Proposed syllabus

for

UG (Hon's) BOTANY

Learning Outcomes based Curriculum Framework

(LOCF) For

Undergraduate Programme

(Three year/six semesters)

B.Sc. BOTANY HONOURS

To be implemented from the academic session 2021-22

Department of Botany

School of Life Science

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Preamble

Over the past decades the higher education system of our country has undergone substantial structural and functional changes resulting in both quantitative and qualitative development of the beneficiaries. Such changes have gained momentum with the introduction of Choice Based Credit System (CBCS) which further expects learning outcome based curriculum in order to maximize the benefits of the newly designed curriculum. The learning outcome based curriculum in general and in Botany in particular will definitely help the teachers of the discipline to visualize the curriculum more specifically in terms of the learning outcomes expected from the students at the end of the instructional process. It is pertinent to mention here that the purpose of education is to develop an integrated personality of the individual and the educational system provides all knowledge and skills to the learner for this.

The template as developed has the provision of ensuring the integrated personality of the students in terms of providing opportunity for exposure to the students towards core courses, discipline specific courses, generic elective courses, ability enhancement courses and skill enhancement courses with special focus on technical, communication and subject specific skills through practical and other innovative transactional modes to develop their employability skills. The template of learning outcome based curriculum has categorically mentioned very well defined expected outcomes for the programme like core competency, communication skills, critical thinking, affective skills, problem-solving, analytical, reasoning, research-skills, teamwork, digital literacy, moral and ethical awareness, leadership readiness and so on along with very specific learning course outcomes at the starting of each course. Therefore, this template on Learning Outcomes based Curriculum Framework (LOCF) for B.Sc. with Botany/ Botany Honors will definitely be a landmark in the field of outcome based curriculum construction.

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1. Introduction

This curriculum framework for the bachelor-level program in Botany is developed keeping in view of the student centric learning pedagogy, which is entirely outcome-oriented and curiosity-driven. To avoid rote -learning approach and foster imagination, the curriculum is more leaned towards self-discovery of concepts. The curriculum framework focuses on pragmatist approach whereby practical application of theoretical concepts is taught with substantial coverage of practical and field works. The platform aims at equipping the graduates with necessary skills for botany-related careers, careers with general graduate-level aptitude and for higher education in Botany and allied subjects. Augmented in this framework are graduate attributes including critical thinking, basic psychology, scientific reasoning, moral ethical reasoning and so on, qualification descriptors that are specific outcomes pertinent to the discipline of botany, learning outcomes for the two programmes these frameworks have been developed, learning outcomes for individual courses, pedagogical methods and assessment methods. While designing these frameworks, emphasis is given on the objectively measurable teaching-learning outcomes to ensure employability of the graduates. In line with recent trends in education section, these frameworks foster implementation of modern pedagogical tools and concepts such as flip-class, hybrid learning, MOOCs and other e-learning platforms. In addition, the framework pragmatic to the core; it is designed such a way to enable the learners implementing the concepts to address the real world problems. A major emphasis of these frameworks is that the curriculum focuses on issues pertinent to India and also of the west; for example, biodiversity and conservation of endemic and threatened species that are found in India, Indian climatological variables, Indian biodiversity and so on. Above all, these frameworks are holistic and aim to mould responsible Indian citizen who have adequate skills in reflective thinking, rational skepticism, scientific temper, digital literacy and so on such that they are equipped to fight immediate social issues apropos to Indian milieu, including corruption and inequity.

Aims:

1. To transform curriculum into outcome-oriented scenario
2. To develop the curriculum for fostering discovery-learning
3. To equip the students in solving the practical problems pertinent to India
4. To adopt recent pedagogical trends in education including e-learning, flipped class, hybrid learning and MOOCs
5. To mold responsible citizen for nation-building and transforming the country towards the future

2. Learning Outcome Based Curriculum *Vis- A -Vis* Objective Based Curriculum

Curriculum is the heart of any educational system. It can be focused either to achieve the objectives of each course of the programme or on the expected learning outcomes from each course. The objective based curriculum refers to the overall targets to be achieved through curriculum which may be long term or immediate. On the other hand, the learning outcome based curriculum is very specific in nature in terms of changes in the cognitive, affective and psychomotor behavior of the students as a result of their exposure to the curriculum. The outcome based curriculum provides the teacher very specific targets which he can achieve through the selected instructional process as compared to the objective based curriculum which provides general outcomes.

The learning outcome based curriculum has very close relationship with the learning of the students whereas objective based curriculum focusses on only providing knowledge to the students. In other words, higher cognitive skills are developed through learning outcome based curriculum. Hence, it is preferred to develop learning outcome based curriculum which will provide specific directions to the teacher with respect to the transaction process and expected changes in the behavior of the students as well.

a. Nature and extent of the B.Sc Botany Programme

Botany, as traditionally delimited epistemologically, is the broad discipline encompassing various subjects involved with the study of plants. Emphasis has been shifted to modern science at the cost of traditional botany. This shift is discussed at various forums. There is need to balance the traditional botany and upcoming modern computational and applied approach.

In view of above, adequate balance of topics is proposed displaying latest APG IV based phylogenetic systematics of plants covering higher plants, lower plants, aquatic (fresh and marine water) plants, nature/ field study, functional aspects of various cellular processes of plants, molecular genetics and modern tools i.e. tissue culture, genetic engineering and computational studies are required to be introduced at undergraduate level.

This modified syllabus has been drafted to enable the students to equip for national level competitive exams that they may attempt in future. To ensure implementation of a holistic pedagogical model, several allied disciplines are covered/introduced in this framework.

including Chemistry, Mathematics and a number of generic, and ability enhancement electives. In addition, employability of B.Sc. Botany graduate is given due importance such that their core competency in the subject matter, both theoretical and practical, is ensured. To expand the employability of graduates, a number of skill development courses are also introduced in this framework.

b. Aims of Bachelor's degree programme in Botany

The broad aims of bachelors degree programme in Botany are:

1. To provide an environment that ensures cognitive development of students in a holistic manner. A dialogue about plants and its significance is fostered in this framework, rather than didactic monologues on mere theoretical aspects
2. To provide the latest subject matter, both theoretical as well as practical, such a way to foster their core competency and discovery learning. A botany graduate as envisioned in this framework would be sufficiently competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.
3. To mould a responsible citizen who is aware of most basic domain-independent knowledge, including critical thinking and communication.
4. To enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination

3. Program Learning Outcomes

The student graduating with the Degree B.Sc (Honours) Botany should be able to acquire

Core competency: Students will acquire core competency in the subject Botany, and in allied subject areas.

The student will be able to identify major groups of plants and compare the characteristics of lower (e.g. algae and fungi) and higher (angiosperms and gymnosperms) plants.

Students will be able to use the evidence based comparative botany approach to explain the evolution of organism and understand the genetic diversity on the earth.

- The students will be able to explain various plant processes and functions, metabolism, concepts of gene, genome and how organism's function is influenced at the cell, tissue and organ level.
- Students will be able to understand adaptation, development and behavior of different forms of life.
- The understanding of networked life on earth and tracing the energy pyramids through nutrient flow is expected from the students.
- Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Botany.

Analytical ability: The students will be able to demonstarte the knowledge in understanding research and addressing practical problems.

- Application of various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyze the data to decipher the degree to which their scientific work supports their hypothesis.

Critical Thinking and problem solving ability: An increased understanding of fundamental concepts and their applications of scientific principles is expected at the end of this course. Students will become critical thinker and acquire problem solving capabilities.

Digitally equipped: Students will acquir digital skills and integrate the fundamental concepts with modern tools.

Ethical and Psycological strengthing: Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.

Team Player: Students will learn team workmanship in order to serve efficiently institutions, industry and society.

Indipendent Learner: Apart from the subject specific skills, generic skills, especially in botany, the program outcome would lead to gain knowledge and skills for further higher studies, competitive examinations and employment. Learning outcomes based curriculum would ensure equal academic standards across the country and broader picture of their

competencies. The Bachelor program in Botany and Botany honours may be mono-disciplinary or multidisciplinary.

4. Course Learning Outcomes

The course learning outcomes are aligned with program learning outcomes but these are specific-to-specific courses offered in a program. The course level learning shall be reflected as program level learning. The core courses shall be the backbone of this framework whereas discipline electives, generic electives and skill enhancement courses would add academic excellence in the subject together with multi-dimensional and multidisciplinary approach.

In course learning outcomes, the student will attain subject knowledge in terms of individual course as well as holistically. The example related to core courses and their linkage with each other is stated below:

	Core Course (CC)													
Programme Outcomes	**CC 1**	**CC 2**	**CC 3**	**CC 4**	**CC 5**	**CC 6**	**CC 7**	**CC 8**	**CC 9**	**CC 10**	**CC 11**	**CC 12**	**CC 13**	**CC 14**
Core competency	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Critical thinking	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Analytical reasoning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Research-skills	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Teamwork	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

Discipline Specific Elective (DSE)			
Programme Outcomes	**DSE1**	**DSE 2**	**DSE 3**
Additional Academic Knowledge	☑	☑	☑
Problem- solving	☑	☑	☑
Additional analytical skills	☑	☑	☑
Additional Research- skills	☑	☑	☑

	Generic Elective Courses (GEC)			
Programme Outcomes	GEC 1	GEC 2	GEC 3	GEC 4
Additional Academic Knowledge	☑	☑	☑	☑
Exposure beyond discipline	☑	☑	☑	☑
Problem- solving	☑	☑	☑	☑
Analytical reasoning	☑	☑	☑	☑

	Ability enhancement Course				
Programme Outcomes	AEC 1	AEC 2	AEC 3	AEC 4	AEC 5
Additional Academic Knowledge	☑	☑	☑	☑	☑
Psychological skills	☑	☑	☑	☑	☑
Problem-solving	☑	☑	☑	☑	☑

	Skill Enhancement Course (SEC)				
Programme Outcomes	SEC1	SEC 2	SEC 3	SEC 4	SEC 5
Additional Knowledge enhancement	☑	☑	☑	☑	☑
Exposure beyond discipline	☑	☑	☑	☑	☑
Analytical reasoning	☑	☑	☑	☑	☑
Digital Literacy	☑	☑	☑	☑	☑
Moral and ethical awareness	☑	☑	☑	☑	☑

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The core courses would fortify the students with in-depth subject knowledge concurrently; the discipline specific electives will add additional knowledge about applied aspects of the program as well as its applicability in both academia and industry. Generic electives will introduce integration among various interdisciplinary courses. The skill enhancement courses would further add additional skills related to the subject as well as other than subject. In brief the student graduated with this type of curriculum would be able to disseminate subject knowledge along with necessary skills to suffice their capabilities for academia, entrepreneurship and Industry.

5. Teaching Learning Outcomes

The learning outcomes based course curriculum framework of botany is designed to persuade the subject specific knowledge as well as relevant understanding of the course. The academic and professional skills required for botany-based professions and jobs are also offered by same course in an extraordinary way. In addition, the learning experiences gained from this course should be designed and implemented for cognitive development in every student. The practical associated with this course helps to develop an important aspect of the teaching-learning process. Various types of teaching and learning processes will need to be adopted to achieve the same. The important relevant teaching and learning processes involved in this course are;

- Class lectures
- Seminars
- Tutorials
- Group discussions and Workshops
- Peer teaching and learning
- Question preparation
  - Subjective type
    - Long answer
    - Short answer
  - Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning

- Practicum, and project-based learning
- Field-based learning
- Substantial laboratory-based practical component and experiments
- Open-ended project work,
- Games
- Technology-enabled learning
- Internship in industry, and research establishments.

The effective teaching strategies will also need to be adopted to develop problem-solving skills, higher-order skills of reasoning and analysis. The designed course also encourages fostering the social values/responsibility for maintaining and protecting the surrounding environment for improved living conditions. A learner centric and active participatory pedagogy shall be introduced in this framework.

6. Learning outcomes- based curriculum framework for B.Sc. Botany (Honours)

a) *Hallmark Attributes of a Botany Graduate*

Hallmark attributes of botany graduate under the outcome-based teaching- learning framework may encompass the following:

- **Core competency:** The botany graduates are expected to know the fundamental concepts of botany and plant science. These fundamental concepts would reflect the latest understanding of the field, and therefore, are dynamic in nature and require frequent and time-bound revisions.
- **Communication skills:** Botany graduates are expected to possess minimum standards of communication skills expected of a science graduate in the country. They are expected to read and understand documents with in-depth analyses and logical arguments. Graduates are expected to be well-versed in speaking and communicating their idea/finding/concepts to wider audience
- **Critical thinking:** Botany graduates are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientific arguments.
- **Psychological skills:** Graduates are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational

viii. To think any apply understanding of the subject of plant sciences in identifying the problems which can be solved through the use of plants

ix. To think of the adopting expertise in plant structure, functions and solvethe problems of environment, ecology, sustainable development, hunger.

c) *Distribution of different types of courses with their credits for B.Sc. Botany (Honors)*

Semester	Core Courses (14)	GE (4)	DSE (3*)	AEC (5)	SEC (2)	Seminar (1)	Dissertation (1)	Internship (1)	Additional Credit Courses (Optional)
I	C1 C2	GE1		AEC1	SEC1				
II	C3 C4	GE2		AEC2	SEC2				
III	C5 C6 C7	GE3		AEC3					
IV	C8 C9 C10	GE4		AEC4					
V	C11 C12		DSE1 DSE2	AEC5					
VI	C13 C14		DSE3			Seminar	Dissertation		
Summer								Internship	
MOOC's***									
Credits	14x5 (70)	4x5 (20)	3x5 (15)	2x5 (10)	2x2 (4)	2	7	6	
% Courses	52.23	14.9	11.19	07.46	02.98	01.49	05.22	04.47	

*** MOOC's courses should be offered at least one time during entire UG programme in lieu of Core Course. If the core is not available any course similar to Generic elective, Discipline specific elective, AEC course, Skill enhancement course may be offered on MOOC's platform. If any such course related to subject is not available, on MOOC's platform, department may continue with regular courses.

7. Course Structure at a Glance

(a) Core Courses

Sr. No.	Name of the course	Type of course	L	T	P	Credits
1.	Phycology and Microbiology	Core course	3	0	2	5
2	Biomolecules and Cell Biology	Core course	3	0	2	5
3.	Mycology and Phytopathology	Core course	3	0	2	5
4.	Archegoniatae : Bryophytes, Pteridophytes, Gymnosperms	Core course	3	0	2	5
5.	Anatomy of Angiosperms	Core course	3	0	2	5
6.	Economic Botany and Plant Resource Utilization	Core course	3	0	2	5
7.	Genetics and Cytogenetics	Core course	3	0	2	5
8.	Molecular Biology	Core course	3	0	2	5
9.	Plant Ecology and Phytogeography	Core course	3	0	2	5
10.	Plant Systematics	Core course	3	0	2	5
11.	Plant Physiology	Core course	3	0	2	5
12.	Plant Metabolism	Core course	3	0	2	5
13.	Biodiversity and Conservation	Core course	3	0	2	5
14.	Reproductive Biology of Angiosperms	Core course	3	0	2	5

(b) Discipline Specific Elective Course

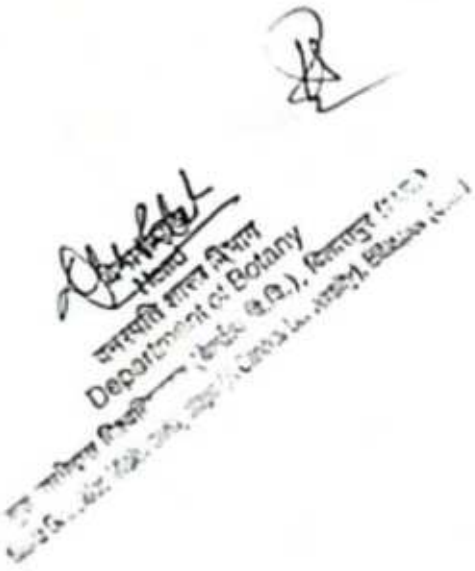
S N	Name of the course	Type of course	L	T	P	Credits
1	Plant Biotechnology and Genetic Engineering	Discipline Specific Elective Course	3	0	2	5
2	Plant Biochemistry	Discipline Specific Elective Course	3	0	2	5
3	Research Methodology	Discipline Specific Elective Course	3	0	2	5
4	Biostatistics	Discipline Specific Elective Course	3	0	2	5
5	Natural Resource Management	Discipline Specific Elective Course	3	0	2	5
6	Industrial and Environmental Microbiology	Discipline Specific Elective Course	3	0	2	5
7	Aquatic Botany	Discipline Specific Elective Course	3	0	2	5
8	Bioinformatics	Discipline Specific Elective Course	3	0	2	5
9	Elements of Plant Breeding	Discipline Specific Elective Course	3	0	2	5
10	Bio-Analytical Techniques	Discipline Specific Elective Course	3	0	2	5

(c) Generic Elective Courses

Sr. No.	Name of the course	Type of course	L	T	P	Credits
1	Food Science	Generic Elective Courses	3	0	2	5
2	Community Forestry	Generic Elective Courses	3	0	2	5
3	Seed Technology	Generic Elective Courses	3	0	2	5
4	Industrial Microbiology	Generic Elective Courses	3	0	2	5
5	Plant-Microbes Interaction	Generic Elective Courses	3	0	2	5
6	Global Climate change	Generic Elective Courses	3	0	2	5
7	Plant Diversity and Human Welfare	Generic Elective Courses	3	0	2	5
8	Environmental Protection	Generic Elective Courses	3	0	2	5
9	Environmental Toxicity	Generic Elective Courses	3	0	2	5
10	Environmental Microbiology	Generic Elective Courses	3	0	2	5
11	Algal Biotechnology	Generic Elective Courses	3	0	2	5

(d) Ability Enhancement Courses

Sr. No.	Name of the course	Type of course	L	T	P	Credits
1	Mushroom Culture Technology	Ability Enhancement Courses	2	0	0	2
2	Medicinal Botany	Ability Enhancement Courses	2	0	0	2
3	Plants in Traditional Systems of Medicine	Ability Enhancement Courses	2	0	0	2
4	Good Laboratory Practices	Ability Enhancement Courses	2	0	0	2
5	Intellectual Property Rights	Ability Enhancement Courses	2	0	0	2
6	History of Indian Science	Ability Enhancement Courses	2	0	0	2



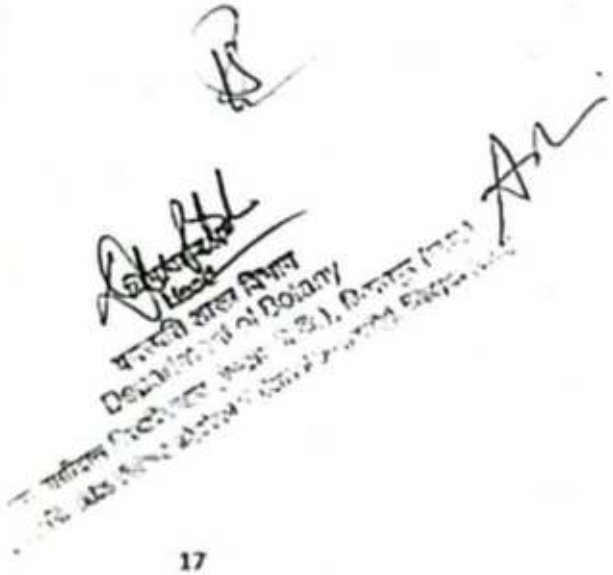
(e) Skill Enhancement Courses

Sr. No.	Name of the course	Type of course	L	T	P	Credits
1	Botanical Garden and landscaping	Skill Enhancement Courses	2	0	0	2
2	Agriculture and Food Microbiology	Skill Enhancement Courses	2	0	0	2
3	Bio-fertilizers	Skill Enhancement Courses	2	0	0	2
4	Herbal Technology	Skill Enhancement Courses	2	0	0	2
5	Environmental impact analysis	Skill Enhancement Courses	2	0	0	2
6	Floriculture	Skill Enhancement Courses	2	0	0	2
7	Forensic Botany	Skill Enhancement Courses	2	0	0	2

8. Assessment Methods

Academic performance in various courses i.e. core, discipline electives, generic electives and skill enhancement courses are to be considered as parameters for assessing the achievement of students in botany. A number of appropriate assessment methods of botany will be used to determine the extent to which students demonstrate desired learning outcomes. Following assessment methodology should be adopted;

- The oral and written examinations (Scheduled and surprise tests),
- Closed-book and open-book tests,
- Problem-solving exercises,
- Practical assignments and laboratory reports,
- Observation of practical skills,
- Individual and group project reports,
- Efficient delivery using seminar presentations,
- *Viva voce* interviews are majorly adopted assessment methods for this curricullum.
- The computerized adaptive testing, literature surveys and evaluations, peers and self-assessment, outputs form individual and collaborative work are also other important approaches for assessment purposes.



A continuous assessment method throughout the programme shall inculcate regular reading habit in the students' and continuous observation about weaker aspect of the students'.

a) *Suggested List of Seminar Topics*

1. Molecular Taxonomy; A New Classification system
2. Development issues in plants
3. Metabolic Pathways, evolutionary background and their Regulation
4. Biodiversity and climate change
5. Current Developments in Techniques
6. Biotechnology: Past, present and Future
7. Role of DNA sequencing in evolutionary history.
8. Genetic control of sex determination
9. Current trends in DNA sequencing
10. DNA markers and Genetic diversity
11. Comparative genomics in understanding of gene function
12. Seed morphology of important plants and their identification
13. Floral biology: monocot vs. dicot
14. Monocot and dicot embryos
15. Variability in seed development
16. Certified seed production in crops
17. Strategies for hybrid seed production
18. Method of seed production.
19. Role of fruits in human nutrition
20. Characteristics of important pomological traits
21. Concept of a good nursery
22. Nutritive value of fresh and processed fruits
23. RNA interference
24. Gene editing
25. Plant based drugs
26. Functional foods
27. DNA barcoding

b) *Suggested List of Topics for Group Discussion*

1. Molecular Taxonomy, New Classification systems
2. Tree of Life and its root
3. Marine phytoplanktons and its ecological importance including oxygen evolution
4. Bioprospecting and Biopiracy
5. Evolution of major plant lineages
6. Molecular systematics vs. traditional taxonomy
7. Physiology: Developments in various processes and functions of plants
8. Biochemical Pathways and their evolutionary background, Regulation
9. Biodiversity Hotspots.
10. Biotechnology: Past present and Future
11. Origin of Bryophytes through: Algae vs. Pteridophytes
12. Origin of Bryophytes: Monophyletic concepts vs. Polyphyletic
13. Evolution of Gametophytes in Bryophytes: Retrogressive vs. Progressive
14. Evolution of Sporophytes in Bryophytes: Progressive sterilization vs. Progressive simplification
15. Fossil Psilophytes vs. Living Psilophytes
16. Origin of seeds
17. Emergence of flowers and flowering genes
18. Evolution of Stelar structure
19. Dominant phase in plants life cycle: Gametophyte vs. Sporophytes
20. Heterospory vs. Origin of seed habit
21. Evolution of Sporophytes: Telome concept vs. others
22. GM crops for food and non-food products
23. Impact of climate change on food production – Quality and quantity
24. Climate change: threat to food security
25. Stratospheric Ozone depletion and marine productivity
26. Good ozone vs. bad ozone
27. Air pollution and climate change
28. Biodiversity under climate changing scenarios
29. Scenario of the planet earth without healthy plants

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30. Plant Invasion in India
31. Allelopathic interactions in Terrestrial plant world
32. How can man exploit Allelopathy for human welfare?
33. Preparing crops for tomorrow ; Convensional Breeding
34. Land races verses hybrids or transgenes
35. Gemome modification/ editing
36. Bypass pathways in plants

c) *Suggested Topics for Individual/ Team Projects*

1. Rural Areas: Flora of a village, Biodiversity of Village, Soil types, Agricultural weeds
2. Urban areas: Flora of City, Major Trees of the City, Shrub treasure of the city, urban weeds, Unusual trees; Collection of leaf types
3. Metropolitan Areas: Flora of City, Major Tree plants of the City, Weeds of the mega cities
4. Digital portal for plants: Campus, city or particular area
5. Flora sampling
6. Air pollution tolerance index (APTI) : Screening of sensitive/tolerant plant species at various locations in particular area

SCHOOL OF SCIENCES: (LIFE SCIENCE)

B.Sc. (BOTANY) Hon's

Semester	Course Opted	Course Code	Name of the course	Credit	Hour/ week	End semester marks	Internal Marks	Total marks
			SEMESTER I					
Semester I	Core-1	BOUATT1	Phycology and Microbiology	3	3	70	30	100
	Core-1 Lab	BOUALT1	Lab based on core 1	2	4	70	30	100
	Core-2	BOUATT2	Bio-molecules and cell Biology	3	3	70	30	100
	Core-2 Lab	BOUALT2	Lab based on core 2	2	4	70	30	100
	Generic Elective Course (GEC- 1)	BOUATG	Opted from the basket	3	3	70	30	100
	Generic Elective Course-1 Lab	BOUALG	Lab based on GEC-1	2	4	70	30	100
	Ability Enhancement Course (AEC-1)	BOUATA	Opted from the basket provided by University	2	2	70	30	100
	Skill Enhancement Course (SEC -1)	BOUDTL	Opted from the basket provided by University	2	2	70	30	100
	Additional Credit Course							
			TOTAL	19	25			800
			SEMSTER II					
Semester II	Core-3	BOUBTT3	Mycology and Phytopathology	3	3	70	30	100
	Core-3 Lab	BOUBLT3	Lab based on core 3	2	4	70	30	100
	Core- 4	BOUBTT4	Archegoniate: Bryophytes, Pteridophytes and Gymnosperm	3	3	70	30	100
	Core- 4 Lab	BOUBLT4	Lab based on core 4	2	4	70	30	100
	Generic Elective Course (GEC- 2)	BOUBTG	Elective from the Basket	3	3	70	30	100
	Generic Elective Course-2 Lab	BOUBLG	Lab based on GEC-2	2	4	70	30	100

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	Ability Enhancement Course (AEC-2)	BOUATA	Opted from the basket provided by University	2	2	70	30	100
	Skill Enhancement Course (SEC-2)	BOUDTL	Opted from the basket provided by University	2	2	70	30	100
	Additional Credit Course							
			Total	19	25			800
SUMMER Internship: 5 days		BOUBEI	Industrial/Institutional/ others	2	100	70	30	100
SEMESTER III								
Semester III	Core- 5	BOUCTT5	Anatomy of Angiosperms	3	3	70	30	100
	Core- 5 Lab	BOUCLT5	Lab based on core 5	2	4	70	30	100
	Core- 6	BOUCTT6	Economic Botany and Plant Resource Utilization	3	3	70	30	100
	Core- 6 Lab	BOUCLT6	Lab based on core 6	2	4	70	30	100
	Core- 7	BOUCTT7	Genetics and Cytogenetics	3	3	70	30	100
	Core- 7 Lab	BOUCLT7	Lab based on core 7	2	4	70	30	100
	Generic Elective Course (GEC- 3)	BOUCTG	Elective from the Basket	3	3	70	30	100
	Generic Elective Course-3 Lab	BOUCLG	Lab based on GEC-3	2	4	70	30	100
	Ability Enhancement Course (AEC-3)	BOUATA	Opted from the basket provided by University	2	2	70	30	100
	Additional Credit Course							
			Total	22	30			900
SEMESTER IV								
Semester IV	Core- 8	BOUDTT8	Molecular Biology	3	3	70	30	100
	Core- 8 Lab	BOUDLT8	Lab based on core 8	2	4	70	30	100
	Core- 9	BOUDTT9	Plant Ecology and Phytogeography	3	3	70	30	100

	Core- 9 Lab	BOUDLT9	Lab based on core 9	2	4	70	30	100
	Core- 10	BOUDTT10	Plant Systematics	3	3	70	30	100
	Core- 10 Lab	BOUDLT10	Lab based on core 10	2	4	70	30	100
	Generic Elective Course (GEC- 4)	BOUCTG	Elective from the Basket	3	3	70	30	100
	Generic Elective Course-4 Lab	BOUDLG	Lab based on GEC-4	2	4	70	30	100
	Ability Enhancement Course (AEC-4)	BOUATA	Opted from the basket provided by University	2	2	70	30	100
	Additional Credit Course							
			TOTAL	22	30			900
	SUMMER Internship: 15 days							
SUMMER Internship: 15 days		BOUDEF1	SwayamSwachhta / NSS / Industrial/ others	2	100	70	30	100
	SEMESTER V							
Semester V	Core -11	BOUETT11	Plant Physiology	3	3	70	30	100
	Core -11 Lab	BOUELT11	Lab based on core 11	2	4	70	30	100
	Core -12	BOUETT12	Plant Metabolism	3	3	70	30	100
	Core -12 Lab	BOUELT12	Lab based on core 12	2	4	70	30	100
	Discipline Specific Elective (DSE-1)	BOUETD	From the DSE basket	3	3	70	30	100
	DSE-1 Lab	BOUELD	Lab based on DSE-1	2	4	70	30	100
	Discipline Specific Elective (DSE-2)	BOUETD	From the DSE basket	3	3	70	30	100
	DSE-2 Lab	BOUELD	Lab based on DSE-2	2	4	70	30	100
	Ability Enhancement Course (AEC-5)	BOUATA	Opted from the basket provided by University	2	2	70	30	100
	Additional Credit Course							
			TOTAL	22	30			900
	SEMESTER VI							

	Core-13	BOUFTT13	Biodiversity and Conservation	3	3	70	30	100
	Core -13 Lab	BOUFLT13	Lab based on core 13	2	4	70	30	100
	Core -14	BOUFTT14	Reproductive biology of Angiosperm	3	3	70	30	100
	Core -14 Lab	BOUFLT14	Lab based on core 14	2	4	70	30	100
	Discipline Specific Elective (DSE-3)	BOUETD	From the DSE basket	3	3	70	30	100
	DSE-3 Lab	BOUELD	Lab based on DSE-3	2	4	70	30	100
	Seminar/ group discussion (SMR)	BOUFDT2	SMR topic from the basket	2		35	15	50
	Dissertation / Project			7		120	60	200
	Additional Credit Course							
			TOTAL	24	33			850
			TOTAL CREDITS	134				

CORE COURSES

These are 14 courses. All courses are compulsory. These courses have the following **credit** pattern.

L	T	P	Cr
3	0	2	5

Core Course 1: Phycology and Microbiology

L	T	P	Cr
3	0	2	5

Learning outcomes

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

- Develop understanding on the concept of microbial nutrition
- Classify viruses based on their characteristics and structures
- Develop critical understanding of plant diseases and their remediation.
- Examine the general characteristics of bacteria and their cell reproduction/ recombination
- Increase the awareness and appreciation of human friendly viruses, bacteria, algae and their economic importance
- Conduct experiments using skills appropriate to subdivisions

Key Words:

Eubacteria, Archebacteria, Chlorophyta, Rhodophyta, Chromista, Diatom

Unit I: Introduction to microbial world — 15 lectures

Microbial nutrition, nutritional types, growth and metabolism. Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

Unit II: Viruses and Bacteria — 15 lectures

General characteristics; classification (Baltimore), structure and replication of DNA virus (T_4 and λ), lytic and lysogenic cycle; RNA virus (TMV), viroides and prions. General characteristics; Archaebacteria, Eubacteria, wall-less forms (mycoplasmas); Cell structure; Reproduction and recombination (conjugation, transformation and transduction). Binary fission and endospore.

Unit III: Algae, Cyanophyta and Xanthophyta — 15 lectures

Life histories of algae, commonly found algae of India, Classification (by Fritsch), Algal cultivation methods, Algal cell structure, Phylogenetic systematics of red, brown and green algae, Dinoflagellates, Diatoms, Cryptomonads and other unicellular algae, Algal evolution, Algal bioprospecting. Ecology and occurrence; Range of thallus organization; Cell structure; Reproduction, Morphology and reproduction of *Spirulina* and *Nostoc*. Ecology and occurrence; Range of thallus organization; Cell structure; Reproduction, Morphology and life-cycle of *Vaucheria*

Unit IV: Chlorophyta and Phaeophyta and Rhodophyta 15 lectures

General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Volvox*, *Trebouxia*, *Ulva*, *Oedogonium* and *Chara*. Red tides and other algal adaptations. Commercial cultivation and economic importance of green algae. General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Ectocarpus*, *Fucus* and red algae (*Porphyra* and *Polysiphonia*). Commercial cultivation and economic importance of brown and red algae.

Practical

Microbiology

1. Electron micrographs/Models of viruses – T4 and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria from temporary/permanent slides/photographs. Water bloom. Electron micrographs or charts of bacteria, binary fission, endospore, conjugation.
3. Gram-staining of root nodule and curd.
4. Micrometry and counting of cells by Haemocytometer

Phycology

1. Study of phototactic isolation of zoids of *Ulva* through chart.
2. Microscopic observation of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas*, *Volvox*, *Oedogonium*, *Coleochaete*, *Chara*, *Vaucheria*, *Sargassum/ Ectocarpus*, *Fucus and Polysiphonia*, *Prochloron* through temporary preparations and permanent slides.

Suggested Readings

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Wiley, J.M, Sherwood, L.M. and Woolverton, C.J. (2013). Prescott's Microbiology. 9th Edition. McGraw Hill International.
3. Vashishta B.R., Sinha A.K. and Singh V. P. (2008). Botany for Degree Students. Algae. S Chand and Co, New Delhi.
4. Sharma T.A., Dubey, R.C. and Maheshwari, D.K. (1999). A Text Book of Microbiology. S Chand and Co, New Delhi.
5. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
6. Campbell, N.A., Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky P.V. and Jackson, R.B. (2008). Biology, 8th edition. Pearson Benjamin Cummings, USA.
7. Pelczar, M.J. (2001). Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

Core Course 2: Biomolecules and Cell Biology

L	T	P	Cr
3	0	2	5

Learning outcomes

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

- Develop understanding on chemical bonding among molecules
- Identify the concept that explains chemical composition and structure of cell wall and membrane
- Classify the enzymes and explain mechanism of action and structure
- Compare the structure and function of cells & explain the development of cells
- Describe the relationship between the structure and function of biomolecules

Key Words:
Neiclic Acids, Amino Acids, Proteins, Lipids, Fatty Acids, Signal Transduction

Unit I: Bioenergetics — 5 lectures

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule. Types and significance of chemical bonds; Structure and properties of water; significance of pH and buffers.

Unit II: Biomolecules — 20 lectures

Carbohydrates: Nomenclature and classification and isomeric form; Monosaccharides; Disaccharides; Oligosaccharides and polysaccharides. Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; Triacylglycerols structure, functions and properties; Phosphoglycerides. Proteins: Structure of amino acids; Levels of protein structure-primary, secondary, tertiary and quaternary; Protein denaturation and biological roles of proteins. Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

Unit III: Enzymes — 15 lectures

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

Unit IV: Cell Biology and Signal transduction — 20 lectures

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Plant and animal cells; Origin of eukaryotic cell (Endosymbiotic theory). Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and

facilitated transport, endocytosis and exocytosis. **Nucleus: Structure-nuclear** envelope, **nuclear** pore complex, nuclear lamina, molecular **organization of** chromatin; nucleolus. Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament; Intracellular trafficking. Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast. Lysosomes and Vacuoles. Endomembrane system: Endoplasmic Reticulum – Types and Structure. Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle - checkpoints and regulation; role of protein kinases. Signal Transduction: Receptors and primary and secondary signal transduction

Practical

Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.

1. Study of plant cell structure with the help of epidermal peel mount of Onion/ *Rhoeo*/ *Crinum*.
2. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
3. Measurement of cell size by the technique of micrometry.
4. Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollen grains).
5. Study of cell and its organelles with the help of electron micrographs.
8. Cytochemical staining of: DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique.
9. Study the phenomenon of plasmolysis and deplasmolysis.
10. Study the effect of organic solvent and temperature on membrane permeability.
11. Study different stages of mitosis and meiosis.
12. Acid/ Alkaline phosphatase or amylase: Enzyme characteristics: pH/temperature/ kinetics
13. Immobilization of whole cell and isolated oraganelle.
14. Separation of protein by SDS-PAGE (only demonstration to class by the instructor.

Suggested Readings

1. G.M. Cooper. (2015). The cell: A Molecular Approach. 7th Edition. Sinauer Associates.
2. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K., Walter, P. (2014). Molecular Biology of Cell. 6th Edition. WW. Norton & Co.
3. Campbell, M.K. (2012) Biochemistry, 7th ed., Published by Cengage Learning.
4. Campbell, P.N. and Smith, A.D. (2011). Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
5. Tymoczko, J.L., Berg, J.M. and Stryer, L. (2012). Biochemistry: A short course, 2nd ed., W.H.Freeman.
6. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2011) Biochemistry, W.H.Freeman and Company
7. Nelson, D.L. and Cox, M.M. (2008). Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.
8. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
9. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell. 8th edition.Pearson Education Inc. U.S.A.

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10. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, M.A.
11. Becker, W.M., Kleinsmith, L.J., Hardin, J. and Bertoni, G. P. (2009). The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Core Course 3: Mycology and Phytopathology

L	T	P	Cr
3	0	2	5

Learning outcomes

On completion of this course, the students will be able to;

1. Identify true fungi and demonstrate the principles and application of plant pathology in the control of plant disease.
2. Demonstrate skills in laboratory, field and glasshouse work related to mycology and plant pathology.
3. Develop an understanding of microbes, fungi and lichens and appreciate their adaptive strategies
4. Identify the common plant diseases according to geographical locations and device control measures

Key Words:

Ascomycota, Zygomycota, Basidiomycota, Etiology, Chytridiomycota, Oomycota

Unit I: Introduction to fungi and classification — 15 lectures

General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification. **Chytridiomycota and Zygomycota:** Characteristic features; Ecology and significance; Thallus organisation; Reproduction; Life cycle with reference to *Synchytrium, Rhizopus* **Ascomycota: General characteristics** (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; Life cycle and classification with reference to *Saccharomyces, Aspergillus, Penicillium, Alternaria, Neurospora* and *Peziza.*

Unit II: Basidiomycota, Allied fungi and Oomycota — 15 lectures

General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), loose and covered smut (symptoms only), *Agaricus*; Bioluminescence, Fairy Rings and Mushroom Cultivation. Allied fungi: General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies. **Oomycota:** General characteristics; Ecology; Life cycle and classification with reference to *Phytophthora, Albugo.*

Unit III: Symbiotic associations and applied Mycology — 15 lectures

Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance. Role of fungi in biotechnology; Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology

Unit IV: Phytopathology

15 lectures

Terms and concepts; General symptoms; Geographical distribution of diseases; Etiology; Symptomology; Host-Pathogen relationships; Disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine. Bacterial diseases – Citrus canker and angular leaf spot of cotton. Viral diseases – Tobacco Mosaic viruses, vein clearing. Fungal diseases – Early blight of potato, Black stem rust of wheat, White rust of crucifers.

Practical

Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, ascocarps & basidiocarps).

1. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
2. *Aspergillus* and *Penicillium*: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
3. *Peziza*: sectioning through ascocarp.
4. *Alternaria*: Specimens/photographs and temporary mounts.
5. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
6. *Agaricus*: Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*, fairy rings and bioluminescent mushrooms to be shown.
7. Study of plasmodiophoromycetes from actual specimens and /or photograph. Study of *Sternonitis* sporangia.
8. *Albugo*: Study of symptoms of plants infected with *Albugo*; asexual phase study through section/temporary mounts and sexual structures through permanent slides.
9. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs).
10. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.

Suggested Readings

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

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Core Course 4: Archegoniatae : Bryophytes, Pteridophytes, Gymnosperms

L	T	P	Cr
3	0	2	5

Learning outcomes

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

- Demonstrate an understanding of archegoniatae, Bryophytes, Pteridophytes and Gymnosperms
- Develop critical understanding on morphology, anatomy and reproduction of Bryophytes, Pteridophytes and Gymnosperms
- Understanding of plant evolution and their transition to land habitat
- Demonstrate proficiency in the experimental techniques and methods of appropriate analysis of Bryophytes, Pteridophytes, Gymnosperms

Key Words:

Moss, Hornworts, Liverworts, Fern, Pine

Unit I: Introduction — 5 lectures

Unifying features of archegoniates; Transition to land habit; Alternation of generations.

Unit II: Bryophytes and type of bryophytes — 15 lectures

General characteristics; Adaptations to land habit; Classification (up to family); Range of thallus organization, Morphology, anatomy, reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Anthoceros*, *Sphagnum and Fimaria*; Common mosses of India, Ecological and economic importance of bryophytes with special reference to *Sphagnum*.

Unit III: Pteridophytes — 20 lectures

General characteristics; Classification (up to family); General account of early land plants. Morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris* (Developmental details not to be included). Apogamy and apospory, heterospory and seed habit, telome theory, stellar evolution; Common ferns of India, Ecological and economic importance.

Unit IV: Gymnosperms — 20 lectures

General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum* (excluding developmental details); *Cycas* and *Pinus* of India, Ecological and economic importance.

Practical

1. *Riccia* – Morphology of thallus.
2. *Marchantia*- Morphology of thallus, whole mount of rhizoids and Scales, vertical section of thallus through Gemma cup (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).
3. *Anthoceros*- Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).

4. *Sphagnum*- Morphology of plant, whole mount of leaf (permanent slide only).
5. *Funaria*- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule; whole mount of protonema.
6. *Psilotum*- Study of specimen, transverse section of synangium (permanent slide).
7. *Selaginella*- Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
8. *Equisetum*- Morphology, transverse section of internode, longitudinal section of strobilus, whole mount of sporangiophore, whole mount of spores (temporary slide), transverse section of rhizome (permanent slide).
9. *Pteris*- Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
10. *Cycas*- Morphology (coralloid roots, leaf), whole mount of microsporophyll, transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).
11. *Pinus*- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), transverse section of needle, transverse section of stem, longitudinal section of / transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone, tangential longitudinal section and radial longitudinal sections stem (permanent slide).
12. *Gnetum*- Morphology (stem, male and female cones), transverse section of stem, vertical section of ovule (permanent slide)
13. Botanical excursion.

Suggested Readings

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

Core Course 5: Anatomy of Angiosperms

L	T	P	Cr
3	0	2	5

Learning outcomes

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

Develop an understanding of concepts and fundamentals of plant anatomy
examine the internal anatomy of plant systems and organs
Develop critical understanding on the evolution of concept of organization of shoot and root apex.
Analyze the composition of different parts of plants and their relationships
Evaluate the adaptive and protective systems of plants

Keywords:

Tissue, Tunica Corpus, Cambium, Secondary Growth, Korper-Kappe, Quiescent, Endodermis

Unit I: Adaptive and Protective Systems — 15lectures

Introduction to Epidermal tissue system, cuticle, trichomes, stomata (structure, function and classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes, mesophytes and hydrophytes. Applications in systematics, forensics and pharmacognosy.

Unit II: Introduction to plant anatomy and plant body — 15 lectures

Internal organization of plant body: tissue system, types of cells and tissues. Classification of tissues; Simple and complex tissues, cyto-differentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Wall ingrowths and transfer cells, Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.

Unit III: Apical meristems — 15 lectures

Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cyto-histological zonation); Types of vascular bundles; Structure of dicot and monocot stem. Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermas and origin of lateral root.

Unit IV: Vascular Cambium and Wood — 15 lectures

Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Anomalous secondary growth; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm, rhytidome and lenticels.

Practical

Study of anatomical details through permanent slides/temporary stain mounts/ macerations/museum specimens with the help of suitable examples or experimentally

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1. Study of stomata through peal method and replica method.
2. Simple microtomy – hand sections and / or using microtome- handheld or rotary microtome
3. Staining techniques
4. Apical meristem of root, shoot and vascular cambium.
5. Distribution and types of parenchyma, collenchyma and sclerenchyma.
6. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
7. Wood: ring porous; diffuse porous; tyloses; heart- and sapwood.
8. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
9. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
10. Root: monocot, dicot, secondary growth.
11. Stem: monocot, dicot - primary and secondary growth; anomalous secondary growth in *Achyranthes*, *Boerhaavia* and *Dracaena*; periderm; lenticels.
12. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
13. Adaptive Anatomy: xerophytes, hydrophytes.
14. Secretory tissues: cavities, lithocysts and laticifers.

Suggested Readings

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
4. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.
5. Any local/state/regional flora published by BSI or any other agency

Core Course 6: Economic Botany and Plant Resource Utilization

L	T	P	Cr
3	0	2	5

Learning outcomes

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

- Understand core concepts of Economic Botany and relate with environment, populations, communities, and ecosystems
- Develop critical understanding on the evolution of concept of organization of apex new crops/varieties, importance of germplasm diversity, issues related to access and ownership
- Develop a basic knowledge of taxonomic diversity and important families of useful plants
- Increase the awareness and appreciation of plants & plant products encountered in everyday life
- Appreciate the diversity of plants and the plant products in human use

Keywords:

Quarantine, germplasm, Cryopreservation, Transgenics, Timber, Aromatic Plants, cereals

Unit I: Origin and conservation of Cultivated Plants 14 lectures

Origin, Importance and domestication: Origin of Agriculture and ancient economic botany, Vavilov's Centres of Origin and diversity of crop plants, domestication, evaluation, bioprospection, Major plant introductions; Crop domestication and loss of genetic diversity; **Germplasm augmentation and conservation:** History and importance of germplasm collection; Overview of : Ecogeographical distribution of diversity, General account of : Biotechnology in plant germplasm acquisition, plant tissue culture in disease elimination, in vitro conservation and exchange, cryopreservation, transgenics – exchange and biosafety issues,

Plant Quarantine: Principles, objectives and relevance of plant quarantine; Introductory regulations and plant quarantine set up in India; economic significance of seed borne pests, pathogens and weeds; detection and post entry quarantine operations.

Unit II: Botany, Utilization of Plant Wealth (Cereals and Millets, Pulses and Legumes, Sources of Sugars and Starches) 14 lectures

Origin, evolution and biosystematics, morphology, and uses of some selected crops: **Cereals:** Wheat, Rice, maize, sorghum, pearl millet and minor millets. Pulses: Origin, morphology, uses, Importance to man and ecosystem of pulses (Pigeon pea, Chickpea, Black gram, Green gram, Cowpea, Soyabean, Pea, Lentil, Horsegram), and Legumes (lab-lab bean, ricebean, winged bean, French bean, lima bean, sword bean). Morphology and processing of sugarcane, products and by-products. Morphology, propagation & uses of Sugarbeet, Sugarpalm and sweet sorghum. Potato, Sweet Potato and Tapioca.

Unit III: Botany, Utilization of Plant Wealth (Spices, Beverages, Oil seeds fats and Essential oils) 16 lectures

Spices: Listing of important spices (Saffron, Cloves, Cardamom, Cinnamon, Tejpat, Nutmeg and Mace, Anise, Cumin, Celery, Tamrind, Vanilla, Asafoetida, Dill, Fenugreek, Fennel,

Coriander), their botanical name, family and part used. Origin, distribution, ecology, botany, cultivation practices, processing of economic plant part / product , main chemical constituents, and economic importance of the Major spices, namely Turmeric, Ginger, Capsicum, Black Pepper , Coriander. **Beverages:** Tea and Coffee : History, origin , growing countries, Botany, cultivation practices, common diseases and pests, major chemical constituents, processing and quality control of economic product, **Oil seeds and fats:** General description, classification, extraction and uses of groundnut, coconut, linseed, soybean, mustard. **Essential Oils:** General description, uses extraction / distillation of essential oil, chemical constituents of major essential oil yielding aromatic plants, namely Rose, Geranium, Lemongrass / Palmarosa / Citronella, Vetiver, Menthol mint, Basil, Lavender, Eucalyptus, Clove, Camphor and Sandal wood.

Unit IV: Botany, Utilization and Processing of Plant Wealth (Aromatic Plants, Drug-yielding and Medicinal plants, Timber plants) 16 lectures

Drug-yielding and Medicinal plants: Fumitories and Masticatories : Processing, therapeutic uses, and health hazards of habit-forming drugs, Botany and cultivation / regulatory practices of such drug yielding plants with special reference to *Papaver* , *Cannabis* and Tobacco. Major Medicinal Plants : Botany, Uses, Cultivation and Processing of major medicinal plants, namely : Ashwagandha, Kalmegh, Satavar, Ghrit Kumari (*Aloe vera*), Quinghao (*Artemisia annua*), Isabgol, Senna, Bhui Amla (*Phyllanthus*), Stevia, Sarpagandha, Atropa, Digitalis, Licorice, Gilloi (Tinospora), **Natural Rubber: Para- rubber**: tapping, processing and uses. **Timber plants and Fibres:** General account and Botany of the Tree, wood structure and quality characteristics, and timber processing with special reference to, Saal (*Shorea robusta*), Teak and Pine. General account of the Fiber yielding plants, Classification based on the origin of fibers, Extraction, processing, morphology and uses of fibers, with special reference to Cotton, Sunhemp, flax, Coir, Jute. **Seaweeds:** Economically important seaweed resources of India, Production of carrageenan, algin, agar and agarose, seaweeds as fertilizers, edible seaweeds, seaweeds as fodder, drugs from algae, cosmetics and neutraceuticals from algae, algae based biofuel.

Practical

1. Cereals: Wheat (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests) Rice(habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. Legumes: Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. Sources of sugars and starches: Sugarcane (habit sketch; cane juice- micro-chemical tests), Potato(habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains, micro-chemical tests).
4. Spices: Black pepper, Fennel, Curcuma and Clove (habit and sections).
5. Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. Sources of oils and fats: Coconut- T.S. nut, Mustard-plant specimen, seeds; tests for fats in crushed seeds.
7. Essential oil-yielding plants: Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and *Cymbopogon* spp., Mint, Basil, *Eucalyptus* (specimens/photographs).
8. Rubber: specimen, photograph/model of tapping, samples of rubber products.
9. Drug-yielding plants: Specimens of Ashwagandha, Artemisia, Kalmegh, Phyllanthuds, Satavar, Gilloi, *Digitalis*, *Papaver* and *Cannabis*.

10. Tobacco: specimen and products of Tobacco.
11. Woods: *Tectona, Pinus*: Specimen, Section of young stem.
12. Fiber-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

Suggested Readings

1. Chrispeels, M.J. and Sadava, D.E. (1994) Plants, Genes and Agriculture. Jones & Bartlett Publishers.
2. CSIR- Central Institute of Medicinal and Aromatic Plants, Lucknow (2016). Aush Gyanya : Handbook of Medicinal and Aromatic Plant Cultivation.
3. Kochhar, S.L. (2016). Economic Botany: A Comprehensive Study. 5th Edition. Cambridge
4. Samba Murty, AVSS and Subrahmanyam, N.S. (1989). a text book of Economic Botany. Wiley Eastern Ltd., New Delhi
5. Sambamurty, AVSS and Subrahmanyam, N.S. (2008). A Textbook of Modern Economic Botany. 1st Edition, Paperback . CBS Publishers & Distributors Pvt.Ltd.; 1st edition (4 September 2008)
6. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
7. Any local/state/regional flora published by BSI or any other agency.

Core Course 7: Genetics and Cytogenetics

L	T	P	Cr
3	0	2	5

Learning outcomes

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

- Have conceptual understanding of laws of inheritance, genetic basis of loci and alleles and their linkage.
- Comprehend the effect of chromosomal abnormalities in numerical as well as structural changes leading to genetic disorders.
- Develop critical understanding of chemical basis of genes and their interactions at population and evolutionary levels.
- Analyze the effect of mutations on gene functions and dosage.
- Examine the structure, function and replication of DNA.

Keywords:

Mendelism, Linkage, gene mapping, Crossing over, Ploidy, Hardy-Weinberg, Genetic Drift, Natural Selection

Unit I: Principles of genetics and Biology of Inheritance 15 lectures

Mendelism: History; Mendel's Laws of inheritance; Chromosome theory of inheritance and linkage; Incomplete dominance and codominance; Interaction of Genes; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Mendellian segregation and gene interaction: Numericals; Polygenic inheritance; Mitosis and Meiosis in plants, animal and human; Cell cycle and cell division.

Unit II: Extra-nuclear Inheritance, Linkage, Crossing over and chromosome mapping 15 lectures

Determining non-Mendelian Inheritance; Maternal effects and cytoplasmic 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*. Linkage and crossing over; Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Linkage and Gene mapping, and numericals based on gene mapping;

Unit III: Variation in Chromosome Number and Structure, Mutations 15 lectures

Chromosome morphology and Karyotype concept, Deletion, Duplication, Inversion, Translocation, Position effect; Euploidy, Aneuploidy and Amphiploidy and their implications, FISH and GISH in chromosome and genome identification. Types of mutations; Molecular basis of Mutations; Induction of mutations and Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: CIB method. Role of Transposons in mutation.DNA repair mechanisms.

Unit IV: Fine Structure of Gene, Gene Interaction, Population and Evolutionary Genetic 15 lectures

Evolution of Gene Concept - Classical vs molecular concepts of gene : One gene one character;

One gene-one enzyme, one gene-one polypeptide hypothesis and beyond; Cis- trans complementation test for functional allelism and gene as unit of function, mutation and recombination, non-coding RNA. Concept of sex determination and Sex chromosomes; Patterns of Sex determination in plants and animals (human, Drosophila and other animals) ; Sex-linked, sex-limited and sex-influenced characters; Dosage compensation. Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

Practical

1. Mitosis, and study of chromosome morphology through squash preparation, including effect of chemicals on mitosis.
2. Meiosis and study of chiasma frequency through temporary squash preparation.
3. Laws through seed ratios. Laboratory exercises in probability and chi-square.
4. Chromosome mapping using point test cross data.
5. Pedigree analysis for dominant and recessive autosomal and sex linked traits.
6. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
7. Blood Typing: ABO groups & Rh factor.
8. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
9. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
10. Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red-green Color blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached earlobe.
11. To test PTC tasting ability in a random sample and calculate gene frequencies for the taster and non-taster alleles.
12. Identification of inactivated X chromosome as Barr body and drumstick.

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics. 8th edition. John Wiley & sons, India.
2. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. 10th edition. W. H. Freeman and Co., U.S.A.
3. Gupta, P.K. (2018) Genetics. 5th Edition, Rastogi Publications, Meerut.
4. Hartl, D.L. and Jones, E.W. (1999). Essential Genetics, 2nd Edition, Jones and Barlett Publishers, Boston.
5. Jain, H.K. (1999). Genetics: Principles, Concepts and Implications. Science Pub Inc.
6. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. 9th edition. Benjamin Cummings, U.S.A.
7. Singh, R. J. (2016). Plant Cytogenetics, 3rd Edition. CRC Press, Boca Raton, Florida, USA.
8. Singh, R.J. (2017). Practical Manual on Plant Cytogenetics. CRC Press, Boca Raton, Florida, USA.
9. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. 5th edition. John Wiley & Sons Inc., India.
10. Strickberger, M.W. (1985) Genetics, 3rd Edition. Pearson Printice Hall (printed in India by Anand Sons).

Core Course 8: Molecular Biology

L	T	P	Cr
3	0	2	5

Learning outcomes

On completion of this course, the students will be able to;

1. Analyse the structures and chemical properties of DNA and RNA through various historic experiments.
2. Differentiate the main types of prokaryotes through their grouping abilities and their characteristic
3. Evaluate the experiments establishing central dogma and genetic code.
4. Gain an understanding of various steps in transcription, protein synthesis and protein modification.

Keywords:

Central Dogma, DNA Replication, Post translational modification, Wobble hypothesis, Exons, Cistrons

Unit I: Nucleic Acids: Carriers of Genetic Information and Structure

15 lectures

Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiments). DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure Organelle DNA – mitochondria and chloroplast DNA. The Nucleosome Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit II: Central dogma and The replication of DNA

15 lectures

Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semi-conservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication. DNA proofreading. Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Central Dogma Reverse (RNA viruses etc.),

Unit III: Genetic code and transcription

15 lectures

Genetic code (deciphering & salient features) and wobble hypothesis. Transcription in prokaryotes and eukaryotes. Priaciples of transcriptional regulation; Concept of operon Prokaryotes: lac operon. Regulation of lactose metabolism and tryptophan synthesis in *E.coli*. Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing.

Unit IV: Processing and modification of RNA and translation

15 lectures

Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing

pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing(5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport.

Translation: Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins, Protein targeting.

Practical

1. Preparation of LB medium and raising *E.Coli*.
2. Isolation of genomic DNA from *E.Coli*.
3. DNA isolation from cauliflower head.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
7. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.

Suggested Readings

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, 6th edition. Pearson Benjamin Cummings. CSHL Press, New York, U.S.A.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, 5th edition. John Wiley and Sons Inc., U.S.A.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics, 9th edition. Benjamin Cummings. U.S.A.
4. Russell, P. J. (2010). i-Genetics- A Molecular Approach, 3rd edition. Benjamin Cummings, U.S.A.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis, 10th edition. W. H. Freeman and Co., U.S.A.
6. J. E. Krebs, E.S. Goldstein and S.T. Kilpatrick. (2017). Lewin's Genes XII. 12th Edition: Jones and Bartlett.

Core Course 9: Plant Ecology and Phytogeography

L	T	P	Cr
3	0	2	5

Learning outcomes

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

1. Understand core concepts of biotic and abiotic
2. Classify the soils on the basis of physical, chemical and biological compo nents
3. Analysis the phytogeography or phytogeographical division of India
4. Evaluate energy sources of ecological system
5. Assess the adaptation of plants in relation to light, temperature, water, wind and fire.
6. Conduct experiments using skills appropriate to subdivisions

Keywords:

Soil, Community, Ecotone, Succession, Competition, r and k selection, ecologic al pyramids, Climax community

Unit I: Introduction, soil and water

15 lectures

Basic concepts; Levels of organization. Abiotic and biotic Components and their interrelationships and dynamism, homeostasis. Soil: Origin; Types and Formation; Composition; Physical, Chemical and Biological components; Soil profile. Types of soils in India. Water: States of water in the environment; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Atmospheric moisture; Water in soil; Ground water table. Water resources of India

Unit II: Ecological adaptations, Population ecology

15 lectures

Variations in adaptation of plants in relation to light, temperature, water, wind an d fire. Biotic interactions: Competition: Inter- and intraspecific competition; Ammensalism, het erotrophy; mutualism, commensalism, parasitism; herbivory, carnivory, protocooperation, Population ecology: Characteristics and population growth, population regulation, life history strategies; *r* and *k* selection. Ecological Speciation.

Unit III: Plant Communities and Ecosystem

15 lectures

Community characteristics: analytical and synthetic; Concept of ecological amplitu de; Habitat and niche; Ecotone and edge effect; Succession: processes, types; climax concept. Primary vs Secondary succession. Ecosystem: Structure; Processes; Trophic organization; Food chains and Food webs; Ecological pyramids. Ecosystems of India.

Unit IV: Functional Aspects of Ecosystem and Phytogeography

15 lectures

Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles of carbon, nitrogen and phosphorus. Phytogeography: Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phyto-geographical division of India; Local Vegetation.

Practical

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

Suggested Readings

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

Head
Department of Botany

Core Course 10: Plant Systematics

L	T	P	Cr
3	0	2	5

Learning outcomes

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

- Classify Plant systematics and recognize the importance of herbarium and Virtual herbarium
- Evaluate the Important herbaria and botanical gardens
- Interpret the rules of ICN in botanical nomenclature
- Assess terms and concepts related to Phylogenetic Systematics
- Generalize the characters of the families according to Bentham & Hooker's system of classification

Keywords:

Monophyly, paraphyly, polyphyly, apomorphy, plesiomorphy, homoplasy

Unit I: Significance of Plant systematics and Taxonomic hierarchy

18 lectures

Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from palynology embryology, cytology, phytochemistry and molecular data. Field inventory; Importance of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: intended (yolked) and bracketed keys. Phenetics vs. Cladistics, Taxonomic Hierarchy: Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concepts (biological, morphological, evolutionary).Modes of speciation. Problems with species concepts.Rankless system of phylogenetic systematics

Unit II: Botanical Nomenclature and System of Classification 15 lectures

Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids. System of classification: Natural system of classification (Bentham and hooker), Takhtajan classification of Angiosperms, Principles of Angiosperm Phylogeny Group (A PG IV) classification.

Unit III: Biometrics, Numerical Taxonomy and Cladistics 15 lectures

Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences).

Unit IV: Phylogenetic Systematics 12 lectures

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly, clades, synapomorphy, symplesiomorphy, apomorphy, lineage sorting, serial homology etc). Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

Practical

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):

Ranunculaceae	-	*Ranunculus, Delphinium*
Brassicaceae	-	*Alyssum / Iberis*
Papaveraceae	-	*Argemone*
Myrtaceae	-	*Eucalyptus, Callistemon*
Umbelliferae	-	*Coriandrum /Anethum / Foeniculum*
Asteraceae	-	*Sonchus/Launoea, Vernonia/Ageratum, Eclipta/Tridax*
Solanaceae	-	*Solanumnigrum/Physalis*
Lamiaceae	-	*Salvia/Ocimum*
Euphorbiaceae	-	*Euphorbia hirta/ Jatropha, Croton*
Liliaceae	-	*Asphodelus/Lilium/Allium*
Poaceae	-	*Triticum/Hordeum/Avena*

2. Field visit (local or outside depending on situation) –
3. Mounting of a properly dried and pressed specimen of any 20 wild plant with Herbarium label (to be submitted in the record book).
4. Construction of plant phylogenetic trees using various loci (rbcL, ITS, trnLetc) with various phylogenetic methods (Neibour Joining, Maximum Likelihood etc)

Suggested Readings

1. Singh, (2012). *Plant Systematics*: Theory and Practice Oxford & IBH Pvt. Ltd., New Delhi.3rd edition.
2. Jeffrey, C. (1982). An Introduction to *Plant Taxonomy*. Cambridge University Press, Cambridge.
3. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics-A Phylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.
4. Radford, A.E. (1986). Fundamentals of *Plant Systematics*. Harper and Row, New York.
5. Sambamurty A.V.S.S. (2005). Taxonomy of Angiosperms. I. K. International Pvt. Ltd., New Delhi. Singh, V., Pande, P. C. & Jain, D. K. (2008). Taxonomy and Economic Botany. Rastogi Publications, Meerut.
6. Pandey, B. P. (2009). A Textbook of Botany Angiosperms. . S. Chand and Company Ltd., New Delhi.
7. Hall, B.G. (2011). *Phylogenetic Trees Made Easy: A How-To Manual*. Sinauer Associates, Inc. USA
8. Any local/state/regional flora published by BSI or any other agency

Core Course 11: Plant Physiology

L	T	P	Cr
3	0	2	5

Learning outcomes

On completion of this course, the students will be able to;

1. Understand Water relation of plants with respect to various physiological processes.
2. Explain chemical properties and deficiency symptoms in plants
3. Classify aerobic and anaerobic respiration
4. Explain the significance of Photosynthesis and respiration
5. Assess dormancy and germination in plants

Keywords:

Hydroponics, Nitrogenase, Photosynthesis, Photorespiration, CAM, Phytochrome, Phytohormone

Unit I: Water Potential and Other Potential Physiological Aspect of Plant

15 lectures

Water relation of plants, unique physico chemical properties of water; water absorption, uptake and bulk movement of water, stomatal regulation of transpiration, anti transpirants; Inorganic nutrition, (macro and micro), deficiency symptoms, hydroponic studies; mineral absorption, translocation and assimilation. (including explanation on active passive uptake, Channels, carriers and pumps).

Unit II: Nitrogen Nutrition

12 lectures

Metabolism: Nitrogen nutrition, organic nitrogen, nitrogen fixation in microbes/legumes, nif genes and NOD factors, nitrate and ammonia assimilation, inter relationship between photosynthesis and nitrogen metabolism. (Emphasis on various enzymes specially nitrogenase).

Unit III: Photosynthesis and Photorespiration

18 lectures

Photosynthesis: Importance of photosynthesis for food security and environment. (a) Light reaction: Radiant energy, photosynthetic apparatus, pigments and their biosynthesis; light harvesting complex; light absorption and composition and characteristics of two photosystems, photosynthetic electron transport, (b) Dark reaction: Carbon dioxide fixation in C3, C4 and CAM plants, photorespiration and its significance, environmental factors affecting photosynthesis. (Explain RUBISCO). Respiration: Aerobic and anaerobic respiration; cyanide independent respiration; fermentation; cytochrome system; carbohydrate and lipid metabolism; high energy compounds and factors affecting respiration.

Unit IV: Phytochrome, Phytohormone and Plant Cycle

15 lectures

Growth and development (a) Phytochromes and light control, role of phytochrome in tropisms, flowering and fruiting. (b) Phytohormones: Auxin; cytokinin; Gibberellins; ethylene; ABA. Synthesis, distribution and physiological effects. Application of hormones in agriculture and horticulture. Polyamines, brassinosteroids and their functions. Seed dormancy

and germination, senescence, circadian rhythms in plants (exogenous factors and physioloical mechanism).

Practical

1. Analysis of plant tissue for water, organic and inorganic content determination of a few macronutrient (K/Na) by Flame photometer
2. Quantitative and qualitative estimation of sugars
3. Qualitative and quantitative determination of amino acids
4. Quantitative estimation of protein
5. Determination of ascorbic acid content of tissue (DCIP red)
6. Pigments extraction, separation through solvent partitioning and chromatographic techniques
7. Spectrophotometric estimation of chlorophyll
8. Enzyme activity with respect to temperature, pH and substrate concentration.
9. Effect of inorganic nutrients on plant growth
10. Assay of photosynthetic electron transport activity from isolated chloroplast/Algae using DCIP reduction
11. Assay of respiratory electron transport activity from potato using DDCP dye oxidation.
12. Estimation of nitrate/nitrite reductase activity in leaves/algae
13. Seed viability – TTC test
14. Estimation of transpiration through different simple methods.

Suggested Reading

Buchanan, B.B. and Gruissem, W. (2015). ***Biochemistry and molecular biology of plants.*** Willy Blackwell ASPB USA.

Campbell, M.K. and Farrell, S.O. (2007). *Biochemistry.* Thomson Brooks/cole, USA.

Dey, P.M. and Harborne, J.B. (2000). *Plant biochemistry.* Academic Press, UK.

Goodwin, T.W. and Mercer, E.I. (2003). ***Introduction to plant biochemistry.*** CBS Publishers & Distributors, New Delhi, India.

Ross and Salisbury. (2009). *Plant Physiology.* Cengage Learning (Thompson), New Delhi, India.

Segel, I.H. and Segel, E. (1993). ***Enzyme kinetics: Behavior and analysis of rapid equilibrium and steady-state enzyme systems.*** Wiley-Interscience, USA.

Taiz, L., Zeiger, E. Mollar, I. M. and Murphy, A. (2015). Plant physiology and Development 6th edition. . Sinauer Associates Inc., USA.

Core Course 12: Plant Metabolism

L	T	P	C
3	0	2	5

Learning outcomes

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

1. Differentiate anabolic and catabolic pathways of metabolism
2. Recognize the importance of Carbon assimilation in photorespiration
3. Explain the ATP-Synthesis
4. Interpret the Biological nitrogen fixation in metabolism

Keywords:

Anabolism, catabolism, Pentose phosphate pathway, ATP synthesis, Electron Transport Chain, MAP kinase cascade

Unit I: Concept of Metabolism 10 lectures Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and isozymes). Historical background, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres,

Unit II: Carbon Assimilation, Metabolism and Oxidation 20 lectures Photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction/ Carbon assimilation: C_3 and C_4 pathways; photorespiration; Crassulacean acid metabolism; Factors affecting CO2 reduction. Synthesis and hydrolysis of sucrose and starch. Glycolysis and its regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Unit III: ATP-Synthesis 12 lectures

Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers.

Unit IV: Lipid and Nitrogen Metabolism, Mechanism of Signal Transduction

18 lectures

Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, α oxidation. Biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Nitrate and Ammonia assimilation; Transaminase reactions. Receptor- ligand interactions; Secondary messengers concept, Calcium- calmodulin, MAP kinase cascade.

Practical

1. Solvent partitioning of photosynthetic pigments.
2. Experimental demonstration of Hill's reaction.
3. To study the effect of light intensity on the rate of photosynthesis.
4. Effect of carbon dioxide on the rate of photosynthesis.
5. To compare the rate of respiration in different parts of a plant.
6. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
7. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
8. Demonstration of fluorescence by isolated chlorophyll pigments.
9. Demonstration of absorption spectrum of photosynthetic pigments.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. 4th edition. John Wiley and Sons.U.S.A.
2. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology and Development. 6th edition. Sinauer Associates Inc. USA.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.
4. H. W. Heldt and B. Piechulla.(2019). Plant Biochemistry. 4th Edition. Paperback. Academic Press.
5. B. Buchanan, W. Gruissem and R. L. Jones (Eds) (2015) Biochemistry and Molecular Biology of Plants. Second Edition. Paper back. Wiley-Blackwell.

Core Course 13: Biodiversity and Conservation

L	T	P	C
3	0	2	5

Learning outcomes:

The students will have following important knowledge after completing the course

Basic concepts of diversity and its important components

Distribution pattern of biodiversity on the globe

Importance of biodiversity for human beings

Why biodiversity conservation is needed?

Unit I- Biodiversity:

Concept and definition, Composition and Scales of Biodiversity: Genetic Diversity, Species diversity, Ecosystem Diversity, Agrobiodiversity.

Unit II- Biodiversity Distribution:

Origin of Species; Global biodiversity patterns and biodiversity in geologicaltimes; Current Centers of Biodiversity

Unit III - Values of Biodiversity:

Utilitarian value and their categories, Direct and Indirect values; value, value of biodiversity in monetary terms.

Unit IV - Threats to Biodiversity:

Habitat loss and its fragmentation, Transformation, Degradation and Loss: Invasive Species: introduction and biological impacts of invasive species onterrestrial/ aquatic systems; Pollution and biodiversity.

Unit V- Biodiversity Extinction:

Types of Extinctions, Processes responsible for Species Extinction, Current andFuture Extinction Rates, IUCN Threatened Categories

Lab (BOPDLD9)

1. To determine the species diversity in different terrestrial ecosystems.

1. 2 To determine various diversity indices (Shannon-Wiener, Concentration of Dominance, Species richness, Equitability and B-diversity)
2. Field visits to different degraded ecosystems.

Suggested Readings:

1. Groom, M. J., Meffe, G. R. and C. R. Carroll. 2006. Principles of Conservation Biology.Sinauer Associates, Inc., USA.
2. Krishnamurthy, K. V. 2003. Textbook of Biodiversity. Science Publication.
3. Primack, R. 2006. Essentials of Conservation Biology.Sinauer Associates, Inc., USA.
4. Hambler, C. 2004. Conservation. Cambridge University Press.
5. Van Dyke,F.2008.Conservation Biology Foundations, Concepts, Applications 2nd Edition, Springer.

Core Course 14: Reproductive Biology of Angiosperms

L	T	P	Cr
3	0	2	5

Learning outcomes

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

1. Recall the history of reproductive biology of angiosperms & recognize the importance of genetic and molecular aspects of flower development
2. Understand structure and functions of anther wall and pollen wall
3. Evaluate the special structures of Ovule
4. Solve Self-incompatibility in Pollination and fertilization & relate between Embryo, Endosperm and Seed
5. Comprehend the causes of Polyembryony and apomixes with its classification

Keywords:

Gametogenesis, Self-incompatibility, In vitro fertilization, Cybrids, Polyembryony, Apomixes

Unit I: Introduction 10 lectures

History (contributions of G.B. Amici, W. Hofmeister E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope. Types of reproduction and regeneration in plants: Sexual, asexual / vegetative reproduction.

Unit II: Flower Formation, Male and Female Gametophyte Development 15 lectures

Flower as a modified determinate shoot. Flower development: genetic and molecular aspects. Anther and pollen biology: Anther wall: Structure and functions, micro-sporogenesis, Micro-gametogenesis; Pollen wall structure, MGU (male germ unit), NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, Abnormal features: Pseudomonads, polyads, massulae, pollinia. Ovule:Types of ovules; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– mega-sporogenesis (monosporic, bisporic and tetrasporic) and mega- gametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac.

Unit III: Pollination, Fertilization and Self-Incompatibility 10 lectures

Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization. Self-incompatibility: Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self-incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization; Cybrids, *in vitro* fertilization.

Unit IV: Embryo, Endosperm and Seed, Polyembryony and Apomixes

10 lectures

Structure and types of embryo; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; structure and development of endosperm; Embryo-endosperm relationship; Nutrition of embryo. Seed structure, importance and dispersal mechanisms. Polyembryony and apomixes: Introduction, Classification; Causes and applications.

Practical

1. Anther: Wall structure; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bi-celled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, pseudomonads, polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test. Demonstration of pollen germination using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/ campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/ specimens/ photographs).
4. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature embryo sac.
5. Intra-ovarian pollination; Test tube pollination through photographs.
6. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
7. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi.
2. Pandey, A.K. (1997). Introduction to Embryology of Angiosperms. CBS Publishers & Distributors, New Delhi.
3. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
4. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
5. Johri, B.M. 1 (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

DISCIPLINE SPECIFIC ELECTIVE COURSES

These are 09 courses, out of which the students are to select 3 courses in B.Sc. (Honors). These courses have the following credit pattern.

L	T	P	Cr
3	0	2	5

Discipline Specific Elective Course 1: Plant Biotechnology and Genetic Engineering

L	T	P	Cr
3	0	2	5

Learning outcomes

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

Understand the core concepts and fundamentals of plant biotechnology and genetic engineering
Develop their competency on different types of plant tissue culture
Analyze the enzymes and vectors for genetic manipulations
Examine gene cloning and evaluate different methods of gene transfer
Critically analyze the major concerns and applications of transgenic technology

Keywords:

Callous, Protoplast, Gene Cloning, Vectors, Transgenic technology, Embryo culture, Anther culture

Unit I: Plant Tissue Culture — 11 lectures

Historical perspective; Formulation of nutrient media; Sterilization, role of vitamins and hormones; Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Organ culture, Embryo culture, Anther and triploid culture, Callus culture, Protoplast isolation, culture and fusion; Tissue culture applications including micropropagation, androgenesis, production of virus free plants, secondary metabolite production, haploids, triploids and hybrids and germplasm conservation, Cryopreservation and usages.

Unit II: Enzymes and Vectors for Genetic Manipulations — 11 lectures

Restriction Endonucleases (History, Types I-IV and subtypes of II, Structures, biological role, Mechanism, and usages in cloning); Restriction Mapping (Linear and Circular); Ligases enzymes, Cloning Vectors: History, basic sequences of any vector, types of bacterial vectors (pUC18 and pUC19, pBR322, Ti plasmid, BAC); Yeast vector, viral vectors including Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

Unit III: Gene Cloning and Methods of Gene Transfer — 11 lectures

Basic concept of Gene cloning, advantages of gene cloning, Bacterial Transformation methods and selection of recombinant clones using various strategies, PCR- mediated gene cloning; GeneConstruct;Plant transformation vector, T-DNA and viral vector, *Agrobacterium*-mediated Transformation protocols, molecular mechanism of T-DNA transfer, direct gene transfer method by Electroporation, Microinjection, Microprojectile bombardment ;Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP), chloroplast transformation, transgene analysis, Mutant formation, Maker-free and novel selection strategies.

Unit IV: Major Concerns and Applications of Transgenic Technology

12 lectures

Transgenic technology and sustainable agriculture, Biosafety concerns with transgenic technology, History of transgenic development across the world, Major concerns with implementation of transgenic technology in India. Applications as Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits in major crops (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug)

Practical

1. (a) Preparation of liquid and solid MS medium.
   (b) Demonstration of *in vitro* sterilization of seeds and germination in MS media containing petri plates.
   (c) *in vitro* selection and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
2. Callus formation in tobacco and rice using MS medium containing phytohormones.
3. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
4. Isolation of protoplasts and protoplast culture using photographs
5. Construction of restriction map of circular and linear DNA from the data provided.
6. Study of methods of gene transfer through photographs: Agrobacterium-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
7. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
8. Isolation of plasmid DNA.
9. Restriction digestion and gel electrophoresis of plasmid DNA.

Suggested Readings

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam The Netherlands.
2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
3. A. Slater, N.W. Scott and M.R. Fowler (2008). Plant Biotechnology. Second Edition. Oxford.
4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K.
5. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.
6. Chrispeels, M.J. and Sadava, D.E. (1994). Plants, Genes and Agriculture. Jones & Bartlett Publishers.
7. N. Santosh and A. Madhavi. (2010). Practical Book of Biotechnology and Plant Tissue Culture. S. Chand & Co.

Discipline Specific Elective Course 2: Plant Biochemistry

L	T	P	C
3	0	2	5

Learning outcomes:

At the end of the course the students will be able to,

- Comprehend different fundamental concepts related to plant biochemistry like plant cell organelles, photosynthesis, respiration and lipid metabolism etc.
- Analyze the structure and properties of various enzymes
- Evaluate the process of ATP Synthesis, nitrogen metabolism and lipid metabolism

Keywords:

CAM, TCA, Biosynthesis, Mobilization, Peroxidation, Enzyme catalysis, ATP Synthesis, Conformational Theory

Unit I: Plant Cell Organelles — 5 lectures

Chloroplasts, Mitochondria, Peroxisomes and vacuoles: their structure and function

Unit II: Photosynthesis and Respiration — 20 lectures

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration. Assimilate Partitioning: Synthesis and hydrolysis sucrose and starch, Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway and ATP synthesis (Substrate level phosphorylation, chemismotic hypothesis: Conformational theory, uncouplers)

Unit III: Nitrogen and Lipid Metabolism — 10 lectures

Biological nitrogen fixation; Nitrate and ammonia assimilation; Amino acid biosynthesis, Biosynthesis and oxidation-saturated and unsaturated lipids; lipid mobilization & peroxidation

Unit IV: Enzymes — 10 lectures

Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition. Inhibitors. Post-translational Modification

Practical

1. Demonstration of Hill reaction.
2. Demonstrate the activity of catalase and study the effect of pH and enzyme concentration.
3. To study the effect of light intensity and bicarbonate concentration on O_2 evolution in photosynthesis.
4. Comparison of the rate of respiration in any two parts of a plant.
5. Separation of amino acids by paper chromatography.
6. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.

7. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
8. Demonstration of fluorescence by isolated chlorophyll pigments.
9. Demonstration of absorption spectrum of photosynthetic pigments.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. 4th edition. John Wiley and Sons.U.S.A.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. 6th edition. Sinauer Associates Inc. USA.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.
4. Heldt, H. W. and Piechulla, B. (2010). Plant Biochemistry. 4th Edition. Paperback. Academic Press.
5. Buchanan, B., Gruissem, W. and Jones R. L. (Eds) (2015). Biochemistry and Molecular Biology of Plants. 2nd Edition. Paper back. Wiley-Blackwell.

Discipline Specific Elective Course 3: Research Methodology

L	T	P	Cr
3	0	2	5

Learning outcomes:

At the end of the course the students will be able to,

- Understand the concept of research and different types of research in the context of biology
- Develop laboratory experiment related skills.
- Develop competence on data collection and process of scientific documentation
- Analyze the ethical aspects of research
- Evaluate the different methods of scientific writing and reporting

Keywords:

Qualitative, Quantitative, Reproducibility, Scientific methodology, Plagiarism, Scientific misconduct, Ethics in Science

Unit I: Basic Concepts of Research 12 lectures Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs empirical). Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.

Unit II: Data Collection and Documentation of Observations 12 lectures Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

Unit III: Overview of Biological Problems 10 lectures History; Key biology research areas, Model organisms in biology (A brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network.

Unit IV: Ethics and Good Practical's and Art of Scientific Writing 11 lectures

Authors, acknowledgements, reproducibility, plagiarism, Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Power-point presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.

Practical

1. Experiments based on chemical calculations.
2. Plant microtechnique experiments.
3. The art of imaging of samples through microphotography and field photography.
4. Poster presentation on defined topics.
5. Technical writing on topics assigned.
6. Identification of different type of research in day by day life
7. Testing of a formulated hypothesis with type I and type II errors
8. Curation of relevant scientific literature from Google Scholar

9. Poster presentation on defined topics
10. Demonstration for checking of plagiarism using recommended software
11. Technical writing on topics assigned.
12. More Practical may be added depending on the local habitats and available facilities

Suggested Readings

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Ruzin, S. E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

Discipline Specific Elective Course 4: Biostatistics

L	T	P	Cr
3	0	2	5

Learning outcomes:

At the end of the course the students will be able to,

- Comprehend the fundamental concepts related to descriptive and inferential biostatistics.
- Develop skills in data tabulation, its treatment, analysis, interpretation and graphical representation of data.
- Analyze the implications of inferential statistics in biology.
- Develop their competence in hypothesis testing and interpretation.

Keywords:

Probability, Frequency, ANOVA, t-test, P-value, Hypothesis testing, Correlation, regression

Unit I: Biostatistics

15 lectures

History of the field and connection with population genetics, levels of measurements, types of variables, precision vs accuracy.

Unit II: Data Summarization and Visualization

15 lectures

Types of variables, frequency tabulations (EFD, ERFD, ECD), various types of charts, error bars, scatterplots

Unit III: Descriptive Statistics

15 lectures

Mean, median, mode, geometric mean - merits & demerits. Measures of dispersion - range, standard deviation, mean deviation, quartile deviation - merits and demerits; Co- efficient of variations.

Unit IV: Correlation, Regression and Statistical inference

15 lectures

Types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression. Hypothesis testing and P values, Confidence Intervals, Student 't' test, chi square test, ANOVA.

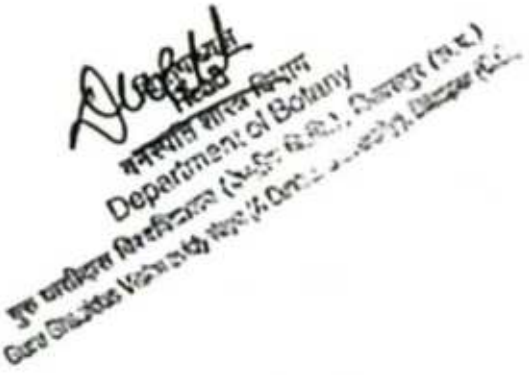
Practical

1. Calculation of mean, standard deviation and standard error
2. Calculation of correlation coefficient values and finding out the probability
3. Calculation of 'F' value and finding out the probability value for the F value.
4. Student's t-test: Independent and dependent. Hand calculation and calculation using MS Excel
5. ANOVA and Tukey's HSD: Hand calculation and calculation using MS Excel

Suggested Readings

1. Danniel, W.W.(1987). Biostatistics, New York, John Wiley Sons.

2. Sundarrao, P.S.S and Richards, J. Christian. An introduction to Biostatistics, 3rd edition. Medical College, Vellore
3. Selvin, S. (1991). Statistical Analysis of epidemiological data New York University Press
4. Campbell, R.C. (1998). Statistics for Biologists, Cambridge University Press.



Discipline Specific Elective Course 5: Natural Resource Management

L	T	P	Cr
3	0	2	5

Learning outcomes:

At the end of the course the students will be able to,

1. Understand the concept of different natural resources and their utilization.
2. Critically analyze the sustainable utilization land, water, forest and energy resources.
3. Evaluate the management strategies of different natural resources.
4. Reflect upon the different national and international efforts in resource management and their conservation

Keywords:

Sustainability, EIA, GIS, Carbon Footprint, renewable energy, CBD, Nagoya Protocol

Unit I: Natural Resources and Sustainable Utilization — 8 lectures

Definition and types, concept, approaches (economic, ecological and socio-cultural) for sustainable utilization.

Unit II: Land, Water and Biological Resources — 15 lectures

Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management. Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies. Biodiversity-definition and types; Significance; Threats; Management strategies; Bio- prospecting; IPR; CBD; National Biodiversity Action Plan).

Unit III: Forests and Energy — 10 lectures

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

Unit IV: Contemporary Practices in Resource Management — 12 lectures

EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management. National and international efforts in resource management and conservation

Practical

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
2. Collection of data on forest cover of specific area.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Ecological modeling.
6. More Practical may be added depending on the local habitats and available facilities

Suggested Readings

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.
4. United States Government Accountability Office (2008) Natural Resource Management. Nova Science Publishers Inc, 10th Edition
5. Stacy Keach (2016) Natural Resources Management. Syrawood Publishing House
6. Rathor, V.S. and Rathor B. S. (2013) Management of Natural Resource for Sustainable Development. Daya Publishing House, New Delhi

Discipline Specific Elective Course 6: Industrial and Environmental Microbiology

L	T	P	Cr
3	0	2	5

Learning outcomes:

At the end of the course the students will be able to:

1. Understand the concept and role of microbes in industry and environment.
2. Critically analyze the types of bioreactors and the fermentation process.
3. Evaluate the role of microorganisms in industry and microbes in agriculture.
4. Reflect upon different Landscaping practices and garden design
5. Develop skills on the remediation process of contaminated soils

Keywords:

Trickling filters, Biofilm, bioreactors, fermenter, PGPR, Biocontrol

Unit I: Scope & Use of Fermentation and Bioreactor Technology 10 lectures

An introduction to fermentation process; History, scope, range, equipment, kinetics of growth and product formation. Solid-state and liquid-state (stationary and submerged) fermentations; Batch, Fed-batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilot-scale and production fermenters; constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter. Isolation, preservation and improvement of industrially important microorganisms, Media for Industrial Process, Sterilization, Development of inoculums for industrial process, aeration.

Unit II: Microbial Production of Industrial Products and Important Enzymes

10 lectures

Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol), antibiotic (Penicillin), vinegar and microbial cells.

Unit III: Micro-Organisms for Fermentation 10 lectures

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

Unit IV: Microbes and Role in Environment for Agriculture and Remediation of Contaminated Soils. 15 lectures

Microbiology of air (Aeromicrobiology), nature of bioaerosol, launching and control of bioaerosol, Aeromicrobiology of building, hospital and waste deposition site, aeroallergens,

pollen allergy, Soil surface and sub-surface soil microbiology, distribution of microbes in air; Isolation of microorganisms from soil, air and water, biogeochemical cycle (nitrogen). Aquatic microbiology-Freshwater, brackish water, estuaries and marine. Water pollution, role of microbes in sewage and domestic waste water treatment systems. Secondary treatment of waste water, Activated sludge, Microorganisms as indicators of water quality, coliform and fecal coliform in water samples. Determination of BOD, COD, TDS and TOC of water samples. Biological N_2-fixation; Phosphate solubilization, plant growth promoting rhizobacteria (PGPR), Mycorrhizae; Bioremediation of contaminated soils, arbuscular mycorrhizal colonization in plant roots *Rhizobium* –legume symbiosis, Biocontrol.

Practical

1. Principles and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.
3. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.
4. More Practical may be added depending on the local habitats and available facilities

Suggested Readings

1. Pelzar, M.J. Jr., Chen E.C. S. and Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R. and Case, C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.
3. Casia, J.R.L.E (2009) Industrial Microbiology. New Age International (P) Ltd. Publisher, New Delhi
4. Stanbury, P. F., Whitaker, A. and Hall, S.J. (1979). Principles of Fermentation Technology. Aditya Books (P) Ltd., New Delhi.
5. Atlas and Bartha (2000). Microbial Ecology. Benjamin Cummings.

Discipline Specific Elective Course 7: Aquatic Botany

L	T	P	Cr
3	0	2	5

Learning outcomes:

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

- Develop their understanding on commonly occurring marine and limnetic algae of Indian coasts along with the current understanding of its biology
- Analyze the properties of mangroves, other aquatic angiosperms and microalgae
- Reflect upon the values and uses of aquatic plants

Keywords:

Seaweeds, Dinoflagellate, Mangroves, Limnology, Estuarine Flora, Carbon capture and sequestration, biofuel

Unit I: Marine and Limnetic Macro Algae — 12 lectures

Common seaweeds of Indian subcontinent: *Ulva, Cladophora, Caulerpa, Gracillaria, Sargassum* etc. Life cycle, ecology and species identification features. Common terrestrial algae including cyanobacteria and lichen photobionts of Indian subcontinent and its lifecycle, ecology and taxonomy: *Chlorella, Scenedesmus, Trebouxia, Trentepohlia*

Unit II: Mangroves — 11 lectures

Famous mangrove forests of India including Sundarbans, Pichavaram, Kerala Mangroves, Rathnagiri mangroves. Common species of mangroves and mangrove associated plants, including *Avicennia, Rhizophora, Laguncularia, Sonneria, Acanthus and Aegiceras*. Lifecycle of mangrove selected species. Ecological significance of mangroves.

Unit III: Phytoplanktons, Cyanobacteria, Dinoflagellates and Diatoms — 10 lectures

Common marine microalgae of India including phytoplanktons and picoplanktons, Common diatoms and dinoflagellates of Indian Ocean, Common limnetic and terrestrial cyanobacteria of India.

Unit IV: Aquatic Angiosperms, Values and Uses of Aquatic Plants — 12 lectures

Common aquatic angiosperms of India including Lotus, water lilly, Water hyacinth and so on. Ecology, life cycle, taxonomy and economic importance of aquatic angiosperms. Values and uses of aquatic plants: Economic importance of aquatic plants, Ecosystem services of aquatic plants including biogeochemical cycles, oxygen production and carbon sequestration, biodiesel and so on, seaweed-based industries in India and abroad, edible seaweed and algal resources of India, aesthetic, cultural, spiritual importance of aquatic plants.

Practical

1. Visit to nearby lentic ecosystem (pond/lake), collection and identification of aquatic plants by morphology and microscopy
2. Visit to nearby lotic ecosystem (river, streams), collection and identification of aquatic plants by morphology and microscopy

3. Collection of diatoms from soils and muddy streams and its photomicroscopy.
4. Scanning Electron Microscopy of diatoms and/or demonstration of SEM images
5. Collection and microscopic observation of phytoplanktons and cyanobacteria
6. More Practical may be added depending on the local habitats and available facilities

Suggested Readings

1. Lee, R.E. (2008). Phycology. 4th edition. Cambridge University Press, Cambridge.
2. Wile, J.M, Sherwood, L.M. and Woolverton, C.J. (2013). Prescott's Microbiology. 9th Edition. McGrawHill International.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi
4. Hoek, C. Van, D. (1999) An Introduction to Phycology. Cambridge University Press.

Discipline Specific Elective Course 8: Bioinformatics

L	T	P	C
3	0	2	5

Learning outcomes:

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

Understand the concept of databases and use of different public domain for DNA and proteins sequence retrieval.
Understand the concept of pairwise alignment of DNA sequences using algorithms.
Explain the structure of proteins homology modeling approach using SWISS MODEL and SWISS-PDB.
Reflect upon the role of various models in molecular evolution.
Analyze the role of (QSAR) techniques in Drug Design.

Keywords:

BLAST, FASTA, UPGMA, Parsimony, Bayesian Inference, Phylogeny, QSR

Unit I

10 lectures

Introduction to bioinformatics, over view and exploring and querying (search and retrieval) available bioinformatics resources NCBI, PUBMED, EBI, EMBL, gene bank etc.

Unit II

12 lectures

Pair wise alignment of protein and DNA sequences using algorithm software to deduce homology nd interpretation of data. Database searches for homology using BLAST and FASTA and interpretation of the results to derive biological significance of the queried DNA/protein sequences.

Unit III

13 lectures

Prediction of structure of proteins by homology modeling approach using SWISSMODEL and SWISS-PDB. Models of molecular Evolution, Selection of best-fitting models, Methods of Phylogeny reconstruction: Phenetic vs. Cladistic, Neighbor Joining, UPGMA, Maximum Parsimony, Maximum Likelihood, Bayesian Inference, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

Unit IV

10 lectures

Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

Practical

(Every topic can have multiple practical, a few for general guidance is given below)

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.
6. Comparative analysis of different databases in metabolomics

7. More Practical may be added depending on the local habitats and available facilities

Suggested Readings

1. Arthur M. Lesk. (2003). Introduction to Bioinformatics, Oxford University Press, Indian edition.
2. Des Higgins and Willie Taylor. (2000). Bioinformatics, Sequence, structure and databanks. A practical approach. Oxford University Press, Indian edition, Second impression, New Delhi.
3. Imtiaz Alam Khan. (2005). Elementary bioinformatics. Pharma Book Syndicate , Hyderabad.
4. Irfan Ali Khan and Attiya Khanum (eds.). (2005). Basic concepts of Bioinformatics, Ukaaz Publications, Hyderabad.
5. Irfan Ali Khan and Attiya Khanum (eds.). (2004). Introductory Bioinformatics. Ukaaz Publications, Hyderabad.
6. Krane Dan, E. and Raymer M.L. (2004). Fundamental concepts of Bioinformatics. Pearson education. New Delhi. Second Indian reprint.
7. Rastogi, S.C., Mendiratta, N. and Rastogi. P. (2004). Bioinformatics, methods and applications, genomics, proteomics and drug discovery, Prentice hall of India, pvt. Ltd., New Delhi.
8. Baxevanis, A. D. and Ouellette, B. F. F. (2002). Bioinformatics: A Practical Guide to the analysis of Genes and Proteins. (2nd Ed.), New York, John Wiley & Sons, Inc. Publications.
9. Attwood, T. K. and Parry-Smith, D. J. (2001). Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Pvt. Ltd.

Discipline Specific Elective Course 9: Elements of Plant Breeding

L	T	P	Cr
3	0	2	5

Learning outcomes:

On completion of this course students will be able to:

- Develop conceptual understanding of plant genetic resources, plant breeding, gene bank and gene pool.
- Familiarize with genetic basis of heterosis.
- Classify Sexual and Asexual modes of reproduction.
- Explain monogenic and polygenic inheritance
- Reflect upon the role of various non- conventional methods used in crop improvement.

Keywords:

Nobilization, Self-incompatibility, Gene Pool, Inbreeding depression, Heterosis, Epistasis, Polyploidy

Unit I: Nature and Scope of Plant Breeding 12 lectures Introduction and objectives of Plant Breeding, Indeotype Concept, Major International and National Plant Breeding Institutes / Centers, Some reputed Indian and International Plant Breeders, Significant achievements of plant breeding (Semi-dwarf wheat and rice, Nobilization of Indian Canes, Hybrid Millets, Hybrid Cotton, Disease resistance and Transgenic varieties), Undesirable consequences of Plant Breeding (Genetic erosion, Narrow Genetic base, Increased susceptibility to minor diseases). Crop Genetic Resources and Centres of Diversity, Exploration and Collection, Origin and domestication of major crop plants; Basics of Gene Banks, Gene Pool: Primary, Secondary and Tertiary Gene Pools.

Unit II: Methods of Crop Improvement 12 lectures Reproduction, Pollination and Mating Systems: Mitosis and Meiosis, Modes of Reproduction (vegetative, asexual, apomixes, sexual), Pollination and mating systems, Self- Incompatibility: Homo- and hetero-morphic systems, Mechanism of self-incompatibility and its overcoming and utilization in plant breeding; Male Sterility: Genetic, Cytoplasmic and Cytoplasmic Genetic male sterility, Chemically induced male sterility, its utilization and limitations; Methods of Plant Breeding: Introduction, Acclimatization; Domestication; Selection methods for : Self-pollinated, Cross-pollinated and vegetative and clonal propagation; Hybridization: For self, cross and vegetatively propagated plants – Basics of Procedure, advantages and limitations; Procedure for Release of varieties and IPR rights.

Unit III: Quantitative Inheritance, Heterosis and Inbreeding Depression 10 lectures

Concept of quantitative characters: Monogenic vs polygenic Inheritance; Multiple factor hypothesis, polygenic inheritance and continuous variation, Components of genetic variance: different types of gene actions, heritability; Examples of inheritance of Kernel colour in wheat, Skin colour in human beings. **Heterosis and Inbreeding depression:** History, Genetic basis of Heterosis and Inbreeding Depression (Dominance, Over-dominance and Epistasis hypothesis); Application of Heterosis

Unit IV: Non-conventional Methods in Crop improvement and Biotechnology

11 lectures

Mutations: Spontaneous and Induced Mutations; Artificial Induction of Mutations, Role of mutations in Plant breeding; **Polyploidy:** Autopolyploidy and Allopolyploidy and their role in Evolution and crop improvement, **Induction of Polyploidy**, Applications and limitations of polyploidy in crop improvement. **Distant hybridization**: Objectives of interspecific hybridization, Bariers to interspecific hybridization, Cytological and genetic basis of hybrid sterility, Zygote formation and embryo rescue in distant hybrids; Applications and limitations of distant hybridization (for alien addition and transfer of small chromosome fragments, realization of interspecfic and amphiploid hybrids, synthetic crops such as Triticale, realization of haploidy e.g. barley and wheat by chromosome elimination method. **Biotechnology in crop improvement**: Scope and importance of Biotechnology in India; Cell, Tissue and Organ Culture, Elements of Somatic Hybridization; Molecular markers; Transgenics – scope and limitations; Bt-Cotton.

Practical

1. Methods of emasculation (Wheat, Barley, Mustard, Pigeon pea, Cotton)
2. Pollen viability test
3. Seed viability test
4. Effect of radiation and chemical mutagens on seed germination, seedling growth and cell division (mitotic index).
5. More Practical may be added depending on the local habitats and available facilities

Suggested Readings

1. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH. 2nd edition.
2. Das, L.D. Vijendra (2006) Plant Breeding. New Age International Publishers, New Delhi.
3. Sharma, J.R.(1994) : Principles and practices of Plant Breeding. Tata McGraw-Hill Publishing Company Ltd. , New Delhi
4. Singh, B.D. (2012). Plant Breeding: Principles and Methods. Kalyani Publishers. 9th edition.
6. Singh, Phundan (1996): Essentials of Plant Breeding. Kalyani Publishers, New Delhi-2.

Discipline Specific Elective Course 10: Bio-Analytical Techniques

L	T	P	Cr
3	0	2	5

Learning outcomes:

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

- Develop conceptual understanding of cell wall degradation enzymes and cell fractionation.
- Classify different types of chromatography techniques.
- Explain the principles of Light microscopy, compound microscopy, Fluorescence microscopy and confocal microscopy
- Apply suitable strategies in data collections and disseminating research findings.

Keywords:

HPLC, Fluorochrome, AGE, PAGE, FACS, SEM, TEM

Unit I: Cellular Fractionation and Separation Techniques 10 lectures Good laboratory practices, Cell fractionation, Cell wall degradation enzymes, Sedimentation of cellular particles, Mobility of particles under external centrifugal forces, type of centrifugation: Differential and density gradient centrifugation, type of rotors, analytical centrifugation for estimation of mass of biological molecules, Svedberg equation, ultracentrifugation and applications

Unit II: Characterization of Biomolecules 13 lectures

Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion- exchange chromatography; Molecular sieve chromatography; Affinity chromatography. Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE

Unit III: Visualization Molecules in Living Cells 12 lectures Principles of microscopy; Light microscopy; compound microscopy, Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching. Use in biological research, auto-radiography, pulse chase experiment.

Unit IV: Data Collection, Processing and Analysis 10 lectures Data collection methods, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

Practical

1. To separate nitrogenous bases by paper chromatography.
2. To separate sugars by thin layer chromatography.

3. Isolation of chloroplasts by differential centrifugation.
4. To separate chloroplast pigments by column chromatography.
5. To estimate protein concentration through Lowry's methods.
6. To separate proteins using PAGE.
7. To separation DNA (marker) using AGE.
8. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
9. Demonstration of ELISA.
10. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
11. Preparation of permanent slides (double staining).
12. More Practical may be added depending on the local habitats and available facilities

Suggested Readings

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

GENERIC ELECTIVE COURSES

These are 11 courses, out of which the **students are to select any 4 courses** by Honours **students.** These courses have the following **credit pattern.**

L	T	P	Cr
3	0	2	5

Generic Elective Course 1: Food Science

L	T	P	Cr
3	0	2	5

Learning outcomes:

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

1. Classify the proteins, lipids and Minerals in food chemistry
2. Recognize Sources of microorganisms and food borne illness
3. Evaluate the food Processing industries and preservation techniques
4. Comprehend the interrelationships among different components of beverages technology and Check Food Packaging
5. Assess food laws and quality control at international standards
6. Classify into harmful and beneficial bio-colors, flavors, vitamins, bio-preservatives, antibiotics and industrial alcohol

Keywords:

Food chemistry, Food microbiology, Food toxins, Food safety, Quality control, Nutrition, Genetically modified foods

Unit I

7 lectures

Food Chemistry: Sources and Classification of Carbohydrates, proteins, lipids and Minerals.Participation in metabolic pathways.

Unit II

8 lectures

Food Microbiology: Sources of microorganisms in food, Principles of food spoilage, Food borne illness. Food Processing: Dairy industry, Fruit processing, meat industry, processing and preservation. Beverages technology: Coffee, beer and wine etc.

Unit III

8 lectures

Nutrition, Nutraceuticals and functional foods: Classification and characteristics of functional foods. Processing technology and incorporation. Food Toxins: Natural, microbial and chemical toxins in food processing. Food Packaging: Aseptic and Packaging of specific foods, fruits, vegetables, dairy products, cereals snacks etc.

Unit IV

7 lectures

Food laws and quality control: Food safety and standard act (2006) and other Indian and International standards. Food Biotechnology: Biotechnology in food industry, production of biocolours, flavours, vitamins, biopreservatives, antibiotics and industrial alcohol. Genetically modified foods.

Practical

1. Non thermal and thermal methods of food preservations
2. Meat and Poultry processing technology
3. Post-harvest technology at small scale

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4. Food drying
5. Fermentation technology
6. Project work
7. Industrial visit
8. Fruit and vegetables processing
9. Determination of
   a. Moisture of food samples
   b. Protein
   c. ash
   d. Fat
   e. Sugars- reducing and non-reducing

Suggested readings

1. Damodaran, S., Parkin, K.L. and Owen, R. (2008). Fennema's Food Chemistry . CRC Press.
2. Chopra, H. K. and Panesar, P.S. (2010). Food Chemistry. Narosa Publishing (2010).
3. Pelczar, M.J. and Michael, J. (1999). Microbiology. McGraw-Hill.
4. Jay, J.M. (2005). Modern Food Microbiology (7th edition) by Golden Food Science Text Series.
5. Frazier, W.C. and Westhoff, D.C. (2015). Food Microbiology (5th edition) Mcgraw-Hill.
6. Kumari, S. (2012). Basics of Food Biochemistry and Microbiology. Koros Press.
7. Whitaker. J.R. (2016). Handbook of Food Enzymology. CRC press
8. Shewfelt, R.L.(2013). Introducing Food Science. CRC Press.
9. Smith, J.S. and Hui, Y.H.(2014) Food Processing. Wiley.
10. Varzakas, T. and Tzia, C. (2016). Handbook of Food Processing. CRC Press.
11. Potter, N. N.(2007). Food Science. CBS Publishers.

Generic Elective Course 2: Community Forestry

L	T	P	C
3	0	2	5

Learning outcomes:

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

1. Understand community forestry and its conservation
2. Examine the use of trees and community forestry
3. Interpret the role of indigenous/ tribal people in conservation of forest
4. Examine the role of various community forestry conservation programs
5. Measure the different properties of trees such as wood volume, age, height, volume etc.

Keywords:

Community forestrty, Commercial forestry, Conservation, Land uses, Timber harvesting

Unit I — 8 lectures

Defining community forestry and conservation, Indigenous community-based forestry systems and their changes, Case studies of indigenous forest management systems: India. , History of commercial forestry in India, Diseases of commercial forestry, maintenance of forests, Protection form fire, illicit felling, Measurement of Trees- Height, girth, wood density, wood quality, clear and selective felling.

Unit II — 8 lectures

Role of community forestry in Environmental conservation, Water shed management, soil management and poverty reduction, Trees as a forest management tool: managing vegetation to modify climate, soil conditions & ecological processes, Social considerations on land-uses.

Unit III — 7 lectures

State-sponsored community forestry and conservation programs, Changing paradigms in forestry and environmental conservation, Community- managed commercial timber harvesting.

Unit IV — 7 lectures

Community-based forestry and collaborative conservation in India, factors contributing to the rise of community forestry, Role of tribes in Forest and management.

Practical

1. Methods of measurement of wood volume of standing trees and logs, wood density, specific gravity, yield, and non woody products.
2. Protection of woody and non woody plants from fire and pathogens.
3. Measurement of Trees using different methods
   i. Total Height
   ii. Bole Height
   iii. dbh
   iv. Volume (with and w/o bark) of standing trees

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v. Age
- Properties of wood: density
- Counting of number of trees through various methods
- Statistical analysis of the data

Suggested Reading

1. Agrawal, A and C.C. Gibson. (2001). Introduction: The Role of Community in Natural Resource Conservation. In: Agrawal, A and C.C. Gibson (eds). Communities and the Environment. NJ: Rutgers University Press
2. Mosse, D. (2001). 'People's knowledge', participation and patronage: operations and representations in rural development. In: Cook, B & Kothari, U (eds). Participation the new tyranny? Zed Press
3. Ong, C.K. & Huxley, P.K. (1996). Tree Crop Interactions – A Physiological Approach. ICRAF.
4. Robinson, D. (2018). The Economic Theory of Community Forestry (Routledge Explorations in Environmental Economics) Routledge.
5. Sagreiya, K.P. (1979). Forests and Forestry. National Book Trust, India, New Delhi, P1-307.

Generic Elective Course 3: Seed Technology

L	T	P	Cr
3	0	2	5

Learning outcomes:

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

1. Understand the theoretical orientation of seed development
2. Analyse the different ways of seed processing in different plants
3. Examine the various methods of Seed testing
4. Understand the method of seed production in different plants
5. Explain the concept of hybrid seed production

Keywords:

Seed development, Seed morphology, Seed dormancy, Seed testing, Seed entomology, Seed storage and Viability

Unit I — 8 lectures

Theory of seed development and morphology, Principles of seed production in agricultural crops, seed production in vegetables, fruits, flowers, forage and fodder crops. Seed Dormancy-possible reasons and methods of breaking of dormancy.

Unit II — 8 lectures

Concept of seed processing, diversity in seed storage and viability issues, Methods of testing of seed viability. Behaviour of seed germination and concept of speed of germination/seed vigour, design of experiments for evaluation of seed related traits

Unit III — 7 lectures

Methods used for seed testing, ISTA (International Seed Testing Association) Rules procedure of seed certification and quality control, basis outlines of seed pathology and seed entomology.

Unit IV — 7 lectures

Economics of seed production and marketing, seed production in medicinal and aromatic plants, Concept of hybrid seed and production

Practical:

1. Seed viability testing
2. Seed moisture analysis
3. Seed priming for breaking seed dormancy
4. Seed constituents analysis
5. Seed germination studies ; monocots , dicots
6. Synthetic seed development

Suggested Readings

1. Agrawal, P. K., (2010).Principles of Seed Technology. Indian Council of Agricultural Research, New Delhi.
2. Agrawal, R.L. (2015). Seed Technology. Oxford & Ibh Publishing Co Pvt Ltd.
3. Basra, A. (2006). Handbook of Seed Science and Technology. CRC Press.
4. Khare, D. and Bhale, M. S. (2014). Seed Technology 2nd Revision, Jain Book Agency.
5. International Rules for Seed Testing, 2018 (Free online)

Generic Elective Course 4: Industrial Microbiology

L	T	P	Cr
3	0	2	5

Learning outcomes:

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

- Understand concepts of industrial microbiology
- Apply the usage of microorganisms in industry
- Measure the growth of microorganisms
- Analyze the use of microbes in industries such as dairy and medicines
- Explain the concept of fermentation
- Understand the use of patent with respect to industrial microbiology

Keywords:

Industrial microorganisms, Culture collection, Strain maintenance, Growth curves, Fermentation, Sterilization

Unit I

7 lectures

Fundamentals of Industrial microbiology: Definition, history and scope, Desirable characteristics and selection of industrial microorganisms, Isolation of suitable industrial microorganism form natural habitat. Culture collection Centers, Strain improvement and maintenance.

Unit II

8 lectures

Definition of growth, mathematical nature and expression of growth, Generation time, growth curves in bacteria. Measurement of growth (cell number, cell mass and cell constituent. Effect of environment on the microbial growth (temp. pH and others), Fermented dairy products (yoghurt, butter milk and cheese fermentation, baking product (bread), fermented beverages (beer, wine and ethanol), Single cell protein, probiotics and prebiotics; Recombinant protein, Enzymes (amylase), organic acid (citric acid), antibiotic (penicillin).

Unit III

8 lectures

Fermentation and fermenter, Concept of fermentation and discovery of fermentation. Fermentation system, Fermentor design, Scale up study, metabolic control of product formation. Batch, Fed-batch and Continuous fermentation, solid and liquid state fermentation, Down-stream processes, fermentation economics: market potential, fermentation and product recovery cost.

Unit IV

7 lectures

Patent and secret processes: concept of patent, composition and characteristics of patent; protection of right. Media for fermentation, sterilization, development of inoculums, aeration.

Practical:

1. Largely based on Theory contents

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2. Visit to some nearby Fermentor, Malt or wine industry
3. Practice of cleaning and disinfecting of the glassware/plasticware
4. Use of laminar flow
5. Measurement of Microbial growth
6. Preparation of wine from grapes
7. Preparation of different culture media
8. Measurement of growth - cell number, cell mass and cell constituent
9. Study impact of environmental conditions on microbial growth.

Suggested Readings

1. Casida, L. E. J. R. (2016). Industrial Microbiology. New Age International Publisher.
2. Sivakumaar, P.K. (2010). An Introduction to Industrial Microbiology. S Chand publishing.
3. Waites, M.J., Morgan, N.L., Rockey, Higton G. (2001). Industrial Microbiology: An Introduction. Blackwell Science.
4. Okafor, N., Benedict, C. and Okeke. (2017). Modern Industrial Microbiology and Biotechnology. Taylor & Francis.

Generic Elective Course 5: Plant-Microbes Interaction

L	T	P	Cr
3	0	2	5

Learning outcomes:

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

- Analyse the interactions between plants and pathogenic fungi, bacteria and viruses
- Understand the interaction between plant and non-pathogenic symbiotic bacteria/fungi.
- Illustrate the defense reactions of the host plant
- Explain the concept of plant immunity

Keywords:

Beneficial microbes, Plant pathogens, Plant diseases, Plant immunity, Virulence and disease resistance

Unit I **7 lectures**

Overview of plant microbes interactions, Introduction, beneficial microbes, Rhizobium bacterium and nitrogen fixation, mycorrhizal fungi.

Unit II **8 lectures**

Plant pathogens, *Agrobacterium tumefaciens* and crown gall disease, mechanisms of plant disease mechanism, some bacterial plant diseases, Plant viruses and mechanism of plant against viruses attacks.

Unit III **7 lectures**

Fungal pathogen- mechanism of plant disease, Oomycete pathogens, Fungal mediated plant.

Unit IV **8 lectures**

General concept of plant immunity, PAMP-triggered immunity (PTI) and effectors-triggered immunity (ETI). Transcription activator like effector and their role in virulence and disease resistance.

Practical:

1. Largely based on Theory contents
2. Isolation identification and handling of Rhizobium and mycorrhiza
3. Visit to some nearby forests to identify crown-galls, identify the causal organism
4. Practice of cleaning and disinfecting of the glassware/plasticware
5. Use of laminar flow
6. Measurement of Microbial growth
7. Preparation media for studying bacterial growth
8. Preparation of different culture media
9. Measurement of growth - cell number, cell mass and cell constituent
10. Study impact of environmental conditions on microbial growth

Suggested Readings

1. Lugtenberg, B. (2015). Principles of Plant-Microbes Interactions: Microbes for sustainable

Agriculture, Springer.
2. Stacey, G. and Keen, N. T. (1997). Plant-Microbes Interactions, Vol 4, . Springer.
3. Ramasamy, K. (2015). Plant Microbes Interactions, New India Publishing Agency.
4. Martin, F. and Kamoun, S. (2014). Effectors in Plant-Microbes Interactions 1st Edition, Wiley Blackwell.

Generic Elective Course 6: Global Climate change

L	T	P	C
3	0	2	5

Learning outcomes:

After completing this course the learner will be able to;

- Develop understanding on the concept and issues of global environmental change
- Analyse the causes and effects of depletion of stratospheric ozone layer
- Examine the climate change and its effect on living beings
- Understand the physical basis of natural green gashouse effect on man and materials
- Evaluate human influenced driver of our climate system and its applications

Keywords:

Climate change, Ozone depletion, UV-B, Greenhouse effects, Atmospheric depositions, Eutrophication

Unit I 5 lectures

Global Environmental change issues.

Unit II 9 lectures

Stratospheric ozone layer: Evolution of ozone layer; Causes of depletion and consequences; Effects of enhanced UV-B on plants, microbes, animals, human health and materials; Global efforts for mitigation ozone layer depletion.

Unit III 8 lectures

Climate change: Greenhouse effects; causes; Greenhouse gases and their sources; Consequences on climate, oceans, agriculture, natural vegetation and humans; International efforts on climate change issues.

Unit IV 8 lectures

Atmospheric deposition: Past and present scenario; Causes and consequences of excessive atmospheric deposition of nutrients and trace elements; Eutrophication; Acid rain and its effects on plants, animals, microbes and ecosystems.

Practical:

There are no structured class lab experiments involved. However the students are expected to visit various sites on the web, make teams for group-discussion indulge in debates, collect justifiable information from various sources, make historical report on the science, impact, future and politics behind climate change.

Suggested Readings:

1. Adger, N. Brown, K. and Conway, D. (2012). Global Environmental Change: Understanding the Human Dimensions. The National Academic Press.
2. Turekian. K. K. (1996). Global Environmental Change-Past, Present, and Future.

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Prentice-Hall.

3. Matthew. R. A. (2009). Jon Barnett, Bryan McDonald. Global Environmental Change and Human Security . MIT Press., USA.
4. Hester, R.E. and Harrison, R.M. (2002). Global Environmental Change. Royal Society of Chemistry.

Generic Elective Course 7: Plant Diversity and Human Welfare

L	T	P	Cr
3	0	2	5

Learning outcomes:

After the completion of this course, the learner will be able to:

- Develop understanding of the concept and scope of plant biodiversity
- Identify the causes and implications of loss of biodiversity
- Apply skills to manage plant biodiversity
- Utilize various strategies for the conservation of biodiversity
- Conceptualize the role of plants in human welfare with special reference to India

Keywords:

Biodiversity, Biodiversity loss, Hot spots, Biodiversity management, Conservation strategies, Biodiversity awareness programmes

Unit I: Plant Diversity and its Scope — 7 lectures

Levels of biodiversity: Genetic, Species and Ecosystem; Agrobiodiversity and cultivated plant taxa and related wild taxa. Values and uses of Biodiversity, Methodologies for valuation, Ethical and aesthetic values, Uses of plants; Ecosystem services.

Unit II: Loss of Biodiversity — 7 lectures

Loss of biodiversity- causes and implications, Hot spots of biodiversity, extinction of species, projected scenario for biodiversity loss.

Unit III: Management of Plant Biodiversity — 7 lectures

Organizations associated with biodiversity management, IUCN, UNEP, WWF, UNESCO, NBPGR; Methodology for execution; Biodiversity legislation; Information management and communication.

Unit IV: Conservation of Biodiversity, Role of Plants in Relation to Human Welfare — 9 lectures

Conservation of genetic, species and ecosystem diversity, *In situ* and *ex situ* conservation strategies, India's biodiversity and its conservation Social approaches to conservation, Biodiversity awareness programmes, Sustainable development. Importance of forestry their utilization and commercial aspects; Avenue trees; Ornamental plants of India; Alcoholic beverages; Fruits and nuts; Wood and its uses; their commercial importance.

Practical

1. Visit any unattended area with natural vegetation
2. Use Quadrat method to evaluate the minimum size of the quadrat required for vegetation study
3. Find out the minimum number of quadrats need for analyzing the vegetation structure in the study area
4. Find out the alpha-diversity of plants in the area

Suggested Readings

1. Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity - Principles and Practices.Oxford and IBH Publications Co. Pvt. Ltd. New Delhi
2. Singh, J.S., Singh, S.P. and Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
3. Reddy, K.V. and Veeraiah, S. (2010). Biodiversity and Plant Resources. Aavishkar publication, New Delhi.
4. Heywood, V. H. and Watson, R. T. (1995). Global biodiversity and Assessment. Cambridge University Press.

Generic Elective Course 8: Environmental Protection

L	T	P	C
3	0	2	5

Learning outcomes:

After completing this course the learner will be able to

- Evaluate the utility of international legislations and policies for environmental protection.
- Critically analyze the public participation for environmental protection

Keywords:

Environmental protection, Environment conservation, Environmental policies, Environmental movements, Environmental awareness, Environmental ethics

Unit I: International and National Legislations, Policies for Environmental Protection 8 lectures

Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report(1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Basel Convention (1989), Kyoto Protocol- 1997, Ramsar Convention 1971.

Unit II: Environment Conservation Related Laws in India: 8 lectures

Salient features of Wild life protection act 1972, Water Pollution (Prevention and Control) Act-1974, Forest conservation act 1980, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy -2006, Central and State Pollution Control Boards: Constitution and power.

Unit III: Public Participation for Environmental Protection 7 lectures

Environmental movement and people's participation with special references to Gandhamardan, Chilika and Narmada BachaoAndolan, Chipko and Silent valley Movement;

Unit IV 7 lectures Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society. WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics.

Practical

1. Water/Soil analysis - DO, salinity, pH, chloride, total hardness, alkalinity, acidity, nitrate, calcium, Magnesium and phosphorus.
2. Gravimetric analysis-Total solid, dissolved solid, suspended solid in an effluent
3. Microbial assessment of air (open plate and air sample) and water

Suggested Readings

1. Waste engineering - treatment, disposal and reuse, Metcalf and Eddy Inc., Tata McGraw Hill, New Delhi.
2. De, A. K. (1994). Environmental Chemistry. Wiley Eastern Ltd, 3rd Edition, New Delhi.

3. Allsopp, D., Seal, K. J., and Gaylarde, C. (2004). Introduction to Biodeterioration, ELBS / Edward Arnold. Cambridge University Press, UK
4. Banker, K. H. and Herson, D. S. (1994). Bioremidation. Mc.GrawHill Inc, New York.
5. Ahmed, N., Qureshi, F. M. and Khan, O. Y. (2001). Industrial and Environmental Biotechnology. Horizon Scientific Press, England
6. Rochelle, P. A. (2001). Environmental Molecular Microbiology. pp. 125–40. Norfolk, England: Horizon Scientific Press.
7. Jadhav, H.V. and Bhosale, V.M. (2006) Environmental Protection and Laws. V. M. Himalaya publishing House.
8. Maier, R. M. et al. (2009). Environmental Microbiology. 2nd edition, Academic Press Elsevier, Calefornia, USA
9. Atlas, R. M. and Bartha, R. (1997). Microbial Ecology. 4 edition TBS Publisher.
10. Maier, R. M. (2000). Environmental Microbiology. Elsevier, San Diego, California
11. Pepper, I. and Gerba, C. P. (2004). Environmental Microbiology (2nd Edition). Academic Press.

Generic Elective Course 9: Environmental Toxicity

L	T	P	Cr
3	0	2	5

Learning outcomes

After completing this course the learner will be able to;

- Develop conceptual understanding on organic and inorganic compounds
- Analyse the ecological considerations of xenobiotics in the environment
- Examine the role of enzymes in the treatment of toxic compound

Keywords:

Toxic chemicals, Bioaccumulation, Biomagnification, Heavy metals, Bioassays, Health standards, Ecotoxicology

Unit 1:

7 Lectures

Introduction to Toxicology Definitions, Classification, Origin and General Nature of Toxicants in Environment, concepts; Toxic chemicals in the environment - air, water & their effects; Basic Probit analysis; Toxicants – Toxicity, mechanism of toxicity, dose effect, Dose response relationship; determination of toxicity of chemicals.

Unit 2 :

7 Lectures Toxic

Mechanisms, Bioaccumulation and Biomagnification of toxic materials in food chain, detoxification, bioconcentration; Toxicology of major pesticides and heavy metals (Aluminium, arsenic, cadmium, chromium, lead and mercury) - biotransformation, biomonitoring, residual effects; bioindicator– definition, groups and examples.

Unit 3:

8 Lectures

Bioassays, Concepts, types, characteristics and significance of bioassay; Bioassay test models and classification - Microbiol, algal, invertebrates and alternative toxicity tests; Immunotoxicity, histotoxicity, cell toxicity. Ecotoxicology – Legislative perspectives.

Unit 4:

8 Lectures

Occupational Health, Occupational hazards in industries and other sectors, Safety requirements and Measures; Occupationally induced illness, non-occupational illness, Occupational diseases, occupational health practice; risk assessment techniques for accidental release of toxic and inflammable materials; Role of WHO in occupational health. Occupational health Standards - ISO.

Practical:

1. Practical's are largely based on the instrumentation demonstration used for toxicants analysis.
2. Study of TSPM, PM10 and PM2.5 in ambient air.
3. Determination of SO2, NOx, Cl2 and O3 using UV-Vis Spectrophotometry.
4. Determining IC50, LD50 etc. of toxicants like heavy metals, pesticides etc.
5. Sampling and analysis of Metal ion in soil, water and food samples using ICPMS.
6. Bioassays for taxicant analysis

Suggested Readings

Head
Department of Botany

1. Tarlya, R. R. (2013) Elements of industrial hazards: Health, safety, environment and loss prevention Taylor and Francis
2. Theodore, Louis (2012) Environmental health and hazard risk assessment: Principles and calculations, CRC Press
3. Wong, Ming H. (Ed.) (2013) Environmental contamination: Health risks and ecological restoration, CRC press
4. Ware, George M.(Ed) (2007) Reviews of environmental contamination and toxicology. Vol. 190: Continuation of residue reviews, Springer Publishers
5. Manahan, Stanley E. (2013) Fundamentals of environmental and toxicological chemistry: Sustainable sciences, CRC press

Generic Elective Course 10: Environmental Microbiology

L	T	P	Cr
3	0	2	5

Learning outcomes:

On the completion of the course the students shall be able to:

1. Develop understanding on the microbiology diversity, processes and applications in the environment.
2. Analyze the contribution of microbiology area of science in water treatment, solid waste management, bioremediation and phytoremediation.
3. Evaluate the implications of mass cultivation, inoculums preparation, quality control, and vermicomposting
4. Apply the skills for environmental protection

Keywords:

Microbial communities, Culturable microorganisms, Water microbiology, Aeromicrobiology, Biogeochemical cycling, Vermicomposting

Unit I

7 lectures

Introduction to environmental microbiology; History and scope, cultivation of microbial communities, importance and significance of community culture. Methods for detection of community cultures, culturable microorganisms, phylogenetic and molecular profiling of microbes in the environment

Unit II

8 lectures

Water microbiology: waste water treatment, method, aerobic and anaerobic processes, solid waste management, landfills, containment types, composting and applications; Bioremediation and phytoremediation, bio-filters, microbial polymers, microbial plastics, Bioaccumulation, Biomagnification, marine pollution, concepts and remediation strategies.

Unit III

8 lectures

Aeromicrobiology: Aerosols and Bioaerosols: Sources and Launching, Diversity and Survival of microbes in air, control, Intramural and extramural aero-microbiology, Aeroallergens, Pollen allergy, Hypersensitivity, effect of climate change on pollen and spore discharge. aquatic microbiology: aquatic environment; fresh water, brackish and marine and their microbiology, hydrothermal vents, hot spring, Arctic and Antarctic environment. Soil Microbiology: Soil formation, microbiology of surface and subsurface soil, sampling of soil and deep subsurface soil, rhizospheric and agricultural soil. Environmentally stressed soil.

Unit IV

7 lectures

Biogeochemical cycling: carbon and Nitrogen, Importance. Biofertilizers: Definition, types, mass cultivation, inoculums preparation, quality control, significance and applications, Vermicomposting.

Practical:

1. Largely based on Theory contents
2. Isolation identification and handling of soil microbiota
3. Visit to some nearby forests collect soil and isolate microbes
4. Practice of cleaning and disinfecting of the glassware/plasticware
5. Use of laminar flow
6. Learn the technique of vermiculture and vermicomposting of garden/kitchen waste.
7. Measurement of soil Microbial growth
8. Preparation media for studying bacterial growth
9. Preparation of Biofertilizer
10. Measurement of growth - cell number, cell mass and cell constituent
11. Study impact of environmental conditions on microbial growth.

Suggested Readings

1. Sharma. P.D. (2005). Environmental Microbiology. Alpha Science International Ltd. ISBN. 1842652761
2. Bertrand, J. C., Caumette, P., Laboron, R., Matheron, R., Normand, P., Sime-Ngando. (2015). Environmental Microbiology: Fundamental and Applications of Microbial Ecology. Editor: Springer
3. Pepper, Ian., Gerba, C. and Gentry, T. (2014). Environmental Microbiology Academic Press.
4. Pradipta, K. and Mohapatra, I.K. (2008). Textbook of Environmental Microbiology. I. K. International Pvt. Ltd.

Generic Elective Course 11: Algal Biotechnology

L	T	P	Cr
2	0	2	4

Learning outcomes:

On completion of this course, the students will be able to;

- Understand core concepts and fundamentals of various levels of algal growth
- Translate various algal technologies for benefit of ecosystem
- Demonstrate algal growth in different types of natural water.
- Analyze emerging areas of Algal Biotechnology for identifying commercial potentials of algal products & their uses.

Keywords:

Culture techniques, Algal growth, Algal blooms, Eutrophication, Algal immobilization, Biofertilizers, Pollution indicators

Unit I — 7 lectures

A brief account of culture techniques and media for algal research. Measurement of algal growth: lag phase, log phase, stationary phase and death phase using biomass, chlorophyll content.

Unit II — 7 lectures

Limits to algal growth in natural waters. Dynamics and consequences of marine & freshwater algal blooms; Causative factors for eutrophication and its impact on algal blooms.

Unit III — 7 lectures

Algal immobilization: methods and applications, Algal technologies for the restoration/ maintenance of soil fertility; reclamation of usar soils. Restoration of degraded aquatic systems through algae; High rate algal ponds for the treatment of wastewaters for the production of useful biomass & fuels.

Unit IV — 9 lectures

Emerging areas of Algal Biotechnology: Single cell proteins, bio-fertilizers, Algae as food, medicine, feed, Biofuel, industrial products such as phyco-colloid (Agar-agar, Algin, Carrageenan, Diatomite); A brief account of commercial potentials of algal products & their uses. Algae as indicators of pollution. Biofouling, Sewage disposal. Waste-land reclamation. Use of Algae in experimental studies. Algae in space. Algal toxins.

Practical

1. Preparation of growth culture medium for algae (freshwater and marine).
2. Culture of algae and measurement of growth curve of microalgae using biomass and chlorophyll.
3. Isolation, inoculation and growth of microalgae.
4. Extraction and separation of photosynthetic pigments or non photosynthetic pigments like mycosporine/scytonema etc. from algae.
5. Effect of Mineral nutrient (N, P) on growth (Eutrophication).
6. More Practical may be added depending on the local habitats and available facilities

Suggested Readings

1. Hoek, C. and Van D. (2009) Algae: An Introduction to Phycology. Cambridge University Press
2. Bast, F. (2014). An Illustrated Review on Cultivation and Life History of Agronomically Important Seaplants. In Seaweed: Mineral Composition, Nutritional and Antioxidant Benefits and Agricultural Uses, Eds. Vitor Hugo Pomin, 39-70. Nova Publishers, New York ISBN: 978-1-63117-571-8
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. Bast, F. (2014). Seaweeds: Ancestors of land plants with rich diversity. Resonance, 19(2) 1032-1043 ISSN: 0971-8044

ABILITY ENHANCEMENT COURSES

These are 6 courses, out of which the students are to select any 5 courses for B.Sc. (Honors).

These courses have the following credit pattern.

L	T	P	Cr
2	0	0	2

Ability Enhancement Course 1: Mushroom Culture Technology

L	T	P	Cr
2	0	0	2

Learning outcomes:

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

- Recall various types and categories of mushrooms.
- Demonstrate various types of mushroom cultivating technologies.
- Examine various types of food technologies associated with mushroom industry.
- Value the economic factors associated with mushroom cultivation
- Device new methods and strategies to contribute to mushroom production.

Keywords:

Edible mushrooms, Poisonous mushrooms, Cutivation technology, Mushroom bed, Mushroom unit, Storage and Nutrition

Unit I

7 lectures

Introduction, History. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India - *Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus.*

Unit II

9 lectures

Cultivation Technology : Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparations of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation- Low cost technology; Composting technology in mushroom production.

Unit III

7 lectures

Storage and nutrition: Short-term storage (Refrigeration – up to 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.

Unit IV

7 lectures

Food Preparation: Types of foods prepared from mushroom. Research Centres - National level and Regional level. Cost benefit ratio - Marketing in India and abroad, Export Value.

Suggested Readings

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

Ability Enhancement Course 2: Medicinal Botany

L	T	P	Cr
2	0	0	2

Learning outcomes:

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

- Recognize the basic medicinal plants
- Apply techniques of conservation and propagation of medicinal plants.
- Setup process of harvesting, drying and storage of medicinal herbs
- Propose new strategies to enhance growth of medicinal herbs considering the practical issues pertinent to India

Keywords:

Medicinal plants, Traditional systems, endangered medicinal plants, Ethnobotany, Folk medicines, Ethnic communities

Unit I: History and Traditional Systems of Medicine — 8 lectures

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

Unit II: Conservation and Augmentation — 7 lectures

Conservation of Endemic and endangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacred groves, National Parks; Ex situ conservation: Botanic Gardens, Ethnomedicinal plant Gardens. Propagation of Medicinal Plants: Objectives of the nursery, its classification, important components of a nursery, sowing, pricking, use of green house for nursery production, propagation through cuttings, layering, grafting and budding.

Unit III: Ethnobotany and Folk Medicine — 7 lectures

Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India.

Unit IV — 8 lectures

Brief description of selected plants and derived drugs, namely Guggul (*Commiphora*) for hypercholesterolemia, *Boswellia* for inflammatory disorders, Arjuna (*Terminalia arjuna*) for cardioprotection, turmeric (*Curcuma longa*) for wound healing, antioxidant and anticancer properties, Kutaki (*Picrorhiza kurroa*) for hepatoprotection, Opium Poppy for analgesic and antitussive, Salix for analgesic, Cincona and Artemisia for Malaria, Rauwolfia as tranquilizer, Belladona as anticholinergic, Digitalis as cardiotonic, Podophyllum as antitumor.

Practical

Demonstration and practice of cultural practices for seed / vegetative / clonally propagated medicinal plants (Mentha arvensis, Satavar, Artemisia, Aloe vera, Stevia, Ashwagandha).

1. Harvesting, drying, storage (Stevia, Kalmegh and Satavar)
2. Harvesting and distillation of Mints, Basil
3. Extraction of alkaloids / Withanaloids (Belladona, Ashwagandha)
4. Aditional Practical may be added depending on the local habitats and available facilities

Suggested Readings

1. Akerele, O., Heywood, V. and Synge, H. (1991). The Conservation of Medicinal Plants. Cambridge University Press.
2. AYUSH (www.indianmedicine.nic.in). *About the systems—An overview of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy.* New Delhi: Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry and Family Welfare, Government of India.
3. CSIR- Central Institute of Medicinal and Aromatic Plants, Lucknow (2016). *Aush Gyanyur.* Handbook of Medicinal and Aromatic Plant Cultivation.
4. Dev, S. (1997). Ethnotherapeutics and modern drug development: The potential of Ayurveda. *Current Science* 73:909-928.
5. Evans, W.C. (2009). Trease and Evans Pharmacognosy, 16th edn. Philadelphia, PA: Elsevier Saunders Ltd.
6. Jain, S.K. and Jain, Vartika. (eds.) (2017). Methods and Approaches in Ethnobotany: Concepts, Practices and Prospects. Deep Publications, Delhi
7. Kapoor, L. D. (2001). *Handbook of Ayurvedic medicinal plants.* Boca Raton, FL: CRC Press.
8. Saroya, A.S. (2017). Ethnobotany. ICAR publication.
9. Sharma, R. (2003). Medicinal Plants of India-An Encyclopaedia. Delhi: Daya Publishing House.
10. Sharma, R. (2013) Agro Techniques of Medicinal Plants. Daya Publishing House, Delhi.
11. Thakur, R. S., H. S. Puri, and Husain, A. (1989). *Major medicinal plants of India.* Central Institute of Medicinal and Aromatic Plants, Lucknow, India.

Ability Enhancement Course 3: Plants in Traditional Systems of Medicine

L	T	P	C r
2	0	0	2

Learning outcomes:

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

- Conceptualize ethnobotany as an interdisciplinary science
- Restate the established methodology of ethnobotany studies
- Categories various indigenous ethnic groups and their environmental practices.
- Understand the legalities associated with ethnobotany.

Keywords:

Ethnobotany, Ethnic groups, Ethnobotanical sources, Biopiracy, Endangered taxa

Unit I: Ethnobotany

7 lectures

Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils and miscellaneous uses.

Unit II: Methodology of Ethnobotanical Studies

7 lectures

a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.

Unit III: Role of Ethnobotany in Modern Medicine

9 lectures

Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadiractha indica* b) *Ocimum sanctum* c) *Vitex negundo*. d) *Gloriosa superba* e) *Tribulus terrestris* f) *Pongamia pinnata* g) *Cassia auriculata* h) *Indigofera tinctoria*. Role of ethnobotany in modern medicine with special example *Rauvolfia sepentina, Trichopus zeylanicus, Artemisia, Withania*. Role of ethnic groups in conservation of plant genetic resources.Endangered taxa and forest management (participatory forest management).

Unit IV: Ethnobotany and Legal Aspects

7 lectures

Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.

Practical

1. Visit to the field and botanical garden in the nearby area and attempt to identify the plants
2. Attempt be made to grow the ethnobotanical plants
3. Visit the villages and rural areas to consult some senior people to discuss the traditional medicines being used since ages.

4. Prepare a list of plants that provide parts for traditional uses and construct a chart or check-list in terms of botanical significance, chemical constituent, medicinal use, and major industries available in India and the world; Economical-value strength.

Suggested Readings

1. Jain, S.K. (1995). Manual of Ethnobotany, Scientific Publishers, Jodhpur.
2. Jain, S.K. (1981). Glimpses of Indian Ethnobotany, Oxford and I B H, New Delhi.
3. Jain, S.K. (1989). Methods and approaches in ethnobotany. Society of ethnobotanists, Lucknow, India.
4. Jain, S.K. (1990). Contributions of Indian ethnobotny. Scientific publishers, Jodhpur.
5. Colton, C.M. (1997). Ethnobotany – Principles and applications. John Wiley and sons.
6. Rama, R, N and Henry, A.N. (1996). The Ethnobotany of Eastern Ghats in Andhra Pradesh, India.Botanical Survey of India. Howrah.
7. Sinha, R. K. (1996). Ethnobotany; The Renaissance of Traditional Herbal Medicine – INA – SHREE Publishers, Jaipur.
8. Faulks, P.J. (1958).An introduction to Ethnobotany, Moredale pub. Ltd.

Ability Enhancement Course 4: Good Laboratory Practices in Plant Sciences

L	T	P	Cr
2	0	0	2

Learning outcomes

After completing this course, the learner will be able to:

- Apply practical skills in science courses with the understanding of general laboratory practices
- Use various micro techniques used in botany
- Apply various techniques to study plant tissues
- Explore various research issues and their solutions

Keywords:

Laboratory calculations, Staining procedures, Reactive dyes, Tissue preparation, Fixatives

Unit I: General Laboratory Practices 8 lectures/Practical Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Preparation of solutions. Molarity and normality of common acids and bases. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

Unit II: Plant Micro-Techniques 7 lectures/Practical Staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and fluoro-chromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials.

Unit III: Methods to Study Plant Cell/Tissue Structure

8 lectures/Practical

Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning; Tissue preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non- coagulant fixatives; tissue dehydration using graded solvent series; Paraffin and plastic infiltration; Preparation of thin and ultrathin sections.

Unit IV: Overview of Biological Problems 7 lectures/Practical History; Key relevant problems associated in plant biology research areas, their solution and basic understanding of plant research Model.

Suggested Readings

1. Seiler, J.P. (2005). Good Laboratory Practices: the why and how. Springer-Verlag Berlin and Heidelberg GmbH & Co. K; 2nd Ed.
2. Garner, W.Y., Barge M.S., Ussary. P.J. (1992). Good Laboratory Practice Standards: Application for field and Laboratory studies. Wiley VCH.

Ability Enhancement Course 5: Intellectual Property Rights

L	T	P	Cr
2	0	0	2

Learning outcomes

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

- Understand the concept of IPR
- Differentiate between various agreements of IPR
- Compare copyrights, patents and Geographical Indicators
- Examine various legal issues related to IPR
- Relate to various cyber issues concerning IPR

Keywords:

Copyright act, IPR and WTO, Patents, Bioprospecting, Biopiracy, Database

Unit I: Introduction to Intellectual Property Right (IPR) — 7 lectures

Copyright Act and IPR, Economic importance. IPR in India and world: Genesis and scope, some important examples. IPR and WTO (TRIPS, WIPO). Objectives, Rights, Patent Act 1970 and its amendments.

Unit II: Patents, Copyrights and Trademarks — 7 lectures

Procedure of obtaining patents, working of patents. Infringement of patents, Copyrights: work protected under copyright laws, Rights, Transfer of Copyright, and Infringement. Trademarks: Objectives of trademarks, Types, Rights, Protection of goodwill, Infringement, Passing off, Defenses, Domain name.

Unit III: Protection of Traditional Knowledge, Industrial Designs and Plant Varieties — 7 lectures

Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bioprospecting and Bio-piracy. Alternative ways, Protectability, need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Plant varieties protection in India. Rights of farmers, National gene bank; Benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit IV: Information Technology Related I P R — 7 lectures

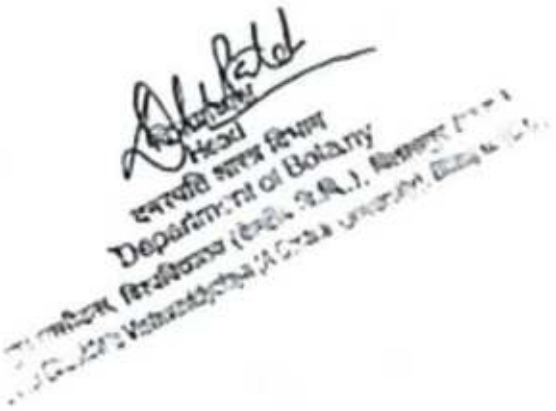
Computer Software and Intellectual Property, Database and Data Protection, Protection of Semiconductor chips, Domain Name Protection. Patenting Biotech Inventions: Objective, Applications, Concept of Novelty; Concept of inventive step, Microorganisms, and Moral Issues in Patenting Biotechnological inventions.

Practical:

There are no experimental lab based Practical. However, the students are expected to prepare some project report based on the Success stories of Traditional Patents secured by India. Likewise, prepare a database for Indian products wherein is issue is still under consideration of the competent authorities. Prepare the dos and don'ts on Patents for Botanists

Suggested Readings

1. Gopalakrishnan, N.S. and Agitha, T.G. (2009). Principles of Intellectual Property Eastern Book Company, Lucknow.
2. David Kitchin Q.C., Llewelyn, D., Mellor, J., Meade, R., Thomas Moody-Stuart, and D. Keeling, Jacob, R. (2005). Kerly's Law of Trade Marks and Trade Names (14th Edition) Thomson, Sweet & Maxweel.
3. Parulekar, A. and D' Souza, S. (2006). Indian Patents Law – Legal & Business Implications; Macmillan India Ltd.
4. Wadehra, B.L. (2000). Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India.
5. Narayanan, P. (2010). Law of Copyright and Industrial Designs; Eastern law House, Delhi.



Ability Enhancement Course 6: History of Indian Science

L	T	P	Cr
2	0	0	2

Learning outcomes

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

- Develop understanding of various branches of science during different eras
- Analyze the role played by different Indian organizations in science
- Appraise the contribution of different Indian Scientists in science

Keywords:

Astronomy, Ancient India, Colonial India, Mordern India, Agricultural techniques, Green revolution

Unit I: Science in Ancient and Medieval India 8 lectures

History of development in astronomy, mathematics, engineering and medicine subjects in Ancient India, Use of copper, bronze and iron in Ancient India, The geography in literature of Ancient India. Influence of the Islamic world and Europe on developments in the fields of mathematics, chemistry, astronomy and medicine, innovations in the field of agriculture-new crop introduced new techniques of irrigation.

Unit II: Indian Science in before and after Independence 7 lectures

Introduction of different surveyors, botanists and doctors as early scientist in Colonial India, Indian perception and adoption for new scientific knowledge in Modern India, Establishment of premier research organizations like CSIR, DRDO and ICAR and ICMR, Establishment of Atomic Energy Commission, Launching of the space satellites, Botanical survey of India.

Unit III: Prominent Indian scientists 8 lectures

Eminent scholars in mathematics and astronomy: Baudhayana, Aryabhtatta, Brahmgupta, Bhaskaracharya, Varahamihira, and Nagarjuna, Medical science of Ancient India (Ayurveda and Yoga): Susruta, Charak. Scientists of Modern India: Srinivas Ramanujan, C.V. Raman, Jagdish Chandra Bose, Homi Jehangir Bhabha and Vikram Sarabhai.

Unit IV: Prominent research in Plant Sciences in Republic of India

7 lectures

History of plant tissue culture from India, Green revolution in India: causes, details, and outcomes. First gene cloning in plants, First genome sequencing from India. Premier Plant Research institutes and scientists in India, GM Mustard. Allelopathy Plant research in India

Practical:

There are no experimental lab based Practical. However, the students are expected to prepare some term paper reports on the Life and works of some noted Indian Scientists especially the Botanists. Likewise, students need to prepare and organize some discussion on the ancient and medieval science in India and trace the reasons of inadequate visibility in the world. Prepare term papers on GM Crops, the controversies and procedure for approval. Prepare term papers on the significance of Allelopathic research from India

Suggested Readings

1. Kuppuram, G. (1990). History of Science and Technology in India, South Asia Books.
2. Handa, O.C. (2014) Reflections on the history of Indian Science and Technology, Pentagon Press.
3. Basu, A. (2006). Chemical Science in Colonial India: The Science in Social History, K.P. Bagchi & Co.
4. Habib, I. (2016.). A people's history of India 20: Technology in Medieval India, 5th Edition, Tulika Books.
5. Rahman, A. (1982). Science and Technology in Medieval India – A Bibliography of Source Materials in Sanskrit, Arabic and Persian, New Delhi: Indian National Science Academy.
6. Subbarayappa, B.V. and Sarma, K.V. (1985). Indian Astronomy – A Source Book, Bombay.
7. Srinivasan, S. and Ranganathan, S. (2013). Minerals and Metals heritage of India, National Institute of Advanced Studies.
8. Srinivasiengar, C. N. (1967). The History of Ancient Indian Mathematics, World Press Private Ltd. Calcutta.
9. Bhardwaj, H. C. (2000). Metallurgy in Indian Archaeology. Tara Book Agency.

SKILL ENHANCEMENT COURSES

(Practical based)

These are 7 courses, out of which the students are to select any 2 courses in B.Sc. Botany (Honors). These courses have the following credit pattern.

L	T	P	Cr
2	0	0	2

Skill Enhancement Course 1: Botanical Garden and landscaping

L	T	P	Cr
2	0	0	2

Learning outcomes:

After the completion of this course the learner will be able to:

- Apply the basic principles and components of gardening
- Conceptualize flower arrangement and bio-aesthetic planning
- Design various types of gardens according to the culture and art of bonsai
- Distinguish between formal, informal and free style gardens
- Establish and maintain special types of gardens for outdoor and indoor landscaping;

Keywords:

Gardening, Landscaping, Flower arrangement, Vertical gardens, Roof gardens, Computer aided designing

Unit I **8 lectures**

Principles of gardening, garden components, adornments, lawn making, methods of designing; rockery, water garden, etc. Special types of gardens, their walk-paths, bridges, constructed features. Greenhouse. Special types of gardens, trees, their design, values in landscaping, propagation, planting shrubs and herbaceous perennials. Importance, design values, propagation, plating, climbers and creepers, palms, ferns, grasses and cacti succulents.

Unit II **7 lectures**

Flower arrangement: importance, production details and cultural operations, constraints, post-harvest practices. Bioaesthetic planning, definition, need, round country planning, urban planning and planting avenues, schools, villages, beautifying railway stations, dam sites, hydroelectric stations, colonies, river banks, planting material for play grounds.

Unit III **8lectures**

Vertical gardens, roof gardens. Culture of bonsai, art of making bonsai. Parks and public gardens. Landscape designs, Styles of garden, formal, informal and free style gardens, types of gardens, Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporate.

Unit IV **7 lectures**

Establishment and maintenance, special types of gardens, Bio-aesthetic planning, eco- tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping; Computer Aided Designing (CAD) for outdoor and indoorscaping Exposure to CAD (Computer Aided Designing)

Practical

1. Field trips: Field visit to any Botanical Garden, Identify the trees shrubs and other herbaceous vegetation,
2. Prepare beds for growing nursery for herbs, shrubs and trees.
3. Count the number of types of animals, birds, and insects in the garden

4. Identification of pathogenic and non-pathogenic diseases of garden plants and grasses
5. More Practical may be added depending on the local habitats and available facilities
6. Try to grow herbs hydroponically

Suggested Readings

1. Berry, F. and Kress, J. (1991). Heliconia: An Identification Guide . Smithsonian Books.
2. Butts, E. and Stenson, K. (2012).Sheridan Nurseries : One hundred years of People,Plans, and Plants. Dundurn Group Ltd.
3. Russell, T. (2012). Nature Guide: Trees: The world in your hands (Nature Guides).

Skill Enhancement Course 2: Agriculture and Food Microbiology

L	T	P	C
2	0	0	2

Learning outcomes:

After completing this course the learner will be able to;

- Develop understanding of the significance of intrinsic and extrinsic factors on growth of micro-organism
- Identify ways to control microbial spoilage of foods
- Analyze the practices involved in Food Microbiology

Keywords:

Symbiotic bacteria, Free living bacteria, Cyanobacteria, Biofertilizers, Food poisoning, Food intoxication, Fermented foods.

Unit I: Role of Microorganisms in Agriculture

8 lectures

Role of symbiotic and free-living bacteria and cyanobacteria in agriculture., Mycorrhiza, Plant Growth Promoting Microorganisms (PGPM) and Phosphate Solubilizing Microorganisms (PSM).

Unit II: Biocontrol and Biofertilization

8 lectures

Biocontrol of plant pathogens, pests and weeds, Restoration of waste and degraded lands,Biofertilizers: Types, technology for their production and application, vermi–compost.

Unit III: Food Microbiology-I

7 lectures

Intrinsic and extrinsic factors influencing growth of microorganisms in food, Microbes as source of food: Mushrooms, single cell protein.

Unit IV: Food Microbiology-II

7 lectures

Microbial spoilage of food and food products: Cereals, vegetables, pickles, fish and dairy products. Food poisoning and food intoxication. Food preservation processes. Microbes and fermented foods: Butter, cheese and bakery products.

Suggested readings

1. Adams, M.R. and Moss M. O. (2008). Food Microbiology, 3rd Edition, Royal Society of Chemistry, Cambridge, U.K.
2. Sylvia D.M. (2004). Principles and Applications of Soil Microbiology, 2nd Edition, Prentice Hall, USA.
3. W.C. Frazier (1995). Food Microbiology, 4th Edition, Tata McGraw Hill Education, Noida, India.
4. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction. 1st Edition, Blackwell Science, London, UK.
5. Pelczar M.J., Chan E.C.S. and Krieg N.R. (2003). Microbiology. 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi.
6. N. S. Subba Rao. (2000). Soil microbiology. 4th Edition, Oxford and IBH publishing Co. Pvt. Ltd., Calcutta, New Delhi, India.
7. Rangaswami, G. and Bagyaraj, D.J. (2006) Agricultural Microbiology. 2nd Unit 2nd Edition, PHI Learning, New Delhi, India.

Skill Enhancement Course 3: Biofertilizers

L	T	P	Cr
2	0	0	2

Learning outcomes:

On the completion of this course, the students will be able to;

1. Develop their understanding on the concept of bio-fertilizer
2. Identify the different forms of biofertilizers and their uses
3. Compose the Green manuring and organic fertilizers
4. Develop the integrated management for better crop production by using both nitrogenous and phosphate bio fertilizers and vesicular arbuscular mycorrhizal (VAM).
5. Interpret and explain the components, patterns, and processes of bacteria for growth in crop production

Keywords:

Useful microbes, Cyanobacteria, Mycorrhiza, Organic farming, Recycling, Vermicompost

Unit I — 9 lectures

General account about the microbes used as biofertilizer — Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis. *Azospirillum:* isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. *Azotobacter:* classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication.

Unit II — 7 lectures

Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

Unit III — 7 lectures

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Unit IV — 7 lectures

Organic farming – Green manuring and organic fertilizers – Recycling of bio-degradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.

Suggested Readings

1. Dubey, R.C. (2005). A Text book of Biotechnology S.Chand & Co, New Delhi.
2. John Jothi Prakash, E. (2004). Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
3. Kumaresan, V.(2005). Biotechnology, Saras Publications, New Delhi.

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Department of Botany

4. NIIR Board. (2012). The complete **Technology** Book on Biofertilizer and organic farming. 2nd Edition. NIIR Project **Consultancy** Services.
5. **Sathe, T.V. (2004)** Vermiculture **and Organic** Farming. **Daya publishers.**
6. **Subba Rao N.S.** (2017). Biofertilizers **in Agriculture and Forestry**. Fourth Edition. **Medtech.**
7. **Vayas,S.C, Vayas, S. and Modi, H.A. (1998). Bio-fertilizers and organic Farming Akta Prakashan, Nadiad**

Skill Enhancement Course 4: Herbal Technology

L	T	P	Cr
2	0	0	2

Learning outcomes:

On completion of this course the students will be able to;

- Develop their understanding on Herbal Technology
- Define and describe the principle of cultivation of herbal products.
- List the major herbs, their botanical name and chemical constituents.
- Evaluate the drug adulteration through the biological testing
- Formulate the value added processing / storage / quality control for the better use of herbal medicine
- Develop the skills for cultivation of plants and their value added processing / storage / quality control

Keywords:

Herbal medicines, Plant products, Biopesticides, Pharmacognosy, Adulteration, Secondary metabolites

Unit I 7 lectures

Herbal Technology: Definition and scope; Herbal medicines: history and scope; Traditional systems of medicine, and overview of AYUSH (Traditional Indian Systems of Medicine); Cultivation - harvesting - processing - storage of herbs and herbal products.

Unit II 7 lectures

Value added plant products: Herbs and herbal products recognized in India; Major herbs used as herbal medicines, nutraceuticals, cosmeticals and biopesticides, their Botanical names, plant parts used, major chemical constituents.

Unit III 8 lectures

Pharmacognosy - Systematic position, botany of the plant part used and active principles of the following herbs: Tulsi, Ginger, Curcuma, Fenugreek, Indian Gooseberry, *Catharanthus roseus*, *Withania somnifera*, *Centella asiatica*, *Achyranthes aspera*, Kalmegh, Giloe (Tinospora), Saravar. Herbal foods, future of pharmacognosy.

Unit IV 8 lectures

Analytical pharmacognosy: Morphological and microscopic examination of herbs, Evaluation of drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds). Plant gene banks, Cultivation of Plants and their value added processing / storage / quality control for use in herbal formulations, Introductory knowledge of Tissue culture and Micro propagation of some medicinal plants (*Withania somnifera*, neem and tulsi).

Suggested Readings

1. Agarwal, P., Shashi, Alok., Fatima, A. and Verma, A. (2013). Current scenario of Herbal Technology worldwide: An overview. *Int J Pharm Sci Res*; 4(11): 4105-17.
2. Arber, Agnes. (1999). Herbal Plants and Drugs. Mangal Deep Publications, Jaipur.
3. Varzakas, T., Zakynthinos, G, and Francis Verpoort, F. (2016). Plant Food Residues as a Source of Nutraceuticals and Functional Foods. Foods 5 : 88.
4. Aburjai, T. and Natsheh, F.M. (2003). Plants Used in Cosmetics. Phytotherapy Research 17 :987-1000.
5. Patri, F. and Silano, V. (2002). Plants in cosmetics: Plants and plant preparations used as ingredients for cosmetic products - Volume 1. ISBN 978-92-871-8474-0, pp 218.
6. AYUSH (www.indianmedicine.nic.in). *About the systems—An overview of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy.* New Delhi: Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry and Family Welfare, Government of India.
7. Evans, W.C. (2009): Trease and Evans PHARMACOGNOSY. 16th Edition, SAUNDERS / Elsevier.
8. Sivarajan, V.V. and India, B. (1994). Ayurvedic Drugs and Their Plant Sources.. *Oxford & IBH Publishing Company*, 1994 - Herbs - 570 pages.
9. Miller, L. and Miller, B. (2017). Ayurveda & Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing. *Motilal Banarsidass,; Fourth edition .*
10. Kokate, C.K. (2003). Practical Pharmacognosy. Vallabh Prakashan, Pune.

Skill Enhancement Course 5: Environmental impact analysis

L	T	P	Cr
2	0	0	2

Learning outcomes:

After completing this course the learner will be able to;

- Have critical understanding of environmental impact
- Learn important steps of EIA process
- Interpret the environmental appraisal and procedures in India.

Keywords:

Environmental management, Environmental impact assessment, Project proponent, Consultant, Environmental audit, Risk assessment, Legislation

Unit I: Origin and Development

8 lectures

Purpose and aim, core values and principles, History of EIA development, Environmental Management Plan, Environmental Impact Statement, Scope of EIA in Project planning and Implementation.

Unit II: EIA Process

8 lectures

Components of EIA, EIA Methodology- Screening, Scoping, Baseline data, Impact Identification, Prediction, Evaluation and Mitigation, Appendices and Forms of Application, Techniques of Assessment-Cost-benefit Analysis, Matrices, Checklist, Overlays, Impact on Environmental component: air, noise, water, land, biological, social and environmental factors. EIA Document.

Unit III: Main participants in EIA Process

7 lectures

Role of Project proponent, environmental consultant, PCBs, PCCs, public and IAA. Public participation.

Unit IV: Environmental Appraisal and Procedures in India and EIA

7 lectures

Methodology, indicators and mitigation, Environmental Audit of different environmental resources, Risk Analysis, Strategic environmental assessment, ecological impact assessment: legislation.

Practical

1. Prepare a Matrix of every environmental existing resource of your college or your hostel/mohalla or any defined area and evaluate each component using established methods and make audit analysis
2. Prepare a case report of Environmental impact of any area under development

Suggested readings:

1. Kulkarni, V. and Ramachandra, T.V. (2006). Environmental Management, Capital Pub. Co. New Delhi.

2. Petts, J. (2005). Handbook of Environmental Impact Assessment- Volume 1 and 2. Blackwell Publishers, UK.
3. Glasson, J. Therivel, R. and Chadwick. (2006). A. Introduction to Environmental Impact Assessment. Routledge, London.
4. Canter, W. L. (1995). Environmental Impact Assessment, McGraw-Hill Science/ Engineering/ Math, New York.
5. Morris, P. and Therivel, R. (1995). Methods of Environmental Impact Assessment, UCL Press, London.
6. Petts, J. (1999). Handbook of Environmental Impact Assessment, volume 1 and 2, Blackwell Science, Oxford.
7. Therivel, R. and Partidario, M. R. (1996). The Practice of Strategic Environmental Assessment, Earthscan, London.
8. Vanclay, F. and Bronstein, D. A. (1995). Environmental and Social Impact Assessment, Wiley & Sons, Chichester.

Skill Enhancement Course 6: Floriculture

L	T	P	Cr
2	0	0	2

Learning outcomes:

After completing this course the learner will be able to;

- Develop conceptual understanding of gardening from historical perspective
- Analyze various nursery management practices with routine garden operations.
- Distinguish among the various Ornamental Plants and their cultivation
- Evaluate garden designs of different countries
- Appraise the landscaping of public and commercial places for floriculture.
- Diagnoses the various diseases and uses of pests for ornamental plants.

Keywords:

Gardening, Transplanting, Mulching, Plant growth regulators, Ornamental plants, Commercial floriculture

Unit I

8 lectures

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

Unit II

8 lectures

Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and fern allies; Cultivation of plants in pots; Indoor gardening; Bonsai. Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India.

Unit III

5 lectures

Landscaping, Places of Public Importance: Landscaping highways and Educational institutions.

Unit IV

9 lectures

Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolus, Marigold, Rose, Lilium, Orchids). Diseases and Pests of Ornamental Plants.

Suggested Readings

1. Randhawa, G.S. and Mukhopadhyay, A. (1986). Floriculture in India. Allied Publishers.
2. Adams, C., M. Early and J. Brrok (2011). Principles of Horticulture. Routledge, U.K.

Skill Enhancement Course 7: Forensic Botany

L	T	P	Cr
2	0	0	2

Learning outcomes

After completing this course, the learner will be able to:

- Conceptualize classification of plants from forensic point of view.
- Understand forensic importance of different parts of plants.
- Collect and preserve botanical evidences of crime and analyze classic and DNA based forensic botany cases.

Keywords:

Plant classification, Forensic importance, Poisonous plants, Drugs, Botanical evidences, Sample analysis

Unit I **7 lectures/Practical**

General plant classification schemes, Sub specialization of forensic botany- plant morphology, plant anatomy, plant systematic, palynology, plant ecology, limnology, Plant architecture– roots, stems, flowers, leaves. Practical plant classification schemes: - vegetables and herbs, fruits bearing trees and plants, landscaping plants: trees, shrubs and vines, grasses, plant cell structure and functions.

Unit II **8 lectures/Practical**

Various types of woods, timbers, seeds and leaves and their forensic importance, Identification and matching of various types of wood, timber varieties, seeds and leaves. Types of fibers – forensic aspects of fiber examinations, Identification and comparison of man-made and natural fibres. Various types of Planktons and diatoms and their forensic importance, Study and identification of pollen grains, Identification of starch grains, powder and stains of spices etc. Paper and Paper Pulp identification

Unit III **8 lectures/Practical**

Various types of poisonous plants-*Abrus precatorius*, *Aconitum*, *Anacardium occidentale*, *Argemone Mexicana*, *Calotropis*, *Cannabis sativa*, *Claviceps purpuria*, *Cinchonca*, *Croton tiglium* ,*Atropa belladonna*, *Erythraxylum coco*, *Gloriosa superb*, *Jatropha curcas*, *Lathyrus sativus*, *Manihot utilissima*, *Nerium indicum*, *Nicotiana tabacum*, *Plumbago*, *Ricinus communis*, *Semicarpus anacardium*, *Strychnos nux vomica*, *Thevetia nerifolia*, Types of plants yielding drugs of abuse – opium, cannabis, coco, tobacco, dhatura, *Psilocybin* mushrooms.

Unit IV **7 lectures/Practical**

Collection and preservation of botanical evidences: Botanical samples, outdoor crime scene consideration, Analysis of samples, DNA analysis, plant DNA typing, Classic forensic botany cases: Case histories by using Plant anatomy and systematic, Palynology, Plant ecology, Limnology, Plant Molecular Biology and DNA, Drug enforcement and DNA.