CENTRAL UNIVERSITY OF JAMMU

COURSE BOOKLET

Integrated B.Sc. (Hons.) - M.Sc. Botany

जम्मू केंद्रीय विश्वविद्यालय
Central University of Jammu
वनस्पति विज्ञान विभाग
Department of Botany
राया-सूचानी (बागला), साम्बा-181143, जम्मू (जम्मू और कश्मीर
Rahya-Suchani (Bagla), Samba-181143, Jammu (J & K)

Department of Botany

Introduction

The Department of Botany, Central University of Jammu, warmly welcomes you as you begin your academic journey in the five-year Integrated B.Sc. (Hons.)–M.Sc. Botany programme. This programme offers more than classroom learning; it provides an opportunity to become part of a dynamic academic community committed to understanding plants and applying botanical science for societal and environmental well-being.

Established in the academic session 2016-2017, the Department was created with the objective of addressing agriculture- and plant-related challenges of the region through scientific inquiry and the application of modern plant biology tools.

VISION

To emerge as a centre of excellence in plant sciences through quality education, innovative research, and societal engagement, in alignment with the principles of NEP 2020. The Department of Botany envisions nurturing competent, ethical, and environmentally conscious human resource capable of addressing national and global challenges related to biodiversity conservation, sustainable development, climate change, and food security, while contributing meaningfully to the knowledge economy and nation-building.

MISSION

In accordance with the objectives of NEP 2020, the Department of Botany is committed to:

- Providing holistic, multidisciplinary, and research-oriented education in plant sciences that fosters critical thinking, analytical skills, and scientific temper among learners.
- Promoting experiential learning through laboratory work, field-based studies, internships, and project-based learning to bridge theory with real-world applications.
- Integrating traditional knowledge systems with modern scientific tools and emerging technologies in teaching and research.
- Adopting flexible, learner-centric, and outcome-based curricula with multiple entry–exit options, academic flexibility, and skill enhancement as envisaged in NEP 2020.
- Encouraging innovation, creativity, and entrepreneurship through interdisciplinary research, collaborations, and community-oriented initiatives.
- Leveraging blended and digital learning platforms to enhance access, inclusivity, and quality of education.
- Cultivating ethical values, environmental stewardship, teamwork, and social responsibility to develop globally competent and socially responsive citizens.

Departmental Excellence

The Department is supported by a team of experienced faculty members actively engaged in teaching and research across multiple domains of plant sciences. Continuous upgradation of laboratory facilities, emphasis on field-based learning, and encouragement of interdisciplinary approaches ensure a strong academic and research environment.

Your Programme

The Integrated B.Sc. (Hons.)–M.Sc. Botany programme is carefully designed to build strong conceptual foundations in Botany while providing exposure to allied disciplines in science and humanities. This integrated structure reflects the interdisciplinary nature of contemporary biological sciences and prepares students to address real-world challenges.

Research and Innovation

The Department maintains a robust research culture with quality publications in reputed national and international journals published by APS, AIP, ScienceDirect, Nature, Springer, and Wiley. Academic excellence is further strengthened through modern laboratories, collaborative research initiatives, and regular scientific events.

What Awaits You

As a student of the Department, you will have access to advanced research facilities, mentorship from dedicated faculty, and opportunities to participate in national and international conferences, workshops, and seminars. The curriculum ensures balanced development of theoretical knowledge and practical skills essential for successful careers in research, education, agriculture, conservation, and allied fields. The Department looks forward to nurturing your academic growth and professional development and remains committed to providing a supportive and enriching learning environment.

Once again, welcome to the Department of Botany, Central University of Jammu.

FACULTY INFORMATION

Department Faculty Directory

S No.	Name of Faculty	Photograph	Area of Specialization(s)
1	**Prof. Brijmohan Singh Bhau** Professor bsbhau@cujammu.ac.in 9957574216		• Biotechnology • Plant-microbe interaction • Nanotechnology • Genomics
2	**Dr. Yogesh Kumar** Associate Professor & Head yogesh.bot@cujammu.ac.in 7696180390		• Plant Virology • Molecular Biology • Host-pathogen interaction
3	**Dr. Deepak Bhardwaj (on-lien)** Associate Professor deepakbhardwaj.bot@cujammu.ac.in 9999361548		• G-protein and Helicase-Mediated Signaling in Plants • CRISPR-Cas9 Gene Editing in Plant Systems • Nitric Oxide Signaling in Heat Stress and Stomatal Regulation • Nutrient Sensing Mechanisms in Plants with Arbuscular Mycorrhizal Fungi
4	**Dr. Samantha Vaishnavi** Assistant Professor (Sr.) samantha.bot@cujammu.ac.in 9419165680		• Genetics • Cytogenetics
5	**Dr. Vikas Srivastava** Assistant Professor (Sr.) vikas.bot@cujammu.ac.in 9818079654		• Plant Metabolic and Stress Biology

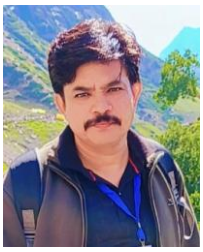
6	**Dr. Ashok Kumar** Assistant Professor ashok.bot@cujammu.ac.in 7876677238		• Taxonomy of Plants and Systematics
7	**Dr. Sapna Devi** Assistant Professor sapna.bot@cujammu.ac.in 9086121387		• Mycology • Plant Pathology • Mushroom Cultivation • Diversity and distribution of bryophytes • Pteridophytes

Department Office Contact:

Botany Office Email: office.bot@cujammu.ac.in

Clerical Staff: **Mrs. Neelu**
Phone: 7780889342

Lab Attendant: **Mr. Pankaj Gupta**
Phone: 7006691414



Lab Attendant: **Mr. Basant Singh**
Phone: 9906229405

PROGRAMME OVERVIEW

Integrated B.Sc. (Hons.)–M.Sc. Botany

PROGRAMME EDUCATIONAL OBJECTIVES (PEOS)

The programme **Integrated B.Sc. (Hons.) - M.Sc. Botany** aims to:

PEO1: Provide a strong foundation in core and applied areas of plant sciences that develops analytical thinking, experimental competence, and problem-solving abilities.

PEO2: Equip students with multidisciplinary knowledge and skill-oriented training that prepares them for higher education, research careers, entrepreneurship, and diverse employment opportunities in botany and allied fields.

PEO3: Promote an integrated understanding of plant sciences by emphasizing their practical applications, societal relevance, and contributions to sustainable development and environmental management.

PEO4: Foster scientific inquiry, innovation, and discovery-based learning through exposure to contemporary theoretical concepts, modern laboratory techniques, and research-oriented approaches.

PEO5: Support holistic personality development by inculcating ethical values, social responsibility, effective communication, teamwork, leadership qualities, and adaptability to flexible and lifelong learning pathways.

PROGRAMME OUTCOMES (POs)

Upon successful completion of the Programme, the students will be able to:

Upon successful completion of the Integrated B.Sc. (Hons)–M.Sc. Botany programme, the students will be able to:

PO1: Develop analytical abilities and practical skills to effectively solve both theoretical and applied problems in plant sciences.

PO2: Acquire multidisciplinary knowledge and skill-based competencies that enable them to pursue higher studies, research, and career opportunities, including self-employment and entrepreneurship in botany-related fields.

PO3: Demonstrate a comprehensive understanding of plant sciences, highlighting their applications, relevance, and significance to society beyond theoretical concepts.

PO4: Apply up-to-date theoretical and practical knowledge to strengthen core competencies, encourage discovery-based learning, and foster scientific inquiry.

PO5: Exhibit holistic development through ethical conduct, constitutional and human values, effective communication, teamwork, leadership skills, and informed choice of flexible learning pathways.

Integrated 4+1 B.Sc. (Hons.)–M.Sc. Botany (NEP 2020 & UGC Compliant)

- **Program Duration:** 5 Years (**Four years for B.Sc. Honours / B.Sc. Honours with Research + One year for M.Sc**.)
- **Structure:** 10 Semesters with a total minimum of 208 credits to accommodate advanced master's coursework and a research project.
- **Four-Year B.Sc. (Honours):** As per UGC/NEP guidelines, the honours degree spans four years, offering an in-depth core discipline focus and flexibility for interdisciplinary electives.
- **Honours by Research Option:** Eligible students (CGPA ≥ 8.0 or 75% marks) may opt for an additional research project in the fourth year, leading to a Research Honours Degree recognized by the UGC.
- **Entry–Exit Modes:** True to NEP's multiple entry–exit provisions, students can:
    - Exit after Year 1 with a Certificate.
    - Exit after Year 2 with a Diploma.
    - Exit after Year 3 with a B.Sc. (General).
    - Complete Year 4 for B.Sc. (Honours) / B.Sc. (Honours) with Research.
    - Completion of Year 5: Integrated M.Sc. Degree.
- **UGC Compliance:** Curriculum, credit requirements, and grading align strictly with UGC mandates (minimum 160 credits for honours). Continuous assessments and CGPA-based evaluations ensure transparency and quality.

Course Matrix for Five Year Integrated B.Sc. (Hons.)-M.Sc. Botany (3+2 years), For those who have completed first three years of the Integrated programme (Level 7).

Semester	Core Course (CC)	Open Elective Course (OEC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Value Addition Course (VAC)	Total Credits
I	**CC-1 (3+1)** **CC-2 (3+1)**	**OEC-1 (4)** **OEC-2 (4)**	**AEC-1 (2)**	**SEC-1 (2)**	**-**	**20**
II	**CC-3 (3+1)** **CC-4 (3+1)**	**OEC-3 (4)** **OEC-4 (4)**		**SEC-2 (2)**	**VAC-1 (2)**	**20**
III	**CC-5 (3+1)** **CC-6 (3+1)**	**OEC-5 (4)** **OEC-6 (4)**	**AEC-2 (2)**	**SEC-3 (2)**		**20**
IV	**CC-7 (3+1)** **CC-8 (3+1)**	**OEC-7 (4)** **OEC-8 (4)**		**SEC-4 (2)**	**VAC-2 (2)**	**20**
V	**CC-9 (3+1)** **CC-10 (3+1)**	**OEC-9 (4)** **OEC-10 (4)** **OEC-11 (4)**	**-**	**-**	**-**	**20**
VI	**CC-11 (3+1)** **CC-12 (3+1)**	**OEC-12 (4)** **OEC-13 (4)** **OEC-14 (4)**	**-**	**-**	**-**	**20**
Total	**48**	**56**	**4**	**8**	**4**	**120**
VII	**CC-13 (3+1)** **CC-14 (3+1)** **CC-15 (3+1)**	**OEC-15 (4)** **OEC-16 (4)**	**-**	**SEC-5 (2)**	**-**	**22**
VIII	**CC-16 (3+1)** **CC-17 (3+1)** **CC-18 (3+1)**	**OEC-17 (4)** **OEC-18 (4)**	**-**	**SEC-6 (2)**	**-**	**22**
IX	**CC-19 (3+1)** **CC-20 (3+1)** **CC-21 (3+1)**	**OEC-19 (4)** **OEC-20 (4)**	**-**	**SEC-7 (2)**	**-**	**22**

X	**Project/ Dissertation/ Internship(12)**	**OEC-21 (4) OEC-22 (4)**	**-**	**SEC-8 (2)**	**-**	**22**
Total	**48**	**32**	**-**	**8**	**-**	**88**
Grand Total	**96**	**88**	**4**	**16**	**4**	**208**

Abbreviation(s):

Ability Enhancement Course	**AEC**	**Core Course**	**CC**
Skill Enhancement Course	**SEC**	**Open Elective Course**	**OEC**
		Value Addition Course	**VAC**

Course Matrix for Five Year Integrated B.Sc.-M.Sc. (Botany)

(Semesters I to X)

w.e.f. Academic Session 2022-2023

Course Matrix

Semester – I

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
IBOT1C001T	Plant Kingdom: Diversity in Forms, Structure and Reproduction (Theory+Lab)	CC	4(3+1)	3-0-2
IBOT1C002T	Principles and Techniques in Plant Sciences (Theory+Lab)	CC	4(3+1)	3-0-2
	SEC-I	SEC	2	2-0-0
	AEC-I	AEC	2	2-0-0
	Open Elective-I	OE	4	4-0-0
	Open Elective-II	OE	4	4-0-0
	Total		**20**	

The student must earn a minimum of 20 credits during Semester I. In addition to two core courses of 4 credits each (comprising 3 credits for theory and 1 credit for lab), the student must earn 12 additional credits, of which at least 2 credits should be from a Skill Enhancement Course (SEC) and 2 credits from an Ability Enhancement Course (AEC) from the open elective basket offered by the Department, other Departments, or through MOOC courses on the SWAYAM platform.

Semester – II

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
IBOT1C005T	Economic Botany (Theory+Lab)	CC	4 (3+1)	3-0-2
IBOT1C006T	Basics of Biochemistry (Theory+Lab)	CC	4 (3+1)	3-0-2
	SEC-II	SEC	2	2-0-0
	VAC-I	VAC	2	2-0-0
	Open Elective-III	OE	4	4-0-0
	Open Elective-IV	OE	4	4-0-0
	Total		**20**	

The student must earn a minimum of 20 credits during Semester II. In addition to two core courses of 4 credits each (comprising 3 credits for theory and 1 credit for lab), the student must earn 12 additional credits, of which at least 2 credits should be from a Skill Enhancement Course (SEC) and 2 credits from a Value-added Course (VAC) from the open elective basket offered by the Department, other Departments, or through MOOC courses on the SWAYAM platform.

Semester-III

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
IBOT2C001T	Fungi, Cryptogams and Phanerogams (Theory+Lab)	CC	4 (3+1)	3-0-2
IBOT2C002T	Fundamentals of Cell Biology (Theory+Lab)	CC	4 (3+1)	3-0-2
	SEC-III	SEC	2	2-0-0
	AEC-II	AEC	2	2-0-0
	Open Elective-V	OE	4	4-0-0
	Open Elective-VI	OE	4	4-0-0
	Total		**20**	

The student must earn a minimum of 20 credits during Semester III. In addition to two core courses of 4 credits each (comprising 3 credits for theory and 1 credit for lab), the student must earn 12 additional credits, of which at least 2 credits should be from a Skill Enhancement Course (SEC) and 2 credits from an Ability Enhancement Course (AEC) from the open elective basket offered by the Department, other Departments, or through MOOC courses on the SWAYAM platform.

Semester-IV

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
IBOT2C003T	Anatomy and Embryology of Phanerogams (Theory+Lab)	CC	4 (3+1)	3-0-2
IBOT2C004T	Taxonomy and Systematics (Theory+Lab)	CC	4 (3+1)	3-0-2
	SEC-IV	SEC	2	2-0-0
	VAC-II	VAC	2	2-0-0
	Open Elective-VII	OE	4	4-0-0
	Open Elective-VIII	OE	4	4-0-0
	Total		**20**	

The student must earn a minimum of 20 credits during Semester IV. In addition to two core courses of 4 credits each (comprising 3 credits for theory and 1 credit for lab), the student must earn 12 additional credits, of which at least 2 credits should be from a Skill Enhancement Course (SEC) and 2 credits from a Value-added Course (VAC) from the open elective basket offered by the Department, other Departments, or through MOOC courses on the SWAYAM platform.

Semester-V

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
IBOT3C001T	Plant Physiology (Theory+Lab)	CC	4 (3+1)	3-0-2
IBOT3C002T	Molecular Biology and Plant Biotechnology (Theory+Lab)	CC	4 (3+1)	3-0-2
	Open Elective-IX	OE	4	4-0-0
	Open Elective-X	OE	4	4-0-0
	Open Elective-XI	OE	4	4-0-0
	Total		**20**	

The student must earn a minimum of 20 credits during Semester V. In addition to two core courses of 4 credits each (comprising 3 credits for theory and 1 credit for lab), the student must earn 12 additional credits from the open elective basket offered by the Department, other Departments, or through MOOC courses on the SWAYAM platform.

Semester-VI

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
IBOT3C003T	Fundamentals of Genetics and Cytogenetics (Theory+Lab)	CC	4 (3+1)	3-0-2
IBOT3C004T	Ecology and Environment (Theory+Lab)	CC	4 (3+1)	3-0-2
	Open Elective-XII	OE	4	4-0-0
	Open Elective-XIII	OE	4	4-0-0
	Open Elective-XIV	OE	4	4-0-0
	Total		**20**	

The student must earn a minimum of 20 credits during Semester VI. In addition to two core courses of 4 credits each (comprising 3 credits for theory and 1 credit for lab), the student must earn 12 additional credits from the open elective basket offered by the Department, other Departments, or through MOOC courses on the SWAYAM platform.

Semester VII (Honours/Honours with Research)

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
IBOT4C001T	Mycology and Phytopathology	CC	4 (3+1)	3-0-2
IBOT4C002T	Phycology, Bryology and Pteridology	CC	4 (3+1)	3-0-2
IBOT4C003T	Molecular Cell Biology	CC	4 (3+1)	3-0-2
	SEC-V	SEC	2	2-0-0
	Open Elective-XV	OE	4	4-0-0
	Open Elective-XVI	OE	4	4-0-0
	Total		**22**	

The student must earn a minimum of 22 credits during Semester VII. In addition to three core courses of 4 credits each (comprising 3 credits for theory and 1 credit for lab), the student must earn 10 additional credits, of which at least 2 credits should be from a Skill Enhancement Course (SEC), from the open elective basket offered by the Department, other Departments, or through MOOC courses on the SWAYAM platform.

Semester-VIII (Honours)

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
IBOT4C003T	Gymnosperms and Palaeobotany	CC	4 (3+1)	3-0-2
IBOT4C004T	Reproductive and Developmental Biology of Angiosperms	CC	4 (3+1)	3-0-2
IBOT4C005T	Cellular and Molecular Genetics	CC	4 (3+1)	3-0-2
	SEC-VI	SEC	2	2-0-0
	Open Elective-XVII	OE	4	4-0-0
	Open Elective-XVIII	OE	4	4-0-0
	Total		**22**	

The student must earn a minimum of 22 credits during Semester VIII. In addition to three core courses of 4 credits each (comprising 3 credits for theory and 1 credit for lab), the student must earn 10 additional credits, of which at least 2 credits should be from a Skill Enhancement Course (SEC), from the open elective basket offered by the Department, other Departments, or through MOOC courses on the SWAYAM platform.

Semester VIII (Honours with Research)

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
IBOT4C003T	Gymnosperms and Palaeobotany	CC	4 (3+1)	3-0-2
IBOT4C004T	Reproductive and Developmental Biology of Angiosperms	CC	4 (3+1)	3-0-2
IBOT4C001D	Dissertation	CC	12	0-0-24
	SEC-VI	SEC	2	2-0-0
	Total		**22**	

The student must earn a minimum of 22 credits during Semester VIII. In addition to two core courses of 4 credits each (comprising 3 credits for theory and 1 credit for lab) and 12 Credits for Dissertation, the student has to earn 02 more credits from a Skill Enhancement Course (SEC) offered by the Department.

Skill Enhancement Courses (SEC) Offered by the Department of Botany

Sr. No.	Level	Course Code	Course Name	Credits	LTP
1	UG	IBOT1C003T	Mushroom Cultivation	2	2-0-0
2	UG	IBOT1C007T	Processing of Plant-based Products	2	2-0-0
3	UG	UBOT0O001T	Techniques in Floriculture and Horticulture	2	2-0-0
4	UG	UBOT0O004T	Gardening and Landscaping	2	2-0-0
5	PG	UBOT0O016T	Plant Tissue Culture: Techniques and Applications	2	2-0-0
6	PG	UBOT0O017T	Gene Editing Techniques	2	2-0-0
7	PG	UBOT0O022T	Biological Instrumentation and Methods in Plant Molecular Biology	2	2-0-0
8	PG	UBOT0O023T	Entrepreneurship Avenues in Botanical Sciences	2	2-0-0

Value-Addition Courses (VAC) Offered by the Department of Botany

Sr. No.	Level	Course Code	Course Name	Credits	LTP
1	UG	UBOT1O001T	Plants in the Indian Traditional System of Knowledge	2	2-0-0
2	UG	UBOT1O002T	Basics of Herbal Drug Technology	2	2-0-0
3	UG	UBOT1O003T	History of Science and Technology in India	2	2-0-0

List of Open Elective courses (OE) offered by Department of Botany

Sr. No.	Level (UG/PG)	Course Code	Course Name	LTP
1	UG	IBOT1O001T	Introduction to Plant Biology	4-0-0
2	UG	IBOT1O002T	Vermicomposting and Mushroom Farming	4-0-0
3	UG	IBOT1O003T	Climate Change and Disaster Management	4-0-0
4	UG	IBOT1O004T	Biostatistics and R-programming	4-0-0
5	UG	UBOT0O002T	Biostatistics	4-0-0
6	UG	UBOT0O003T	Basics of Plant Virology	4-0-0
7	UG	UBOT0O005T	Molecular Diagnostics	4-0-0
8	UG	UBOT0O006T	Biodiversity and its Conservation	4-0-0
9	UG	UBOT0O007T	Insights into Immunology	4-0-0

10	UG	UBOT0O008T	Enzymology	4-0-0
11	UG	UBOT0O009T	Microbial World	4-0-0
12	UG	UBOT0O010T	Environmental Studies	4-0-0
13	PG	UBOT0O012T	Agriculture, Monsoons and Rural Development	4-0-0
14	PG	UBOT0O013T	Molecular Systematics	4-0-0
15	PG	UBOT0O014T	Ecology and Biodiversity Conservation	4-0-0
16	PG	UBOT0O015T	Plant Breeding	4-0-0
17	PG	UBOT0O018T	Medicinal and Ornamental Plants of India	4-0-0
18	PG	UBOT0O019T	Molecular Plant Pathology	4-0-0
19	PG	UBOT0O020T	Basics of Biophysics	4-0-0
20	PG	UBOT0O021T	Systems Biology	4-0-0

SYLLABI OF THE CORE COURSES

Plant Kingdom – Diversity in Forms, Structure and Reproduction

LTP: 3-0-2 **Credits:** 4

Course Objective

The course aims to provide students with a comprehensive understanding of the diversity, structure, reproduction, and evolutionary relationships of major plant groups, ranging from algae to angiosperms, along with an introductory insight into microbes such as bacteria and viruses, to develop a holistic perspective of biological diversity.

Course Outcomes

On completion of the course, students will be able to:

1. Explain the diversity of forms and structural organisation among algae.
2. Describe the biodiversity of fungi and evaluate their economic importance.
3. Explain the morphological diversity and uses of lichens.
4. Describe the morphological diversity of bryophytes, pteridophytes, gymnosperms, and angiosperms.
5. Explain the morphology, structure, and reproduction in bacteria and viruses.

Theory

Unit I: Introduction to Plant Diversity

Diversity of life on Earth; characteristics of living organisms; origin of life; cellular organisation – prokaryotes and eukaryotes; evolution by endosymbiosis; classification of organisms – Five Kingdom system; general characteristics of plants and their diversity; domains of organisms with reference to primary and ancient lineages.

Unit II: Microbes and Algae

Viruses – discovery, general structure, replication, DNA and RNA viruses, lytic and lysogenic cycles. Bacteria – discovery, general characteristics, cell structure, and modes of reproduction. Algae – diversity and major classes, origin and occurrence, habitat, thallus organisation, cell structure, pigments and reserve food materials, general reproduction, and life cycles.

Unit III: Fungi and Cryptogams

Fungi – diversity, major classes, origin, occurrence, cell structure, general reproduction, and life cycles. Lichens – diversity, major classes, morphology, reproduction, and economic importance (as pollution indicators).
Bryophytes – origin, occurrence, thallus organisation, reproduction, and life cycle.

Pteridophytes – major classes, origin, occurrence, sporophyte and gametophyte, reproduction, and life cycles.

Unit IV: Phanerogams

Gymnosperms – major classes, origin, occurrence, general characteristics, reproduction, life cycle, and affinities with pteridophytes and angiosperms. Angiosperms – major classes, origin, occurrence, introduction to monocots and dicots, and modes of reproduction.

Practicals

1. Study of different thallus forms of algae (Cyanophyceae, Chlorophyceae, Phaeophyceae, and Rhodophyceae) using specimens/photographs.
2. Study of local algal biodiversity through temporary mounts.
3. Identification of major groups of fungi using temporary mounts/photographs.
4. Identification of different types of lichens.
5. Identification of different types of bryophytes using specimens/photographs.
6. Identification of different types of pteridophytes using specimens/photographs.
7. Identification of different types of gymnosperms using specimens/photographs.
8. Identification of angiosperms with reference to monocots and dicots from the local area.
9. Study of electron micrographs/models of viruses (T-phage and TMV); line drawings/photographs of lytic and lysogenic cycles.
10. Study of bacterial types using temporary/permanent slides and photographs; electron micrographs of bacterial reproduction (binary fission and conjugation).

Suggested Readings

1. Lee, R.E. (2008). *Phycology*. Cambridge University Press, Cambridge, 4th Edition.
2. Prescott, L.M., Harley, J.P., & Klein, D.A. (2005). *Microbiology*. McGraw-Hill, India, 6th Edition.
3. Kumar, H.D. (1999). *Introductory Phycology*. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). *Farming the Ocean: Seaweed Cultivation and Utilisation*. Aravali International, New Delhi.
5. Campbell, N.A., Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V., & Jackson, R.B. (2008). *Biology*. Pearson Benjamin Cummings, USA, 8th Edition.

6. Pelczar, M.J. (2001). *Microbiology*. Tata McGraw-Hill, New Delhi, 5th Edition.

7. Vashishta, P.C., Sinha, A.K., & Kumar, A. (2010). *Pteridophyta*. S. Chand, Delhi.

8. Bhatnagar, S.P., & Moitra, A. (1996). *Gymnosperms*. New Age International (P) Ltd., New Delhi.

9. Parihar, N.S. (1991). *An Introduction to Embryophyta, Vol. I: Bryophyta*. Central Book Depot, Allahabad.

10. Gifford, E.M. (1989). *Morphology and Evolution of Vascular Plants*. New York.

Principles and Techniques in Plant Sciences

LTP: 3-0-2 **Credits:** 4

Course Objective

The course aims to provide students with foundational knowledge and hands-on understanding of laboratory principles, experimental techniques, instrumentation, and analytical methods used in plant and biological sciences to enable their effective and professional application in biological research.

Course Outcomes

On successful completion of the course, students will be able to:

1. Understand laboratory organisation, sterilisation methods, culture techniques, and the working principles of common laboratory instruments used in plant and biological sciences.
2. Explain histological principles including fixation, dehydration, sectioning, staining, and localisation techniques for studying plant tissues.
3. Analyse the principles and applications of light, fluorescence, and electron microscopy along with sedimentation and centrifugation techniques.
4. Describe the principles and applications of chromatographic and electrophoretic techniques used for separation and analysis of biological molecules.
5. Develop hands-on skills in handling laboratory equipment, preparing biological samples, performing analytical techniques, and preserving plant materials using standard laboratory protocols.

Theory

Unit I: Laboratory Set-up

Working principles and applications of magnetic stirrer, distillation unit, laminar air flow, autoclave, colorimeter, and spectrophotometer. Importance and methods of sterilisation. Media preparation – solid and liquid media; simple and complex media; nutrient agar slants, plates, and stabs. Inoculation techniques – streak plate, pour plate, and spread plate methods. Cultivation chambers and culture transfer techniques. Pure culture techniques. Importance of laboratory record maintenance (filing, orderly arrangement, date of manufacturing, storage conditions, and temperature).

Unit II: Histology

Mechanism of fixation and types of fixatives. Tissue dehydration – general protocol and rapid dehydration. Dehydration using graded solvent series of ethanol or acetone. Tissue infiltration and embedding. Sectioning, mounting, and staining techniques (safranine, cotton blue, acetocarmine, iodine). Alternate methods of microtomy – cryotome and vibratome. Localisation techniques: immunolocalisation and GUS staining.

Unit III: Microscopy and Centrifugation

Introduction to optics and principles of image formation. Magnification and microscopes. Types of microscopes – simple and compound; bright-field and dark-field; phase contrast; fluorescence microscopy; confocal microscopy and deconvolution. Electron microscopy – brief concepts of SEM and TEM. Basic principles of sedimentation. Types of preparative and analytical centrifugation.

Unit IV: Chromatography and Electrophoresis

Chromatography – principles and chromatographic performance parameters. Thin-layer chromatography, partition chromatography, ion-exchange chromatography, gas chromatography, and high-performance liquid chromatography (HPLC). Electrophoresis – general principles, support media, electrophoresis of proteins and nucleic acids; capillary electrophoresis; agarose gel electrophoresis; sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE).

Practicals

1. Identification of different types of laboratory glassware used for experimentation.
2. Study of the parts and working of dissection and compound microscopes.
3. Preparation of various stains and chemicals used in biological experiments.
4. Preparation of permanent slides using microtome and double staining techniques.
5. Preparation of a standard curve using a spectrophotometer.
6. Performance of agarose gel electrophoresis using a given DNA sample.
7. Separation of given material using a centrifuge.
8. Separation of chlorophyll a and chlorophyll b using paper chromatography.
9. Study of pollen and seed coat sculpturing using scanning electron microscopy.
10. Preservation of plant samples (algae, bryophytes, pteridophytes, gymnosperms, and angiosperms) using different preservatives.

Suggested Readings

1. Wilson, K., Hofmann, A., Walker, J.M., & Clokie, S. (Eds.). (2018). *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
2. Skoog, D.A., Holler, F.J., & Crouch, S.R. (2017). *Principles of Instrumental Analysis*. Cengage Learning.
3. Hunt, L., Koenders, A., & Gynnild, V. (2012). Assessing practical laboratory skills in undergraduate molecular biology courses. *Assessment & Evaluation in Higher Education*, 37(7), 861–874.

Economic Botany

LTP: 3-0-2 **Credits:** 4

Course Objective

The course aims to provide students with a comprehensive understanding of the economic importance of plants and plant products, their taxonomic diversity, and their role in human culture, agriculture, medicine, and industry, with emphasis on traditional knowledge and sustainable utilisation of plant resources.

Course Outcomes

On successful completion of the course, students will be able to:

1. Explain the role of plants in human culture and agriculture, including centres of origin, domestication, and crop improvement.
2. Describe the origin, morphology, processing, and uses of major food crops, spices, beverages, and medicinal plants.
3. Analyse the botanical features and economic importance of fruits, nuts, timber, fibres, oils, and essential oil–yielding plants.
4. Illustrate the economic significance of rubber, sugar crops, and lower plants and microbes in agriculture, medicine, and environmental management.
5. Demonstrate skills in identifying economically important plants and plant products using morphological, anatomical, and microchemical techniques.

Theory

Unit I: Plants as Part of Human Culture

Origin and role of agriculture in shaping human history; centres of origin of cultivated plants (Vavilov); domestication of plants and evolution of crop plants; development of new varieties.

Unit II: Food, Spices, Beverages and Medicinal Plants

Origin, morphology, and uses of cereals (rice, wheat, maize); pulses (gram, soybean, pea); vegetables (potato, tomato, onion); spices (ginger, turmeric, clove); beverages (tea and coffee) and their processing. General features and uses of medicinal plants including *Cinchona, Rauwolfia, Atropa, Catharanthus, Papaver, Cannabis,* and *Azadirachta*.

Unit III: Fruits, Nuts, Timber and Fibres

Origin, morphology, and uses of fruits (apple, banana, mango) and nuts (almond, walnut, cashew). Botanical description and uses of timber (teak, bamboo, deodar); oils (groundnut, olive, mustard, coconut); essential oils (rose, lemongrass); fibres (cotton, jute, flax).

Unit IV: Rubber, Sugar and Importance of Lower Plants and Microbes

Rubber-yielding plants (*Hevea brasiliensis* and *Ficus elastica*) and sugar-yielding plants (sugarcane and sugar beet). Economic importance of algae, fungi, lichens, bryophytes, and pteridophytes in agriculture, medicine, food, nitrogen fixation, waste treatment, and pollution monitoring.

Practicals

1. Cereals – Study of habit, L.S./T.S. of grain, starch grains, and microchemical tests of rice and wheat.
2. Legumes – Study of habit, fruit, seed structure, and microchemical tests of pea and groundnut.
3. Sugars – Study of habit of sugarcane and sugar beet.
4. Spices – Study of habit and sections of black pepper, fennel, clove, and cumin seeds.
5. Beverages – Study of morphology of tea and coffee plants.
6. Oils and fats – Coconut (T.S. of mature fruit); mustard (plant and seed morphology and microchemical tests).
7. Essential oil–yielding plants – Morphological study of *Rosa, Vetiveria, Cymbopogon, Santalum,* and *Eucalyptus* (specimens/photographs).
8. Rubber – Study of plant morphology, tapping models, and rubber products.
9. Drug-yielding plants – Study of specimens of *Digitalis, Rauwolfia, Papaver,* and *Cannabis*.
10. Woods – Study of specimens and sections of young stem of *Tectona, Dalbergia sissoo,* and *Pinus*.
11. Fibre-yielding plants – Cotton (lint and fuzz fibres, cellulose test); jute (lignin test on stem section and fibre).

Suggested Readings

1. Kochhar, S.L. (2012). *Economic Botany in Tropics*. MacMillan & Co., New Delhi.
2. Wickens, G.E. (2001). *Economic Botany: Principles and Practices*. Kluwer Academic Publishers, The Netherlands.
3. Chrispeels, M.J., & Sadava, D.E. (2003). *Plants, Genes and Agriculture*. Jones & Bartlett Publishers.

Basics of Biochemistry

LTP: 3-0-2 **Credits:** 4

Course Objective

The course aims to provide students with a comprehensive understanding of the chemical basis of life by introducing the structure, properties, functions, and interrelationships of major biomolecules, with emphasis on structure–function relationships from a biological perspective.

Course Outcomes

On successful completion of the course, students will be able to:

1. Explain the fundamental chemical and cellular principles underlying biological systems, with special reference to the role of water and aqueous environments in life processes.
2. Describe the structure, classification, chemical properties, and biological roles of carbohydrates and glycoconjugates.
3. Analyse the structural features, properties, and biological functions of amino acids, proteins, and lipids.
4. Illustrate the structure and functions of nucleotides, nucleic acids, and enzymes in cellular processes.
5. Demonstrate basic biochemical laboratory skills including solution preparation, buffer systems, qualitative analysis of biomolecules, and separation techniques.

Theory

Unit I: Foundation of Biochemistry

Fundamentals of biochemistry; cellular and chemical foundations of life. Water – unique properties, weak interactions in aqueous systems, ionization of water, buffering action in biological systems, water as a universal solvent and reactant, and fitness of the aqueous environment for life.

Unit II: Carbohydrates

Monosaccharides – structure of aldoses and ketoses; ring structure and conformation of sugars; mutarotation, anomers, epimers, and enantiomers. Structure of biologically important sugar derivatives; oxidation and reduction of sugars. Formation of disaccharides; reducing and non-reducing disaccharides. Polysaccharides – homo- and heteropolysaccharides; structural and storage polysaccharides. Glycoconjugates – proteoglycans, glycoproteins, and glycolipids (gangliosides and lipopolysaccharides); carbohydrates as informational molecules.

Unit III: Amino Acids, Proteins and Lipids

Amino acids – structural features and classification; physical and chemical properties including acid–base

behaviour and titration curves; uncommon amino acids and their functions. Proteins – primary, secondary, and tertiary structures and functions. Lipids – building blocks (fatty acids, glycerol, ceramide); storage lipids (triacylglycerols and waxes); membrane lipids including glycerophospholipids, galactolipids, sulpholipids, ether lipids, sphingolipids, and sterols; plant steroids; lipids as signals, cofactors, and pigments.

Unit IV: Nucleotides, Nucleic Acids and Enzymes

Nucleotides – structure and properties of nitrogenous bases, pentoses, and nucleosides. Watson–Crick model of DNA; forms and structure of DNA. Structure and function of RNA (mRNA, tRNA, rRNA). Other functions of nucleotides as energy sources, components of coenzymes, and second messengers. Enzymes – classification and mode of action.

Practicals

1. Laboratory safety measures and good laboratory practices.
2. Preparation of normal and molar solutions.
3. Preparation of buffer solutions – phosphate and acetate buffers.
4. Determination of pKa of acetic acid and glycine.
5. Qualitative tests for carbohydrates.
6. Qualitative tests for lipids.
7. Qualitative tests for amino acids and proteins.
8. Qualitative tests for nucleic acids.
9. Separation of amino acids, sugars, or bases using paper chromatography or thin-layer chromatography.

Suggested Readings

1. Campbell, M.K. (2012). *Biochemistry*. 7th ed., Cengage Learning.
2. Campbell, P.N., & Smith, A.D. (2011). *Biochemistry Illustrated*. 4th ed., Churchill Livingstone.
3. Tymoczko, J.L., Berg, J.M., & Stryer, L. (2012). *Biochemistry: A Short Course*. 2nd ed., W.H. Freeman.
4. Berg, J.M., Tymoczko, J.L., & Stryer, L. (2011). *Biochemistry*. W.H. Freeman and Company.
5. Nelson, D.L., & Cox, M.M. (2008). *Lehninger Principles of Biochemistry*. 5th ed., W.H. Freeman and Company.
6. Karp, G. (2010). *Cell Biology*. 6th ed., John Wiley & Sons, USA.

7. Hardin, J., Becker, G., & Skliensmith, L.J. (2012). *Becker's World of the Cell*. 8th ed., Pearson Education Inc., USA.

8. Cooper, G.M., & Hausman, R.E. (2009). *The Cell: A Molecular Approach*. 5th ed., ASM Press & Sinauer Associates.

9. Becker, W.M., Kleinsmith, L.J., Hardin, J., & Bertoni, G.P. (2009). *The World of the Cell*. 7th ed., Pearson Benjamin Cummings.

Fungi, Cryptogams and Phanerogams

LTP: 3–0–2 **Credits:** 4

Course Objective

To provide a comprehensive understanding of the diversity, classification, morphology, anatomy, reproduction, evolutionary trends and ecological significance of fungi, algae, bryophytes, pteridophytes, gymnosperms and angiosperms.

Course Outcomes

On successful completion of the course, the students will be able to:

1. Explain the diversity, classification, life cycles and ecological significance of fungi and their allies.
2. Describe the range of thallus organisation, reproductive strategies and ecological roles of major algal groups.
3. Analyse the evolutionary transition of plants to land, alternation of generations, and comparative morphology and reproduction of bryophytes and pteridophytes.
4. Interpret the evolutionary trends, morphology, anatomy and reproductive features of gymnosperms and angiosperms, including fossil evidence.
5. Demonstrate practical skills in identifying cryptogamic and phanerogamic plant groups using morphological, anatomical and reproductive characters through laboratory techniques.

Theory

Unit I: Hidden Mycological World

General characteristics of fungi; classification (Alexopoulos & Mims, 1996; Hibbett et al., 2007). Life cycles of Chytridiomycetes (*Synchytrium*), Oomycetes (*Phytophthora*), Zygomycetes (*Rhizopus*), Ascomycetes (*Saccharomyces, Aspergillus, Neurospora*) and Basidiomycetes (*Puccinia, Agaricus*). Allied fungi: slime moulds—general characteristics, occurrence, types of plasmodia and fruiting bodies. Ecological significance of fungi: mycorrhiza, sugar fungi, cellulose- and lignin-degrading fungi.

Unit II: Mesmerising Algal World

General characteristics and classification (Fritsch, 1935, 1945; Lee, 1999, 2008). Range of thallus organisation and reproduction* in Cyanobacteria (*Oscillatoria, Nostoc*), Chlorophyta (*Chlamydomonas, Volvox*), Charophyta (*Chara*), Xanthophyta (*Vaucheria*), Phaeophyta (*Ectocarpus, Fucus*) and Rhodophyta (*Polysiphonia*). Ecological significance of algae.

*Developmental details not to be included.

Unit III: Wonders of Archegoniates

Transition of plants to land habit—major theories and postulates; evolution of alternation of generations. Bryophytes: general characteristics, classification, range of thallus organisation and comparative reproduction* of liverworts (*Riccia, Marchantia*), leafy liverwort (*Porella*), hornworts (*Anthoceros*) and mosses (*Funaria*). Ecological significance of bryophytes with special reference to *Sphagnum*. Early land plants (*Rhynia*); fossil and extinct pteridophytes. General characteristics, classification, morphology and comparative reproduction* of Psilopsida

(*Psilotum*), Lycopsida (*Selaginella*), Sphenopsida (*Equisetum*) and Pteropsida (*Pteris, Marsilea*). Ecological importance of pteridophytes.

Unit IV: Diverse Spermatophytes

Palaeobotany: geological time scale, fossils and fossilisation processes. Morphology, anatomy and affinities of fossil plants (Pteridospermales and Bennettitales). Gymnosperms: general characteristics, classification, morphology and comparative reproduction* of Cycadales (*Cycas*), Coniferales (*Pinus*) and Ephedrales (*Ephedra*); ecological significance. Angiosperms: general characteristics, habitat diversity, adaptations, morphology and reproduction of dicotyledons (Ranunculaceae, Brassicaceae) and monocotyledons (Liliaceae, Poaceae).

*Developmental details not to be included.

Practicals

1. Study of vegetative and reproductive structures of *Peronospora, Albugo, Rhizopus, Penicillium, Aspergillus, Puccinia, Agaricus* and *Alternaria* using temporary mounts, permanent slides and photographs.
2. Study of ectomycorrhiza, endomycorrhiza and slime moulds using temporary mounts and photographs.
3. Study of morphology of vegetative and reproductive structures of *Nostoc, Chlamydomonas, Volvox, Chara, Sargassum, Ectocarpus* and *Polysiphonia*.
4. Study of morphology, anatomy and reproductive structures of *Riccia, Marchantia, Anthoceros* and *Funaria*.
5. Study of morphology, anatomy and reproductive structures of *Psilotum, Selaginella, Equisetum, Pteris* and *Marsilea*.
6. Study of morphology, anatomy and reproductive structures of gymnosperms (*Cycas, Pinus, Ginkgo* and *Ephedra*).
7. Study of morphology, anatomy and reproductive structures of angiosperms (*Ranunculus, Brassica, Allium cepa* and *Zea mays*).

Suggested Readings:

1) Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2) Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, McGraw Hill, India. 6th edition.
3) Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4) Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
5) Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
6) Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
7) Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
8) Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.

9) Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot. Allahabad
10) Gifford, E.M. (1989). Morphology and evolution of vascular plants (No. 04; QK641, G5 1989).
11) Kumar, H.D. (1999). Introductory Phycology, 2nd edition. New Delhi, Delhi: Affiliated East-West Press.
12) Lee, R.E. (2008). Phycology, 4th edition. Cambridge, Cambridge: Cambridge University Press.
13) Pelczar, M.J. (2001). Microbiology, 5th edition. New Delhi, Delhi: Tata McGraw-Hill Co.
14) Talaro, KP, Talaro A. 2006. Foundations in Microbiology. New Delhi, Delhi: McGraw-Hill
15) Campbell, N.A., Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V., Jackson, R.B. (2008). Biology, 8th edition. San Francisco, California: Pearson Benjamin Cummings.
16) Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, 6th edition. New Delhi, Delhi: McGraw Hill.
17) Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and Their Allies. (2nd Edition), Medtech Publishers Delhi.
18) Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, 4th edition. Singapore, Singapore: John Wiley & Sons.
19) Agrios, G.N. (2005). Plant Pathology, 5th edition. Cambridge, U.K.: Academic Press.
20) Burchett, Stephen and Burchett, Sarah. (2018). Plant Pathology. New York: Garland Science.
21) Sharma, P.D. (2011). Plant Pathology. Meerut, U.P.: Rastogi Publication.
22) Webster, J., Weber, R. (2007). Introduction to Fungi, 3rd edition. Cambridge, U.K.: Cambridge University Press.
23) Raven, F.H., Evert, R.F., Eichhorn, S.E. (1992). Biology of Plants. New York, NY: W.H. Freeman and Company.
24) Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. San Francisco, U.S.A: Pearson Benjamin Cummings.
25) Kaur I., Uniyal P.L. (2019). Textbook of Gymnosperms. New Delhi, Delhi: Daya Publishing House.
26) Kaur I., Uniyal P.L. Textbook of Bryophytes. New Delhi, Delhi: Daya Publishing House (in Press).
27) Parihar, N.S. (1972). An Introduction to Embryophyta. Vol. II: Pteridophyta. Allahabad, UP: Central Book Depot.
28) Parihar, N.S. (1991). An Introduction to Embryophyta. Vol. I: Bryophyta. Allahabad, UP: Central Book Depot.
29) Bhatnagar, S.P., Moitra, A. (1996). Gymnosperms. New Delhi, Delhi: New Age International (P) Ltd Publishers.
30) Coulter, J.M., Chamberlain, C.J. (1910). Morphology of Gymnosperms. Chicago, University of Chicago Press.
31) Schofield, W.B. (1985). Introduction to bryology. New York, USA. Macmillan, (Reference book for Unit 2) 5. Chand Publication.
32) Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Botany For Degree Students Pteridophyta, New Delhi, Delhi: S. Chand Publication. Delhi, India.

Fundamentals of Cell Biology

LTP: 3-0-2 **Credits:** 4

Course Objective

The course aims to provide students with a strong foundation in cell biology by enabling them to understand the structure, organisation, and functioning of cells, their envelopes and internal components, and the fundamental processes of cell division and regulation.

Course Outcomes

On successful completion of the course, students will be able to:

1. Explain and compare the structural organisation of prokaryotic and eukaryotic cells, including cell envelopes, and relate these structures to their functions.

2. Describe the structure and functions of plasmodesmata, nucleus, mitochondria, and chloroplasts, and analyse the relationship between organelle structure and function.

3. Analyse the organisation and functions of the endomembrane system and associated organelles involved in protein and lipid synthesis, modification, and transport.

4. Illustrate the organisation of chromosomes, cytoskeleton, and stages of the cell cycle, including mitosis and meiosis, and explain their biological significance.

5. Demonstrate practical skills in cell biology techniques including microscopy, cytochemical staining, micrometry, and analysis of cell division.

Theory

Unit I: Introduction to Cell and Cell Envelopes

Cell as a unit of life – discovery, structure, properties, and functions; cell theory. Characteristics of prokaryotic cells (Archaea and Eubacteria) and eukaryotic cells (plant, animal, and fungal); plant cell types. Plasma membrane – brief history, chemical composition, fluid mosaic model, and functions. Membrane transport – passive transport (diffusion and facilitated diffusion), active transport (carriers, channels, and pumps), endocytosis, and exocytosis. Plant cell wall – types, chemical composition, and important functions.

Unit II: Plasmodesmata and Cell Organelles

Plasmodesmata – structure and function. Nucleus – nuclear envelope, nuclear pore complex, nuclear lamina; nucleolus – structure and function. Structural organisation and functions of mitochondria and chloroplasts; organelle DNA – structure and function.

Unit III: Endomembrane System and Associated Organelles

Endoplasmic reticulum – types (RER and SER) and structure; RER as the site for protein synthesis, targeting, insertion, folding, processing, and quality control; SER in lipid synthesis and export of proteins and lipids. Golgi apparatus – organisation, protein glycosylation, sorting, and export. Structure and function of lysosomes, peroxisomes, and glyoxysomes. Plant vacuoles – structure and function.

Unit IV: Cytoskeleton and Cell Division

Chromosome – gross morphology; fine structure in prokaryotes and eukaryotes; nucleosome model. Cell cycle – interphase (G1, S, and G2 phases); mitosis and meiosis – stages, significance, and overview of cell cycle regulation. Experimental model systems in cell biology – *Neurospora crassa, Caenorhabditis*

elegans, Drosophila, and *Arabidopsis*. Cytoskeleton – structure of microtubules, microfilaments, and intermediate filaments.

Practicals

1. Study of plant cell structure using epidermal peel mounts of *Allium, Rhoeo,* or *Crinum*.
2. Demonstration of protoplasmic streaming in *Hydrilla* leaf.
3. Measurement of cell size using micrometry.
4. Counting of cells per unit volume using haemocytometer (yeast/pollen grains).
5. Study of cell organelles using electron micrographs.
6. Cytochemical staining of DNA using Feulgen staining.
7. Cytochemical staining of plant cell wall using Periodic Acid–Schiff's (PAS) technique.
8. Study of the effect of organic solvents and temperature on membrane permeability.
9. Study of stages of mitosis using acetocarmine squash preparations and permanent slides.
10. Study of stages of meiosis using acetocarmine squash preparations and permanent slides.

Suggested Readings

1. Cooper, G.M., & Hausman, R.E. (2018). *The Cell: A Molecular Approach*. 7th ed., Oxford University Press, USA.
2. Alberts, B., et al. (2015). *Molecular Biology of the Cell*. 6th ed., Garland Science, New York.
3. Karp, G., & Iwasa, J. (2015). *Cell and Molecular Biology: Concepts and Experiments*. 8th ed., John Wiley & Sons, USA.
4. Lodish, H.F., et al. (2021). *Molecular Cell Biology*. 9th ed., W.H. Freeman, New York.
5. Hardin, J., Becker, G., & Skliensmith, L.J. (2012). *Becker's World of the Cell*. 8th ed., Pearson Education Inc., USA.
6. DeRobertis, E.D.P., & DeRobertis, E.M.F. (2010). *Cell and Molecular Biology*. 8th ed., Lippincott Williams & Wilkins.
7. Gupta, P.K. (2017). *Cytology, Genetics and Evolution*. 8th ed., Rastogi Publications.
8. Cohn, N.S. (1969). *Elements of Cytology*. 2nd ed., Harcourt, Brace and World, USA.
9. Sadava, D.E. *Cell Biology: Organelle Structure and Function*. Jones & Bartlett Publishers.
10. Taiz, L., Zeiger, E., Møller, I.M., & Murphy, A. (2018). *Fundamentals of Plant Physiology*. Sinauer Associates.

Anatomy and Embryology of Phanerogams

LTP: 3-0-2 **Credits: 4**

Course Objective

To provide students with a thorough understanding of the structure, organization, and development of plant body and reproductive systems, combining theoretical knowledge with practical skills in plant anatomy and embryology, so that they can analyse, interpret, and apply these concepts in plant research, improvement, and conservation.

Course Outcomes

1. Explain and analyse the structure, organization, and functions of plant tissues, organs, and meristems, including roots, stems, and leaves, in both monocot and dicot plants.
2. Understand the processes of secondary growth, wood formation, and adaptive anatomical features in different plant types, including hydrophytes, xerophytes, alpine plants, epiphytes, and halophytes.
3. Describe the structure, development, and function of male and female reproductive units, including anther, ovule, pollen, embryo sac, and the Male and Female Gametophytic Units (MGU and FGU).
4. Interpret the processes of pollination, fertilization, post-fertilization events, embryo and endosperm development, and seed formation, including apomixis, polyembryony, and seed dispersal adaptations.
5. Develop practical skills in plant anatomy and embryology through observation, dissection, preparation of temporary and permanent mounts, and use of digital resources, enabling scientific documentation and presentation of plant structure and development.

Theory

Unit 1: Tissue Systems and Anatomy of Plant Parts

Origin of vascular plants, structural adaptations, and the origin of multicellularity. Classification of tissues into simple, complex, and secretory types. Study of tissue systems including epidermal, ground, and vascular systems. Understanding encrustation, incrustation, and ergastic substances. Stem anatomy covering the organization of the shoot apex, anatomy of dicot and monocot stems, and types of vascular bundles. Leaf anatomy including dicot and monocot leaves and Kranz anatomy. Root anatomy focusing on the root apex, structure of dicot and monocot roots, and the origin of lateral roots.

Unit 2: Secondary Growth and Adaptations

Structure, function, and seasonal activity of the vascular cambium. Processes of secondary growth in both roots and stems. Wood anatomy detailing axial and radial elements, types of rays, and axial parenchyma. Development and composition of the periderm. Study of adaptive and protective systems such as the cuticle, epicuticular waxes, trichomes, and stomata. Exploration of adaptive features in various plant types, including hydrophytes, xerophytes, alpine plants, epiphytes, insectivorous plants, and halophytes.

Unit 3: Pre-fertilization Events

Structure and functions of the anther wall, microsporogenesis, and microgametogenesis. Pollen wall structure and functions, NPC (Number, Position, and Character), pollen viability, storage, and the Male Germ Unit (MGU). General structure and types of pistils and ovules. Processes of megasporogenesis and megagametogenesis. Organization and ultrastructure of the mature embryo sac and the structure and

significance of the Female Germ Unit.

Unit 4: Pollination and Post-fertilization Events Types of pollination including self, cross, geitonogamy, and xenogamy. Structure of the stigma and style along with pollen–pistil interactions. Path of the pollen tube in the pistil and the process of double fertilization. Basic concepts of self-incompatibility and methods to overcome it. Types, development, structure, and functions of the endosperm. General patterns and comparison of dicot and monocot embryo development, including suspensor structure and functions and the embryo–endosperm relationship. Nutrition of the embryo and haustorial systems. Seed structure and its importance as a dispersal and storage organ, including germination and seedling formation. Introduction to polyembryony and apomixis, including their types, causes, and applications.

Practicals

Plant Anatomy

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

Plant Embryology Practicals

1. Study of anther wall and ontogeny of anthers; tapetum (amoeboid and glandular); microspore mother cells; spore tetrads; uninucleate, bicelled and dehisced anthers using temporary stained TS of anther.
2. Study of pollen morphology: pseudomonads, polyads and pollinia using slides, digital resources or fresh material; study of pollen wall ultrastructure (micrographs); assessment of pollen viability using tetrazolium test/FDA; calculation of percentage germination using hanging drop/sitting drop

method.

3. Analysis of temporary mounts of pollen grains cleared with 1N HCl/KOH to study germ pores and ultrastructure of Male Germ Unit (MGU) through micrographs.
4. Study of ovule types (anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic) and special structures (endothelium, obturator, hypostase, caruncle, aril) using permanent slides, specimens or digital resources; study of developmental sequence of monosporic embryo sac and ultrastructure of Female Germ Unit.
5. Dissection of developing seeds for endosperm with free-nuclear haustoria; study of embryogenesis by examining dicot embryo development through permanent slides and by dissecting developing seeds at various stages; study of suspensor through electron micrographs.
6. Study of seed dispersal mechanisms through adaptations observed in live specimens or digital images.

Suggested Readings:

1. Fahn A. (1974) Plant Anatomy. Pergamon Press, USA.
2. Mauseth J.D. (1988) Plant Anatomy. The Benjamin/Cummings Publisher, USA.
3. Esau K. (1977) Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.
4. Evert R.F. (2006) Esau's Plant Anatomy: Meristem, Cells, and Tissues of the Plant Body: Their Structure, Function, and Development, Third Edition. John Wiley & Sons, Inc.
5. Beck, C.B. (2010). Plant Structure and Development. Second edition. Cambridge University Press, Cambridge, UK, New York, USA.
6. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA. 3.
7. Bhojwani S.S. and Bhatnagar S.P. (2011) The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
8. Raghavan V. (2000) Developmental Biology of Flowering plants, Springer, Netherlands.
9. Raghavan V. (2006) Double Fertilization, Embryo and Endosperm Development in Flowering Plants, Springer-Verlag, Netherlands.
10. Raghavan V. (1997) Molecular Embryology of Flowering Plants, Cambridge University Press.
11. Bhojwani S.S., Bhatnagar S.P. & Dantu P.K. (2015). The Embryology of Angiosperms, 6th Edition. By VIKAS PUBLISHING HOUSE. ISBN: 978-93259-8129-
12. P. Maheshwari, (2004). An introduction to the embryology of Angiosperms. Tata McGraw-Hill Edition, ISBN: 0-07-099434-X.
13. Johri, B.M. (1984). Embryology of Angiosperms. Netherlands: Springer-Verlag. ISBN: 13:978-3-642-69304-5
14. Raghavan, V. (2000). Developmental Biology of Flowering plants. Netherlands: Springer. ISBN: 978-1-4612-7054-6.
15. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.
16. Mangla, Y., Khanduri, P., Gupta, C.K. 2022. Reproductive Biology of Angiosperms: Concepts and Methods. Cambridge University Press ISBN 978-1-009-16040-7.
17. Tandon R, Shivanna KR, Koul M Reproductive Ecology of Flowering Plants: Patterns and Processes 1st ed. 2020 Edition ISBN 978-9811542091. Springer Verlag.

18. Kapoor, R., Kaur, I. Koul M. 2016. Plant Reproductive Biology and Conservation IK International Publishing House Ltd. India ISBN: 9789382332909.

Additional Resources:

1. Bahadur, B. Rajam, M.V., Sahijram, L., Krishnamurthy, K.V. (2015). Plant Biology and Biotechnology. Volume 1: Plant Diversity, Organization, Function and Improvement.
2. Crang, R., Lyons-Soboski, S., Wise, R. (2018) Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants 1st ed. Springer.
3. Cutler, D.F., Botha, T., Stevenson, D.W. (2007). Plant Anatomy - An Applied Aspect. Blackwell Publishing, USA.
4. Evert, R.F. (2017) Esau's Plant Anatomy; Meristems, Cells and Tissues Of The Plant Body- Their Structure, Function And Development. 3rd Edn Wiley India.
5. Moza M. K., Bhatnagar A.K. (2007). Plant reproductive biology studies crucial for conservation. Current Science 92:1907.
6. Shivanna, K.R., Tandon, R. (2014). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London.
7. Shivanna, K.R., Tandon, R. (2020). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London.
8. Shivanna, K. R., & Rangaswamy, N. S. (2012). Pollen biology: a laboratory manual. Springer Science & Business Media.

Taxonomy and Systematics

L-T-P: 3-0-2 **Credits:** 4

Course Objective:

To provide students with comprehensive knowledge and practical skills in plant taxonomy, systematics, and identification, enabling them to understand historical and modern classification systems, nomenclature principles, and molecular approaches for systematic plant study.

Course Outcomes:

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

1. Demonstrate a thorough understanding of the historical development of Angiosperms classification and major contributions of key taxonomists, along with familiarity with classification systems such as Bentham & Hooker, Engler & Prantl, and APG IV.
2. Acquire practical skills in field inventory, Herbarium Techniques, and the use of Virtual Herbarium, E-flora, and taxonomic keys for accurate plant identification.
3. Explore and evaluate significant herbaria and botanical gardens in India and globally, understanding their roles in plant conservation, research, and documentation.
4. Apply the International Code of Botanical Nomenclature (I.C.B.N.) and principles of priority, along with effective publication, citation norms, and proper documentation of botanical names, including hybrids and cultivars.
5. Understand and apply modern approaches in Biosystematics, Chemotaxonomy, Numerical taxonomy, Cytotaxonomy, and Molecular Systematics for systematic classification and phylogenetic analysis of plants.

Theory

Unit 1: History of Plant Classification and Identification

Exploration into the historical narrative of Angiosperms classification; Examination of the major contributions of prominent figures in plant classification history, including Parasara, Charaka, Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan, Cronquist, Bremer, and MW Chase. Comprehensive coverage of the classification systems of Bentham and Hooker (up to series) and Engler and Prantl (up to series). Inclusion of the Angiosperm Phylogeny Group (APG IV) Classification, highlighting major clades. Practical aspects of field inventory, Herbarium Techniques, Functions of Herbarium, and exploration of significant herbaria and botanical gardens globally and in India. Emphasis on Virtual Herbarium, E-flora, including Flora, Monographs, Journals. Comprehensive study of Biosystematics, Chemotaxonomy, Numerical taxonomy, and cytotaxonomy.

Unit 2: Nomenclature and Documentation

Examination of I.C.B.N., Typification, Principles of priority, and their limitations. Detailed discussions on Effective and valid publication, Citation norms, Rejection, and retention of names. Special focus on Names of hybrids and cultivars, Concepts of biocode, and the application of Keys for plant identification, both single access and multi-access. Evaluation of the significance of computers and databases in plant identification.

Unit 3: Molecular Systematics

Exploration of Molecular Systematics, delving into context and controversies. Analysis of Proteins, Amino acid sequence, Storage Protein, Serology, and isozyme. Examination of Nucleic acids, Base ratio, Polymerase chain reaction, Fragment analysis, restriction sites, and the application of sequencing in molecular systematics. Evidence compilation from cytology, phytochemistry (Alkaloids, Phenolics, Glycosides in brief), and molecular data (cp DNA, mt DNA, nuclear DNA, PCR amplification, sequence data analysis).

Unit 4: Taxonomic Hierarchy and Basic Terms and Concepts of Phylogeny

Conceptualization of taxa (family, genus, species) and exploration of Categories and taxonomic hierarchy. In-depth exploration of Species concept (taxonomic, biological & evolutionary). Introduction to Cladistics, encompassing terms and concepts such as primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly, clades, and grades. Methodology of Cladistics and various methods of illustrating evolutionary relationships, such as phylogenetic tree and cladogram.

Practicals

1. Conduct an in-depth examination of families based on Bentham and Hooker's classification, utilizing representative species indigenous to the local region. Focus Families: At least twelve families including *Apiaceae, *Asteraceae, *Brassicaceae, *Euphorbiaceae, *Fabaceae, *Lamiaceae, *Malvaceae, *Poaceae, *Ranunculaceae, *Solanaceae, Acanthaceae, Rubiaceae, Apocynaceae, Moraceae, and Orchidaceae.
2. Acquire proficiency in the binomial nomenclature of indigenous plant species using the Gamble flora as a reference.
3. Identify the family, genus, species, and morphological characteristics of plant parts deemed valuable according to the theoretical framework.
4. Create a minimum of two herbarium specimens, employing available resources such as literature, herbaria, e-resources, and taxonomic keys for identification.

Suggested Readings & Resources

Books:

- Simpson, M. G. (2019). *Plant Systematics*, 3rd Edition, Academic Press.

- Singh, G. (2019). *Plant Systematics: An Integrated Approach*, 4th Edition, CRC Press.
- Pandey, A. K., Kasana, S. (2021). *Plant Systematics*, 2nd Edition, CRC Press.
- Maheshwari, J. K. (1963/1966). *The Flora of Delhi / Illustrations to the Flora of Delhi*.
- Harris, J. G., Harris, M. W. (2001). *Plant Identification Terminology: An Illustrated Glossary*.

Online Resources:

- Angiosperm Phylogeny Website
- Digital Atlas of Ancient Life
- Kew Herbarium Catalogue
- e-Flora of India
- Plants of the World Online (POWO)

Plant Physiology

L-T-P: 3-0-2 **Credits:** 4

Course Objective:

To provide students with a comprehensive understanding of plant physiological processes, including water relations, mineral nutrition, photosynthesis, respiration, hormonal regulation, growth and development, and plant responses to environmental stimuli, along with practical skills to study and analyse these processes.

Course Outcomes:

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

1. Describe the concepts of water potential, osmosis, water uptake, transpiration, and nutrient transport in plants, including their mechanisms and significance.
2. Outline the process of photosynthesis, including light reactions, carbon fixation, and the role of photosynthesis in the global carbon cycle. Evaluate factors influencing photosynthetic efficiency and differentiate between C3, C4, and CAM pathways.
3. Discuss the role of phytohormones in regulating plant growth and development, covering processes such as cell division, growth, photomorphogenesis, senescence, and abscission.
4. Analyse plant responses to environmental stimuli, including light, gravity, temperature, and stressors, and explain mechanisms such as phototropism, gravitropism, thigmotropism, and photoperiodism.
5. Discuss defense mechanisms employed by plants against biotic and abiotic stressors and understand the signal transduction pathways underlying plant responses.

Theory

Unit 1: Plant Water Relations and Mineral Nutrition

Introduction to Plant Physiology, Water and Plant Cells: Mechanisms of water uptake and transport, osmosis and its role in plant cells, movement, ascent of sap (include root pressure and guttation), transpiration and its significance, and cohesion-tension theory, Water potential and its components, stomatal movements –ion theory. Soil-Plant Relationships: Soil composition, nutrient availability, and root adaptations. Mineral Nutrition: Essential elements, nutrient uptake, and transport in plants, classification of mineral elements: Essential elements (macro- and micronutrients) and beneficial elements, General role of essential elements, transport of ions across membrane, active and passive transport (brief account of carriers, channels and pumps). Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading.

Unit 2: Photosynthesis and Respiration

Overview of Photosynthesis: Light reactions and Calvin cycle, Light Capture and Energy Conversion: Photosynthetic pigments, light absorption, and electron transport, Carbon Fixation and Calvin Cycle: Carbon dioxide fixation, RuBisCO enzyme, carbohydrate synthesis, Photosynthetic Efficiency: Factors influencing photosynthetic rate, environmental regulation, and C3/C4/CAM pathways, Photosynthesis

and Global Carbon Cycle: Impacts of photosynthesis on atmospheric carbon dioxide levels. Photorespiration. Metabolite pool and exchange of metabolites, synthesis and degradation of sucrose and starch. Respiration in plants and Cyanide resistant respiration.

Unit 3: Plant Growth and Development and response to light and temperature

Hormonal Regulation of Plant Growth: Phytohormones and their roles in plant growth and development, Auxins, cytokinins, gibberellins, abscisic acid, and ethylene, Photomorphogenesis: Light-mediated regulation of plant development, Senescence and Abscission: Aging processes in plants and leaf/fruit shedding. Photoperiodism - discovery (SDP, LDP, day neutral plants), concept of florigen; phytochrome (discovery and physiological role), vernalization: Genes involved in environmental responses.

Unit 4: Nitrogen metabolism and Plant Responses to Environmental Stimuli

Nitrate assimilation (NR and NiR), biological nitrogen fixation in legumes (nodulation and role of dinitrogenase) Ammonia assimilation: GS-GOGAT, reductive amination and transamination. ROS, RNS and anti-oxidative defence strategies. Plant Responses to Light, Gravity and Touch (Phototropism): Gravitropism and thigmotropism, Plant Responses to Temperature: Effects of temperature on plant growth and metabolism, Plant Responses to Biotic and Abiotic Stress: Défense mechanisms against pathogens, drought, salinity, and other stressors, Signal Transduction Pathways: Mechanisms underlying plant responses to environmental cues.

Practicals

1. To demonstrate imbibition.
2. To demonstrate osmosis in the living cells of potato.
3. To measure the rate of transpiration by using Ganong's potometer under two environmental conditions such as direct sunlight and diffused sunlight.
4. To find out the stomatal frequency and transpiration index of a leaf.
5. To Study Hill's reaction
6. To show the effect of carbon dioxide concentration on the rate of photosynthesis by using test tube funnel experiment.
7. To separate the leaf pigments by paper chromatographic technique.
8. To separate the leaf pigments by thin layer chromatographic technique.
9. To determine respiration in the absence of O2.
10. To demonstrate Respiratory Quotient (RQ)
11. To demonstrate alcoholic fermentation of sugar by microorganisms and anaerobic respiration.

12. To estimate the sugar content of the given sample of orange fruit by colorimetric method.
13. To study the effect of different concentrations of ABA on stomatal closure.
14. To study the effect of light and dark on seed germination.
15. To study induction of amylase activity in germinating barley grains.
16. To study the effect of ethylene on fruit ripening.
17. To study the effect of auxin on rooting.

Suggested Readings:

1. Govindjee, & Whitmarsh, J. (Eds.). (2011). *Photosynthesis: Plastid Biology, Energy Conversion and Carbon Assimilation* (Advances in Photosynthesis and Respiration) (Vol. 34). Dordrecht, Netherlands: Springer.
2. Taiz, L., & Zeiger, E. (2010). *Plant Physiology*. Sunderland, MA: Sinauer Associates.
3. Campbell, N. A., & Reece, J. B. (2008). *Biology* (8th ed.). San Francisco, CA: Pearson Benjamin Cummings.
4. Davies, P. J. (Ed.). (2010). *Plant Hormones: Biosynthesis, Signal Transduction, Action!* Dordrecht, Netherlands: Springer.
5. Quail, P. H. (2002). Photosensory Perception and Signalling in Plant Cells: New Paradigms? *Current Opinion in Plant Biology*, 5(5), 469–475.

Molecular Biology and Plant Biotechnology

L-T-P: 3-0-2 **Credits:** 4

Course Objective:

To provide students with a strong foundation in molecular biology concepts and plant biotechnology techniques, including molecular mechanisms, gene regulation, tissue culture, genetic engineering, genome editing, and their applications in research, agriculture, and sustainable development.

Course Outcomes:

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

1. Explain the central dogma of molecular biology and analyse the structure and function of nucleic acids, DNA replication, and chromatin organization.
2. Differentiate between prokaryotic and eukaryotic transcription and translation, including gene regulation mechanisms at transcriptional, post-transcriptional, and translational levels.
3. Apply basic plant biotechnology techniques such as tissue culture, genetic engineering, and genomics/transcriptomics analysis in research and practical applications.
4. Evaluate genome editing technologies in plants, including CRISPR/Cas9, TALENs, and ZFNs, and their applications in crop improvement.
5. Analyse plant metabolic pathways, explore strategies for metabolic engineering and stress tolerance, and understand the ethical and regulatory considerations in plant biotechnology.

Theory

Unit 1: Introduction to Molecular Biology

Discovery of nucleic acids, Experiments that established nucleic acids (DNA & RNA) as the carrier of genetic information: Griffith's, Hershey & Chase, Avery, McLeod and McCarty. Central Dogma: Nucleic Acids: Structure and Function of DNA and RNA, DNA Replication: General principles – bidirectional, semiconservative and semi-discontinuous replication. Brief account of initiation, elongation, and termination. Chargaff's rule; Watson and Crick model; salient features of DNA double helix. Types of DNA: A, B & Z conformations, denaturation and renaturation, types of RNA (brief account of mRNA, rRNA, tRNA, small RNAs). Organellar DNA: Chloroplast and Mitochondria.

Unit 2: Gene Expression and Regulation

Transcription: RNA synthesis: Initiation, elongation, and termination. Differences between prokaryotic and eukaryotic transcription. Post-transcriptional modifications: capping, splicing, polyadenylation. Translation: Ribosome structure and function. Genetic code: Codons, amino acids, start, and stop codons. Mechanism of translation: Initiation, elongation, and termination. Regulation of translation: Translational

control elements, riboswitches. Gene Regulation: Transcriptional regulation: Operons, transcription factors (brief account), enhancers, silencers.

Unit 3: Fundamentals of Plant Biotechnology

Overview of the field, its importance, and applications. Plant Tissue Culture: Techniques involved in growing plant cells, tissues, and organs in an artificial environment. Genetic Engineering Basics: Restriction endonucleases- biological role and application. Cloning vectors- Plasmids, phagemid, cosmid, shuttle vector, eukaryotic vectors. Principles and techniques of genetic engineering, including gene cloning and transformation: Recombinant DNA, bacterial transformation and selection of recombinant clones. Genomic and cDNA libraries, PCR.

Unit 4: Advanced Plant Biotechnology

Methods of gene transfer to plants: Agrobacterium-mediated transformation (Ti and Ri plasmids, development of binary vectors), Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; selection of transgenic plants: selectable marker genes (Positive selection markers – antibiotic- and herbicide-resistance conferring genes) and reporter genes (Luciferase, GUS, GFP); Introduction to genome editing. Pest resistant (Bt-cotton) and herbicide resistant plants; Transgenic crops with improved quality traits (Flavr Savr™ tomato, Golden™ rice); Biosafety of transgenic plants.

Practicals

Molecular Biology

1. Preparation of LB medium and raising E. coli.
2. Preparation of stock solutions of different molarity and molality.
3. To study the restriction digestion and gel electrophoresis of plasmid DNA through pictures.
4. To quantify the unknown DNA by diphenylamine reagent (colorimetry).
5. To study of DNA replication mechanisms through photographs and appropriate study materials (Rolling circle, Theta replication and semi-discontinuous replication).
6. To study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through electron and fluorescence micrographs.
7. To observe the photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's and Hershey).
8. To study the following through photographs: Assembly of Spliceosome machinery, Splicing mechanism in group I & group II introns and Ribozyme.

Plant Biotechnology

9. To prepare the MS medium.

10. To demonstrate the in vitro sterilization and inoculation methods using leaf and nodal explants.
11. To study the anther, embryo and endosperm culture, micropropagation, somatic embryogenesis and artificial seeds through videos and pictures.
12. Isolation of cauliflower genomic DNA.
13. To study the isolation of protoplasts through pictures.
14. To study the methods of gene transfer through photographs: Agrobacterium-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment etc.
15. To study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato.

Suggested Readings:

1. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino, & Darrell Killian (2019). *Concepts of Genetics*. Pearson; 12th edition.
2. Snustad, D.P. and Simmons, M.J. (2019). *Principles of Genetics*. John Wiley, 7th edition.
3. Griffiths, A.J.F., John Doebley J., Peichel, C., Wassarman D.A. (2020). *Introduction to Genetic Analysis*. W H Freeman & Co; 12th edition.
4. Brown, T. A. (2020) *Gene Cloning & DNA Analysis: An Introduction*. 8th edn. UK: Wiley Blackwell.
5. Glick, B.R., & Patten C. (2022). *Molecular Biotechnology: Principles and Applications*. 6th edn. Washington, U.S.: ASM Press.

Fundamentals of Genetics and Cytogenetics

LTP: 3-0-2 **Credits: 4**

Course Objective:
To provide students with a solid foundation in classical and non-Mendelian genetics, chromosome structure and function, cytogenetics, and extrachromosomal inheritance, equipping them with the essential knowledge and practical skills required for advanced studies in genetics and cytogenetics.

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

1. Describe Mendelian and non-Mendelian inheritance patterns, including codominance, incomplete dominance, gene interactions, pleiotropy, and multiple alleles.
2. Solve genetic problems involving monohybrid and dihybrid crosses, incomplete dominance, multiple alleles, sex linkage, and epistasis using Punnett squares.
3. Explain chromosome structure, linkage, crossing-over, and perform chromosome mapping using two- and three-point test crosses.
4. Identify and describe structural and numerical chromosomal aberrations and evaluate their significance in evolution and breeding.
5. Explain extrachromosomal inheritance, including chloroplast and mitochondrial mutations, maternal effects, infective heredity, and cytoplasmic male sterility in plants.

Theory

Unit 1: Mendelian genetics and its extension
Pre- Mendelian genetic concepts, Concepts of phenotype and genotype, haploid and diploid, alleles, heredity and variation; Mendelian experiments on pea plants – concept of dominant and recessive traits, monohybrid cross in pea plant, Law of segregation, back cross and test cross, dihybrid cross in pea plant, Law of independent assortment, penetrance and expressivity (genetic problems related to above topics); Extensions of Mendelian principles - codominance, incomplete dominance, gene interactions - complementary gene interaction/ duplicate recessive epistasis (flower colour in *Lathyrus odoratus*), supplementary gene interaction/ recessive epistasis (grain colour in maize), dominant epistasis (fruit colour in *Cucurbita pepo*), duplicate dominant epistasis (shepherd's purse fruit shape), dominant recessive epistasis; multiple alleles - ABO blood groups and Rh factor in humans, pleiotropy.

Unit 2: Chromosome structure, types and function
Chromosome - gross morphology, fine structure and molecular organization of chromatin; Structure and significance of centromere and telomeres; Structure and functions of specialized chromosomes – polytene, lampbrush and B-chromosome; Review of meiosis; Synapsis, synaptonemal complex, Chromosomal theory of inheritance; Linkage - complete linkage and incomplete linkage, significance of linkage; Crossing-over – definition, recombination and recombination frequency; mechanism of crossing over and chiasma formation, cytological basis of crossing-over – Creighton and McClintock's experiments on maize, Stern's experiment in Drosophila; Understanding linkage and crossing over, and their implications in inheritance patterns; Chromosome mapping - two factor and three factor crosses, interference and coincidence.

Unit 3: Structural and numerical changes in chromosomes

Basic and haploid chromosome number; Structural chromosomal aberrations – Origin, genetical and cytogenetical identification of deletion, duplication, inversion (paracentric, pericentric), translocation (reciprocal and Robertsonian translocations). Role of aberrations in evolution; Numerical variations of chromosomes – Origin, cytological and breeding behaviour of aneuploids (monosomics, trisomics) and euploids (autopolyploids, allopolyploids), Induction of polyploidy, Role of polyploids in evolution – wheat, cotton and *Brassica*.

Unit 4: Extrachromosomal inheritance

Chloroplast mutation - Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects - Shell coiling in snail; Infective heredity- Kappa particles in *Paramecium*; Cytoplasmic male sterility in plants.

Practical

1. To study mitosis in *Allium cepa* through temporary squash preparation of root tips.
2. To study meiosis in *Allium cepa / Tradescantia / Phlox* through smear preparation of anthers.
3. Genetic problems on monohybrid cross.
4. Genetic problems on dihybrid cross.
5. To study deviations of Mendelian dihybrid ratio and incomplete dominance and (12:3:1, 9:3:4, 9:7, 15:1, 13:3) through seed samples.
6. Chromosome mapping using test cross data.
7. Study of autosomal and sex-linked dominant and recessive inheritance through pedigree analyses.
8. Photographs/Permanent slides showing translocation ring, quadrivalents, laggards, dicentrics / inversion bridge through permanent slides.
9. Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red-green Colour blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached ear lobes.
10. To study the syndromes (Downs, Klinefelters, and Turners) through karyotypes.

Suggested readings

1) Klug, W. S., Cummings, M., Spencer, C. A., Palladino, M. A., & Darrell, K. (2019). Concepts of Genetics (12th ed.). San Francisco, NY: Pearson. ISBN-13: 9780134604718.
2) Griffith, A. J. F., Wessler, S. R., Carroll, S. B., & Doebley, J. (2010). Introduction to Genetic Analysis (10th ed.). W. H Freeman & Co. ISBN-13: 978-0716768876
3) Gardner, E. J., Simmons, M. J., & Snustad, D. P. (2006). Principles of Genetics (8th ed.). USA: Wiley. ISBN-13: 978-8126510436.
4) Elrod, S., & Stansfield, W. (2010). Schaum's Outline of Genetics (5th ed.). McGraw Hill. ISBN-13: 978-0071625036.

Ecology and Environment

LTP: 3-0-2 **Credits: 4**

Course Objective:

To provide students with a comprehensive understanding of ecological principles, population and community dynamics, ecosystem functioning, species distribution, and human impacts on the environment, enabling them to apply ecological knowledge and research skills to real-world environmental issues.

Course Outcomes:

1. Demonstrate understanding of fundamental ecological concepts, levels of organization, habitat, and niche, and link ecological principles to real-world environmental challenges.
2. Analyse population dynamics, growth models, limiting factors, population regulation mechanisms, and human population trends.
3. Evaluate community structure, species interactions, keystone species, succession processes, and ecosystem stability.
4. Examine ecosystem components, energy flow, nutrient cycling, primary productivity, human impacts, biogeographic patterns, and conservation strategies.
5. Apply ecological concepts and quantitative methods to practical investigations, including population studies, species interactions, nutrient cycling, succession, productivity measurements, and field-based conservation observations.

Theory

Unit 1: Introduction to Ecology

Overview of Ecology: Definition, branches, and its significance in understanding ecosystems and environmental issues. Historical Development: Contributions of key figures such as Darwin and Odum to ecological theory. Levels of Organization: Understanding individual, population, community, ecosystem, and biosphere levels. Application in Environmental Issues: Linking ecological principles to real-world challenges like climate change and habitat loss. Habitat and Niche: Understanding habitat and niche, their characteristics, and their importance in species survival and coexistence.

Unit 2: Population Ecology

Population Dynamics: Characteristics of populations, growth models (exponential and logistic), and carrying capacity. Limiting Factors: Understanding factors that limit population growth and the concept of carrying capacity. Population Regulation: Exploring density-dependent and density-independent regulation mechanisms. Human Population: Trends, implications, and strategies for addressing related challenges.

Unit 3: Community Ecology

Community Structure: Factors influencing structure and understanding ecological communities. Species Interactions: Types of interactions like competition, predation, mutualism, and their examples. Keystone Species: Importance and examples, trophic cascades, and food webs. Succession and Stability: Types of succession, factors affecting it, and its relationship with stability.

Unit 4: Ecosystem Functioning and Biogeography

Ecosystem Introduction: Components, types, energy flow, and nutrient cycling. Primary Productivity: Understanding factors influencing productivity and ecosystem energetics. Human Impact: Threats to ecosystems and biodiversity, consequences, and conservation strategies. Biogeography: Factors influencing species distribution, biogeographic realms, and their characteristics. Synthesis and Application: Integrating concepts, real-world applications, research methodologies, and future directions in ecology.

Practicals

1) To investigate the population growth of a model organism under controlled conditions and understand the concepts of exponential and logistic growth models.
2) To examine the effects of different species interactions (competition, predation, mutualism) on community structure and dynamics.
3) To quantify nutrient cycling rates in a terrestrial or aquatic ecosystem and understand the importance of nutrient availability for ecosystem functioning.
4) To determine the habitat preferences of selected species and explore the concept of niche specialization for species survival and coexistence.
5) To observe the effects of trophic cascades on community dynamics and understand the role of keystone species in ecosystem stability.
6) To estimate the carrying capacity of an ecosystem for a particular species and investigate the factors influencing population regulation.
7) To study the process of ecological succession in a disturbed area and analyze the changes in species composition and ecosystem structure over time.
8) To measure primary productivity in a selected ecosystem and assess the factors influencing energy flow and ecosystem energetics.
9) To analyze species distribution patterns in different biogeographic regions and identify the factors shaping species diversity and distribution.
10) To assess the ecological consequences of human activities on local ecosystems and propose conservation strategies to mitigate negative impacts.
11) Field visit

Suggested readings:

1) Molles Jr., M. C. (2014). Ecology: Concepts and Applications. McGraw-Hill Education.
2) Odum, E. P., & Barrett, G. W. (2005). Fundamentals of Ecology. Brooks Cole.
3) Rockwood, L. L. (2015). Principles of Population Ecology. Wiley.
4) Mittelbach, G. G., & McGill, B. J. (2019). Community Ecology. Oxford University Press.
5) Van Dyke, F. (2013). Conservation Biology: Foundations, Concepts, Applications. Springer.

Mycology and Phytopathology

LTP: 3-0-2 **Credits: 4**

Course Objective:

This course provides an advanced understanding of fungal biology, plant-pathogen interactions, and disease management. It covers fungal diversity, reproduction, molecular mechanisms of pathogenesis, and host defence strategies. Emphasis is placed on modern diagnostic techniques, biocontrol methods, and sustainable disease management approaches. Through laboratory work and case studies, students will develop practical skills in fungal identification, molecular detection, and innovative disease control strategies, preparing them for careers in research, academia, and agriculture.

Course Outcomes:

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

1. Demonstrate an advanced understanding of fungal biology, classification, ultrastructure, and reproduction, with insights into molecular systematics and phylogenetics.
2. Analyse plant-pathogen interactions at biochemical and molecular levels, including pathogenicity determinants, host defence mechanisms, and effector biology.
3. Apply modern diagnostic techniques such as PCR-based pathogen detection, biochemical assays, and metagenomics for disease surveillance and management.
4. Evaluate sustainable and innovative disease management strategies, including biocontrol, CRISPR-based resistance breeding, and nanotechnology in plant protection.

Theory

Unit 1: Fungal Biology, Structure, and Reproduction

Introduction to mycology, historical perspectives on fungal classification and evolution; fungal morphology and structural organization, including hyphal growth, branching patterns, and aggregation; cell wall composition, biosynthesis of chitin and β-glucans, antifungal targets; reproduction in fungi, including sexual, asexual, and parasexual cycles; mechanisms of homothallism, heterothallism, heterokaryosis, stress response and survival mechanisms of fungi in extreme environments.

Unit 2: Fungal Diversity, Industrial and Pathogenic Significance

Modern fungal classification (Tedersoo et al. (2018), Galindo et al. (2021), and Wijayawardene et al. (2020a, 2022a) with emphasis on phylogenetics and molecular markers (ITS, LSU, SSU); diversity and characteristics of major fungal groups, including Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, and Deuteromycotina; role of fungi in biotechnology and industry, including fermentation, enzyme production, antibiotics, and organic acids; fungi as biocontrol agents and symbionts in agriculture; fungal infections in humans (mycoses) and emerging phytopathogenic fungi under climate change scenarios; major fungal diseases of crops, including brown spot of rice, stripe rust of wheat, red

rot of sugarcane, tikka disease of groundnut, white blister of crucifers, downy mildew of vegetables, and powdery mildew of wheat.

Unit 3: Plant-Fungal Interactions

Concept of plant diseases, disease triangle, role of environmental factors in disease outbreaks; types of fungal inocula, survival strategies, and dispersal mechanisms; host penetration strategies, including direct penetration, entry through wounds, and natural openings; role of fungal enzymes, including cutinases, cellulases, pectinases, and proteases in pathogenesis; secondary metabolites and toxins as virulence factors, including host-specific and non-host-specific toxins; fungal effectors and their role in host immune suppression; plant defense responses, including pattern-triggered immunity (PTI) and effector-triggered immunity (ETI); emerging molecular techniques in disease diagnostics, including qPCR, ELISA, and biosensors.

Unit 4: Advanced Disease Management Strategies

Regulatory frameworks in plant disease management, including quarantine laws and biosecurity measures; biological control using mycoparasites, antagonistic microbes, and endophytes; sustainable cultural practices, including crop rotation, rogueing, sanitation, and soil amendments; chemical control strategies, including fungicide classification, mode of action, and resistance management; advancements in plant disease resistance breeding, including CRISPR/Cas-mediated genome editing for fungal disease resistance; application of nanotechnology in disease control, including nanoparticle-based fungicides and disease detection; climate-resilient integrated disease management (IDM) strategies.

Practical

1. Microscopic identification of fungal structures using lactophenol cotton blue staining, SEM analysis of fungal hyphae.
2. Isolation and culturing of phytopathogenic fungi using selective media, maintenance and subculturing techniques.
3. Molecular identification of fungal pathogens using DNA extraction, PCR amplification, and ITS sequencing.
4. Biochemical characterization of fungal enzymes, including cellulases and pectinases, involved in pathogenesis.
5. Disease symptomatology and histopathological analysis of infected plant tissues.
6. In vitro antifungal assays for screening the efficacy of fungicides and biocontrol agents.
7. Interaction studies between plant pathogens and biocontrol fungi using dual-culture assays.
8. Fungal biodiversity assessment using metagenomics and next-generation sequencing (optional module).

Suggested readings:

Core Textbooks:

- **Agrios, G.N.** (2005). *Plant Pathology* (5th Edition). Elsevier.
- **Alexopoulos, C.J., Mims, C.W., & Blackwell, M.** (1996). *Introductory Mycology* (4th Edition). Wiley.

- **Webster, J., & Weber, R.** (2007). *Introduction to Fungi* (3rd Edition). Cambridge University Press.
- **Lucas, J.A., Bowyer, P., & Anderson, H.M.** (2017). *Plant Pathology and Plant Pathogens* (3rd Edition). Wiley.
- **Sumbali, G. (2010). *The Fungi* (2nd ed.). Narosa Publishing House. ISBN: 978-8184870374.**

Advanced References on Molecular and Applied Aspects:

- **Dean, R., Van Kan, J.A., Pretorius, Z.A., Hammond-Kosack, K.E., Di Pietro, A., Spanu, P.D., Rudd, J.J., Dickman, M., Kahmann, R., Ellis, J., & Foster, G.D.** (2012). "The top 10 fungal pathogens in molecular plant pathology." *Molecular Plant Pathology, 13*(4), 414-430.
- **Horbach, R., Navarro-Quesada, A.R., Knogge, W., & Deising, H.B.** (2011). "When and how to kill a plant cell: Infection strategies of plant pathogenic fungi." *Journal of Plant Physiology, 168*(1), 51-62.
- **Strange, R.N., & Scott, P.R.** (2005). "Plant disease: A threat to global food security." *Annual Review of Phytopathology, 43*, 83-116.
- **Zeilinger, S., Gupta, V.K., Dahms, T.E.S., Silva, R.N., Singh, H.B., Upadhyay, R.S., Gomes, E.V., Tsui, C.K.M., & Nayak, S.C.** (2016). "Friends or foes? Emerging insights from fungal interactions with plants." *FEMS Microbiology Reviews, 40*(2), 182-207.

References on Diagnostic and Disease Management Techniques:

- **Gullino, M.L., & Kuijpers, L.** (1994). "Social and political implications of managing plant diseases with restricted fungicides in Europe." *Annual Review of Phytopathology, 32*, 559-579.
- **Huang, J., Jie, S., & Li, X.** (2021). "Nanotechnology for plant disease management: Current perspectives and future directions." *Trends in Plant Science, 26*(10), 956-970.
- **Schena, L., Nigro, F., Ippolito, A., & Gallitelli, D.** (2004). "Real-time quantitative PCR: A new technology to detect and study phytopathogenic and antagonistic fungi." *European Journal of Plant Pathology, 110*, 893-908.

Supplementary Online Resources and Journals:

- **Molecular Plant Pathology (Wiley)** – A leading journal covering molecular aspects of plant diseases. https://bsppjournals.onlinelibrary.wiley.com/journal/13643703
- **Annual Review of Phytopathology** – Publishes comprehensive reviews on emerging research in plant pathology.

  https://www.annualreviews.org/journal/phyto
- **Fungal Biology Reviews (Elsevier)** – Covers advances in fungal taxonomy, ecology, and biotechnology. https://www.sciencedirect.com/journal/fungal-biology-reviews

Phycology, Bryology, and Pteridology

LTP: 3-0-2 **Credits: 4**

Course Objective:

This course provides postgraduate students with an advanced understanding of algae, bryophytes, and pteridophytes, emphasizing their diversity, structural complexity, and evolutionary significance. It integrates taxonomic, molecular, and functional aspects, highlighting their role in plant evolution, physiological adaptations, and ecological interactions**.**

Course Outcomes:

On successful completion of this course, students will be able to**:**

1. Analyse the taxonomic and evolutionary trends of algal groups based on morphology, reproduction, and molecular characteristics.
2. Examine the structural and reproductive features of different bryophytes and their phylogenetic significance.
3. Evaluate evolutionary advancements in pteridophytes, focusing on vascular development, stelar organization, and reproductive strategies.
4. Understand molecular, developmental, and ecological aspects of cryptogams in plant adaptation and evolution**.**

Theory

Unit 1: Systematics and Evolutionary Trends in Algae

Recent classification of algae (McCoy, 2020) covering Chlorophyceae, Xanthophyceae, Phaeophyceae, Rhodophyceae, and Cyanophyceae. Evolutionary relationships among algal groups, diversity in chloroplast structure, cell wall composition, and storage reserves. Life cycle variations: monogenetic, digenetic, and trigenetic types. Algal symbioses: lichens, mycophycobioses, and endosymbioses**.**

Unit 2: Advanced Studies in Bryophytes

Recent classification of Bryophytes (Bell, 2007), Bryophytes as the earliest land plants; Comparative morphology, anatomy, and reproduction of thalloid liverworts (Sphaerocarpales, Metzgeriales, Marchantiales) and leafy liverworts (Calobryales, Jungermanniales). Morphology and anatomy of Anthocerophyta, Funariales, and Sphagnales. Water-conducting cells, sporophyte evolution, and phylogenetic relationships with vascular plants**.**

Unit 3: Evolutionary Development and Diversity in Pteridophytes

Origin and classification of pteridophytes (Mark W. Chase and Alastair, 2016). Evolution of vascular tissues: protoxylem, metaxylem, and stelar types. Apospory, apogamy, and parthenogenesis. Heterospory and seed habit, distinction between eusporangiate and leptosporangiate ferns. Fossil pteridophytes: *Rhynia*, *Lepidodendron*, *Sphenophyllum*, and *Calamites*. Comparative morphology, anatomy, and reproduction of *Psilotum*, *Lycopodium*, *Selaginella*, *Isoetes*, *Equisetum*, and *Marsilea***.**

Unit 4: Developmental and Molecular Insights in Cryptogams

Sporophyte evolution from algae to vascular plants. Comparative embryology and alternation of generations. Molecular phylogenetics of cryptogams. Epigenetic regulation, small RNAs, and chromatin

modifications in bryophytes and pteridophytes. Adaptations to environmental stress: desiccation tolerance, UV protection, and extremophile survival strategies. Symbiotic interactions: mycorrhizal associations in pteridophytes, algal-endophyte associations, and bryophyte-cyanobacteria partnerships**.**

Practical

1. Structural study of algal, bryophyte, and pteridophyte representatives (fresh and preserved specimens).
2. Slide preparation and staining of reproductive structures.
3. Observation of spore germination, gametophyte development, and sporophyte formation.
4. Chromatographic analysis of algal photosynthetic pigments.
5. DNA extraction and PCR-based identification of cryptogams.
6. Phylogenetic tree construction for major algal and pteridophyte groups.
7. Field study on bryophyte and pteridophyte diversity in different habitats.
8. Interaction of cryptogamic plants with soil microbiomes.

Suggested readings:

Core Textbooks:

- **Bold, H.C., & Wynne, M.J.** (1985). *Introduction to the Algae: Structure and Reproduction*. Prentice-Hall.
- **Graham, L.E., & Wilcox, L.W.** (2000). *The Origin of Land Plants: A Multigenic Perspective*. University of Chicago Press.
- **Lee, R.E.** (2018). *Phycology (5th Ed.)*. Cambridge University Press.
- **Parihar, N.S.** (1996). *An Introduction to Embryophyta, Vol. I: Bryophyta*. Central Book Depot.
- **Parihar, N.S.** (1996). *An Introduction to Embryophyta, Vol. II: Pteridophyta*. Central Book Depot.
- **Raven, P.H., Evert, R.F., & Eichhorn, S.E.** (2005). *Biology of Plants (7th Ed.)*. W.H. Freeman and Company.
- **Shaw, A.J., & Goffinet, B.** (2013). *Bryophyte Biology (2nd Ed.)*. Cambridge University Press.
- **van den Hoek, C., Mann, D.G., & Jahns, H.M.** (1995). *Algae: An Introduction to Phycology*. Cambridge University Press.

Phycology (Algae)

- **Barsanti, L., & Gualtieri, P.** (2014). *Algae: Anatomy, Biochemistry, and Biotechnology (2nd Ed.)*. CRC Press.
- **Bellinger, E.G., & Sigee, D.C.** (2015). *Freshwater Algae: Identification and Use as Bioindicators*. Wiley-Blackwell.

- **Richmond, A., & Hu, Q.** (2013). *Handbook of Microalgal Culture: Applied Phycology and Biotechnology (2nd Ed.)*. Wiley-Blackwell.
- **Round, F.E.** (1984). *The Ecology of Algae*. Cambridge University Press.
- McCoy, S. J., et al. (2020). *A New Framework for Algal Classification: Emphasizing Molecular Data for Species Delineation*. *Journal of Phycology*, 56(6), 1050-1064. https://doi.org/10.1111/jpy.13045

Bryology (Bryophytes)

- Bell, A. M. D., et al. (2007). *The Evolution of Bryophyte Classification: A Molecular Phylogenetic Approach*. *Botanical Journal of the Linnean Society*, 155(3), 379-403. https://doi.org/10.1111/j.1095-8339.2007.00649.x
- **Longton, R.E.** (1992). *The Role of Bryophytes in Terrestrial Ecosystems*. Journal of Bryology, **17**, 135-161.
- **Mishler, B.D.** (2018). *Bryophyte Ecology and Evolution: The Biology of Mosses, Liverworts, and Hornworts*. CRC Press.
- **Schofield, W.B.** (1985). *Introduction to Bryology*. Macmillan Publishing Company.
- **Watson, E.V.** (1971). *The Structure and Life of Bryophytes (3rd Ed.)*. Hutchinson & Co.

Pteridology (Pteridophytes - Ferns and Lycophytes)

- **Gifford, E.M., & Foster, A.S.** (1989). *Morphology and Evolution of Vascular Plants (3rd Ed.)*. W.H. Freeman & Company.
- **Moran, R.C.** (2004). *A Natural History of Ferns*. Timber Press.
- **Ranker, T.A., & Haufler, C.H.** (2008). *Biology and Evolution of Ferns and Lycophytes*. Cambridge University Press.
- **Tryon, R.M., & Tryon, A.F.** (1982). *Ferns and Allied Plants: With Special Reference to Tropical America*. Springer.

Molecular, Ecological, and Evolutionary Perspectives:

- **Bateman, R.M., & DiMichele, W.A.** (1994). *Heterospory: The Most Iterative Key Innovation in the Evolutionary History of the Plant Kingdom*. Biological Reviews, **69**, 345-417.
- Pteridophyte Phylogeny Group I. (2016). *A classification for extant ferns*. *Journal of Systematics and Evolution*, 54(6), 563–603. https://doi.org/10.1111/jse.12229
- **Kenrick, P., & Crane, P.R.** (1997). *The Origin and Early Diversification of Land Plants: A Cladistic Study*. Smithsonian Institution Press.
- **Niklas, K.J.** (1997). *The Evolutionary Biology of Plants*. University of Chicago Press.

- **Pryer, K.M., Schneider, H., & Smith, A.R.** (2001). *Horsetails and Ferns Are a Monophyletic Group and the Closest Living Relatives to Seed Plants*. Nature, **409**, 618-622.

Recent Research Articles and Reviews:

- **Cardon, Z.G., & Gray, D.W.** (2017). *Photosynthetic Symbioses in Bryophytes and Ferns: Functioning and Evolutionary Perspectives*. Journal of Experimental Botany, **68**, 3609-3623.
- **de Vries, J., & Archibald, J.M.** (2018). *Endosymbiosis and Its Implications for Evolutionary Theory and Cell Biology*. Nature Reviews Microbiology, **16**, 177-189.
- **Gao, L., & Goffinet, B.** (2020). *Advances in Bryophyte Genomics and Evolutionary Research*. New Phytologist, **227**, 565-570.
- **Rensing, S.A.** (2018). *Great Moments in Evolution: The Conquest of Land by Plants*. Current Opinion in Plant Biology, **42**, 49-54.

Molecular Cell Biology

3-0-2 **Credits: 4**

Course Objective:

This course provides an advanced understanding of molecular mechanisms governing plant cellular functions, with a strong emphasis on gene expression regulation, signal transduction, organelle dynamics, and stress adaptation. Students will explore plant-specific cellular processes such as plastid biogenesis, phytohormone signaling, secondary metabolism, and plant-microbe interactions. By integrating classical and modern molecular biology techniques, including CRISPR, transcriptomics, and advanced microscopy, the course aims to bridge fundamental plant cell biology with cutting-edge research in crop biotechnology and stress resilience.

Course Outcomes:

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

1. Critically analyse plant cellular architecture, organelle biogenesis, and inter-organellar communication using advanced microscopy and imaging techniques.
2. Investigate molecular mechanisms governing plant gene expression, chromatin remodelling, RNA processing, and translational regulation under normal and stress conditions.
3. Interpret complex signalling networks, including hormone cross-talk, stress perception pathways, and plant-microbe interactions, using bioinformatics and experimental approaches.
4. Develop and apply advanced experimental strategies, such as CRISPR-based genome editing, high-throughput omics technologies, and molecular phenotyping, for studying plant cellular processes and stress tolerance.

Theory

Unit 1: Plant Cellular Structure, Organization, and Dynamics

Plastid biogenesis, chloroplast development, interconversion of plastid types, stromule formation, plastid-nuclear communication, membrane transport, vesicular trafficking, SNARE proteins, endocytic and exocytic pathways, plasmodesmata, intercellular communication, vacuole function, ion homeostasis, secondary metabolite accumulation, programmed cell death, super-resolution microscopy, live-cell imaging, FRAP, FRET, TEM, cryo-electron microscopy.

Unit 2: Gene Expression and Regulation in Plants

Chromatin dynamics, DNA methylation, histone modifications, chromatin remodelling complexes, transcriptional control, transcription factors, enhancer elements, RNA polymerase complexes, plant-specific transcriptional regulators, alternative splicing, RNA interference, miRNA, siRNA, RNA transport, long non-coding RNAs, post-translational modifications, protein turnover, RNA-Seq, scRNA-Seq.

Unit 3: Plant Signal Transduction and Stress Perception Mechanisms

Hormone signaling; auxin, cytokinin, gibberellin, abscisic acid, ethylene, brassinosteroids, strigolactones, jasmonic acid; G-protein-coupled signaling in hormone regulation and stress adaptation; abiotic stress sensing, drought, salinity, heat, cold stress; ROS signaling, redox homeostasis, stress memory; biotic stress signaling, pattern-triggered immunity (PTI), effector-triggered immunity (ETI), systemic acquired resistance (SAR), hypersensitive response (HR); G-protein-mediated defense signaling; plant-microbe interactions, microbial signaling molecules, quorum sensing, pathogen effectors; G-proteins in mycorrhizal and rhizobial signaling; fluorescent biosensors, phosphoproteomics.

Unit 4: Cell Cycle, Programmed Cell Death, and Secondary Metabolism in Plants
Molecular regulation of the plant cell cycle, cyclins, cyclin-dependent kinases, checkpoint control, retinoblastoma-related proteins, programmed cell death, autophagy, apoptosis-like PCD, vacuolar proteases, metacaspases, proteolytic enzymes, secondary metabolite biosynthesis, flavonoids, alkaloids, terpenoids, flow cytometry for cell cycle analysis.

Practical

1. Isolation and Microscopic Characterization of Plant Cell Organelles.
2. Visualization of Plant Cell Membranes and Cytoskeleton Using Fluorescent Dyes.
3. RNA Isolation and Quantification for Gene Expression Analysis.
4. Reverse Transcription and qRT-PCR for Stress-Responsive Genes.
5. Analysis of Phytohormone Signaling Pathways Using Reporter Constructs.
6. Protein-Protein Interaction Studies Using Yeast Two-Hybrid Assay.
7. Transcriptome Data Analysis Using Bioinformatics Tools.
8. Detection of Reactive Oxygen Species (ROS) Under Stress Conditions.
9. Flow Cytometry Analysis of Cell Cycle Progression in Plants.
10. Confocal Microscopy for Visualization of Plant Cell Structures.
11. Electrophoretic Mobility Shift Assay (EMSA) for DNA-Protein Interactions.

Suggested Reading
Textbooks and Reference Books:

- **Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A.** (2015). *Plant Physiology and Development* (6th ed.). Sinauer Associates.
- **Meyerowitz, E. M., & Somerville, C. R.** (2016). *Arabidopsis* (2nd ed.). Cold Spring Harbor Laboratory Press.
- **Ray, A., & Singh, N. K.** (2021). *Molecular Mechanisms of Plant Development and Stress Adaptation*. Springer.
- **Smetanska, I.** (2020). *Plant Biotechnology for Stress Resilience*. Springer.
- **Zhang, X., & He, Y.** (2020). *Epigenetic Regulation in Plant Stress Response*. Springer.
- **Rhee, S. Y., & Bevan, M. W.** (2021). *Plant Genomics and Proteomics: Methods and Protocols*. Springer.
- **Zhang, S., & Zhang, J.** (2020). *Plant Signaling Networks in Stress Responses*. Elsevier.
- **Larkin, J. C., & McClung, C. R.** (2016). *Molecular Plant Biology: Recent Advances in Plant Stress Biology*. Wiley.

- **Kieber, J. J., & Schaller, G. E.** (2021). *Hormone Signaling in Plants: From Mechanisms to Applications*. Springer.
- **Millar, A. H., & Suzuki, N.** (2020). *Molecular Mechanisms of Plant Stress Tolerance*. Wiley-Blackwell.
- **Rook, F., & Saito, K.** (2021). *Molecular Mechanisms of Plant Metabolism and Stress Tolerance*. Springer.
- **Schaller, G. E., & Kieber, J. J.** (2021). *Molecular Mechanisms of Plant Growth and Development*. CRC Press.
- **Sinha, N.** (2018). *Cell Signaling in Plants: Theory and Applications*. Springer.
- **Boller, T., & Felix, G.** (2019). *Molecular Plant Immunity*. Springer.
- **Kumar, P., & Gupta, M.** (2020). *Gene Regulation and Epigenetics in Plants*. Springer.
- **Osbourn, A. E., & Field, B.** (2019). *Plant Secondary Metabolism and Gene Regulation*. Springer.
- **Zhang, C., & Wang, W.** (2021). *Plant Cell Cycle and Development*. Springer.

Additional Suggested Reading:

- **Davies, P. J. (Ed.).** (2004). *Plant Hormones: Biosynthesis, Signal Transduction, Action!* (3rd ed.). Springer. ISBN: 978-1-4020-2685-0.
- **Nath, P., Bouzayen, M., Mattoo, A. K., & Pech, J. C. (Eds.).** (2014). *Fruit Ripening: Physiology, Signaling and Genomics*. CABI. ISBN: 978-1-84593-962-5.
- **Noodén, L. D. (Ed.).** (1988). *Senescence and Aging in Plants*. Academic Press. ISBN: 978-0-12-520915-0.
- **De Moraes, C. M., Mescher, M. C., & Tumlinson, J. H. (Eds.).** (2012). *Biotic Interactions in Plant Defense*. Wiley-Blackwell. ISBN: 978-0-470-95820-8.
- **Pareek, A., Sopory, S. K., Bohnert, H. J., & Govindjee (Eds.).** (2010). *Abiotic Stress Adaptation in Plants: Physiological, Molecular and Genomic Foundation*. Springer. ISBN: 978-90-481-3111-2.

Reports and Online Resources:

Reports

- Intergovernmental Panel on Climate Change (IPCC) Reports.
- Food and Agriculture Organization (FAO) *State of Food Security Reports*.
- Annual Reports on Plant Biotechnology and Agriculture from the *International Plant Biotechnology Journal*.

Online Resources

- FAO: www.fao.org

- The Arabidopsis Information Resource (TAIR): www.arabidopsis.org
- Plant Transcription Factor Database: planttfdb.cbi.pku.edu.cn
- National Center for Biotechnology Information (NCBI) Plant Genome Database: www.ncbi.nlm.nih.gov
- International Society for Plant Molecular Biology: www.ispmb.org

Gymnosperms and Palaeobotany

LTP: 3-0-2 **Credits:4**

Course Objective:

This course aims to provide a comprehensive understanding of gymnosperms, covering their classification, evolutionary trends, and ecological significance. It explores the morphology, anatomy, and reproductive biology of major gymnosperm groups, including fossil representatives, to understand their phylogenetic relationships. The course also highlights the economic importance of gymnosperms, emphasizing their industrial, medicinal, and ecological roles. Additionally, students will gain insights into molecular tools, genome studies, and gene expression analysis relevant to gymnosperms. Finally, the course integrates palaeobotanical techniques to analyse fossilized gymnosperms, enhancing knowledge of plant evolution and diversification over geological time.

Course Outcomes:

On successful completion of this course, the students should be able to:

1) Demonstrate an understanding of gymnosperm characteristics, classification, ecological roles, and their evolutionary and phylogenetic significance.
2) Interpret the structural and reproductive adaptations of both extant and fossil gymnosperms, linking these traits to their evolutionary history.
3) Evaluate the economic value, molecular biology, and genomic advancements in gymnosperms, emphasizing their role in stress resilience and secondary metabolite production.
4) Apply experimental methods, including tissue culture and gene editing, to gymnosperm research, conservation strategies, and industrial application.

Theory

Unit 1: Gymnosperm Fundamentals

Introduction to Gymnosperms: General characteristics and classification of gymnosperms; evolutionary trends and phylogenetic significance; distribution and ecological roles of gymnosperms in India. Principles of Palaeobotany: Geological time scales and fossilization processes; types of fossils and fossil study techniques; methods of carbon dating and their applications.

Unit 2: Morphology, Anatomy, and Life Cycles of Gymnosperms

Study of Major Gymnosperm Groups: Morphology, anatomy, reproduction, structural features, and life cycles of Cycadales, Ginkgoales, and Coniferales. Advanced Gymnosperm Orders: Morphology, anatomy, reproduction, structural features, and life cycles of Ephedrales, Gnetales, and Welwitschiales; unique features and evolutionary significance. Fossil Gymnosperms: Morphology, anatomy, reproduction, and structural features of Cordaitales, Glossopteridales, and Bennettitales.

Unit 3: Applied Aspects and Molecular Insights

Economic Importance of Gymnosperms: Timber and industrial applications; medicinal uses and production of secondary metabolites; ornamental and ecological contributions. Molecular Biology and Genomics: Recent advances in gymnosperm genome sequencing projects; molecular markers for phylogenetic studies; gene expression analysis in gymnosperms under biotic and abiotic stresses.

Unit 4: Palaeobotany – Evolutionary History and Fossil Gymnosperms

Introduction to Palaeobotany: Definition, scope, and significance; fossilization processes, geological time scale, and dating techniques including radiocarbon dating and stratigraphy. Major Fossil Gymnosperms: Progymnosperms (*Aneurophyton*, *Archaeopteris*); Pteridosperms (Seed ferns: *Lyginopteris*, *Medullosa*); extinct orders including Bennettitales, Cordaitales, and Caytoniales; fossil Cycads and Ginkgoales with their evolutionary significance. Techniques in Palaeobotany: Pollen and spore analysis (palynology);

anatomical and ultrastructural studies of fossil plants; fossil DNA and molecular palaeobotany for evolutionary insights. Applications of Palaeobotany: Plant evolution and diversification: concept and significance.

Practical

1) Identification of Gymnosperm species in local ecosystems and document their morphological and ecological characteristics.

   Activities:
   - Conduct a field visit to a botanical garden, forest, or other local habitats.
   - Record gymnosperm species, their ecological niches, and distinguishing features.
   - Create herbarium sheets or photographic documentation

2) To study physiological traits of gymnosperms in natural habitats (Histological Analysis of Gymnosperm Tissues)

   Activities:
   - Measure photosynthetic rate, stomatal conductance, and transpiration using portable equipment (e.g., IRGA or porometer).
   - Soil analysis for moisture content, pH, and nutrient availability near gymnosperms

3) To analyze the anatomical features of gymnosperm tissues

   Activities:
   - Prepare thin sections of gymnosperm leaves, stems, and roots.
   - Stain the sections with appropriate dyes (e.g., safranin, fast green).
   - Study and document tissue structures under a microscope

4) To extract the DNA and perform molecular analysis of gymnosperms.

   Activities:
   - DNA extraction from gymnosperm samples using CTAB or other protocols.
   - Perform PCR amplification using specific primers.
   - Visualize PCR products using agarose gel electrophoresis

5) To quantify and analyze secondary metabolites in gymnosperms

   Activities:
   - Extract secondary metabolites from gymnosperm tissues (e.g., bark or needles).
   - Perform qualitative tests for alkaloids, flavonoids, or phenols.
   - Quantify specific metabolites using spectrophotometry.

Suggested readings

Textbooks:

• Stewart, W.N., Rothwell, G.W. (1993). *Paleobotany and the Evolution of Plants, 2nd edition,* Cambridge University Press, Cambridge, UK.
• Beck, C.B. (2010). *An Introduction to Plant Structure and Development: Plant Anatomy for the Twenty-First Century, 2nd edition,* Cambridge University Press, Cambridge, UK.
• Taylor, T.N., Taylor, E.L., Krings, M. (2009). *Paleobotany: The Biology and Evolution of Fossil Plants, 2nd edition,* Academic Press, San Diego, USA.
• Singh, H. (1978). *Embryology of Gymnosperms,* Gebrüder Borntraeger, Stuttgart, Germany.
• Andrews, H.N. (1961). *Studies in Paleobotany,* John Wiley & Sons, New York, USA.

Research Articles:

• Clement-Westerhof, J.A. (1988). "Aspects of Permian Palaeobotany and Palynology. IV. The Conifer Ortiseia leonardii sp. nov. from the Val Gardena Formation of the Dolomites and its Palaeoecological Implications," *Review of Palaeobotany and Palynology, 55(1),* 57–110.
• Rothwell, G.W., Serbet, R. (1994). "Lignophyte Phylogeny and the Evolution of Spermatophytes: A Cladistic Analysis," *Systematic Botany, 19(3),* 443–482.
• Cantrill, D.J., Poole, I. (2002). "Cretaceous Patterns of Gymnosperm Diversification in the Southern Hemisphere," *Journal of Paleontology, 76(1),* 101–111.
• Nishida, H., Nishida, M., Yamada, T., Ohba, H. (1999). "Leaf Morphology and Cuticle Structure of Cretaceous Conifers from Japan," *Review of Palaeobotany and Palynology, 105(1–2),* 1–24.
• Del Fueyo, G.M., Archangelsky, S. (2002). "The Structure and Affinities of Jurassic Conifers from Patagonia, Argentina," *Review of Palaeobotany and Palynology, 122(1),* 13–34.

Specialized Topics:

• Beerling, D.J., Osborne, C.P. (2002). "Physiological Ecology of Mesozoic Polar Forests in a High CO_2 Environment," *Annals of Botany, 89(1),* 329–339.
• Hilton, J., Bateman, R.M. (2006). "Pteridosperms Are the Backbone of Seed-Plant Phylogeny," *Journal of the Torrey Botanical Society, 133(1),* 119–168.
• Galtier, J., Phillips, T.L. (1999). "The Evolution of Early Seed Plants," *Annual Review of Ecology and Systematics, 30,* 47–73.
• Labandeira, C.C. (2006). "The Four Phases of Plant-Arthropod Associations in Deep Time," *Geological Journal, 41(1),* 195–212.
• Cleal, C.J., Thomas, B.A. (2009). *Plant Fossils: The History of Land Vegetation and its Exploration,* Smithsonian Books, Washington, USA.

Supplementary Reading:

• Scott, A.C., Galtier, J. (1985). "The Earliest Coniferophytes: An Anatomical and Ecological Appraisal," *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 309(1138),* 183–197.
• Niklas, K.J. (1997). *The Evolutionary Biology of Plants,* University of Chicago Press, Chicago, USA.

Reproductive And Development Biology of Angiosperms

LTP: 3-0-2 **Credits: 4**

Course Objective:

This course is designed to provide students with a thorough understanding of the internal basic architecture and cellular composition of plant body. The curriculum incorporates both classical and experimental methodologies to explore fundamental biological phenomena such as sporogenesis, gametogenesis, fertilization and embryogenesis.

Course Outcomes: On successful completion of this course, the students will be able to:

1. Demonstrate principles of plant growth and development, including cell division, differentiation and morphogenesis.
2. Explain the importance of meristems in plant growth and development.
3. Understand pollination mechanisms, process of pollen-stigma interaction and pollen tube growth.
4. Explore the biological processes of sporogenesis, gametogenesis, fertilization, and embryogenesis, culminating in the process of seed development.
5. Acquire comprehensive knowledge of reproductive biology to understand plant breeding and crop improvement.

Syllabus

UNIT 1: Patterns in plant development

Unique features of plant growth, differentiation and development, primary structure and basic vasculature, pits and types; diversity of cell types in plants - modifications in parenchyma, types and distribution of collenchyma and sclerenchyma, origin, structure and functions of xylem and phloem ; meristems - types, composition, structural organization of shoot and root apical meristems, CLAVATA-WUSCHEL feedback loop, formation of lateral roots and root hair; differentiation of epidermis with special reference to stomata, trichomes (GLABRA genes), secretary structures and laticifers.

UNIT 2: Fundamental tissues, secondary growth and senescence

Vascular cambium- organization, formation of secondary xylem and phloem, annual rings; leaf formation and expansion, phyllotaxy, formation of leaf and branch traces; structure and development of flower, floral evocation and floral organ formation, ABC model, MADS box genes and regulation; senescence and programmed cell death (PCD): concept, types and mechanism of cell death, metabolic changes associated with senescence.

UNIT 3: Reproduction methods, male and female gametophytes

Types of reproduction- asexual and sexual modes, variability in sex expression, sex determination mechanisms, structure of anthers- microsporogenesis, role of tapetum, origin and deposition of pollen surface components; structure of pistil, extra cellular components on the surface of stigma and style; ovule development- megasporogenesis, mega-gametogenesis, organization of embryo sac.

UNIT 4: Pollination, fertilization, embryo and endosperm development

Pollination mechanism, pollen load and compatible pollen-stigma interactions, self-incompatibility- types and genetics of control, pollen tube growth, male sterility; double fertilization, embryogenesis, embryo storage products; endosperm- types and development, detailed structure of cereal endosperm, storage products of endosperm, polyembryony, apomixis.

Laboratory

1. Microscopic examination of shoot and root apical meristems (SAM & RAM).
2. To study the primary and secondary growth of root and stem (monocots and dicots).
3. To study the structure of dicot and monocot seed; albuminous and ex-albuminous seeds.

4. To study the diversity of vegetative propagation in plants.
5. To study the sex expression in different plants.
6. Field study of several types of flowers with different pollination mechanisms.
7. To study the microsporogenesis by making acetocarmine squashes of anthers of different developmental stages.
8. To study the pollen mitosis
9. To isolate zygotic, globular, heart-shaped, torpedo shaped and mature embryo from suitable material.
10. To study the polyembryony in *Citrus* by dissections.

Suggested readings:

1. Evert, et al. (2017). Esau's Plant Anatomy. 3rd ed. Wiley, USA.
2. Fahn, A. (1982). Plant Anatomy. 3rd Edn. Pergamon Press, Oxford.
3. Lyndow, R.F. (1990). Plant Development: The Cellular Basis. Unnin Hyman, London.
4. Murphy, T.H. and Thompson, W.F. (1988). Molecular Plant Development. Prentice Hall, New Jersey.
5. Bhojwani, S.S. and Bhatnagar, S.P. (2000). The Embryology of Angiosperms. 4th Edn. Vikas Publishing House, New Delhi.
6. Proctor, M. and Yeo, P. (1973). The Pollination of Flowers. William Collins Sons, London. 14. Raghavan, V. (1997). Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
7. Raghavan, V. (1999). Developmental Biology of Flowering Plants. Springer-Verlag, New York.
8. Raghvan, V. (2006). Double fertilization. Springar Verlag, Berlin-Heidelberg.
9. Shivanna, K.R. and Sawhney, V.K. (1997). Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge.
10. Bewley, J.D. and Black, M. (1994). Seeds Physiology of Development and Germination. Plenum Press, New York.
11. Rajendran, A. & Ramalingam, S. (2021). Reproductive Biology of Angiosperms. Scientific Publishers.

Cellular and Molecular Genetics

3-0-2 **Credits: 4**

Course Objective:

This course provides a comprehensive foundation in classical Mendelian genetics and non-Mendelian inheritance patterns, alongside essential knowledge of cellular and molecular genetics. Students will also gain sufficient basic knowledge to study various advanced molecular techniques in genetics.

Course Outcomes:

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

1. Develop an understanding of chromosome structure, function, and organization, including structural and numerical abnormalities, and acquire knowledge of the cell cycle and its regulatory mechanisms in cellular genetics.
2. Understand the principles of Mendelian inheritance and examine diverse non-Mendelian patterns of genetic transmission.
3. Gain insights into cellular genetics, including chromosome replication, transcription, and translation in prokaryotes and eukaryotes as well as various post transcriptional events.
4. Gain knowledge of various DNA repair mechanisms and transposable elements, and understand their significance in genome evolution.
5. Build sufficient background to engage with advanced molecular techniques in genetics (e.g., PCR, qPCR, CRISPR, molecular cloning).

Unit 1: Basics of Cellular Genetics

Structure and organisation of prokaryotic and eukaryotic genomes; chromosomes: structure, types, and functions; chromatin organisation and histone modifications; cell cycle and its regulation; mitosis and meiosis: significance and genetic consequences; chromosomal aberrations: structural and numerical changes; gene mutations: types, causes, and consequences; epigenetics: DNA methylation and histone modifications.

Unit 2: Mendelian and Non-Mendelian Inheritance

Principles of Mendelian inheritance: segregation, independent assortment, and their exceptions; linkage, recombination, and gene mapping; non-Mendelian inheritance: cytoplasmic inheritance, maternal effects, and genomic imprinting; quantitative inheritance and polygenic traits; genetic interactions: epistasis and pleiotropy; sex determination and sex-linked inheritance; pedigree analysis in human genetics.

Unit 3: Molecular Basis of Genetic Information

Structure and replication of DNA; RNA types and their functions; transcription in prokaryotes and eukaryotes: initiation, elongation, and termination; RNA processing: splicing, capping, and polyadenylation; genetic code: properties and significance; translation: mechanisms and regulation; regulation of gene expression: operon models (lac and trp operons) and epigenetic regulation; mutations at the molecular level: point mutations, insertions, deletions, and frameshifts.

Unit 4: Advanced Concepts in Molecular Genetics

DNA repair mechanisms: direct repair, base excision repair, nucleotide excision repair, and mismatch repair; transposable elements and their role in genome evolution; mechanisms of recombination: homologous and site-specific recombination; CRISPR-Cas systems in genome editing; principles of RNA interference (RNAi) and its applications; molecular tools for genetic studies: PCR, qPCR, and molecular cloning; genome-wide studies: transcriptomics, proteomics, and functional genomics.

Laboratory

1. Isolation of genomic DNA from plant or animal tissues.
2. Estimation of DNA concentration and purity using a spectrophotometer.
3. Agarose gel electrophoresis for the separation of DNA.
4. PCR amplification of a specific DNA fragment.
5. Preparation of karyotypes and analysis of chromosomal aberrations.
6. Study of mitosis in onion root tips and meiosis in flower buds.
7. Restriction digestion of DNA and analysis of restriction fragments.
8. Southern blotting for DNA detection (demonstration).
9. RNA isolation and estimation using a spectrophotometer.
10. Analysis of Mendelian ratios using Drosophila or plant crosses.
11. Gene expression analysis using qPCR (demonstration).
12. Bioinformatics tools for sequence alignment and gene annotation.

Suggested Readings

Textbooks:

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2022). **Molecular Biology of the Cell** (7th ed.). Garland Science.
- Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Matsudaira, P. (2021). **Molecular Cell Biology** (9th ed.). W. H. Freeman.
- Snustad, D. P., & Simmons, M. J. (2020). **Principles of Genetics** (7th ed.). Wiley.
- Brown, T. A. (2020). **Genomes 4**. Garland Science.
- Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. J. (2021). **Concepts of Genetics** (12th ed.). Pearson.
- Nelson, D. L., & Cox, M. M. (2021). **Lehninger Principles of Biochemistry** (8th ed.). W. H. Freeman.
- Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). **Biochemistry & Molecular Biology of Plants** (2nd ed.). Wiley-Blackwell.
- Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2017). **Molecular Biology of the Gene** (7th ed.). Pearson.
- Slatkin, M., & Veuille, M. (2006). **Modern Developments in Theoretical Population Genetics**. Oxford University Press.

Research Papers and Reviews:

Epigenetics and Gene Regulation

- Zhu, J., et al. (2020). *The role of histone modifications in gene regulation and development. Nature Reviews Genetics*, **21**, 41–56.

CRISPR and Genome Editing in Plants

- Zhang, Y., Malzahn, A. A., Sretenovic, S., & Qi, Y. (2019). *The emerging and uncultivated potential of CRISPR technology in plant sciences. Nature Plants*, **5**, 778–794.
  Plant Stress Responses and Molecular Adaptation
- Shankar, R., et al. (2022). *Molecular mechanisms underlying plant responses to abiotic stressors: Insights from omics approaches. Frontiers in Plant Science*, **13**, 998523.
  RNA Biology and Functional Genomics
- Bartel, D. P. (2018). *Metazoan MicroRNAs. Cell*, **173**(1), 20–51.
  High-Throughput Sequencing and Computational Genomics
- Stark, R., Grzelak, M., & Hadfield, J. (2019). *RNA sequencing: The teenage years. Nature Reviews Genetics*, **20**, 631–656.
  Synthetic Biology in Plant Science
- Liu, W., Stewart, C. N. (2016). *Plant synthetic biology. Trends in Plant Science*, **21**(8), 622–630.
  Population Genetics and Evolutionary Studies
- Ellegren, H., & Galtier, N. (2016). *Genome evolution: Causes and consequences of genetic variation. Nature Reviews Genetics*, **17**, 422–437.

Online Resources & Databases:

- **NCBI (National Center for Biotechnology Information)** – https://www.ncbi.nlm.nih.gov/
- **Ensembl Genome Browser** – https://www.ensembl.org/
- **UCSC Genome Browser** – https://genome.ucsc.edu/
- **PlantGDB (Plant Genome Database)** – http://www.plantgdb.org/
- **The Arabidopsis Information Resource (TAIR)** – https://www.arabidopsis.org/

SKILL ENHANCEMENT COURSES OFFERED BY THE DEPARTMENT OF BOTANY

Mushroom Cultivation

LTP: 2-0-0 **Credits: 2**

Course Objective:

The objective of this course is to acquaint students with detailed techniques involved in mushroom farming and help them understand the principles of mushroom cultivation and acquire practical knowledge of growing mushrooms.

Course Outcomes:

On completion of the course, students are able to:

1. Explain the biological characteristics, classification, and diversity of edible mushrooms.
2. Describe the scientific principles underlying mushroom cultivation, including substrate preparation, spawning, and environmental requirements.
3. Analyse factors affecting growth, yield, and quality of cultivated mushrooms.
4. Discuss post-harvest physiology, preservation methods, and quality management of mushroom products.
5. Evaluate the economic, nutritional, medicinal, and commercial significance of mushrooms in agriculture and industry.

SYLLABUS

Unit I: Introduction to Mushrooms

History, production and uses of mushrooms; classification, categorization and diversity of mushrooms, nutritional and medicinal properties of mushrooms, wild mushrooms of Jammu and Kashmir (J&K), some important mushrooms available in local markets in J&K.

Unit II: Mushroom cultivation and production

Design and development of mushroom production units; role of composting in mushroom cultivation, mushroom-spawn; culture maintenance, production of good quality spawn, preparation of pure culture, criteria for selection of good quality spawn, transportation of spawn, casing and case, cropping and harvesting of mushroom.

Unit III: Post-harvest processing and merchandising mushrooms

Management of used substrates and waste disposal of various mushrooms, quality assurance, shelf life, processing and packaging, market opportunities, post-harvest handling, entrepreneurial skills and economics for small enterprise, importance of self-employment, economics of different types of mushrooms, market survey, calculation of cost benefit ratio of mushroom production.

Suggested Readings

1. Mushroom Cultivation, Tripathi, D.P. (2005) Oxford & IBH Publishing Co. PVT. LTD, New Delhi. Reference Books:
2. Mushroom Production and Processing Technology, Pathak Yadav Gour (2010) Published by Agrobios (India).
3. A hand book of edible mushroom, S. Kannaiyan & K. Ramasamy (1980). Today & Tomorrows printers & publishers, New Delhi
4. Bahl, Nita. *Handbook on Mushrooms*. Oxford & IBH Publishing Co., New Delhi; 4th Edition, ISBN: 978-8120413993.

Processing of Plant-based Products

LTP: 2-0-0 **Credits: 2**

Course Objective:

The course aims to make the students competent in processing and preservation techniques of fruits and vegetables. Besides, students will gain the knowledge of food safety and quality management.

Course Outcomes:

After the successful completion of this module students will be able to:

1. Evaluate and rank foods with regard to their degree of processing.
2. Depict the steps involved in processing of common fruits and vegetables for their economic use.
3. Explain the health, social and economic concerns associated with the food processing industry.
4. Set-up their own food processing fruits and vegetables units or contribute to the already existing one.

Syllabus

Unit I: Fruit and vegetable processing

Status of Indian food industry with emphasis on Jammu and Kashmir; nutritional significance of fruits and vegetables; need and scope for processing of fruits and vegetables; Production of fruits and vegetables in India and J&K; Introduction to national and international food laws; Food Safety and Standards Act-2006; FSSAI rules and regulation.

Unit II: Post-harvesting changes and storage of fruits and vegetables

Maturity and ripening of fruits and vegetables; post-harvest physiology and wastage of fruits and vegetables; Storage of fruits and vegetables; Refrigerated and controlled atmospheric storage. Packaging – definition, functions and requirements of fruits and vegetables; drying, dehydration, freezing and canning of fruits and vegetables.

Unit III: Fruits and vegetable products

Selection of raw material – Suitability of various fruits and vegetables for processing; technology for production of processed products of fruits and vegetables (jam, jelly, marmalade, juice, nectar, candy, sauce, chutney and pickles); specifications of various fruit and vegetable products according to FSSAI; tomato products – juice, paste, puree, ketchup, cocktail. Requirements and project formulation for a fruit and vegetable-based processing plant.

Suggested Readings:

1. Home Scale Preservation of Fruits and Vegetables – CFTRI Lab Manual.
2. The Technology of Food Preservation by Desrosier.
3. Potter, N.N. and Hotchkiss, J.H., 2012. *Food Science*. Springer Science & Business Media.
4. Qadri, O.S., Yousuf, B. and Srivastava, A.K., 2015. Fresh-cut fruits and vegetables: Critical factors influencing microbiology and novel approaches to prevent microbial risks – A review. *Cogent Food & Agriculture*, 1(1), p.1121606.
5. Verma, L.R. and Joshi, V.K., 2000. *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management, Volume 2: Technology.*

Techniques in Floriculture and Horticulture

LTP: 2-0-0 **Credits: 2**

Course Objective:

To develop conceptual understanding of principles, practices, and technological interventions in floriculture and horticulture, including plant propagation, nursery and orchard management, post-harvest handling, protected cultivation, and value addition of ornamental, fruit, and aromatic plants, along with awareness of sustainable production systems and regulatory frameworks.

Course Outcomes:

On successful completion of this course, students will be able to:

1. Explain the scope, classification, and production practices of floriculture and horticultural crops, including ornamental, fruit, and aromatic plants.
2. Analyse plant propagation methods, nursery and orchard management practices, and factors influencing growth, productivity, and crop quality.
3. Evaluate pre- and post-harvest technologies, storage, packaging, transportation, and value addition strategies for floriculture and horticultural produce.
4. Interpret principles of organic horticulture, protected cultivation, plant growth regulation, and integrated pest and disease management for sustainable crop production.
5. Assess economic, regulatory, and technological aspects of commercial floriculture and horticulture, including certification, plant variety protection, and funding opportunities.

Syllabus

Unit 1: Floriculture Practices

Importance and scope of floriculture and horticulture in the World and India. Classification of floriculture: according to environment and growth habit – tree, shrubs, climbers, herbs and their uses. Scope of cut and loose flowers in national and global trade. Global scenario of cut flower production, area under cut flowers and production problems in India. Nursery, establishment, care and management of nursery, selection of site and layout, propagation of ornamental plants, lifting, potting, repotting, packaging of ornamental plants. Cultivation practices of important annuals, seasonal and perennials flowers and foliage plants. Principles and styles of flower arrangement. Production of flowers for exhibition. Drying of flowers and dry flower arrangement. Storage and transportation, marketing of Rosa, *Chrysanthemum, Dianthus, Gerbera, Gladiolus, Polianthes, orchids, Anthurium, Lilium, Alstroemeria, Dahlia* and *Tagetes*.

Production technology, post-harvest handling, distillation methods, value addition, aroma chemicals, quality standards and regulations for *Cymbopogon, Citronella, Chrysopogon, Geranium, Mentha, Ocimum, Eucalyptus, Pogostemon* and *Lavandula*.

Unit 2: Horticulture Practices

Importance of horticulture in nutritional security and national economy; Horticultural geography (regions and zones); Orchard establishment and orchard floor management, Present status and prospects of important horticultural crops. Classification of fruit crops; Propagation technique; nursery management, training and pruning, rootstock and scion, causes of unfruitfulness and control. Organic horticulture – definition, components, principles, methods, merits and demerits. Different organic inputs play their role on organic horticulture. Sustainable soil fertility management, weed management practices in organic farming, biological/natural control of pests and diseases, post-harvest management of organic produce. Certification and export. International Federation of Organic Agriculture Movement (IFOAM) and global scenario of organic movement.

Unit 3: Technical aspects and challenges

Special horticultural practices, use of growth regulators, physiological disorders and remedies, Integrated Pest Management (IPM) and Integrated Disease Management (IDM), production for exhibition purposes. Methods of delaying flower opening, pre-cooling, pulsing, packing. Principles and structures used in protected cultivation include hotbed, cold frame, glasshouse, polyhouse, shade net, low tunnels, rain shelters etc. Interaction of light, temperature, humidity, CO_2, water on crop regulation. Greenhouse heating, cooling, ventilation, and shading. Containers and substrates, soil decontamination. Water and nutrient management. Automated greenhouses.

Various schemes and funding opportunities for setting up of commercial floriculture and horticulture units. Protection of plant varieties, farmer's rights and intellectual property rights.

Suggested readings:

1. S.K. Bhattacharjee and Lakshman Chandran De. 2010. *Advanced Commercial Floriculture*, Vols. I and II. Aavishkar Pub. Second Revised and Enlarged Edition, 798.
2. D. Ravinath. 2007. *Floriculture: A Viable Business*. Excel Books.
3. S. Prasad, U. Kumar. 2010. *A Handbook of Floriculture*. Agrobios (India).
4. John M. Dole and Harold F. Wilkins. 2004. *Floriculture: Principles and Species*. Prentice Hall, 2nd edition.
5. Paul V. Nelson (Author). 2002. *Greenhouse Operation and Management*. Prentice Hall; 6th Edition.
6. J.S. Arora. 2007. *Introductory Ornamental Horticulture*. Kalyani Publications.
7. Allan M. Armitage and Judy M. Laushman. 2008. *Specialty Cut Flowers: The Production of Annuals, Perennials, Bulbs and Woody Plants for Fresh and Dried Cut Flowers*. Timber Press, Rev.

Gardening and Landscaping

LTP: 2-0-0 **Credits: 2**

Course Objective:

To develop comprehensive theoretical and conceptual understanding of gardening and landscaping through the study of climatic influences, plant growth and propagation principles, soil science and fertility management, and design and maintenance of indoor and outdoor green spaces with emphasis on sustainable horticultural practices.

Course Outcomes:

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

1. Analyse the influence of weather, climate, and agro-climatic zones on gardening, landscaping, and horticultural crop production.
2. Explain structural and physiological characteristics of horticultural plants along with principles of plant propagation, nursery management, and protected cultivation.
3. Evaluate soil properties, soil fertility parameters, and interpret soil test reports to understand soil productivity and nutrient management strategies.
4. Assess methods for management and reclamation of problematic soils and the role of organic matter, fertilizers, and integrated nutrient management in sustainable horticulture.
5. Interpret principles of landscape planning, garden design, indoor gardening, and ornamental plant utilization for aesthetic and functional green space development.

Syllabus

Unit 1: Foundations of Gardening

Significance of Weather and Climate Elements in Agriculture: Impact of rainfall, temperature, humidity, sunshine, wind speed and direction. Agro-climatic Regions and their Distinct Characteristics. Weather Patterns in Crop Seasons (Winter, Summer, Monsoon). Significance of Weather Forecasting. Morphology, Physiology and Foundational knowledge of horticultural plants. Soil and Growth Medium. Fertilizers and Bio-fertilizers. Irrigation Techniques. Cultivation Techniques and Protected Cultivation. Garden Implements. Plant Health and Maintenance: Diseases and Pest Control. Disease Control in gardening. Recognition of Ailments and Pesticide Application. Methods of Propagation: Time and Techniques of Propagation. Specialized Cultivation: Nursery and Seed Production, Bulb and Corm Production, Pot Plants and Lawn Grasses. Ornamental Plants, Landscape Plants and Bonsai. Flower Crop Cultivation: Strategies for Flower Induction. Use of Growth Regulators. Cultivation in Protected Environments (Poly and Net Houses). Specific Crop Focus: Chrysanthemum, Carnation, Rose, Orchids.

Unit 2: Soil Science and Management

Various aspects of soil, including its physical and chemical properties. Interpretation of soil test reports. Soil texture classification. Important features: porosity, bulk density, particle density and structure. Water holding capacity, pH, electrical conductivity (EC), cation exchange capacity (CEC). Soil solution and classification based on agro-climatic zones. Types of soils: acid, alkaline, saline. Correction techniques

for acid, alkaline, and saline soils. Soil organic matter and its role in influencing soil properties and fertility: Practices for recycling organic matter in the field. Soil fertility, productivity. Various manures, bio fertilizers, essential plant nutrient elements, deficiency symptoms. Chemical fertilizers and factors affecting soil fertility depletion and its maintenance.

Unit 3: Green Space Survey and Indoor Gardening Exploration

Significance and Extent. Historical Development and Varieties of Gardens. Notable Garden Characteristics and Constituents of Gardens. Residential Gardens and Garden Structures. Enhancing Elements and Optimal Lighting. Soil, Water, and Energy Conservation through Landscaping. Plant Selection for Aesthetic and Functional Landscape Values. Garden and Lawn Maintenance. Boulevard Trees. Interior Gardens, Rooftop Gardens, Window Gardens, Container Gardens, Aquariums, Hanging Baskets, Mini Landscapes, Rock Gardens. Choosing and Organizing Indoor Potted Plants, their Care, and Sustainable Practices. Preparation for Garden Competitions and Flower Shows. Crafting Floral Ornaments – Garlands, Bangles, Crowns, Veni, Rangoli, Baskets and Bouquets; Boutonnieres and Corsages.

Suggested Readings:

1. Floriculture in India by G.S. Randhawa and Amitabha Mukhopadhyay Allied Publishers, PVT. Ltd. 1986. Plant Propagation Principles and Practices by Hartman H.T. Prentice-Hall International: London, 1959. Encyclopedia of Gardening by Christopher Brukell. Dorling Kindersley, Ltd. 2007.
2. Propagation Hand Book, Basic Techniques for Gardeners Mechanicsburg, Pa; Stackpole Books, 1995.
3. Horticulture: Principles and Practices by George Acquaah, 4th edition, Pearson Publisher, Prentice Hall, 2009.
4. Gardening in India by Bose, T.K. and Mukerjee, D. New Delhi Oxford & IBH Pub. Co. Pvt. Ltd. 1977.
5. Textbook of Horticulture by Mani Bhushan Rao. Macmillan India Ltd. 2005 (2nd edition).
6. Introduction to Horticulture by Kumar, N. 7th edition, Oxford & IBH Publishing Company Pvt. Ltd. 2010.
7. Introduction to Ornamental Horticulture by J.S. Arora, 1999.
8. Kalyani Publishers, Ludhiana, India. Plant Propagation by Sandhu M.K. New Age International Publishers Ltd. 1989.
9. Ornamental Plants and Garden Design in Tropics and Subtropics (Vol 1 & 2) by T.K. Bose, L.J. Singh, M.K. Sandhu and T.K. Mairy. Publisher: Daya Publishing House; A division of Astral International Pvt. Ltd. 2015.

Plant Tissue Culture: Techniques and Applications

LTP: 2-0-0 **Credits: 2**

Course Objective:

This course aims to provide a thorough understanding of the principles and techniques of plant tissue culture, emphasizing its industrial applications across various sectors. Students will explore the economic and environmental significance of plant tissue culture, analyse associated challenges, and examine future directions for its use in industrial applications.

Course Outcomes:

On successful completion of this course, the students should be able to:

1. Understand plant tissue culture principles, media preparation, explant selection, and contamination control.
2. Explore industrial applications of plant tissue culture, including micropropagation and biotechnological uses.
3. Understand challenges in tissue culture industries, including technology, economics, regulations, and future trends.

Theory

Unit 1: Introduction to Plant Tissue Culture

Definition and History of Plant Tissue Culture (PTC); Fundamental, Principles and Culture types (Callus culture, Organogenesis, Somatic embryogenesis); Plant Growth Regulators in PTC and significance of hormones; Composition of Media (Murashige and Skoog medium, Gamborg's B5 medium); Sterilization Techniques; Factors Affecting Plant Growth (Light, Temperature, Humidity); Contamination Control in Tissue Culture Labs; Explant Selection and Surface Sterilization; Establishment of Cultures and Maintenance.

Unit 2: Industrial Applications of Plant Tissue Culture

Micropropagation: Techniques and Benefits; Case Studies: Commercial Micropropagation in Orchids, Strawberries, and Banana; Use of Tissue Culture in Developing Disease-resistant Crops; Application of Somatic Hybridization and Protoplast Fusion; Genetic Transformation Using *Agrobacterium*-mediated Transformation; Production of Secondary Metabolites (Alkaloids, Flavonoids, etc.) and Role of Tissue Culture in Pharmaceutical and Nutraceutical Industries: Case Study- Atropine, Reserpine, and Taxol production; Cell-suspension and hairy roots for secondary metabolite production; Techniques for

Cryopreservation and Seed Storage; Use of Tissue Culture in Genetic Resource Conservation; Industrial Role in Protecting Plant Biodiversity; Clonal Propagation in Forestry; Horticultural Plant Production (e.g., Flowering Plants, Fruit Trees); Landscape and Greenhouse Applications.

Unit 3: Challenges and Future Directions in Plant Tissue Culture Industry

Cost-related Issues in Industrial PTC; Scaling Up from Laboratory to Commercial Production; Overcoming Contamination, Variability, and In Vitro Selection; Ethical Concerns in Genetic Engineering and Biotechnology; Regulatory Framework for Biotech Products and GMOs; Intellectual Property Rights in Plant Biotechnology; Use of Bioreactors for Enhanced Productivity; Role of Automation and Robotics in Large-scale Production; Future of Automated Tissue Culture Systems; Integration of CRISPR and Gene Editing with Tissue Culture; Application of Artificial Intelligence in Plant Biotechnology; Contribution to Sustainable Agricultural Practices.

Suggested Readings

Core Textbooks:

- Bajpai, P.K. (2006). *Biological Instrumentation and Methodology.* S. Chand & Company Ltd.
- Brown, T.A. (2016). *Gene Cloning and DNA Analysis: An Introduction (7th Edition).* Wiley-Blackwell.
- Chain, E.B., & Bonner, P.L.R. (1998). *Cell Biology: A Laboratory Handbook (3rd Edition).* Academic Press.
- Green, M.R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual (4th Edition).* Cold Spring Harbor Laboratory Press.
- Green, M.R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual (4th Edition).* Cold Spring Harbor Laboratory Press.
- Howe, C. (2007). *Gene Cloning and Manipulation (2nd Edition).* Cambridge University Press.
- Lesk, A.M. (2019). *Introduction to Bioinformatics (5th Edition).* Oxford University Press.
- Lewin, B. (2017). *Genes XII.* Jones & Bartlett Learning.
- Skoog, D.A., & West, D.M. (2014). *Fundamentals of Analytical Chemistry (9th Edition).* Cengage Learning.
- Skoog, D.A., Holler, F.J., & Crouch, S.R. (2017). *Principles of Instrumental Analysis (7th Edition).* Cengage Learning.

Plant Biotechnology and Tissue Culture:

- Davey, M.R., & O'Brien, P.J.L. (2010). *Plant Cell and Tissue Culture.* Wiley-Blackwell.
- Khurana, S.P.S., & Bhatia, M.S. (2018). *Plant Tissue Culture: Techniques and Applications.* Springer.
- Latest journal articles and industry reports on plant tissue culture applications.

- Singh, R.A. (2015). *Plant Biotechnology and Transgenic Plants.* CRC Press.
- Srivastava, V., Mehrotra, S., & Mishra, S. (Eds.). (2018). *Hairy Roots: An Effective Tool of Plant Biotechnology.* Springer.

Advanced References in Molecular Biology and Bioinformatics:

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell (6th Edition).* Garland Science.
- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K.C. (2021). *Molecular Cell Biology (9th Edition).* W.H. Freeman.
- Mount, D.W. (2004). *Bioinformatics: Sequence and Genome Analysis (2nd Edition).* Cold Spring Harbor Laboratory Press.
- Pevsner, J. (2015). *Bioinformatics and Functional Genomics (3rd Edition).* Wiley-Blackwell.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular Biology of the Gene (7th Edition).* Pearson.

References on Laboratory Techniques and Instrumentation:

- Day, R.A., & Underwood, A.L. (2010). *Quantitative Chemical Analysis (6th Edition).* Prentice Hall.
- Ninfa, A.J., Ballou, D.P., & Benore, M. (2009). *Fundamental Laboratory Approaches for Biochemistry and Biotechnology (2nd Edition).* Wiley.
- Switzer, R.L., & Garrity, L.F. (1999). *Experimental Biochemistry (3rd Edition).* W.H. Freeman.
- Voet, D., Voet, J.G., & Pratt, C.W. (2018). *Fundamentals of Biochemistry: Life at the Molecular Level (5th Edition).* Wiley.
- Wilson, K., & Walker, J. (2018). *Principles and Techniques of Biochemistry and Molecular Biology (8th Edition).* Cambridge University Press.

Supplementary Online Resources and Journals:

- *Nucleic Acids Research (Oxford Academic)* – Covers advances in bioinformatics, genomics, and molecular biology.
  • https://academic.oup.com/nar
- *Nature Methods (Springer Nature)* – Focuses on novel laboratory techniques and bioinformatics tools.
  • https://www.nature.com/nmeth/
- *Cold Spring Harbor Protocols* – A leading source for laboratory methods in molecular biology.
  • https://cshprotocols.cshlp.org/

Gene Editing Techniques

LTP: 2-0-0 **Credits: 2**

Course Objective:

This course aims to provide students with a comprehensive understanding of gene editing technologies, their applications and implications in agriculture, medicine, and biotechnology. Students will learn about the fundamentals of gene editing in particular the advanced CRISPR tools, and their ethical considerations, along with exploring the role of gene editing in functional genomics, gene regulation, and crop improvement.

Course Outcomes:

On successful completion of this course, the students should be able to:

1. Understand the significance, technologies, mechanisms, and ethical considerations of gene editing.
2. Explore the components, advanced tools, and applications of CRISPR-Cas systems in gene editing.
3. Understand the applications of gene editing for functional genomics, gene regulation, and crop improvement.

Theory

Unit 1: Fundamentals of Gene Editing

Introduction to gene editing and its significance; overview of genome-editing technologies: meganucleases, zinc-finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), and CRISPR-Cas systems; mechanisms of double-strand break repair: non-homologous end joining (NHEJ) and homology-directed repair (HDR); applications in agriculture, medicine, and biotechnology; ethical considerations and regulatory frameworks**.**

Unit 2: CRISPR-Cas Systems and Applications

Components and mechanisms: crRNA, tracrRNA, and Cas proteins; classification of CRISPR systems and their characteristics; guide RNA design for targeted editing and strategies to minimize off-target effects; advanced CRISPR techniques: base editing, prime editing, CRISPR interference (CRISPRi), and CRISPR activation (CRISPRa); delivery methods: viral and non-viral systems; multiplex genome editing and its potential applications**.**

Unit 3: Functional Genomics and Gene Regulation

Gene editing for functional genomics: knockout and knock-in models; RNA interference (RNAi) and CRISPR-Cas9 in gene function studies; gene regulation via CRISPRi and CRISPRa; epigenome editing for transcriptional modulation; transgenic vs. gene-edited organisms: key differences and implications;

gene therapy advancements using CRISPR; agricultural applications: disease resistance, abiotic stress tolerance, and quality enhancement.

Suggested Readings

Core Textbooks:

- Doudna, J. A., & Sternberg, S. H. (2017). *A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution*. Houghton Mifflin Harcourt.
- Carroll, D. (2017). *Genome Editing: Principles and Applications*. CABI.
- Barrangou, R., & van der Oost, J. (2012). *CRISPR-Cas Systems: RNA-mediated Adaptive Immunity in Bacteria and Archaea*. Springer.
- Ishino, Y., & Koonin, E. V. (2021). *CRISPR: A New Era in Genome Editing*. Elsevier.
- Komor, A. C., Badran, A. H., & Liu, D. R. (2018). *The Expanding Toolbox of CRISPR-Based Genome Editing Technologies*. Nature Reviews Molecular Cell Biology, 19(3), 167–180.

Reference Books:

- Hsu, P. D., Lander, E. S., & Zhang, F. (2014). *Development and Applications of CRISPR-Cas9 for Genome Engineering*. Cell, 157(6), 1262–1278.
- Niemann, H., & Kues, W. A. (2020). *Applications of CRISPR/Cas in Livestock Genetics and Breeding*. Animal Frontiers, 10(3), 48–52.
- Ran, F. A., et al. (2013). *Genome Engineering Using the CRISPR-Cas9 System*. Nature Protocols, 8(11), 2281–2308.
- Zhang, Y., et al. (2022). *Prime Editing: Advances and Challenges in Precision Genome Editing*. Trends in Genetics, 38(1), 44–57.
- Gaudelli, N. M., et al. (2017). *Programmable Base Editing of A•T to G•C in Genomic DNA without DNA Cleavage*. Nature, 551(7681), 464–471.

Research Articles and Journals:

- Jinek, M., et al. (2012). *A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity*. Science, 337(6096), 816–821.
- Cong, L., et al. (2013). *Multiplex Genome Engineering Using CRISPR/Cas Systems*. Science, 339(6121), 819–823.
- Komor, A. C., et al. (2016). *Programmable Editing of a Target Base in Genomic DNA without Double-Stranded DNA Cleavage*. Nature, 533(7603), 420–424.
- Anzalone, A. V., et al. (2019). *Search-and-Replace Genome Editing without Double-Strand Breaks or Donor DNA*. Nature, 576(7785), 149–157.
- Knott, G. J., & Doudna, J. A. (2018). *CRISPR-Cas Guides the Future of Genetic Engineering*. Science, 361(6405), 866–869.

Online Resources:

- Broad Institute CRISPR Guide: https://www.broadinstitute.org/what-broad/areas-focus/project-spotlight/crispr
- NCBI Genome Editing Resources: https://www.ncbi.nlm.nih.gov/genome/editing/

- Addgene CRISPR Resources: https://www.addgene.org/crispr/
- Horizon Discovery Gene Editing Tools: https://horizondiscovery.com/en/genome-editing.

Entrepreneurship Avenues in Botanical Sciences

LTP: 2-0-0 **Credits: 2**

Course Objectives

On successful completion of this course, students will be able to understand the entrepreneurial potential within different areas of botany; develop business ideas based on plant resources, biotechnology, and ecological conservation; learn sustainable and innovative approaches for plant-based enterprises; identify career prospects in various fields of plant sciences; gain insights into industry trends and employment opportunities in India.

Course Outcomes

On successful completion of this course, students should be able to:

- Explain the role of plant taxonomy in conservation, forensic science, and industry.
- Describe plant biotechnology applications in agriculture, medicine, and bio-based industries.
- Analyze urban farming, food processing, and climate-related entrepreneurship.
- Explore career opportunities in plant sciences, research, and startups.

Theory

Unit 1: Plant Diversity, Taxonomy, and Sustainable Entrepreneurship

Plant Taxonomy and Systematics – Role of plant taxonomists in conservation and industry; digital herbariums; AI-based plant identification; entrepreneurship in botanical survey and biodiversity documentation. Forensic Botany and Plant Anatomy in Investigation – Role of plant anatomy in forensic investigations; application of plant DNA in criminal case solving; entrepreneurship in forensic consulting. Economic Botany and Ethnobotany – Medicinal and aromatic plants—cultivation, processing, commercialization; traditional plant-based industries—herbal cosmetics, natural dyes, organic fibers; value-added plant products—essential oils, herbal extracts, nutraceuticals. Sustainable Harvesting and Conservation – Agroforestry and non-timber forest products as business opportunities; ecological entrepreneurship; biodiversity conservation startups.

Unit 2: Plant Biotechnology, Molecular Biology, and Bio-based Industries

Plant Tissue Culture and Micropropagation – Commercial applications in horticulture, forestry, pharmaceuticals; entrepreneurship in mass propagation; seedling production. Genetically Modified Crops and Molecular Biology – CRISPR and gene editing—market trends; regulatory frameworks; commercialization; biotechnology startups—high-yield and climate-resilient crops. Industrial Applications of Algae and Fungi – Algae-based biofuels; bioplastics; pharmaceuticals; myco-entrepreneurship—mushroom farming; fungal biofertilizers; enzymes. Biofertilizers, Biopesticides, and Sustainable Agriculture – Role of beneficial microbes in agriculture; organic and sustainable farming-based enterprises. Synthetic Biology and Innovations in Cosmetics, Food, and Medicine – Plant-based biopolymers; plant-derived pharmaceuticals; herbal cosmetics—organic skincare, haircare, aromatherapy products.

Unit 3: Agri-business, Urban Farming, and Career Avenues in Plant Sciences

Organic and Urban Farming Innovations – Hydroponics; aeroponics; vertical farming—business models; market potential; smart agriculture—IoT, AI, precision farming applications; seed production; plant breeding entrepreneurship. Value Addition in Food Processing and Functional Foods – Herbal teas; plant-based beverages; superfoods; entrepreneurship in farm-to-fork and organic food startups. Ecology, Environment, and Climate Change Entrepreneurship – Carbon credit trading; afforestation projects; waste management; bioremediation startups; role of ecologists in environmental impact assessments. Careers in

Plant Sciences – Taxonomist; forensic botanist; plant molecular biologist; ecologist; opportunities in government agencies, research institutions, biotech companies.

Suggested Readings

Textbooks:

- Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2015). Plant Systematics: A Phylogenetic Approach, 4th edition, Sinauer Associates, Sunderland, USA.
- Simpson, M.G. (2019). Plant Systematics, 3rd edition, Academic Press, London, UK.
- Raven, P.H., Evert, R.F., Eichhorn, S.E. (2012). Biology of Plants, 8th edition, W.H. Freeman, New York, USA.
- Buchanan, B.B., Gruissem, W., Jones, R.L. (2015). Biochemistry & Molecular Biology of Plants, 2nd edition, Wiley-Blackwell, Oxford, UK.
- Slater, A., Scott, N., Fowler, M. (2008). Plant Biotechnology: The Genetic Manipulation of Plants, 2nd edition, Oxford University Press, Oxford, UK.
- Taiz, L., Zeiger, E., Møller, I.M., Murphy, A. (2023). Plant Physiology and Development, 7th edition, Sinauer Associates, Sunderland, USA.

Entrepreneurship and Business in Plant Sciences:

- Hisrich, R.D., Peters, M.P., Shepherd, D.A. (2020). Entrepreneurship, 11th edition, McGraw-Hill, New York, USA.
- Schaper, M., et al. (2014). Entrepreneurship and Small Business, 4th edition, Wiley, Australia.
- Kuckertz, A. (2019). Sustainable Entrepreneurship: A Systematic Review of the Field, Springer, Berlin, Germany.
- Thiel, P. (2014). Zero to One: Notes on Startups, or How to Build the Future, Crown Business, New York, USA.
- Goleman, D. (2021). Ecological Intelligence: The Hidden Impacts of What We Buy, Broadway Books, New York, USA.
- Reddy, P. (2019). Agri-Entrepreneurship: Innovation, Management & Business Opportunity, Springer, Singapore.
- Mukherjee, P.K. (2017). Quality Control and Evaluation of Herbal Drugs, Elsevier, Amsterdam, Netherlands.

Research Articles:

- Chen, S., et al. (2019). "Applications of AI in Plant Taxonomy and Identification," Trends in Plant Science, 24(10), 855–868.
- Pardo, G., et al. (2020). "Sustainable Agriculture and the Role of Biofertilizers," Frontiers in Plant Science, 11, 1018.
- Liu, X., et al. (2021). "CRISPR-Based Gene Editing in Plants: Advances and Applications," Nature Plants, 7(8), 791–805.
- Mishra, A., et al. (2022). "Plant-Based Bioplastics: Sustainable Innovations," Journal of Environmental Management, 312, 114807.
- Ferrer, A., et al. (2020). "The Future of Myco-Entrepreneurship: Applications of Fungi in Industry," Applied Microbiology and Biotechnology, 104(5), 2081–2095.

Specialized Topics:

- Mukherjee, P.K., et al. (2017). Quality Control and Evaluation of Herbal Drugs, Elsevier, Amsterdam, Netherlands.
- Sharma, S., Kumar, N. (2020). Plant-Based Natural Products for Sustainable Health, Springer, Singapore.
- Karp, G. (2018). Cell and Molecular Biology: Concepts and Experiments, 8th edition, Wiley, New Jersey, USA.

- Altman, A., Hasegawa, P.M. (2012). Plant Biotechnology and Agriculture: Prospects for the 21st Century, Academic Press, London, UK.
- Esser, K., et al. (2014). The Mycota: Industrial Applications, Springer, Berlin, Germany.

Supplementary Reading:

- Schiebinger, L., Swan, C. (2007). Colonial Botany: Science, Commerce, and Politics in the Early Modern World, University of Pennsylvania Press, Philadelphia, USA.
- Cragg, G.M., Newman, D.J. (2012). Natural Products: A Continuing Source of Novel Drug Leads, Biochimica et Biophysica Acta (BBA) - General Subjects, 1830(6), 3670–3695.
- Chandra, R., Sharma, S. (2017). Bioremediation of Agrochemicals, CRC Press, Boca Raton, USA.
- Singh, H. (2006). Mycoremediation: Fungal Bioremediation, Wiley-Interscience, Hoboken, USA.
- Leopold, A. (1949). A Sand County Almanac, Oxford University Press, New York, USA.

Online Sources:

- The Plant List – www.theplantlist.org (Comprehensive database of plant taxonomy)
- KEW Science Plants of the World Online – powo.science.kew.org (Global database for plant diversity)
- NCBI GenBank – www.ncbi.nlm.nih.gov/genbank/ (Molecular sequences and plant genomics)
- FAO Agroforestry Guidelines – www.fao.org/agriculture/forestry (Sustainable agriculture and biodiversity conservation)
- The Bioplastic Guide – www.bioplastic.com (Information on plant-derived bioplastics and innovations)
- World Bank Agribusiness Reports – www.worldbank.org/en/topic/agribusiness

Biological Instrumentation and Methods in Plant Molecular Biology

LTP: 2-0-0 **Credits: 2**

Course Objective:

This course provides a comprehensive understanding of the principles, applications, and methodologies used in biological and plant molecular research. It aims to equip students with theoretical knowledge and practical skills in biological instrumentation, molecular characterization, bioanalysis, and gene expression techniques. Students will develop expertise in operating key instruments, analysing biological molecules, and applying advanced molecular techniques in plant biotechnology.

Course Outcomes:

On successful completion of this course, the students should be able to:

1. Understand the principles, operation, and calibration of key biological instruments and their applications in research.
2. Gain proficiency in spectrophotometry, chromatography, electrophoresis, PCR, ELISA, and flow cytometry for molecular and cellular analysis.
3. Develop expertise in nucleic acid isolation, quantification, and assessment techniques for plant molecular studies.
4. Learn the principles of PCR, cloning strategies, and transformation techniques used in plant biotechnology.
5. Explore gene expression analysis methods, including RNAi and bioinformatics tools.
6. Understand the applications of emerging technologies such as high-throughput sequencing, biosensors, microfluidics, and 3D-bioprinting in biological research.

Theory

Unit 1: Principles and Applications of Biological Instrumentation

Introduction to biological instrumentation; Principles of operation and calibration of biological instruments; Microscopes: light, electron, and fluorescence; Spectrometers: UV-Vis, fluorescence, IR, and mass spectrometry; Chromatography: HPLC, GC; Electrophoresis: gel, capillary, and SDS-PAGE; Centrifuges and ultracentrifuges. Methods for isolation of plant genomic DNA, RNA, and plasmid DNA; Quality and quantity assessment using spectrophotometry, fluorometry, and agarose gel electrophoresis; Southern, northern, and western blotting techniques; Restriction enzyme digestion and analysis of DNA fragments; Preparation of competent cells and bacterial transformation techniques.

Unit 2: Analytical and Molecular Techniques in Biological Research

Spectrophotometry and spectrometry for molecular analysis; Fluorescence-based detection and applications; Enzyme-linked immunosorbent assays (ELISA); Western blotting and flow cytometry; Principles of polymerase chain reaction (PCR) and its types: conventional PCR, RT-PCR, qPCR, and multiplex PCR; Primer designing and optimization of PCR conditions; Gene cloning techniques: vectors (plasmids, phagemids, and binary vectors) and their properties; Ligation strategies: sticky-end and blunt-end ligation; Agrobacterium-mediated and direct DNA transformation in plants; Screening and selection of recombinants.

Unit 3: Advanced Techniques and Emerging Technologies in Biological Research

Techniques for gene expression analysis: reporter genes (GUS, GFP, and LUC), microarrays, and RNA sequencing; In situ hybridization for gene expression localization; Protein expression and purification: expression systems, affinity tags, and purification methods; Bioinformatics tools for sequence alignment, primer design, and phylogenetic analysis; Advances in high-throughput sequencing technologies; Applications in genomics, transcriptomics, proteomics, and metabolomics; Instruments for gene editing and delivery systems (microinjection, electroporation); Biosensors: electrochemical, optical, and piezoelectric sensors; Applications in disease detection, environmental monitoring, and wearable devices; Microfluidics and lab-on-a-chip devices for real-time biological analysis; 3D-bioprinting.

Suggested Readings

Core Textbooks:

- Bajpai, P.K. (2006). *Biological Instrumentation and Methodology.* S. Chand & Company Ltd.
- Brown, T.A. (2016). *Gene Cloning and DNA Analysis: An Introduction (7th Edition).* Wiley-Blackwell.
- Chain, E.B., & Bonner, P.L.R. (1998). *Cell Biology: A Laboratory Handbook (3rd Edition).* Academic Press.
- Green, M.R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual (4th Edition).* Cold Spring Harbor Laboratory Press.
- Howe, C. (2007). *Gene Cloning and Manipulation (2nd Edition).* Cambridge University Press.
- Lesk, A.M. (2019). *Introduction to Bioinformatics (5th Edition).* Oxford University Press.
- Lewin, B. (2017). *Genes XII.* Jones & Bartlett Learning.
- Skoog, D.A., & West, D.M. (2014). *Fundamentals of Analytical Chemistry (9th Edition).* Cengage Learning.
- Skoog, D.A., Holler, F.J., & Crouch, S.R. (2017). *Principles of Instrumental Analysis (7th Edition).* Cengage Learning.

Advanced References in Molecular Biology and Bioinformatics:

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell (6th Edition).* Garland Science.
- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K.C. (2021). *Molecular Cell Biology (9th Edition).* W.H. Freeman.
- Mount, D.W. (2004). *Bioinformatics: Sequence and Genome Analysis (2nd Edition).* Cold Spring Harbor Laboratory Press.
- Pevsner, J. (2015). *Bioinformatics and Functional Genomics (3rd Edition).* Wiley-Blackwell.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular Biology of the Gene (7th Edition).* Pearson.

References on Laboratory Techniques and Instrumentation:

- Day, R.A., & Underwood, A.L. (2010). *Quantitative Chemical Analysis (6th Edition).* Prentice Hall.
- Ninfa, A.J., Ballou, D.P., & Benore, M. (2009). *Fundamental Laboratory Approaches for Biochemistry and Biotechnology (2nd Edition).* Wiley.
- Switzer, R.L., & Garrity, L.F. (1999). *Experimental Biochemistry (3rd Edition).* W.H. Freeman.
- Voet, D., Voet, J.G., & Pratt, C.W. (2018). *Fundamentals of Biochemistry: Life at the Molecular Level (5th Edition).* Wiley.
- Wilson, K., & Walker, J. (2018). *Principles and Techniques of Biochemistry and Molecular Biology (8th Edition).* Cambridge University Press.

Supplementary Online Resources and Journals:

- *Nucleic Acids Research (Oxford Academic)* – Covers advances in bioinformatics, genomics, and molecular biology. https://academic.oup.com/nar
- *Nature Methods (Springer Nature)* – Focuses on novel laboratory techniques and bioinformatics tools.
  •https://www.nature.com/nmeth/
- *Cold Spring Harbor Protocols* – A leading source for laboratory methods in molecular biology. https://cshprotocols.cshlp.org/

VALUE-ADDITION COURSES OFFERED BY THE DEPARTMENT OF BOTANY

Plants in the Indian Traditional System of Knowledge

LTP: 2-0-0 **Credits: 2**

Course objective:
The purpose of this course is to explore the intricate relationship between plants and humans such that the students should be able to understand the concept of the Indian system of traditional medicines, cultural significance and conservation of traditional knowledge of plants in different Indian societies.

Course outcomes:

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

1. Explain the concepts and principles of Indian traditional systems of plant knowledge, particularly Ayurveda, and their relevance to healthcare and society.
2. Analyse the ethnobotanical importance of plants and evaluate their role in traditional medicinal practices and local health traditions, with special reference to Himalayan and Jammu & Kashmir flora.
3. Interpret the cultural, religious, and symbolic significance of plants in Indian traditions, rituals, folklore, and belief systems.
4. Assess traditional methods of plant harvesting, cultivation, and conservation, including the role of sacred groves and indigenous resource management practices.
5. Evaluate contemporary issues related to traditional plant knowledge, including intellectual property rights, biopiracy, geographical indications, and access and benefit-sharing mechanisms.

Syllabus

Unit 1: Traditional Systems of Knowledge in Plants
Overview of indigenous cultures and their relationship with plants; Importance of traditional plant knowledge in indigenous cultures of India; Traditional System of Medicine (TSM) in India and its importance.
Introduction, Concept and Principles of Ayurveda; Some important plants of Ayurveda and their utilisation (*Aconitum heterophyllum, Cinnamomum tamala, Emblica officinalis, Elettaria cardamomum Glycyrrhiza glabra, Picrrohiza kurroa*).

Unit 2: Ethnobotany and Cultural Significance of Plants
Concept of herbalism and its significance. Traditional medicinal plant knowledge and its role in healthcare; Symbolism and mythology associated with plants; Indigenous perspectives on plant-human relationships; Local health traditions.
Ethno medicines; Ethnobotanical plants of Jammu & Kashmir (*Acacia catechu, Achyranthes aspera, Acorus calamus, Azadirachta indica, Butea monosperma, Cannabis sativa, Centella asiatica, Justicia adhatoda*).

Unit 3: Traditional Plant Conservation and Protection
Threats to traditional plant knowledge and ways to mitigate them; Sacred Groves; Protection of traditional knowledge bill, 2016. Intellectual property rights about traditional knowledge and culture.
Bio-piracy; Strategies to protect the indigenous knowledge system; Geographical Indicators (GI); Access and benefit sharing.

Suggested Readings:

1) Kunwar, R.M., Sher, H., & Bussmann, R.W. (Eds.). (2021). Ethnobotany of the Himalayas. Springer Nature.
2) Sharma, S and Kumar, R.J. (2021). Sacred groves of India: repositories of a rich heritage and tools for biodiversity conservation. For. Res. 32, 899–916 https://doi.org/10.1007/s11676-020-01183-x.
3) Oommen, O.V., Laladhas, K. P., Nelliyat, P., & Pisupati, B. (Eds.). (2023). Biodiversity Conservation Through Access and Benefit Sharing (ABS): Himalayas and Indian Sub-Continent. Springer Nature.
4) Singh, M.P., Srivastava, J., and Pandey, S.N. (2003). Indigenous Medicinal Plants, Social Forestry, and Tribals. Daya Books.
5) Indian Medicinal Plants (Vol 1- 4) by K.R. Kirtikar and B.D. Basu (2006).
6) Handbook of Ayurvedic Medicinal Plants by L.D. Kapoor (2005).
7) Godagama (2004). The Handbook of Ayurveda Shantha, Bishen Singh Mahendrpal Singh, Dehradun.
8) Jain, S.K. (1989). Methods and approaches in Ethno-botany. Society of Ethnobotanists. CDRI, Lucknow. Pp.127-128.
9) V.V. Sivarajan and I. Balachandran (1994). Ayurvedic Drugs and their Plant Sources by Oxford & IBH.
10) A.K. Sharma (2006). Globalization of Herbal Health. Recent Progress in Medicinal Plants Vol.12.

Basics of Herbal Drug Technology

LTP: 2-0-0 **Credits: 2**

Course objective:

The objective of the course is to make the students understand the use of plants as a source of herbal drugs from cultivation to final drug product, WHO and ICH guidelines for the evaluation of herbal drugs, herbal cosmetics, natural sweeteners, nutraceuticals, and appreciate patenting of herbal products will also be highlighted.

Course outcomes:

On successful completion of this course, the students should be able to:

1) develop conceptual skills about traditional Indian medicinal system, herbal medicines, their processing, storage and marketing.
2) gain knowledge about developing commercial enterprises of herbal medicines.
3) learn the basic tools and techniques for propagation and phytochemical analysis of medicinal plants.
4) gain knowledge of the latest guidelines issued by the regulating authorities for manufacturing herbal drugs.

Syllabus

Unit 1: Raw material for herbal drugs

Definition of herb, herbal medicine, herbal medicinal product, herbal drug preparation Source of Herbs Selection, identification and authentication of herbal materials Processing of herbal raw material. Good agricultural practices in the cultivation of medicinal plants, including Organic farming.

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

Unit 2: Evaluation and regulation of herbal drugs

WHO & ICH guidelines for assessing herbal drugs Stability testing of herbal drugs. Regulations in India (ASU DTAB, ASU DCC).

Regulation of manufacture of ASU drugs - Schedule Z of Drugs & Cosmetics Act for ASU drugs.

Unit 3: Herbal Industry and Good manufacturing of herbal drugs

Herbal drugs industry: Present scope and future prospects. A brief account of plant-based industries and institutions involved in work on medicinal and aromatic plants in India. Components of GMP (Schedule – T) and its objectives.

Infrastructural requirements, working space, storage area, machinery and types of equipment, standard operating procedures, health and hygiene, documentation and records.

Suggested readings:

1) Chopra, R.N., Nayar S.L. and Chopra, I.C. (1956). Glossary of Indian Medicinal Plants, C.S.I.R, New Delhi.

2) Arber, A. (1999). Herbal plants and Drugs. Mangal Deep Publications.
3) Sivarajan V.V. and Balachandran I. (1994). Ayurvedic drugs and their plant source. Oxford IBH publishing Co.
4) Miller, L. and Miller, B. (1998). Ayurveda and Aromatherapy. Banarsidass, Delhi.
5) Green, A. (2000). Principles of Ayurveda, Thomsons, London.
6) Kokate, C.K. (1999). Pharmacognosy, Nirali Prakashan.
7) Textbook of Pharmacognosy by Trease & Evans.
8) Textbook of Pharmacognosy by Tyler, Brady & Robber.
9) Pharmacognosy by Kokate, Purohit and Gokhale
10) Essential of Pharmacognosy by Dr.S.H.Ansari 5. Pharmacognosy & Phytochemistry by V.D.Rangari
11) Pharmacopoeal standards for Ayurvedic Formulation (Council of Research in Indian Medicine & Homeopathy).
12) Mukherjee, P.W. Quality Control of Herbal Drugs: An Approach to Evaluation of Botanicals. Business Horizons Publishers, New Delhi, India, 2002.

History of Science and Technology in India

LTP: 2-0-0 **Credits: 2**

Course objective:

This course will expose the students to the contribution of Indian knowledge to the development of science and technology and make them understand the Importance of the roots of the knowledge system. Further, students will understand the contributions of different civilisations of India in science & technology development and, analyse it and apply it to their day-to-day life.

Course outcomes:

At the end of the Course, Students will be able to:

1) Identify the importance of Traditional knowledge of India in developing science & technology.
2) Explain the need for and importance of traditional knowledge in developing agriculture and other scientific areas.
3) Illustrate the various colonial rules in India, relating them to developing different research organisations.
4) Understand the contribution of different scientists from ancient & modern India.

Syllabus

Unit-1. Science and Technology- The Beginning and later development

Development in different branches of Science in Ancient India: Astronomy, Mathematics, Engineering and Medicine. Developments in metallurgy: Use of Copper, Bronze and Iron in Ancient India. Development of Geography: Geography in Ancient Indian Literature. Scientific and Technological Developments in Medieval India; Influence of the Islamic world and Europe; The role of maktabs, madrasas, and karkhanas set up. Developments in the fields of Mathematics, Chemistry, Astronomy and Medicine. Innovations in the field of agriculture - new crops and new techniques of irrigation.

Unit-2. Developments in Science and Technology in Colonial India

Early European Scientists in Colonial India- Surveyors, Botanists, Doctors, under the Company‘s Service. Indian Response to New Scientific Knowledge, Science and Technology in Modern India: Development of research organisations like CSIR and DRDO; Establishment of Atomic Energy Commission; Launching of the space satellites.

Unit-3. Prominent scientists of India since the beginning and their achievement

Mathematics and Astronomy: Baudhayan, Aryabhtatta, Brahmgupta, Bhaskaracharya, Varahamihira, Nagarjuna. Medical Science of Ancient India (Ayurveda & Yoga): Susruta, Charak, Yoga & Patanjali. Scientists of Modern India: Srinivas Ramanujan, C.V. Raman, Jagdish Chandra Bose, Homi Jehangir Bhabha and Dr Vikram Sarabhai.

Suggested Readings:

1) Arnold, D. (2013). Nehruvian science and postcolonial India. Isis, 104(2), 360–370.
2) Bagla, P., & Menon, S. (2008). Destination Moon: India’s quest for the Moon, Mars, and beyond. HarperCollin
3) Kumar, D. (2001). Reconstructing India: Disunity in the science and technology for development discourse, 1900–1947. Osiris, 15(1), 241–258.

Introduction to Plant Biology

LTP: 4-0-0 **Credits: 4**

Course Objective:

This course is aimed to expose students to basic knowledge of biology. It will deal with the life processes including germination, growth, anatomy and differentiation, physiology and metabolism, flowering and fruiting, and biological interactions.

Course Outcomes

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

1. Explain the origin, evolution, and development of plant sciences and their role in agriculture and human civilization.
2. Describe and differentiate the structural organization of plants, including vegetative and reproductive organs, and distinguish between monocots and dicots.
3. Interpret major physiological processes in plants, including photosynthesis, respiration, transport mechanisms, and mineral nutrition.
4. Apply basic principles of genetics and plant breeding to understand inheritance patterns, hybridization, and crop improvement strategies.
5. Analyse ecological relationships of plants and evaluate conservation strategies, including biodiversity conservation, RET taxa, hotspots, and environmental sustainability.

SYLLABUS

Unit I: History of Plant Sciences

Origin and evolution of botany as a science, history and development of Botany in India and abroad, domestication and origin of agriculture, plants and people.

Unit II: The Structure of Plants

Concept of monocots and dicots – important characteristics of each; vegetative organs of plants – root, stem and leaf, their structure, modification and functions. Reproductive organs of plants – diversity in inflorescence and flower structure.

Unit III: Plant Physiology and Development

Photosynthesis and respiration, brief account of transport processes (active and passive), water and mineral nutrition.

Unit IV: Genetics and Plant Breeding

Mendel's genetic experiments on pea, definition of gene and allele; dominant and recessive; phenotype and genotype; homozygous and heterozygous; monohybrid and dihybrid crosses, backcross and test cross; incomplete dominance and co-dominance, a brief introduction to pure lines; concept of inbreeding depression and heterosis; hybridization and hybrid varieties.

Unit V: Plant Ecology and Conservation

Ecosystem and its components; definition of population, community, food chain and food webs; extinction – human and natural impacts; concepts of RET taxa, hotspots and red data book; brief idea of conservation approaches.

Suggested Readings

1. Dickison, W.C. (2000). *Integrative Plant Anatomy*. Harcourt Academic Press, USA.

2. Fahn, A. (1974). *Plant Anatomy*. Pergamon Press, USA.
3. Mauseth, J.D. (1988). *Plant Anatomy*. The Benjamin/Cummings Publisher, USA.
4. Esau, K. (1977). *Anatomy of Seed Plants*. John Wiley & Sons, Inc., Delhi.
5. Karp, G. (2010). *Cell Biology*. John Wiley & Sons, USA. 6th edition.
6. Hardin, J., Becker, G., Skliensmith, L.J. (2012). *Becker's World of the Cell*, Pearson Education Inc., USA. 8th edition.
7. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). *Introduction to Genetic Analysis*. W.H. Freeman and Co., USA. 10th edition.
8. Odum, E.P. (2005). *Fundamentals of Ecology*. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
9. Singh, J.S., Singh, S.P., Gupta, S. (2006). *Ecology, Environment and Resource Conservation*. Anamaya Publications, New Delhi, India.

Vermicomposting and Mushroom Farming

LTP: 4-0-0 **Credits: 4**

Course Objective:

The objective of this course is to acquaint students with detailed techniques involved in vermicomposting and mushroom cultivation. This will help them in self-employment and increase their chances of getting employed in the mushroom industry. The course also deals with growing edible mushrooms. This includes culture preservation, basic mushroom substrate preparation, composting, spawning techniques, inoculation methods, mushroom harvesting and pest control. Students will understand the principles of mushroom cultivation and acquire practical knowledge of growing mushrooms.

Course Outcomes:

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

1. Explain the principles, ecological significance, and economic importance of vermiculture and mushroom cultivation.
2. Demonstrate knowledge of earthworm biology, vermicomposting methods, and physico-chemical properties of vermicompost for sustainable waste management and soil health improvement.
3. Describe the diversity, nutritional value, and medicinal importance of mushrooms, including locally available species.
4. Apply scientific techniques for mushroom cultivation, including substrate preparation, spawn production, crop management, and harvesting.
5. Evaluate and manage major pests, diseases, and post-harvest challenges in vermiculture and mushroom production for improved yield and quality.

SYLLABUS

Unit I: Introduction to Vermiculture

Definition, history and economic importance of vermiculture; choice of the right worms; local and exotic species of earthworms; life cycle of earthworms – alimentation, fecundity, annual reproduction potential; limiting factors (gases, diet, humidity, temperature, pH, light and climatic factors).

Unit II: Methods of Vermiculture

Earthworm farming (Vermiculture), extraction, vermicomposting harvest, processing, transport and storage. Physico-chemical parameters of vermicompost; different methods of vermicomposting – small- and large-scale bed and pit methods. Small-scale earthworm farming and earthworm compost – earthworm compost for home gardens. Conventional commercial composting; some important pests and diseases of earthworms and their management. Nutritional composition of vermicompost and comparison with other

fertilizers; transport and storage of vermicompost.

Unit III: Introduction to Mushrooms

History, production and uses of mushrooms; classification, categorization and diversity of mushrooms; nutritional and medicinal properties of mushrooms; wild mushrooms of Jammu and Kashmir (J&K); some important mushrooms available in local markets in J&K.

Unit IV: Mushroom Cultivation and Production

Design and development of mushroom production units; role of composting in mushroom cultivation; mushroom spawn; culture maintenance; production of good quality spawn; preparation of pure culture; criteria for selection of good quality spawn; transportation of spawn; casing and case; cropping and harvesting of mushroom.

Unit V: Disease Management in Mushroom Cultivation and Post-Harvest Survey

Major pests affecting mushrooms – flies, nematodes, mites; their identification and management by chemical and non-chemical methods. Major diseases of cultivated mushrooms. Competitor/weed molds – green, yellow and plaster molds.

Suggested Readings

1. Bhatt, J.V. & S.R. Khambata (1959). *Role of Earthworms in Agriculture*. Indian Council of Agricultural Research, New Delhi.
2. Dash, M.C., B.K. Senapati, P.C. Mishra (1980). *Verms and Vermicomposting*. Proceedings of the National Seminar on Organic Waste Utilization and Vermicomposting, Dec. 5–8, 1984 (Part B), School of Life Sciences, Sambalpur University, Jyoti Vihar, Orissa.
3. Edwards, C.A. and J.R. Lofty (1977). *Biology of Earthworms*. Chapman and Hall Ltd., London.
4. Lee, K.E. (1985). *Earthworms: Their Ecology and Relationship with Soils and Land Use*. Academic Press, Sydney.
5. Kevin, A. and K.E. Lee (1989). *Earthworm for Gardeners and Fisherman*. CSIRO, Australia (Division of Soils).
6. Rahudakar, V.B. (2004). *Gandul Khatashivay Naisargeek Paray*. Atul Book Agency, Pune.
7. Satchel, J.E. (1983). *Earthworm Ecology*. Chapman Hall, London.
8. Wallwork, J.A. (1983). *Earthworm Biology*. Edward Arnold (Publishers) Ltd., London.
9. Mushroom Cultivation, Tripathi, D.P. (2005). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
10. Mushroom Production and Processing Technology, Pathak Yadav Gour (2010). Published by Agrobios (India).
11. *A Handbook of Edible Mushrooms*, S. Kannaiyan & K. Ramasamy (1980). Today & Tomorrow Printers & Publishers, New Delhi.
12. *Handbook on Mushrooms*, Nita Bahl. Oxford & IBH Publishing Co.

OPEN ELECTIVE COURSES OFFERED BY THE DEPARTMENT OF BOTANY

Climate Change and Disaster Management

LTP: 4-0-0 **Credits: 4**

Course Objective:

This course explains the key scientific concepts, causes and symptoms of global climate change. The impact of global climate change on ecosystems and human society will be studied. The course also provides a basic conceptual understanding of the relationship between disasters and their development.

Course Outcomes:

After successful completion of this module, students will be able to:

1. Explain the physical basis of the natural greenhouse effect and the ways various human activities increase emissions of greenhouse gases.
2. Develop an understanding of disaster risk and related underlying factors and their impacts.
3. Comprehend approaches and measures of disaster management, preparedness and response, and related policies, laws, and methods.
4. Explain pathways, tools, and entry points for integrating Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) into developmental planning across national, sub-national, and local levels.

SYLLABUS

Unit I: Climate Change

Concepts of climate and weather; greenhouse effect; greenhouse gases – role of carbon dioxide and methane; El Niño and La Niña effects; ocean circulation; science and politics of global warming; climate change impacts on the Indian subcontinent; carbon reservoir; biogeochemistry; carbon footprints.

Carbon cycling – physical carbon pump, biological carbon pump, marine carbon cycle, terrestrial carbon cycle.

Global wind systems – trade winds, highs and lows of westerlies. Vital importance of monsoon rains. Global warming and IPCC.

Unit II: Definition and Types of Disaster

Brief account of hazards and disasters; risk and vulnerability in disasters; natural and man-made disasters including earthquakes, floods, droughts, landslides, land subsidence, cyclones, volcanoes, hurricanes, tsunamis, avalanches, global climate extremes, terrorism, gas and radiation leaks, toxic waste disposal, oil spills, and forest fires.

Unit III: Disaster Risks

Study of important disasters – earthquakes and their types, magnitude and intensity, seismic zones of India, major fault systems of the Indian plate.

Management of floods, drought, and landslides; case studies of disasters in Jammu & Kashmir and Sikkim

(e.g., earthquakes, landslides).
Social, economic, and environmental impacts of disasters; concept of disaster risk governance; climate change adaptation; disaster risk assessment; infrastructure and IDB investment projects.

Unit IV: Qualitative and Quantitative Risk Analysis
Key concepts of qualitative and quantitative risk analysis; determination and measurement of impact and probability of major risks and their effects on infrastructure projects.
Tools for representation of risk (F-N and F-D curves); technical and economic feasibility; investment alternatives; quantitative indicators; principles of efficiency and equity; components of risk governance.

Unit V: Mitigation and Management Techniques of Disaster
Basic principles of disaster management; disaster management cycle; disaster management policy; national and state disaster management bodies.
Early warning systems; building design and construction in highly seismic zones; retrofitting of buildings; training and awareness programmes; project management in disaster management; drills for disaster preparedness; use of GIS and remote sensing techniques in disaster management.

Suggested Readings

1. Cambridge University (2013). *Climate Change: Action, Trends and Implications for Business*. IISD, UNITAR & UNEP (2009). *IEA Training Material: Vulnerability and Climate Change Impact Assessment for Adaptation*.
2. IPCC (2013). *Climate Change 2013: The Physical Science Basis – Summary for Policymakers*. OECD (2009). *Guidance on Integrating Climate Change Adaptation into Development Co-operation*.
3. UNEP (2009). *Climate Change Science Compendium*.
4. UNEP (2009). *Climate in Peril: A Popular Guide to the Latest IPCC Report*.
5. UNEP & UNDP (2011). *Mainstreaming Climate Change Adaptation into Development Planning: A Guide for Practitioners*.
6. UNFCCC. *CGE Climate Change Training Materials*.
7. UNFCCC (2008). *Compendium on Methods and Tools to Evaluate Impacts, Vulnerability and Adaptation to Climate Change*.
8. UNFCCC (2006). *UNFCCC Handbook*.
9. UNFCCC & UNEP (2002). *Climate Change Information Kit*.
10. World Bank Report (2012). *Turn Down the Heat*.

Biostatistics and R-Programming

LTP: 4-0-0 **Credits: 4**

Course Objective:

The present course will apprise students about the methods and principles necessary for understanding computing, analysing and interpreting data. The use and importance of R for analytical programming will further strengthen the computing skills of students.

Course Outcomes:

After the successful completion of this module students will be able to:

1. Install, code and use R programming language in R Studio IDE to perform basic tasks on vectors, matrices and data frames.
2. Describe key terminologies, concepts and techniques employed in statistical analysis.
3. Define, calculate and implement probability and probability distributions to solve a wide variety of problems.
4. Conduct and interpret a variety of hypothesis tests to aid decision making.
5. Analyse and interpret correlation and regression to comprehend the underlying relationships between different variables.

Syllabus

Unit I: Elementary concepts in Statistics

Concepts of statistical population and sample from a population; Types of data-qualitative and quantitative data; nominal, ordinal, ratio, interval data; cross sectional and time series data; discrete and continuous data. Collection and scrutiny of data: Primary data; designing a questionnaire and a schedule; secondary data and sources of secondary data. Descriptive statistics: Concepts of central tendency or location, Absolute and relative measures of dispersion.

Unit II: Probability

Random Experiment; sample point; sample space; Events-mutually exclusive and exhaustive events; dependent and independent events; simple and compound events; equally likely frequency, classical and axiomatic definition of probability; addition and multiplication theorems; conditional probability and independence; Bayes' theorem. (The main thrust is on numerical problems and applications), Discrete and continuous random variables; probability mass and density functions and distribution functions; expectation of a random variable.

Unit III: Standard univariate distributions

Standard univariate discrete and continuous distributions- uniform; binomial; Poisson; geometric; negative binomial and hyper-geometric distributions. Uniform; exponential; normal; Laplace, gamma, beta, lognormal, logistic and Weibull distributions (elementary properties and applications only).

Unit IV: Basics of R programming

Fundamentals of R; Installation of R & R Studio; Features of R; Variables in R; Constants in R; Operators in R; Datatypes and R Objects; Accepting Input from keyboard; Important Built-in functions; Vectors; Control statements; Functions in R; Creating matrices; Accessing elements of a Matrix; Operations on Matrices; Matrix transpose; Strings; Lists; Arrays in R; Importing Data- CSV files; Database data (Oracle 11g); XML files; JSON files; Reading & Writing PDF files; Reading & Writing JPEG files; Saving Data in R.

Unit V: R programming in analysis

Statistical Concepts-Descriptive Statistics; Inferential Statistics; Central Tendency (Mean, Mode, Median); Hypothesis Testing; Probability; t-Test; z-Test; Chi Square test; Correlation; Covariance; Anova; Predictive Modelling; Linear Regression; Normal distribution; Density; Data Visualisation in R using G G Plot; Box Plot; Histograms; Scatter Plotter; Line chart; Bar Chart; Heat maps; Data Visualization using Plotly- 3D view; Geo Maps; Null Handling; Merge; Grep; Scan.

Suggested Readings:

1. Biostatistics, Danniel, W.W., 1987, New York, John Wiley & Sons.
2. An Introduction to Biostatistics, 3rd edition, Sundarrao, P.S.S. and Richards, J., Christian Medical College, Vellore.
3. Statistical Analysis of Epidemiological Data, Selvin, S., 1991, New York University Press.
4. Statistics for Biology, Boston, Bishop, O.N., Houghton Mifflin.
5. The Principles of Scientific Research, Freedman, P., New York, Pergamon Press.
6. Introduction to Statistics and Data Analysis with Exercises, Solutions and Applications in R, Christian Heumann, Michael Schomaker and Shalabh, Springer, 2016.
7. The R Software – Fundamentals of Programming and Statistical Analysis, Pierre Lafaye.
8. A Beginner Guide to R (Use R), Alain F. Zuur, Elena N. Ieno, Erik H. W. G. Meesters, Springer, 2009.

Biostatistics

LTP: 4-0-0 **Credits: 4**

Course objective:

This course is designed to acquaint a student with various statistical tools that can be used in experimental biology setup for better analysis and conclusions.

Course outcomes:

On successful completion of this course, the students should be able to:

1) handle and present massive field and experimental data in a proper form.
2) Analyse the results of their experiment for significance.
3) Compare and contrast different observations/ data of their experimental setups.
4) Present their results in logical form and impress upon their practicality.

Syllabus

Unit 1: Data Collection and Sampling

Statistical Data, Types of Data: attributes and variables, discrete & continuous data, Primary and Secondary data, Different types of scales- nominal, ordinal, ratio and interval. Presentation of data: Sampling methods.

Unit 2: Measures of Central Tendency

Frequency distributions, cumulative frequency distribution and their representation, histogram, frequency polygon and ogives. Stem and leaf chart. Box Plot, Univariate Data-Concepts of central tendency, standard deviation and standard error, dispersion and relative dispersion, moments, measures of skewness and kurtosis.

Unit 3: Correlation and Regression

Bivariate Data: Scatter diagram. Correlation coefficient and its properties, Correlation ratio. Rank – Spearman's and Kendall's measures of correlation. Principle of least squares, linear regression, fitting of curves reducible to polynomials by transformation. Multiple regression, Multiple and partial correlation coefficients.

Unit 4: Data Analysis and Test of Significance

Sampling distribution for discrete data. Analyses of contingency tables; hypothesis of homogeneity and independence. Measures of association, relative risk, odds ratio and confidence interval. Computation and importance of student 't-test, chi-square test, F-test and one-way ANOVA

Suggested Readings:

1. Alan Agresti: Categorical Data analysis; John Wiley and Sons, New York, USA.
2. Bhatt B R, Srivenkatramana T and Rao Madhva K S (1996): Statistics: A Beginner's Text, Vol 1, and New Age International (P) Ltd.

3. Goon A M, Gupta M K, Das Gupta B. (1991): Fundamentals of Statistics. Vol 1, World Press, Calcutta.
4. Anderson T W and Sclove S L (1978): An Introduction to Statistical Analysis of Data, Houghton Mffin\Co.
5. Snedecor G W and Cochran W G (1967): Statistical Methods. Iowa State University Press.
6. Spiegel, M R (1967): Theory and Problems of Statistics, Schaum's Publishing Series.

Basics of Plant Virology

LTP: 4-0-0 **Credits: 4**

Course objective:

The course aims to give an introduction to the origin, evolution, taxonomy, structure, transmission, replication, diagnostics and control strategies of plant viruses. Viruses evolve very fast, cause serious diseases in economically important plants, and pose serious threat to agriculture and food security. Knowledge about plant viruses would prepare the graduates for addressing these issues.

Course outcomes:

On successful completion of this course, the students should be able to:

1) understand the origin and evolution of viruses, the history of virology, taxonomy of viruses, and differentiate between viruses and virus-like infectious agents.
2) describe structures and genome organisations of plant viruses and various events involved in virus replication.
3) describe various methods to study and diagnose plant viruses.
4) strategise control measures, and devise applications of plant viruses.

Syllabus

Unit 1: Introduction to plant viruses and virus-like infectious agents

Introduction to plant viruses, history of virology, origin and evolution of viruses, virus taxonomy. Defective particles, satellite nucleic acids and satellite viruses, viroids, prions, bacteriophages and virophages.

Unit 2: Virus structure and replication

Structure of viruses, genome organization and expression of viral genomes. Replication of RNA and DNA Viruses: entry, genome replication, transcription, translation, assembly and exit with emphasis on TMV, Caulimo virus, Tobacco Mosaic Virus, Tomato leaf curl virus.

Unit 3: Virological techniques

Host range, transmission, movement and symptomatology of plant viruses. Propagation, purification and characterization of plant viruses. Physical, biochemical, serological and molecular methods of virus detection, diagnosis and assay.

Unit 4: Plant virus control and applications

Conventional control of plant viruses, quarantine, conventional resistance to plant viruses, transgenic approach of virus control, antiviral compounds. Applications of plant viruses in biotechnology, nanotechnology, medicine and human health.

Suggested Readings:

1) Roger Hull. Comparative Plant Virology. Academic Press. 2009. ISBN: 978-0123741547

2) Alan J. Cann. Principles of Molecular Virology. 6th Edition. Academic Press. 2015. ISBN: 978-0128019467
3) J. Carter and V. Saunders. Virology: Principles and Applications. John Wiley & Sons Ltd. 2013. ISBN: 978-1119991427
4) S.J. Flint, L.W. Enquist, V.R. Racaniello, A.M. Skalka. 2009. Principles of Virology. American Society for Microbiology. ISBN: 978-1555814434
5) D.M. Knipe and P.M. Howley. Fields Virology. 2013 Lippincott Williams and Wilkins. ISBN: 978-1451105636

Molecular Diagnostics

LTP: 4-0-0 **Credits: 4**

Course Objectives:

The objectives of this course are to provide students with a comprehensive understanding of the principles, techniques, and applications of molecular diagnostics, as well as its role in clinical practice and research.

Course Outcomes:

On successful completing this course, students should be able to:

1) describe various molecular diagnostic techniques and their applications
2) comprehend the principles behind various immunological tests used in molecular diagnostics.
3) understand principles and applications of nucleic acid-based molecular diagnostic techniques.
4) evaluate advances and emerging technologies in molecular diagnostics.
5) consider ethical and regulatory issues in molecular diagnostics.

Pre-requisites:

- Successful completion of courses in, Molecular Biology, Genetics, Biochemistry and Biostatistics.
- Basic knowledge of molecular biology and genetics concepts, including DNA structure, gene expression, and genetic inheritance

Syllabus

Unit 1: Introduction to molecular diagnostics

Introduction to the basics of molecular biology and genetics, including DNA structure, gene expression, and genetic inheritance. Introduction to molecular diagnostics, applications of molecular diagnostics, types of molecular diagnostic techniques and their clinical applications. History and evolution of molecular diagnostics, its current status, and future directions.

Unit 2: Immuno-diagnostic techniques

Immunoassays: Direct, indirect, sandwich, competitive and dot ELISA, enzymes and types of antisera available in immunoassays. Direct, indirect, sandwich, competitive and solid-phase radioimmunoassay (RIA), western blotting, immune-tissue printing, Immunoelectron microscopy (IEM), and immune-capture PCR.

Unit 3: Nucleic acid-based diagnostic techniques

Principles, advantages, and limitations of Polymerase chain reaction (PCR), reverse transcription PCR, gel electrophoresis techniques, nucleic acid hybridization, microarrays, real-time PCR, and their applications in clinical practice and research. Methods of radiolabelled and non-radiolabelled probe preparation, PCR primer and probe designing. Use of molecular diagnostics for infectious diseases, cancer, and genetic disorders.

Unit 4: Advanced and emerging technologies in molecular diagnostics

DNA sequencing and its variations, Next-generation sequencing, liquid biopsy, and circulating tumour DNA. Bioinformatics tools for sequence analysis. 2D gel electrophoresis, MALDI-TOF, and their importance in understanding disease mechanisms and identifying diagnostic biomarkers. Emerging trends and technologies in molecular diagnostics, such as nanotechnology and biosensors.

Unit 5: Ethical and regulatory considerations in molecular diagnostics

Introduction to bioethics and ethical principles relevant to healthcare and diagnostics. Overview of regulatory agencies governing molecular diagnostics (e.g., CDSCO, FDA, EMA, CDC). Principles of quality control and assurance in molecular diagnostics. Ethical challenges posed by emerging technologies in molecular diagnostics. Ethical issues related to genetic testing and personalized medicine.

Suggested readings:

1. Patrinos, G. P., Ansorge, W. J., & Danielson, P. B. (2017). Molecular Diagnostics (3rd ed.). Academic Press Elsevier. ISBN: 978-0-12-802971-8.
2. Buckingham, L. (2019) Molecular diagnostics: fundamentals, methods and clinical applications. FA Davis. ISBN: 978-0803668294
3. Grody, W. W., Nakamura, R. M., Kiechle, F. L., & Strom, C. (Eds.). (2009). Molecular diagnostics: techniques and applications for the clinical laboratory. Academic Press. 978-0123694287
4. Wilson, K., & Walker, J. (2010). Principles and Techniques of Biochemistry and Molecular Biology (7th ed.). Cambridge University Press. ISBN-13: 978-0521731676.
5. Punt, J., Stranford, S., Jones, P., & Owen, J. A. (2018). Kuby Immunology (8th ed.). WH Freeman Publisher. ISBN-13: 978-1319114701.
6. Brown, T. A. (2016). Gene Cloning and DNA Analysis: An Introduction (7th ed.). Wiley-Blackwell. ISBN-13: 978-1119072560.

Biodiversity and its Conservation

LTP-4-0-0 **Credits: 4**

Course Objective:

Purpose of the course is to have sound understanding of biodiversity, species, ecosystems and the interconnection of the living world. Students will be able to use the indices for the analysis of diversity. They will be able to understand the dire need of conservation of biodiversity.

Course Outcomes:

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

1. Understand the concept of biodiversity, importance of biodiversity
2. Use the indices for quantitative analysis of biodiversity in term of species richness and evenness.
3. Get familiar with method of conservation of biodiversity.
4. They will further be able to know about the international bodies involved in biodiversity conservation.

Syllabus

Unit: I Concept and key areas of biodiversity

Concept of biodiversity: diversity forms: ecological, morphological, functional; Biodiversity as source of food, fodder and fuel and medicine, ethical values, cultural values, RET species.

Unit: II Biodiversity pattern and theories of distribution

Latitudinal gradients in species diversity. Concept of hot spot of biodiversity and hot spot of biodiversity region in India and world. The phytogeographic regions of the world.

Unit: III Assessment of biodiversity

Plant collections, Species Inventories, Species Richness and Evenness, Diversity indices. Genetic Diversity Analysis: polymerase chain reaction (PCR), DNA sequencing.

Unit: IV Loss of biodiversity:

Extinction of Species; natural, mass, anthropogenic. Causes of extinction, consequences of extinction of species, biodiversity erosion, Impact of climate change on biodiversity and food security, climate change

Unit: V Conservation strategies:

Programmes for biodiversity conservation, convention on biological diversity (CBD), Conservation strategies; In-situ: Wildlife sanctuaries, National parks, Biosphere reserves, mangrooves. Ex-situ: Botanical Gardens, Seed banks, Field gene banks.

Suggested readings:

1. Gaston, K.J. and Spicer J.I. (2004). Biodiversity: An Introduction. 2nd Edition. Blackwell Science Limited, U.S.A.
2. Hubbel, S.P. (2001). The unified neutral theory of biodiversity and biogeography. Princeton University Press, Princeton NJ.
3. Gaston, K.J & Blackburn, M.J. (2000). Pattern and Process in Macroecology. Blackwell Sciences Limited, Oxford, UK.

4. Huston, M.A. (1994). Biological Diversity. Cambridge University Press, Cambridge, U.K.
5. Ludwig, J.A. and Reynolds J.F. (1988). Statistical Ecology: A primer on methods and computing. John Wiley & Sons, New York.

Insights into Immunology

LTP: 4-0-0 **Credits: 4**

Course Objective:

This course aims to provide comprehensive knowledge of the structure, organization, and functioning of the immune system, including mechanisms of innate and adaptive immunity, roles of immune cells and molecules, and the interactions of immune responses in health and disease, with emphasis on immunological disorders and therapeutic applications.

Course Outcomes:

1) Differentiate between innate and adaptive immunity, detailing key immune cells and their functions.
2) Identify primary immune organs and tissues responsible for immune system functions.
3) Recognize the significance of pattern recognition receptors in pathogen detection.
4) Explain the roles of the complement system and natural killer cells in immune responses.
5) Discuss the central involvement of T cells in immune responses, including their role in immune-mediated diseases, activation, differentiation in cellular immunity, as well as the importance of B cells, antibody production, hypersensitivity reactions, autoimmunity, and cancer immunotherapy.

Syllabus

Unit 1: Introduction to Immunology

Overview of the immune system, Components and organization of the immune system, Functions of the immune system, Distinction between innate and adaptive immunity, Immune cells and their roles, Primary organs and tissues involved in immune function

Unit 2: Innate Immunity

Mechanisms of innate immune response, Pattern recognition receptors, Phagocytosis and its significance, Inflammatory responses, The complement system, Natural killer cells and their cytotoxic functions

Unit 3: Adaptive Immunity: Cellular

Overview of adaptive immunity, T cell development, activation, and differentiation, Role of T cells in immune responses against intracellular pathogens, T cell-mediated immunological disorders

Unit 4: Adaptive Immunity: Humoral

B cell development and activation, Antigen recognition and antibody production, Structure and function of antibodies, Effector mechanisms of antibodies, Immunological memory Role of humoral immunity in vaccination strategies

Unit 5: Immune Responses and Disorders

Hypersensitivity reactions, Autoimmunity, Immunodeficiency disorders, Cancer immunotherapy Principles of immunosurveillance, Discussion on immune system dysfunction and its implications

Suggested readings:

1) Janeway's Immunobiology by Kenneth Murphy et al. (Textbook)
2) Immunology: A Short Course by Richard Coico et al. (Textbook)
3) Immunology for Medical Students by Nima Rezaei et al. (Textbook)
4) Clinical Immunology: Principles and Practice by Robert R. Rich et al. (Textbook)
5) Abbas AK, Lichtman AH, Pillai S. Cellular and Molecular Immunology. Elsevier Health Sciences.

Enzymology

LTP: 4-0-0 **Credits: 4**

Course Objective:

This course aims to provide students with a comprehensive understanding of enzymology, covering the historical background, classification, structure, function, inhibition, regulation, factors affecting activity, and advanced topics in the field. By the end of the course, students should be equipped with the knowledge and skills necessary to comprehend the fundamental principles of enzymology and apply them to various industrial, clinical, and environmental contexts.

Course Outcomes:

1) Understand enzyme classification and historical background, including protein nature, coenzymes, and metal-activated enzymes.
2) Identify and explain enzyme terminology, nomenclature, and activity, incorporating coenzymes, cofactors, and isozymes.
3) Describe enzyme structure at various levels and analyze active sites and substrate binding.
4) Apply enzyme kinetics principles (Michaelis-Menten equation, Km, Vmax) for understanding enzyme catalysis mechanisms.
5) Analyze enzyme inhibition mechanisms, such as reversible and irreversible inhibition, and explore regulatory processes like feedback regulation and allosteric regulation.

Syllabus

Unit 1: Introduction to Enzymes

Historical background and discovery of enzymes

General terminology and nomenclature

Classification of enzymes: protein nature, non-protein enzymes (ribozymes, DNAzymes), metalloenzymes, and metal-activated enzymes

Enzyme activity: chemical nature, specific activity, enzyme units (Katal and IU)

Coenzymes and cofactors: prosthetic groups, classification, and involvement in metabolic pathways

Isozymes, abzymes, synzymes

Unit 2: Enzyme Structure and Function

Enzyme structure: primary, secondary, tertiary, and quaternary structure.

Enzyme active sites and substrate binding.

Enzyme kinetics: Michaelis-Menten equation, Km, Vmax, Lineweaver-Burk plot, turnover number, Kcat.

Enzyme mechanisms: acid-base, covalent, metal ion, proximity, and orientation effects.

Mechanisms of enzyme catalysis: lock and key, induced fit, transition state hypotheses.

Specific examples: mechanism of serine proteases (chymotrypsin, lysozyme, carboxypeptidase A, ribonuclease), proenzymes (zymogens).

Unit 3: Enzyme Inhibition and Regulation

Enzyme inhibition: reversible (competitive, non-competitive, uncompetitive, mixed, substrate, allosteric, product), irreversible (suicide inhibition), examples (penicillin, iodoacetamide, DIPF).
Feedback regulation, allosteric regulation, reversible covalent modification, proteolytic activation.
Organization of enzymes in the cell: localization, compartmentation of metabolic pathways, enzymes in membranes etc.
Mechanisms of enzyme degradation: lysosomal and non-lysosomal pathways, with examples.

Unit 4: Factors Affecting Enzyme Activity

Factors affecting enzyme activity: concentration, pH and temperature.
Kinetics of allosteric enzymes.
Industrial and clinical uses of enzymes (applied enzymology): thermophilic enzymes, amylases, lipases, proteolytic enzymes in industries (meat, leather), enzymes in fermentation processes, cellulose and metal degrading enzymes.

Unit 5: Advanced Topics in Enzymology

Enzyme kinetics of multi-substrate reactions.
Cooperative enzyme kinetics.
Enzyme engineering and directed evolution.
Enzymes in drug discovery and development.
Enzymes in bioremediation and environmental applications.

Suggested readings:

1. Nelson, D.L., Cox, M.M. (2017). "Lehninger Principles of Biochemistry." Publisher: W. H. Freeman.
2. Copeland, R.A. (2020). "Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis." Publisher: Wiley.
3. Palmer, T. (2018). "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry." Publisher: CRC Press.
4. Ruzene, J.S., Campos, V.F. (2016). "Industrial Enzymes: Structure, Function and Applications." Publisher: Springer.
5. Ellis, G.M., Ladisch, M.R. (Eds.). (2017). "Enzymes in Synthetic Biology: Technologies and Applications." Publisher: Academic Press.

Microbial World

LTP: 4-0-0 **Credits: 4**

Course Objectives:

1) Cover foundational microbiology concepts, emphasizing microorganism diversity and characteristics.
2) Study virus, bacteria, viroids, and prions structures, replication cycles, and classification.
3) Analyze how microorganisms contribute to infectious diseases and impact human health.
4) Explore the economic importance of microorganisms in medicine, agriculture, industry, and environmental management.
5) Introduce microbial biotechnology applications, including industrial processes, enzyme production, and bioremediation, while considering environmental and ethical implications.

Course Outcomes:

1) **Understanding Microbiology Fundamentals**: Students will be able to describe the characteristics, classification, and replication cycles of various microorganisms, including viruses, bacteria, viroids, and prions.
2) **Analyzing Microorganism Roles**: Students will demonstrate a comprehensive understanding of the impact of microorganisms on human health through disease and pathogenesis, as well as their economic importance in medicine, agriculture, and industry.
3) **Applying Microbial Biotechnology**: Students will analyze and assess the applications of microbial biotechnology in industrial processes, enzyme production, bioremediation, and environmental management, including nutrient cycling and decomposition.
4) **Developing Practical and Analytical Skills**: Students will gain proficiency in laboratory techniques for handling microorganisms and critically evaluate research and real-world applications of microbiology. Communication skills will be honed through presentations, discussions, and written reports.
5) **Promoting Ethical Practices and Teamwork**: Students will exhibit ethical awareness and responsible practices in microbial applications and collaborate effectively in group projects, demonstrating leadership and teamwork skills.

Syllabus

Unit 1. Foundations of Microbiology

Introduction to the Microbial World

Discovery and Characteristics of Viruses

Classification of Viruses (Baltimore Classification)

General Structure of Viruses, Viroids, and Prions

Replication: DNA Virus (T-Phage) - Lytic and Lysogenic Cycle

Replication: RNA Virus (TMV)

Viral Diseases: Pox, Polio, HIV, Covid, TMV and CMV.

Unit 2: Bacterial Diversity and Physiology

Discovery and General Characteristics of Bacteria

Types of Bacteria: Archaebacteria, Eubacteria, Wallless Forms

Bacterial Cell Structure and Nutritional Types

Bacterial Reproduction: Vegetative, Asexual, and Recombination
Bacterial Diseases: Typhoid, Salmonella, Botulinum, Syphilis, Gonorrhoea and citrus canker.

Unit 3: Applied Microbiology and Economic Importance
Economic Importance of Viruses: Vaccine Production, Research, Medicine, Diagnostics, and Plant Diseases
Economic Importance of Bacteria: Role in Agriculture and Industry (Fermentation and Medicine)
Microbes and Quality of Environment: Distribution and Isolation from Soil, Air, and Water
Microbial Flora of Water: Pollution Sources, Control Measures, and Water Quality Indicators.

Unit 4: Microbial Biotechnology
Bioreactors/Fermenters and Fermentation Processes
Types of Bioreactors: Laboratory, Pilot Scale, and Production Fermenters
Fermentation Techniques: Solid-State and Liquid-State, Batch and Continuous
Microbial Production of Industrial Products: Enzymes, Organic Acids, Alcohol, Antibiotics
Microbial Enzymes of Industrial Importance: Applications and Immobilization Method

Unit 5: Microbial Ecology and Environmental Applications
Microbial Diversity in Natural Environments
Microbial Interactions and Ecosystem Dynamics
Role of Microbes in Environmental Processes: Nutrient Cycling, Decomposition, and Bioremediation
Microbial Applications in Wastewater Treatment and Pollution Control
Microbes in Agriculture: Plant-Microbe Interactions and Biostimulation.

Suggested readings:

1) Pelczar, M.J. (2001). *Microbiology*, 5th edition. New Delhi, Delhi: Tata McGraw-Hill Co. (Chapter 1 for Unit 1;)
2) Talaro, KP, Talaro A. 2006. *Foundations in Microbiology*. New Delhi, Delhi: McGraw-Hill
3) Campbell, N.A., Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V., Jackson, R.B. (2008). *Biology*, 8th edition. San Francisco, California: Pearson Benjamin Cummings.
4) Prescott, L.M., Harley J.P., Klein D. A. (2005). *Microbiology*, 6th edition. New Delhi, Delhi: McGraw Hill. (Chapter 3,5 for Unit 3; Chapter 6 for Unit 1)
5) Tortora, G.J., Funke, B.R., Case. C.L. (2007). *Microbiology*. San Francisco, U.S.A: Pearson Benjamin Cummings.

Environmental Studies

LTP: 4-0-0 **Credits: 4**

Course Objective:

The objective of this course is to provide students with a comprehensive understanding of environmental systems, natural resources, biodiversity, and environmental challenges. The course aims to create awareness about environmental protection, sustainable development, and the role of individuals and society in addressing environmental issues. It also seeks to familiarize students with environmental laws, ethics, and management strategies for mitigating pollution and conserving natural resources.

Course Outcomes:

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

1. Understand the multidisciplinary nature of environmental studies and basic ecosystem functioning.
2. Identify natural resources and major ecosystem types and their significance.
3. Explain biodiversity, its value, threats, and conservation strategies.
4. Describe types of environmental pollution and basic management approaches.
5. Understand sustainable development, environmental laws, and social responsibilities.

Syllabus

Unit 1: Foundations of Environmental Studies

Multidisciplinary nature of environmental studies: Definition, scope, and importance. Need for public awareness. Structure and function of an ecosystem: Producers, consumers, and decomposers. Energy flow, ecological succession, food chains, food webs, and ecological pyramids.

Unit 2: Natural Resources and Ecosystems

Overview of natural resources. Forest, water, mineral, food, and energy resources. Introduction to ecosystem types: Forest, grassland, desert, and aquatic ecosystems.

Unit 3: Biodiversity and Conservation

Introduction to biodiversity. Biogeographical classification of India. Value of biodiversity. Threats to biodiversity. Endangered and endemic species. Conservation strategies (*in situ and ex situ*).

Unit 4: Environmental Pollution and Management

Overview of environmental pollution. Air, water, soil, marine, noise, thermal, and nuclear pollution. Solid waste management. Individual roles in pollution prevention. Pollution case studies. Disaster management.

Unit 5: Social and Legal Aspects of Environmental Protection

Sustainable development. Urban problems and energy issues. Water conservation and management. Resettlement and rehabilitation. Environmental ethics. Climate change and global issues. Environmental protection laws. Enforcement and public awareness.

Suggested Readings:

- Singh, J.S., Singh, S.P. and Gupta, S.R. (2014). *Ecology, Environmental Science and Conservation.* S. Chand Publishing, New Delhi.
- Pepper, I.L., Gerba, C.P. and Brusseau, M.L. (2011). *Environmental and Pollution Science.* Academic Press.
- Raven, P.H., Hassenzahl, D.M. and Berg, L.R. (2012). *Environment.* 8th Edition. John Wiley & Sons.
- Sodhi, N.S., Gibson, L. and Raven, P.H. (eds.) (2013). *Conservation Biology: Voices from the Tropics.* John Wiley & Sons.
- Grumbine, R.E. and Pandit, M.K. (2013). Threats from India's Himalayan dams. *Science,* 339: 36–37.

- McNeill, J.R. (2000). *Something New Under the Sun: An Environmental History of the Twentieth Century.* W.W. Norton & Company.
- Wilson, E.O. (2006). *The Creation: An Appeal to Save Life on Earth.* W.W. Norton, New York.

Agriculture, Monsoons and Rural Development

LTP: 4-0-0 **Credits: 4**

Course Objective:

This course aims to provide an understanding of monsoon patterns in India, their regional variations, and their impact on agriculture. It examines the effects of climate change on monsoon dynamics and crop production, explores sustainable practices for resilience, and analyzes socio-economic implications on rural livelihoods. Additionally, it highlights innovations in agricultural technologies and policies for climate-resilient farming.

Course Outcomes:

On successful completion of this course, the students should be able to:

1. Identify the various monsoon patterns in India and evaluate their influence on crop yield and water management strategies.
2. Gain an understanding of how climate change is altering monsoon patterns and agricultural productivity and will propose strategies to adapt to these changes.
3. Demonstrate knowledge of sustainable farming techniques such as water conservation, drought-resistant crops, and agroecological practices to enhance resilience in monsoon regions.
4. Critically assess the socio-economic challenges and opportunities in rural areas dependent on monsoon agriculture, with an emphasis on poverty, migration, and livelihood diversification.
5. Evaluate the role of advanced technologies, government policies, and global frameworks in developing climate-smart and digitally enhanced agricultural practices.

Theory

Unit 1: Monsoon Patterns and Agriculture

Monsoon formation; atmospheric dynamics; El Niño, La Niña, Indian Ocean Dipole; regional variations; rainfall distribution, intensity, duration; agroclimatic zones; impact on crop yields, soil health, agricultural cycles; Kharif, Rabi cropping systems; water management; rainfed, irrigated agriculture; traditional, modern irrigation; crop adaptation; agronomic practices; crop rotation; varietal selection; historical trends; future projections; GIS-based agroclimatic mapping**.**

Unit 2: Climate Change and Its Impact on Monsoon Agriculture

Climate change; monsoon dynamics; shifts in onset, duration, rainfall distribution; impact on agricultural calendars, crop suitability, cropping systems; climate-induced risks; floods, droughts, extreme weather; soil fertility, crop productivity, food security; climate-resilient crops; innovation in agriculture; adaptation case studies; resilience building; climate modeling tools; Indigenous Knowledge Systems (IKS)**.**

Unit 3: Sustainable Agricultural Practices for Monsoon Regions

Soil, water conservation; mulching, contour plowing, cover cropping, organic matter; rainwater harvesting; traditional methods, farm ponds, check dams; drought-resistant, flood-resistant crops; food security; integrated water management; agroecology, organic farming; crop diversification; intercropping, mixed cropping; sustainable farming case studies; biochar, vermicomposting, integrated nutrient management; policy support; subsidies, farmer incentives**.**

Unit 4: Rural Development and Livelihoods in Monsoon-Dependent Areas

Monsoon agriculture; rural economy; employment, income, food security; challenges; poverty, migration, social inequalities; government policies; MGNREGA, Pradhan Mantri Fasal Bima Yojana; livelihood diversification; agro-industries, vocational training, entrepreneurship; local knowledge; traditional practices; adaptive strategies; off-farm employment, agri-startups; gender roles; agribusiness; organic products, food processing**.**

Unit 5: Innovation and Policy for Climate-Resilient Agriculture

Remote sensing, GIS; soil health, crop monitoring, rainfall patterns; precision farming; automated irrigation, drones, sensors; climate-smart agriculture; mitigation, adaptation, productivity; government policies; National Mission on Sustainable Agriculture, Paris Agreement; digital agriculture, AI, predictive analytics; blockchain, supply chain management; sustainable food systems; youth, innovation, public-private partnerships; AI, ML in agriculture; global adaptation case studies; agrivoltaics, energy-resilience integration.

Suggested readings:

Agriculture and Monsoons:

- Gadgil, S., & Gadgil, S. (2006). *The Indian Monsoon, GDP, and Agriculture*. Economic and Political Weekly, 41(47), 4887-4895.
- Ray, D. K., Gerber, J. S., MacDonald, G. K., & West, P. C. (2015). *Climate variation explains a third of global crop yield variability*. Nature Communications, 6(1), 5989.
- Mall, R. K., Gupta, A., Singh, R., Singh, R. S., & Rathore, L. S. (2006). *Water resources and climate change: An Indian perspective*. Current Science, 90(12), 1610-1626.

Rural Development:

- Chambers, R. (1997). *Whose Reality Counts? Putting the First Last*. Intermediate Technology Publications.
- Ellis, F., & Biggs, S. (2001). *Evolving themes in rural development 1950s-2000s*. Development Policy Review, 19(4), 437-448.
- Hazell, P., & Ramasamy, C. (1991). *The Green Revolution Reconsidered: The Impact of High-Yielding Rice Varieties in South India*. Johns Hopkins University Press.

Agricultural Practices and Challenges:

- Swaminathan, M. S. (2007). *An Evergreen Revolution*. In *Science and Sustainable Food Security*. World Scientific.
- Jodha, N. S. (1986). *Common property resources and rural poor in dry regions of India*. Economic and Political Weekly, 21(27), 1169-1181.

- Paroda, R. S., & Kumar, P. (2000). *Food production and demand in South Asia*. Agricultural Economics Research Review, 13(1), 1-24.

Monsoons and Climate Impact:

- Webster, P. J., & Fasullo, J. (2003). *Monsoons: Processes, predictability, and the prospects for prediction*. Journal of Geophysical Research: Atmospheres, 108(D24).
- Krishnan, R., Sabin, T. P., & Vellore, R. (2016). *The Asian Monsoon in a Changing Climate*. Current Climate Change Reports, 2(2), 145-162.

Policy and Socio-Economic Perspectives:

- Singh, R. B. (2000). *Environmental consequences of agricultural development: A case study from the Green Revolution state of Haryana, India*. Agriculture, Ecosystems & Environment, 82(1-3), 97-103.
- World Bank. (2008). *World Development Report 2008: Agriculture for Development*. Washington, DC: World Bank.
- Mishra, S. K., & Reddy, M. N. (2021). *Agrarian Crisis in India: Farmers' Distress and Rural Development Strategies*. Routledge.

Additional Suggested Reading:

- *India's Agricultural Economy: A Survey of Recent Developments* by C. H. Hanumantha Rao.
- *Monsoons over India* by P. S. S. Rao.
- *Small Farmers in South Asia: Their Characteristics, Productivity, and Efficiency* by Inderjit Singh.
- *The Future of Indian Agriculture: Technology and Institutions* edited by M. S. Swaminathan.
- *Climate Change and Agriculture in India: Impact and Adaptation* by S. K. Sinha and M. J. Swaminathan.
- *Groundwater Governance in India: Stumbling, Dragging, or Running?* by A. Sharma and S. Mukherjee.

Reports and Online Resources:

1. **Reports**
    - Intergovernmental Panel on Climate Change (IPCC) Reports.
    - *National Policy for Farmers 2007*, Ministry of Agriculture, Government of India.
    - *Agricultural Statistics at a Glance* (Annual), Directorate of Economics and Statistics, India.
2. **Online Resources**

- Food and Agriculture Organization (FAO): www.fao.org
- Indian Meteorological Department (IMD): www.imd.gov.in
- National Innovation Foundation (NIF): www.nif.org.in
- Research Papers on Agrarian Studies: www.epw.in

Molecular Systematics

LTP: 4-0-0 **Credits: 4**

Course Objectives

This course aims to provide a comprehensive understanding of molecular systematics, integrating molecular techniques with traditional taxonomy to study biodiversity and evolutionary relationships. It will cover the principles of molecular evolution, the use of molecular markers in species identification and phylogeography, and advanced phylogenetic analysis methods. Students will explore the molecular basis of speciation, population genetics, and adaptive evolution. The course will also highlight recent advancements in next-generation sequencing, bioinformatics, and their applications in conservation and ecological research**.**

Course Outcomes

Upon successful completion of the course, students will be able to:

1. Explain the principles of molecular systematics and its integration with traditional taxonomy.
2. Utilize molecular markers for species identification, phylogeography, and biodiversity studies.
3. Analyse evolutionary relationships using phylogenetic tree construction and molecular data.
4. Interpret molecular evidence in speciation, population genetics, and evolutionary processes.
5. Apply bioinformatics and next-generation sequencing tools in molecular systematics research.

Theory

Unit 1: Foundations of Molecular Systematics

Concept and significance: scope, integration with traditional taxonomy, applications in biodiversity and agriculture; Historical development: transition from morphology to molecular methods, key milestones, role of sequencing technologies; Molecular evolution: mutation, substitution, molecular clock hypothesis, evolutionary rates; Concepts of homology and analogy in molecular data; Role of molecular systematics in evolutionary biology and taxonomy**.**

Unit 2: Molecular Markers and Data Analysis in Systematics

Types of molecular markers: allozymes, RFLP, RAPD, AFLP, ISSR, SSR, mitochondrial DNA, chloroplast DNA, and nuclear DNA; Genome-wide approaches: SNPs, transcriptomics, and comparative genomics; Methods for marker selection, experimental design, and data analysis; Role of molecular markers in species identification, phylogeography, and biodiversity assessment; Applications in conservation genetics and population studies**.**

Unit 3: Phylogenetic Analysis and Evolutionary Relationships

Methods of phylogenetic analysis: distance-based (UPGMA, Neighbor-Joining) and character-based (Maximum Parsimony, Maximum Likelihood, Bayesian Inference); Sequence alignment techniques: multiple sequence alignment and its significance; Phylogenetic tree construction and interpretation;

Bootstrapping and statistical reliability of phylogenies; Molecular clocks and evolutionary dating; Resolving species complexes and cryptic species identification**.**

Unit 4: Molecular Basis of Speciation and Evolutionary Processes

Molecular insights into speciation: sympatric and allopatric speciation; Adaptive radiation and evolutionary convergence; Comparative genomics: identifying orthologous and paralogous genes; Molecular divergence and gene flow in evolutionary studies; Genetic signatures of hybridization and introgression; Population genetics and its role in understanding evolutionary dynamics**.**

Unit 5: Advances and Applications in Molecular Systematics

DNA barcoding: concept, workflow, case studies, applications in forensic botany and conservation; Integration of molecular and morphological data in systematic studies; Biogeography and ecological niche modeling using molecular data; Next-generation sequencing and bioinformatics tools for systematics; Ethical considerations and challenges in molecular systematics; Future directions: genomics-driven taxonomy and AI in systematics research.

Suggested Readings

Textbooks:

- Avise, J.C. (2000). *Phylogeography: The History and Formation of Species*, Harvard University Press, Cambridge, USA.
- Hillis, D.M., Moritz, C., Mable, B.K. (1996). *Molecular Systematics*, 2nd edition, Sinauer Associates, Sunderland, USA.
- Freeman, S., Herron, J.C. (2020). *Evolutionary Analysis*, 6th edition, Pearson, New York, USA.
- Nei, M., Kumar, S. (2000). *Molecular Evolution and Phylogenetics*, Oxford University Press, Oxford, UK.
- Jobb, G., et al. (2009). *Phylogenetic Analysis Using Parsimony (and Other Methods): PAUP*, Sinauer Associates, Sunderland, USA.

Books on Molecular Markers:

- Brown, T.A. (2016). *Gene Cloning and DNA Analysis: An Introduction*, 7th edition, Wiley-Blackwell, Oxford, UK.
- Karp, A., et al. (1998). *Molecular Tools for Screening Biodiversity: Plants and Animals*, Springer, Dordrecht, Netherlands.
- Henry, R.J. (2001). *Plant Genotyping: The DNA Fingerprinting of Plants*, CABI Publishing, Wallingford, UK.

Books on Phylogenetics and Tree Construction:

- Felsenstein, J. (2004). *Inferring Phylogenies*, Sinauer Associates, Sunderland, USA.
- Graur, D., Li, W.-H. (2000). *Fundamentals of Molecular Evolution*, 2nd edition, Sinauer Associates, Sunderland, USA.
- Page, R.D.M., Holmes, E.C. (1998). *Molecular Evolution: A Phylogenetic Approach*, Wiley-Blackwell, Oxford, UK.

Books on Applications and Future Perspectives:

- Lemey, P., Salemi, M., Vandamme, A.M. (2009). *The Phylogenetic Handbook: A Practical Approach to Phylogenetic Analysis and Hypothesis Testing*, 2nd edition, Cambridge University Press, Cambridge, UK.
- Wiley, E.O., Lieberman, B.S. (2011). *Phylogenetics: Theory and Practice of Phylogenetic Systematics*, 2nd edition, Wiley-Blackwell, Oxford, UK.

Supplementary Reading:

- Hall, B.G. (2011). *Phylogenetic Trees Made Easy: A How-To Manual*, 4th edition, Sinauer Associates, Sunderland, USA.
- Zhang, Z. (2019). *Phylogenomics: A Primer*, Springer, Cham, Switzerland.

Ecology and Biodiversity Conservation

LTP: 4-0-0 **Credits: 4**

Course Objective:

The course provides a comprehensive understanding of ecosystems, focusing on their structure, functioning, and dynamics. It explores the ecological and economic significance of forest ecosystems, sustainable management, and conservation. Students will also examine phytogeography, conservation biology, and applied concepts like environmental impact assessments and restoration ecology for sustainable development.

Course Outcomes:

On successful completion of this course, the students should be able to:

1. Gain the ability to analyse and evaluate ecosystem processes, including energy flow, biogeochemical cycles, and the impacts of environmental changes.
2. Understand the diversity of forest ecosystems in India and their ecological and economic roles, enabling them to propose sustainable forest management practices.
3. Develop skills to assess phytogeographic principles and analyse factors influencing plant distribution, endemism, and migration across regions.
4. Demonstrate knowledge of biodiversity conservation strategies, legal frameworks, and the integration of traditional ecological knowledge in addressing environmental challenges.
5. Acquire expertise in applied conservation techniques, including EIA, restoration ecology, GIS applications, and community-based initiatives for ecosystem and biodiversity management.

Theory

Unit 1: Environmental Biology

Scope and importance of environmental biology; ecosystem structure and functioning; abiotic and biotic components of the environment; energy flow: food chains, food webs, and ecological pyramids; biogeochemical cycles: carbon, nitrogen, and phosphorus; ecological succession: types and mechanisms; environmental pollution: air, water, and soil pollution, their causes, and mitigation strategies; climate change and its impacts on ecosystems.

Unit 2: Forest Botany

Types of forests in India: tropical, temperate, and alpine forests; structure and composition of forest ecosystems; forest resources and their ecological and economic significance; forest succession and dynamics; non-timber forest products (NTFPs) and their sustainable management; deforestation: causes, consequences, and afforestation practices; forest conservation strategies: Joint Forest Management (JFM) and agroforestry systems.

Unit 3: Phytogeography

Principles and concepts of phytogeography; phytogeographic regions of India and their floristic composition; factors affecting the distribution of plant species: climatic, edaphic, and biotic factors; endemism: types and significance; plant migration and dispersal; continental drift and its role in species distribution; vegetation types of the world: classification and ecological significance; floristic diversity hotspots in India.

Unit 4: Conservation Biology

Principles and importance of conservation biology; biodiversity: levels, hotspots, and values; causes of biodiversity loss: habitat destruction, overexploitation, invasive species, and climate change; ex situ and in situ conservation strategies: botanical gardens, seed banks, national parks, and wildlife sanctuaries; role of traditional ecological knowledge in conservation; legal frameworks: Forest Conservation Act, Wildlife Protection Act, and Biodiversity Act.

Unit 5: Applied Aspects and Emerging Trends

Role of environmental impact assessments (EIA) in ecosystem management; sustainable development goals (SDGs) and their relevance to environmental and forest conservation; restoration ecology: techniques and challenges; carbon sequestration and forest-based climate solutions; role of remote sensing and GIS in forest and biodiversity management; emerging concepts in conservation: rewilding, assisted migration, and ecological corridors; community-based conservation and eco-tourism.

Suggested Readings

Textbooks

- Odum, E.P., Barrett, G.W. (2005). *Fundamentals of Ecology*, 5th edition, Brooks Cole, Belmont, USA.
- Smith, T.M., Smith, R.L. (2021). *Elements of Ecology*, 10th edition, Pearson, New York, USA.
- Begon, M., Townsend, C.R., Harper, J.L. (2020). *Ecology: From Individuals to Ecosystems*, 5th edition, Wiley-Blackwell, Oxford, UK.
- Primack, R.B. (2020). *Essentials of Conservation Biology*, 7th edition, Oxford University Press, New York, USA.
- Krishnamurthy, K.V. (2017). *An Advanced Textbook on Biodiversity: Principles and Practice*, 3rd edition, Oxford & IBH Publishing Co., New Delhi, India.

Research Articles:

- Vitousek, P.M., et al. (1997). "Human Domination of Earth's Ecosystems," *Science*, 277(5325), 494–499.
- Cardinale, B.J., et al. (2012). "Biodiversity Loss and Its Impact on Humanity," *Nature*, 486, 59–67.

- Tilman, D., et al. (1997). "Biodiversity and Ecosystem Functioning," *Science*, 277(5330), 1300–1302.
- Sala, O.E., et al. (2000). "Global Biodiversity Scenarios for the Year 2100," *Science*, 287(5459), 1770–1774.
- Mace, G.M., et al. (2012). "Biodiversity and Ecosystem Services: A Multilayered Relationship," *Trends in Ecology & Evolution*, 27(1), 19–26.

Specialized Topics:

- Pimm, S.L., et al. (2014). "The Biodiversity of Species and Their Rates of Extinction," *Science*, 344(6187), 1246752.
- Groom, M.J., Meffe, G.K., Carroll, C.R. (2006). *Principles of Conservation Biology*, 3rd edition, Sinauer Associates, Sunderland, USA.
- Chapin, F.S. III, et al. (2000). "Consequences of Changing Biodiversity," *Nature*, 405, 234–242.
- Turner, M.G., Gardner, R.H., O'Neill, R.V. (2001). *Landscape Ecology in Theory and Practice: Pattern and Process*, Springer, New York, USA.
- Sutherland, W.J., et al. (2006). *Ecological Census Techniques: A Handbook*, 2nd edition, Cambridge University Press, Cambridge, UK.

Supplementary Reading:

- Whittaker, R.H., Levin, S.A. (2013). *Niche: Theory and Application in Ecology*, Springer, Berlin, Germany.

Plant Breeding

LTP: 4-0-0 **Credits: 4**

Course Objective:

This course aims to provide students with fundamental knowledge of plant breeding, including its history, significance, and genetic principles. It covers conventional and modern breeding methods for self-pollinated, cross-pollinated, and clonally propagated crops. Students will learn about selection techniques, hybridisation, polyploidy breeding, and the role of biotechnology in crop improvement. The course also addresses challenges in breeding for stress tolerance, quality enhancement, and genetic resource conservation.

Course Outcomes:

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

1. Explain the fundamental principles of plant breeding and its historical, genetic, and agronomic significance in crop improvement.
2. Apply conventional and modern breeding techniques to improve crop yield, stress tolerance, and quality through selection, hybridisation, and genetic manipulation.
3. Utilize molecular and biotechnological tools such as marker-assisted selection, genetic engineering, and genome editing for crop enhancement.
4. Assess the challenges and future prospects of plant breeding in the context of climate change, sustainability, and intellectual property regulations.

Theory

Unit 1: Introduction to Plant Breeding

History and significance of plant breeding; objectives of plant breeding: yield improvement, biotic and abiotic stress resistance, and quality enhancement; modes of reproduction in plants: self-pollination, cross-pollination, and asexual reproduction; genetic consequences of different modes of reproduction; Pure line theory, Heterosis; inbreeding depression- concept and basis, concept of role of genetic diversity in crop improvement.

Unit 2: Methods of Plant Breeding in Self-Pollinated Crops

Principles of selection: mass selection, bulk population breeding, pedigree selection; backcross breeding and gene introgression; hybridisation techniques: emasculation methods (mechanical, chemical, genetic male sterility-based), artificial pollination, selection of desirable recombinants; pure line development and maintenance, genetic purity and seed certification, role of marker-assisted selection (MAS) in self-pollinated crops.

Unit 3: Methods of Plant Breeding in Cross-Pollinated & Clonally Propagated Crops

Hybrid development and utilisation: heterosis, hybrid vigour, CMS (cytoplasmic male sterility), GMS (genic male sterility), three-line and two-line hybrid systems, hybrid seed production in maize and sorghum; synthetic and composite varieties: genetic basis, steps in development, examples in cereals and oilseeds; recurrent selection and population improvement: simple, reciprocal, S1 family selection, half-sib and full-sib selection, index selection, multi-trait selection; clonal selection and breeding in vegetatively propagated crops: somaclonal variation, meristem culture, virus elimination; polyploidy breeding: colchicine-induced polyploidy, autopolyploids vs. allopolyploids, examples in wheat, sugarcane, and ornamentals.

Unit 4: Modern Tools and Techniques in Plant Breeding

Role of biotechnology in plant breeding; mutation and polyploid breeding: chemical mutagens (EMS, sodium azide), radiation mutagens (gamma rays, X-rays), induction, screening, selection and evaluation of mutants; molecular marker-assisted selection (MAS) and its applications; genetic engineering for crop improvement: transgenic plants, CRISPR-Cas systems, and genome editing; tissue culture techniques in plant breeding: somatic hybridisation, micropropagation, and embryo rescue; doubled haploid production; genomic selection and its applications in breeding programmes.

Unit 5: Challenges and Applications of Plant Breeding

Breeding for biotic stress resistance: disease and pest resistance; breeding for abiotic stress tolerance: drought, salinity, and temperature extremes; quality improvement: breeding for nutritional enhancement, seed quality, and post-harvest traits; conservation of genetic resources for plant breeding: gene banks and in situ conservation; intellectual property rights (IPR) and their implications in plant breeding; future prospects of plant breeding in the context of climate change and sustainable agriculture.

Suggested Readings

Textbooks:

- Acquaah, G. (2020). *Principles of Plant Genetics and Breeding*, 3rd edition, Wiley-Blackwell, Oxford, UK.
- Allard, R.W. (1999). *Principles of Plant Breeding*, 2nd edition, Wiley-Blackwell, New York, USA.
- Singh, B.D. (2019). *Plant Breeding: Principles and Methods*, 11th edition, Kalyani Publishers, New Delhi, India.
- Fehr, W.R. (1987). *Principles of Cultivar Development: Theory and Technique*, Macmillan, New York, USA.
- Sharma, J.R. (2003). *Principles and Practice of Plant Breeding*, Oxford & IBH Publishing, New Delhi, India.

Books on Self- and Cross-Pollinated Crops:

- Chahal, G.S., Gosal, S.S. (2002). *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches*, Alpha Science International, Oxford, UK.

- Baker, H.G., Stebbins, G.L. (1965). *The Genetics of Colonizing Species*, Academic Press, London, UK.
- Sprague, G.F., Dudley, J.W. (1988). *Corn and Corn Improvement*, American Society of Agronomy, Madison, USA.

Books on Modern Tools and Techniques:

- Collard, B.C.Y., Mackill, D.J. (2008). *Molecular Breeding for Crop Improvement: Principles and Practices*, Springer, Dordrecht, Netherlands.
- Moose, S.P., Mumm, R.H. (2008). *Molecular Plant Breeding: Integration of Molecular Tools into Traditional Plant Breeding*, Springer, New York, USA.
- Ricroch, A., Chopra, S., Fleischer, S. (2013). *Plant Biotechnology and Agriculture: Prospects for the 21st Century*, Academic Press, London, UK.

Books on Challenges and Applications:

- FAO. (2010). *The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture*, Food and Agriculture Organization, Rome, Italy.
- Tester, M., Langridge, P. (2010). "Breeding Technologies to Increase Crop Production in a Changing World," *Science*, 327(5967), 818–822.
- Lopes, M.S., Reynolds, M.P. (2010). *Breeding for Abiotic Stress Tolerance in Crops*, Springer, Cham, Switzerland.

Supplementary Reading:

- Kingsbury, N. (2009). *Hybrid: The History and Science of Plant Breeding*, University of Chicago Press, Chicago, USA.
- Poehlman, J.M., Sleper, D.A. (2006). *Breeding Field Crops*, 5th edition, Blackwell Publishing, Ames, USA.

Medicinal and Ornamental Plants of India

LTP: 4-0-0 **Credits: 4**

Course Objective:

The course introduces the historical and traditional significance of medicinal plants in healthcare systems like Ayurveda. It covers plant identification, cultivation, conservation strategies, and their commercial applications. Additionally, students will explore entrepreneurial opportunities in the cultivation, processing, and marketing of medicinal and ornamental plants.

Course outcomes:

Successful completion of this course will help the students to:

1. Understand Medicinal Plants: Students will gain a comprehensive understanding of the importance, bioactive compounds, and conservation strategies of medicinal plants in traditional and modern healthcare systems.
2. Have Cultivation Knowledge: Students will be able to identify and describe the medicinal and ornamental properties, cultivation practices, and post-harvest processing of commonly used plants in India.
3. Gain Ecological Awareness: Students will appreciate the ecological role of ornamental plants in biodiversity conservation, landscaping, and carbon sequestration.
4. Apply propogationTechniques: Students will demonstrate proficiency in commercial propagation methods such as seed propagation, vegetative propagation, tissue culture, and micropropagation.
5. Gain Industrial and Entrepreneurial Skills: Students will be equipped to explore careers in the pharmaceutical, herbal product, and flower-based industries, leveraging knowledge of value addition and commercial cultivation.

Theory

Unit 1: Introduction to Medicinal Plants

Historical perspective and importance of medicinal plants in traditional systems of medicine: Ayurveda, Unani, Siddha, and folk medicine; distribution of medicinal plants in India; major bioactive compounds: alkaloids, glycosides, flavonoids, tannins, and essential oils; role of medicinal plants in healthcare and pharmaceutical industries; conservation strategies for medicinal plants: *ex situ* and *in situ* conservation.

Unit 2: Important Medicinal Plants of India

Taxonomical details, Botanical nomenclature, important secondary metabolites, uses of common Indian medicinal plants: *Rauvolfia serpentina* (Sarpagandha), *Withania somnifera* (Ashwagandha), *Azadirachta indica* (Neem), *Ocimum sanctum* (Tulsi), *Phyllanthus emblica* (Amla), *Tinospora cordifolia* (Giloy), *Centella asiatica* (Brahmi), *Curcuma longa* (Turmeric), *Aloe vera* (Ghritkumari), *Bacopa monnieri* (Brahmi), *Terminalia bellerica* (Bibhitaki), *Terminalia chebula* (Haritaki), *Aegle marmelos* (Bel); Medicinal properties and their uses; Cultivation practices, post-harvest processing of medicinal plants.

Unit 3: Introduction to Ornamental Plants

Overview of ornamental plants and their role in landscaping and aesthetic gardening; classification of ornamental plants: flowering plants, foliage plants, and succulents; importance of indigenous ornamental plants in India; principles of garden design and landscape architecture; ecological significance of ornamental plants: role in biodiversity conservation and carbon sequestration.

Unit 4: Important Ornamental Plants of India

Taxonomical details, Botanical nomenclature, important secondary metabolites, uses of common Indian medicinal plants Cultivated ornamental plants: *Hibiscus rosa-sinensis* (China Rose), *Bougainvillea spectabilis* (Bougainvillea), *Chrysanthemum indicum* (Chrysanthemum), *Rosa* spp. (Roses), *Tagetes* spp. (Marigold), *Jasminum* spp. (Jasmine), *Ficus benjamina* (Weeping Fig), *Dracaena* spp., and *Asparagus* spp.; indigenous ornamental trees and shrubs: *Cassia fistula* (Amaltas), *Delonix regia* (Gulmohar), and *Plumeria alba* (Frangipani); cultivation and maintenance practices.

Unit 5: Conservation and Commercial Applications

Conservation of medicinal and ornamental plants: challenges and strategies; role of botanical gardens, nurseries, and gene banks in conservation; commercial propagation techniques: seed propagation, vegetative propagation, tissue culture, and micropropagation; value addition in medicinal and ornamental plants: extraction of bioactive compounds, preparation of herbal products, and flower-based industries; entrepreneurship opportunities in medicinal and ornamental plant cultivation.

Suggested Readings

Textbooks:

- Nambiar, V.P.K., Kutty, C.R. (2007). *Indian Medicinal Plants: A Compendium of 500 Species*, 2nd edition, Orient Blackswan, Hyderabad, India.
- Evans, W.C. (2009). *Trease and Evans' Pharmacognosy*, 16th edition, Elsevier, New York, USA.
- Chopra, R.N., Nayar, S.L., Chopra, I.C. (1999). *Glossary of Indian Medicinal Plants*, National Institute of Science Communication, New Delhi, India.
- Warrier, P.K., Nambiar, V.P.K., Ramankutty, C. (1996). *Indian Medicinal Plants: A Dictionary*, Orient Blackswan, Hyderabad, India.
- Hooker, J.D. (1999). *The Flora of British India*, Volumes 1–7, Bishen Singh Mahendra Pal Singh, Dehradun, India.

Books on Medicinal Plants:

- Kumar, N., Kumar, S. (2020). *Phytochemical Analysis and Medicinal Properties of Medicinal Plants*, Springer, Cham, Switzerland.
- Sharma, R. (2003). *Medicinal Plants of India: An Encyclopedia*, Daya Publishing House, New Delhi, India.

- Pandey, A.K., Singh, R.P. (2012). *Medicinal Plants: Conservation, Cultivation and Utilization*, CABI, Wallingford, UK.

Books on Ornamental Plants:

- Randhawa, G.S., Mukhopadhyay, A. (1986). *Floriculture in India*, Allied Publishers, New Delhi, India.
- Arora, J.S. (2006). *Introductory Ornamental Horticulture*, Kalyani Publishers, Ludhiana, India.
- Bhattacharjee, S.K. (2006). *Ornamental Plants and Garden Design*, Pointer Publishers, Jaipur, India.

Specialized Topics:

- Awasthi, M. (2017). *Conservation of Medicinal and Aromatic Plants*, Scientific Publishers, Jodhpur, India.
- Chadha, K.L. (1995). *Advances in Horticulture: Ornamental Plants*, Malhotra Publishing House, New Delhi, India.

Supplementary Reading:

- Singh, V., Jain, A.K. (2003). *Taxonomy of Angiosperms and Utilization of Plants*, Rastogi Publications, Meerut, India.
- Kaushik, P. (2020). *Bioactive Compounds from Medicinal Plants: Mechanism and Therapeutic Applications*, Springer, Singapore.

Molecular Plant Pathology

LTP: 4-0-0 **Credits: 4**

Course Objective: This course aims to provide students with an in-depth understanding of molecular plant pathology, covering plant-pathogen interactions, plant defence mechanisms, molecular signalling, and advanced genomics and proteomics tools used to study plant diseases. Students will also learn about biotechnological strategies for disease management and the development of disease-resistant crops.

Course Outcomes

On successful completion of this course, the students should be able to:

1. Understand plant-pathogen interactions, the classification of plant pathogens, and the molecular basis of pathogenicity.
2. Learn about plant defence mechanisms, including innate immunity, resistance proteins, and systemic resistance pathways.
3. Explore molecular signalling pathways in plant-pathogen interactions, focusing on plant hormones and small RNAs in immune responses.
4. Understand the applications of genomics and proteomics in plant pathology to study pathogen-host interactions and disease resistance.
5. Gain knowledge of biotechnological approaches for developing disease-resistant plants and molecular techniques for disease diagnosis and management.

Theory

Unit 1: Introduction to Molecular Plant Pathology

Overview of plant-pathogen interactions; classification and characteristics of plant pathogens: fungi, bacteria, viruses, nematodes, and phytoplasmas; molecular basis of pathogenicity: virulence factors, toxins, and effector proteins; infection process: adhesion, penetration, colonisation, and systemic infection; molecular Koch's postulates and their applications.

Unit 2: Plant Defence Mechanisms

Innate immunity in plants: pathogen-associated molecular patterns (PAMPs) and pattern recognition receptors (PRRs); effector-triggered immunity (ETI) and resistance (R) proteins; hypersensitive response (HR), systemic acquired resistance (SAR), and induced systemic resistance (ISR); production of reactive oxygen species (ROS), phytoalexins, and pathogenesis-related (PR) proteins; role of secondary metabolites in defence; epigenetic regulation of plant immunity.

Unit 3: Molecular Signalling in Plant-Pathogen Interactions

Plant hormone signalling pathways in defence: salicylic acid (SA), jasmonic acid (JA), ethylene (ET), and abscisic acid (ABA); crosstalk between signalling pathways; role of small RNAs in regulating plant

immunity; signalling molecules: nitric oxide, calcium ions, and MAPK cascades; quorum sensing in plant pathogens; role of microbial effectors in modulating host signalling.

Unit 4: Genomics and Proteomics in Plant Pathology

Applications of genomics in plant pathology: pathogen genome sequencing and annotation; comparative genomics of plant pathogens and their hosts; transcriptomics to study host-pathogen interactions; proteomics to identify pathogen effectors and plant defence proteins; metabolomics in understanding disease resistance and susceptibility; use of molecular markers in disease diagnosis and resistance breeding.

Unit 5: Biotechnology and Disease Management

Development of disease-resistant plants using genetic engineering: overexpression of R genes, antimicrobial peptides, and RNAi technology; CRISPR-Cas systems for editing pathogen resistance genes; development of pathogen-resistant crops through transgenic approaches; molecular techniques for disease diagnosis: ELISA, PCR, qPCR, and LAMP; use of beneficial microorganisms in biocontrol: PGPR, mycorrhizae, and endophytes; strategies for integrated disease management (IDM).

Suggested Readings:

Textbooks:

- Agrios, G. N. (2005). *Plant Pathology* (5th ed.). Elsevier Academic Press.
- Dickman, M. B., & de Figueiredo, P. (2017). *Molecular Plant Pathology*. Wiley-Blackwell.
- Jones, J. D. G., & Dangl, J. L. (2006). *The Plant Immune System*. Nature Publishing Group.
- Zipfel, C. (2014). *Plant Pattern-Recognition Receptors*. Trends in Immunology.
- Dodds, P. N., & Rathjen, J. P. (2010). *Plant Immunity: Towards an Integrated View of Plant–Pathogen Interactions*. Nature Reviews Genetics.

Reference Books:

- Glazebrook, J. (2005). *Mechanisms of Defense Against Biotrophic and Necrotrophic Pathogens*. Annual Review of Phytopathology.
- McDowell, J. M., & Woffenden, B. J. (2003). *Plant Disease Resistance Genes: Recent Insights and Potential Applications*. Trends in Biotechnology.
- Collinge, D. B., Jørgensen, H. J. L., Lund, O. S., & Lyngkjær, M. F. (2010). *Engineering Pathogen Resistance in Crop Plants*. Annual Review of Phytopathology.
- Boller, T., & Felix, G. (2009). *Elicitors: Perception of Microbe-Associated Molecular Patterns and Danger Signals by Pattern-Recognition Receptors*. Annual Review of Plant Biology.

- Pieterse, C. M. J., Van der Does, D., Zamioudis, C., Leon-Reyes, A., & Van Wees, S. C. M. (2012). *Hormonal Modulation of Plant Immunity*. Annual Review of Cell and Developmental Biology.

Research Articles and Journals:

- Thomma, B. P. H. J., Nürnberger, T., & Joosten, M. H. A. J. (2011). *Of PAMPs and Effectors: The Blurred PTI-ETI Dichotomy*. The Plant Cell, 23(1), 4–15.
- Chisholm, S. T., Coaker, G., Day, B., & Staskawicz, B. J. (2006). *Host-Microbe Interactions: Shaping the Evolution of the Plant Immune Response*. Cell, 124(4), 803–814.
- Tsuda, K., & Katagiri, F. (2010). *Comparing Signaling Mechanisms Engaged in Pattern-Triggered and Effector-Triggered Immunity*. Current Opinion in Plant Biology, 13(4), 459–465.
- López-González, S., Pascual-Pardo, D., Soler, R., & Pozo, M. J. (2021). *Harnessing Beneficial Microbes for Plant Health: Establishing Holistic Principles for Biocontrol and Disease-Suppressive Soils*. FEMS Microbiology Ecology, 97(3), fiaa256.
- Goyal, R. K., & Mattoo, A. K. (2014). *Plant Small RNAs: Biogenesis, Regulation, and Their Role in Stress Responses*. Molecular Plant Pathology, 15(8), 791–804.

Online Resources:

- The American Phytopathological Society (APS): Research articles and plant pathology resources.
- The Plant Journal – Molecular Plant Pathology Special Issues.
- KEGG Pathway Database: Pathogen-host interactions and molecular signaling pathways.
- NCBI GenBank: Plant pathogen genome sequences and annotation tools.
- EMBL-EBI InterPro: Protein function classification and pathogen effector analysis.

Basics of Biophysics

LTP: 4-0-0 **Credits: 4**

Course Objective:

This course provides an understanding of the basic principles of physics and their applications to biological systems. It covers the physical and chemical properties of biomolecules and their roles in biological processes, introduces bioenergetics and thermodynamics in living systems, and familiarizes students with experimental techniques and computational tools used in biophysics. The course aims to foster a quantitative and interdisciplinary approach to studying biology.

Course Outcomes:

On successful completion of this course, students should be able to:

1. Explain how physical principles govern the structure and dynamics of biological systems.
2. Demonstrate an understanding of molecular interactions and biophysical techniques.
3. Analyze thermodynamic principles in metabolic and energy-related biological processes.
4. Apply biophysical models to interpret biological phenomena at the molecular and cellular levels.
5. Integrate mathematical and computational tools for solving problems in biophysics.

Theory

Unit 1: Introduction to Biophysics

Definition, scope, and historical evolution; interdisciplinary nature integrating physics, chemistry, and biology; role of physics in biological systems—mechanics, energy transfer, thermodynamics; structure-function relationships in biomolecules (proteins, nucleic acids, lipids, carbohydrates); biophysical approaches to cellular systems.

Unit 2: Biomechanics and Structural Biophysics

Mechanical properties of biological materials—elasticity, plasticity, viscosity, stress-strain behavior; biomechanics of cellular components—cytoskeleton, extracellular matrix, motility; biophysical principles of muscle contraction, molecular motors; structural characterization—X-ray crystallography, cryo-electron microscopy; computational modeling of macromolecules.

Unit 3: Bioenergetics and Membrane Biophysics

Laws of thermodynamics in biological systems; energy transformations—photosynthesis, respiration, ATP synthesis; free energy, enthalpy, entropy in biochemical reactions; principles of membrane transport—diffusion, osmosis, facilitated transport, ion pumps; membrane potential and action potential in cellular communication.

Unit 4: Molecular Biophysics

Forces in molecular interactions—hydrogen bonding, van der Waals, hydrophobic, electrostatic effects; protein structure and dynamics—folding, stability, misfolding disorders; DNA biophysics—structural polymorphism, supercoiling, chromatin organization; enzyme kinetics—catalysis, substrate specificity, allosteric regulation; ligand-binding studies in drug design.

Unit 5: Methods and Applications in Biophysics

Spectroscopic methods—UV-Vis, fluorescence, circular dichroism, NMR; microscopy—fluorescence, atomic force, confocal; computational biophysics—molecular dynamics, docking, Monte Carlo methods; applications in biomedical sciences—drug discovery, personalized medicine, tissue engineering; emerging trends—quantum biology, nanobiophysics.

Suggested Readings

Textbooks:

- Cotterill, R.M.J. (2002). Biophysics: An Introduction. Wiley.
- Glaser, R. (2012). Biophysics: An Introduction (2nd ed.). Springer.
- Schiessel, H. (2014). Biophysics for Beginners: A Journey through the Cell Nucleus. Pan Stanford Publishing.
- Nelson, P.C., Radosavljevic, M., & Bromberg, S. (2014). Biological Physics: Energy, Information, Life (Updated 1st ed.). W.H. Freeman.
- Boal, D. (2012). Mechanics of the Cell (2nd ed.). Cambridge University Press.

Reference Books:

- Misra, G. (Ed.). (2017). Introduction to Biomolecular Structure and Biophysics: Basics of Biophysics. Springer.

Springer Link:

- Volkenshtein, M.V. (1983). Biophysics. Mir Publishers.

Internet Archive:

- Phillips, R., Kondev, J., Theriot, J., & Garcia, H.G. (2012). Physical Biology of the Cell (2nd ed.). Garland Science.
- Tuszynski, J.A., & Kurzynski, M. (2003). Introduction to Molecular Biophysics. CRC Press.
- Jackson, M.B. (2006). Molecular and Cellular Biophysics. Cambridge University Press.

Research Articles and Journals:

- Leake, M.C. (2012). "The Physics of Life: One Molecule at a Time," arXiv preprint arXiv:1211.4366.

- M. McMahon (2019) Plant Science: Growth, Development, and Utilization of Cultivated Plants, Pearson Publishers, 6th edition; 978-0135184820
- R.A. Larson (2013) Introduction to Floriculture, Academic Press; 2nd edition; ASIN: B01M0176CN
- J. E. Preece and P. E. Read (2005) The Biology of Horticulture: An Introductory Textbook, 2nd Edition, Wiley
- Publishers; ISBN: 978-0471465799

Systems Biology

LTP: 4-0-0 **Credits: 4**

Course Objective

The course aims to introduce the fundamental concepts and principles of systems biology and its importance in modern biological research. Students will become familiar with computational tools for modelling biological networks and gain insights into high-throughput technologies used in systems-level studies. The course will explore dynamic behaviours of biological systems through network theory and systems modelling and develop the ability to apply systems biology approaches to biological and biomedical challenges.

Course Outcomes

On successful completion of this course, students should be able to:

1. Comprehend the fundamental principles and methodologies of systems biology.
2. Analyse complex biological systems using mathematical and computational models.
3. Interpret high-throughput biological data to understand system-wide interactions.
4. Apply network theory to investigate cellular and molecular processes.
5. Design systems biology-based approaches to solve real-world biological and biomedical problems.

Theory

Unit 1: Introduction to Systems Biology

Definition, scope, and evolution from reductionism to holistic approaches; integration of experimental and computational methods; key breakthroughs—Human Genome Project, metabolic engineering, synthetic biology; comparison of reductionist vs. systems-level approaches; applications in modeling biological systems.

Unit 2: High-Throughput Technologies

Overview of high-throughput data generation; Genomics—whole genome sequencing, structural variation, epigenomics; Transcriptomics—RNA sequencing, single-cell analysis; Proteomics—quantification, post-translational modifications, interaction studies; Metabolomics—mass spectrometry, flux analysis; multi-omics integration and analysis tools.

Unit 3: Biological Networks

Types of biological networks—gene regulatory, protein-protein interaction, and metabolic networks; topological properties—robustness, modularity, redundancy; network motifs and functional implications; dynamic modeling approaches—Boolean networks, differential equations; applications in signaling pathways and metabolic regulation; visualization tools (e.g., Cytoscape).

Unit 4: Computational Modeling in Systems Biology

Computational and mathematical modeling approaches; Deterministic models—ODEs for pathway dynamics; Stochastic models—Monte Carlo simulations, Gillespie algorithms; Agent-based models—cellular interactions; applications—biochemical pathways, disease progression, therapeutic predictions; modeling software—MATLAB, COPASI, SBML, BioNetGen.

Unit 5: Applications of Systems Biology

Disease modeling—cancer, metabolic disorders, neurodegenerative diseases; Drug discovery—target identification, multi-omics integration; Synthetic biology—engineering biological circuits; Agriculture—crop improvement, stress tolerance, plant-pathogen interactions; Personalized medicine—omics-based tailored therapies; ethical considerations—data privacy, reproducibility, bioengineering implications.

Suggested Readings

Textbooks:

- Ertel, W. (2024). *Introduction to Artificial Intelligence*. Springer Nature.
- Finlay, J. (1996). *An Introduction to Artificial Intelligence* (1st ed.). CRC Press.
- Mitchell, T.M. (1997). *Machine Learning*. McGraw Hill Education.
- Goodfellow, I., Bengio, Y., Courville, A. (2016). *Deep Learning*. MIT Press.
- Russell, S., Norvig, P. (2021). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson.

Reference Books:

- Harkut, G.D. (2019). "Artificial Intelligence: Scope and Limitations," IntechOpen.
- Boden, M.A. (2018). *Artificial Intelligence: A Very Short Introduction*. Oxford University Press.
- Lane, D. (2021). *Machine Learning for Kids: A Project-Based Introduction to Artificial Intelligence*. No Starch Press.
- Domingos, P. (2015). *The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World*. Basic Books.
- Flach, P. (2012). *Machine Learning: The Art and Science of Algorithms That Make Sense of Data*. Cambridge University Press.

Research Articles and Journals:

- AlQuraishi, M. (2019). "AlphaFold at CASP13," *Bioinformatics*, 36(4), 1081–1082.
- Esteva, A., et al. (2017). "Dermatologist-Level Classification of Skin Cancer with Deep Neural Networks," *Nature*, 542, 115–118.
- Jumper, J., et al. (2021). "Highly Accurate Protein Structure Prediction with AlphaFold," *Nature*, 596(7873), 583–589.

- Zhang, Z., et al. (2021). "AI-Powered Genomics for Precision Medicine," *Genome Biology*, 22(1), 130.

Specialized AI in Biology Resources:

- Tarca, A.L., Carey, V.J., et al. (2013). "Machine Learning for Genomics and Proteomics: Applications in Biological Research," *PLoS Computational Biology*, 9(10), e1003325.
- Angermueller, C., et al. (2016). "Deep Learning for Computational Biology," *Molecular Systems Biology*, 12(7), 878.
- Lecun, Y., Bengio, Y., Hinton, G. (2015). "Deep Learning," *Nature*, 521, 436–444.

Online Resources:

- Stanford University's CS229: *Machine Learning Course Materials*.
- MIT OpenCourseWare: *Introduction to Deep Learning*.
- Kaggle: Hands-on AI projects and biological datasets for practice.
- Google AI Blog: Cutting-edge AI innovations, including AI applications in life sciences.

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