: Name of plant Nutrients; Functions of Nutrients in plant growth and Development
Sources of nutrients for Organic Agriculture: Organic Manure: Rural compost, City compost, Oil cakes, Animal wastes, Green Manure with Leguminous crops in crop rotation. In-situ incorporation of crop residues

Unit- III

Biofertilizers and their method of use: Need and Benefits of Microorganism, Management of Microorganism, mechanism of action in increasing soil fertility
Preparation of vermin compost: Pit construction; Raw materials; Availability of specific species of earth worm; Method of preparation; Quality improvement of finished vermicompost

Unit- IV

Plant Protection Measures: Integrated pest & disease management techniques, Organic pesticides, bio-pesticides. Inorganic pesticides, disadvantages of their use. Seed, seedling and soil Treatment measures. Feasibility of complete dependence on organic sources.Good Harvesting Practices; Storage; Transportation; Supply Chain.

Referred Textbooks:

1. Aasics of Organic Farming by Bansal and Mamta, CBS publication
2. A text book of Modern Organic Farming
3. Principles of Organic Farming: Textbook (By P. L. Maliwal)

IEC-2019-T

Interdisciplinary Course in Botany

Course Name: Nursery and Horticulture Techniques

Unit- I

Introduction to Nursery: Plant nursery: Definition, importance; Basic facilities for a nursery; layout and components of a good nursery. Nursery beds, types, their merits and demerits; precautions to be taken during preparation. Brief account of growing media; nursery tools and implements. Containers for plant nursery, Brief account of plant propagation structures.

Unit- II

Introduction to Horticulture: Horticulture: Definition, importance of horticulture in terms of economy, production, employment generation, environmental protection and human resource development. Fruit and vegetable zones of India and Odisha. Export scenario and scope for Horticulture in India. Classification of horticultural crops based on soil and climatic requirements

Unit- III

Introduction to Vegetable crops: Importance of vegetable cultivation in India and Odisha. Classification and Nutritive value of vegetables Importance, morphology and taxonomy, varieties, climate and soil, seeds and sowing, manuring,irrigation, intercultural operations, diseases and their control, harvesting and yield of following crops: Cultivation of (a) Brinjal(b) Tomato(c) Capsicum (d) Spinach (c) Coriander and (d) Mentha

Unit- IV

Introduction to Fruit crops: Importance of fruit growing in India and Odisha. Nutritive value of fruits. Origin, history, distribution, area and production, uses and composition, varieties, soil and climatic requirements, propagation, planting, training and pruning, manuring and fertilizer application, irrigation, intercropping, harvesting and yield, diseases and pests of the following tropical fruit crops: (a) Mango (b) Guava and (c) Papaya

Referred Text books:

1. Nursery Management of Fruit Crops in India
2. Plant Propagation and Nursery Management

IEC-20220-T

Interdisciplinary Course in Botany
Course Name: Environment Law

Course details

Unit- I

Introduction: Meaning and Definition of Environment and Environment Pollution: Problem and prospects;- Ozone Depletion, Global Warning – Climatic Changes – Need for the preservation, conservation and protection of Environment – Environmental Pollution – Kinds, Causes and effects of Pollution

Unit- II

Protection of Forest and Wildlife: Indian Forest Act, 1927: Kinds of forest: Private, Reserved, Protected and Village Forests, The Forest (Conservation) Act, 1980; The Wild Life (Protection) Act, 1972: Authorities to be appointed and constituted under the Act, Hunting of Wild Animals, Protection of Specified Plants, Protected Area, Trade or Commerce in wild animals, animal articles and trophies; Its prohibition.

Unit- III

International Law: International Environmental Regime – Transactional Pollution – Customary International Law - Stockholm Declaration on Human Environment, 1972 – The role of UNEP for the Protection of Environment – Ramsar Convention 1971 – Bonn Convention (Migratory Birds) 1992 - Nairobi Declarations, 1982 - Rio, Conference on Environment and Development, 1992 (Earth Summit), Rio Declaration

Unit- IV

Convention on Biological Diversity, The Indian Biological Diversity Act 2002, v. Convention on Climate Change 1992 – Kyoto Protocol 1997, Johannesburg Convention 2002

Referred Text books:

1. Environmental Law & Policy in India – Shyam Diwan, Armin Rosencranz
2. Environmental Law in India – P. Leelakrishnan
3. PILand Environmental Protection-Geetanjali Chandra
4. The Water (Prevention and Control of Pollution) Act, 1974
5. The Air (Prevention and Control of Pollution) Act, 1981
7. Richard L. Riversz, et al. (eds.) Environmental Law, the Economy and
8. Sustainable Development (2000), Cambridge.
9. S.K.Nanda, Environmental Law, 2007

10. Relevant Bare Acts/Notifications.
11. Paras Diwan: Studies on Environmental Cases.
12. Lal's Commentaries on Water and Air Pollution and Environment Protection Laws

IEC-202217

: Interdisciplinary Course in Botany
Course Name: Plants and Human Welfare

1. **Botany: An Introduction** - Evolution of Plants, Evolution of Communities, Appearance of Human Beings, Scope of Botany, Importance of Botany, Brief Survey of Plant World.
2. **The Structure and Functions of Living Organisms** - Features common to plants and animals, Systematic Study of Plants, Great Plant Groups, Seed-Plant Body, Root System, Shoot System, Herbs, Shrubs, Trees, Flower, Fruit and seed, Plants and Human Affairs, Harmful Plants.
3. **Plants and Human Prospects** - The Agricultural Revolution, Origin of Crops, The Origin of Maize, New Crops, The Growth of Human Population, Agriculture in the Future, A New Millennium: The Transition to Sustainability, Research Institutes in India.
4. **Human Uses of Plants** - Plants of Economic Importance, Plants as Food (Biennial and Annual Stem, Leaf and Root Crops, Turnips and their Relatives, Lettuce and related Species, Carrots and their relatives, Beets, Spinach, Perennial green vegetables, Vegetables from bulbs: Onions, Garlic, Leeks; Starch from Tubers, Rhizomes and roots, Tubers and Rhizome, White Potatoes, Sweet Potatoes, Sweet Stems and roots, Sugarcane, Sugar beets and other sources of sweeteners), Plants for Construction, Plants in Medicine, Plants for Other Uses, Bioremediation and Phytoremediation.
5. **Plant Diversity: Losses and Conservation** – Reasons of Plant becoming Threatened or Extinct: The Process of Extinction, Characteristics of declining Plant Population, The influence of Humanity, Future Losses and Gains; Reasons for Conservation of Plant Diversity, Plant Conservation and Development, Developing a rationale for conservations, Plant Population Management: Plant Conservation in Protected Areas, Off-site Plant Conservation, Awareness and Education, Conservation by Legislation, Integrated Conservation.

References:

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प्रभारी अकादमिक प्रथम