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UNIVERSITY OF DELHI

Bachelor of Science (Hons) Botany

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges, Non Collegiate Women's Education Board and School of Open Learning

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Preamble

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its programmes in the best interest of their students and in this endeavour it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes.

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the programme of their choice. The Under-Graduate Programmes will prepare the students for both, academia and employability.

Each programme vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programmes also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each programme prepares students for sustainability and life-long learning.

The new curriculum of B.Sc. (Hons) Botany offer essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

The University of Delhi hopes the LOCF approach of the B.Sc. (Hons) Botany will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

B.Sc.(HONS.) BOTANY (CBCS)

INTRODUCTION

The B.Sc. - Botany honours programme is designed to equip students with essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

Choice Based Credit System:

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed.

Outline of Choice Based Credit System:

1. Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.
2. Elective Course: Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

2.1 Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
2.2 Dissertation/Project: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.
2.3 Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

3. Ability Enhancement Courses (AEC)/Competency Improvement Courses/Skill Development Courses/Foundation Course: The Ability Enhancement (AE) Courses may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC). "AECC" courses are the courses based upon the content that leads to Knowledge enhancement. They ((i) Environmental Science, (ii) English/MIL Communication) are mandatory for all disciplines. AEEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.

3.1 AE Compulsory Course (AECC): Environmental Science, English Communication/MIL Communication.

3.2 AE Elective Course (AEEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

Project work/Dissertation is considered as a special course involving application of knowledge in solving / analyzing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

LEARNING OUTCOME BASED CURRICULUM FRAMEWORK

Nature and extent of the B.Sc Honours Botany Programme

Content: Botany is the broad discipline encompassing various subjects involved with the study of plants. B.Sc Botany (H) Programme imparts knowledge on various fields of plant biology through teaching, interactions and practical classes. Present trend has been shifted to frontier areas of plant sciences at the cost of traditional botany. There is need to maintain a balance of the traditional botany and modern science and applied approach. This syllabus has been drafted to enable the learners to prepare them for future employment in various fields including academics as well as competitive exams. Students would gain wide knowledge as follow:

1. Diversity of plants and microbes their habitat, morphology, and reproduction.
2. Genetics and molecular biology of plants
3. Fungi and disease causing microbes and fungi
4. Economic value of plants and their use in Biotechnology

Biodiversity generally refers to the variety and variability of life on earth. Earth is a 'green' planet due to the presence of plants. Plants are relevant to humans as they provide us with food, shelter, clothing, energy, health, aesthetic beauty, environment and even economy. This paper is relevant to ALL students. Introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi and to various plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms) and information on the Ecological and Economic Importance of Microbes, Fungi and various plant groups to enable students understand and appreciate relevance of Microbes and Plants to environment and human well-being. Insight into the line of Plant Evolution on Earth and the consequent Biodiversity is instrumental in creating Awareness on the threats to biodiversity and sensitize young minds towards the Biodiversity Conservation for sustainable development. Combination of Theoretical and Practical components will provide comprehensive information and insight into the

1. Fascinating world of Microbes and Plants.
2. Hands on Training will help students learn use of microscope, mounting, section-cutting and staining techniques for the study of plant materials.
3. Making Drawings in Practical Records will enhance understanding morphological and structural details and related functional aspects in diverse plant groups.
4. Use of Illustrations, Photographs, Charts, Permanent Slides, Museum and Herbarium Specimens along with ICT Methods will provide an interesting insight into the beautiful world of microbes and plants.
5. Scope of Biodiversity includes Medicinal field, Industry, Agriculture, Research and Study, Job Opportunities and Environmental Conservation. This paper is both informative and interesting and will enable students to learn about Biodiversity not only as a plant or nature lover, but also for higher academic pursuits, particularly in the field of Biological Sciences, Environment and Biodiversity Conservation.
6. The relationship between the properties of macromolecules, their cellular activities and biological responses.
7. Understanding of Cell metabolism, chemical composition, physiochemical and functional organization of organelles.
8. Contemporary approaches in modern cell and molecular biology.
9. Understand how plant sciences and microbiology is applied in manufacturing of industrial products
10. Know about design of bioreactors, factors affecting growth and production
11. Comprehend the techniques and the underlying principles in upstream and down- stream processing
12. Learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
13. Understand various biogeochemical cycles – Carbon and Nitrogen, and microbes involved.
14. Understand the basic principles of organism and environment interation and application of the same in solving environmental problems – waste water treatment and bioremediation
15. Learn the basic concepts, principles and processes in plant biotechnology.
16. Have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.
17. Use basic biotechnological techniques to explore molecular biology of plants Explain how biotechnology is used to for plant improvement and discuss the biosefty concern and ethical issue of that use.

Aims of Bachelor's degree programme in (CBCS) B.SC.(HONS.) BOTANY

Content: 1. Provide an introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi, including diverse plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms).

2. To enable students to understand and appreciate the relevance of Microbes and Plants to environment (ecological significance) and human well-being (economic importance).

3. Develop an understanding of Evolution of Plant forms and the consequent Biodiversity. These are instrumental in creating awareness on the threats to biodiversity and sensitize students towards the Conservation of Biodiversity for sustainable development.

4. To study the organization of cell, cell organelles and biomolecules (i.e protein, carbohydrate, lipid and nucleic acid) to gain knowledge on the activities in which the diverse macro molecules and microscopic structures inhabiting the cellular world of life are engaged. This will enable the students to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life.

5. To introduce students to application of microbes in Industrial production and Environmental remediation strategies.

6. New knowledge and widening of the knowledge acquired in by handling of classical and modern plant biotechnology processes, including tissue culture for healthy plants, plants with improved characteristics.

7. To explore the natural genetic variation in plants and to understand how diverse factors (at the cellular level) contribute to the expression of genotypes and hence to phenotypic variation.

8. Understanding of biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals (vaccines, antibodies, antibiotics etc.), food industry (transgenic crops with improved qualities (nutraceuticals, industrial enzymes etc.), agriculture (biotic and abiotic stress tolerant plants, disease and pest resistant plants, improved horticultural varieties etc.), ecology (plants role in bioremediation). This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.

9. In the laboratory classes, students will perform some of the techniques currently used to generate information and detect genetic variation.

10. Understanding of plant classification systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various plants groups.

11. Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system and the use of transgenic technologies for basic and applied research in plants.

12. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and in the application of statistics to biological data

13. To provide new information, enhance core competency and discovery/inquiry based learning of learners. A botany graduate would be competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.

14. To make students aware of most basic domain-independent knowledge, including critical thinking and communication.

15. To enable the graduate to prepare for national and International competitive examinations for employment.

GRADUATE ATTRIBUTES IN SUBJECT

Disciplinary knowledge

The B.Sc. - Botany programme enables the students in gaining knowledge and technical skills to study plants in a holistic manner. Students would get training in various disciplines of plant sciences using a combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to basic and advanced knowledge that are currently used in the study of plant life forms, adaptation, evolution, classification, ultrastructure and various processes in the plant system and interaction of plants with other organisms and with the ecosystem. Knowledge of use of plants in biotechnology, their economic value and their social and environmental significance would be gained by the students.

Scientific reasoning

In addition to academic acquaintance and training in the various fields of plant sciences. Students would also get training in application of the subject, critical thinking, reasoning and analytical skills, effective communication, laboratory safety, and sensitivity to environment and sustainable living.

Critical thinking

The course enhance the skill of thinking about the application of the biology

Disciplinary knowledge

The programme also has a strong interdisciplinary component. Emphasis is given on the experimental learning through hands-on laboratory exercises, field trips and assignments. Current thrust areas of teaching provide students with substantial exposure and skills in plant biology.

Critical thinking

Learning of the basic concepts, principles and processes in plant biology and have the ability of explanation of principles and usage of the acquired knowledge in applied botany. An increased understanding of fundamental concepts and their applications of scientific principles is expected in the student. Students will become critical thinker and acquire problem solving capabilities. They are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientific arguments.

Problem solving

The B.Sc.-Botany programme is formed to gain knowledge and technical skills to study plants in a holistic manner. Students would get training in various disciplines of plant sciences using a combination of core and elective papers with significant inter-disciplinary components.

Analytical reasoning

The student would develop a skill to analyze the knowledge of the subject and think in a multi-directional way to solve the problem and to gain benefit in a sustainable manner. They would be able to think about the use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants. The students will be able to demonstrate the knowledge in understanding research and addressing practical problems. Student will learn the 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.

Reflective thinking

The structure and content of the course enables students to reflect on the learning from different courses and integrate the same for a problem solving approach. They would be capable of correlating various concepts applicable to diverse situations and phenomenon.

Multicultural competence

Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.

Lifelong learning

The subject of botany the applied theoretically and practically applied in day today life. The successful students will be able to learn the basic concepts, principles and processes in plant biology. The have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications. Use basic biology techniques to explore molecular biology of plants

Self-directed learning

The programme also has a strong interdisciplinary component. Emphasis is on experiential learning through hands-on laboratory exercises, field trips and assignments. Current thrust areas of teaching provide students with substantial exposure and skills in plant biology.

Communication Skills

The students will develop a confidence on gaining the knowledge and skill after this course and they will be able to effectively communicate their views, present their work and impress the audience. Students are expected to possess a standard of communication skills expected from 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 a wider audience

Research-related skills

This course provides wide interdisciplinary knowledge and stimulates the students to think beyond the course knowledge, apply this knowledge for solving the environmental problems, efficient use of resources by designing novel and innovativeexperiments. . Students are expected to be aware about activities in the natural surroundings to awaken their curiosity. They are expected to design a scientific experiment through statistical hypothesis testing and reasoning.

Cooperation/Team work

The students would learn team work, division of the work and the corporate life of the academics. They are expected to be team players, with productive cooperation involving members from diverse socio-cultural backgrounds.

Information/digital literacy

The students would learn the use of the new technologies used in learning biology, digital platforms for fast transfer of information. Students will acquire digital skills and integrate the fundamental concepts with modern tools.

Moral and ethical awareness/reasoning

Besides the theoretical knowledge, the student is acquainted with moral and ethical duties, an awareness towards the conservation of nature and natural resources. Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses. Learners are expected to be responsible citizen and be aware of moral and ethical duties. They are expected to define their core ethical virtues good enough to distinguish what construes as illegal and criminal under Indian constitution. Learners should know academic and research ethics, Benefit Sharing, Plagiarism, Scientific Misconduct etc.

Leadership readiness/qualities

The vast and deep knowledge of the subject, analytical and scientific reasoning, effective communication and problem solving task develop special qualities in a person to attract and influence the audience, which would be gained after the completion of this course. Students are expected to be familiar with decision making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become responsible citizens and charismatic inspiring leader.

QUALIFICATION DESCRIPTORS

For a graduate student in Botany (Honours) the qualification descriptorsmay include following:

i. To show a systematic, extensive, coherent knowledge and understanding of academic subjects and their applications, including critical understanding of the established theories, principles and concepts of a number of advanced and emerging issues in the field of Botany;

ii. To gain knowledge to produce professionals in the field of plant sciences in research and development, academics (teaching in Schools, Colleges and University), government and public services e.g. conservationist, plant explorer, ecologist, horticulturist, plant biochemist, genetics, nursery manager, molecular biologist, plant pathologist, taxonomist, farming consultant and environmental consultant. Further application of knowledge can enhance productivity of several economically important products. Knowledge of plant sciences is also necessary for the development and management of forests, parks, wastelands and sea wealth

iii. Display skills and ability to use knowledge efficiently in areas related to specializations and current updates in the subject.

iv. Provide knowledge about plants, current research, scholarly and professional literature of advanced learning areas of plant sciences

v. Use knowledge understanding and skills for critical assessment of wide range of ideas and problems in the field of Botany

vi. Communicate the outcomes of studies in the academic field of Botany through print and digital media.

vii. Apply one's knowledge and understanding of Botany to new/unfamiliar contexts and to identify problems and solutions in daily life

viii. Design and apply the knowledge of plant sciences in identifying the problems which can be solved through the use of plants

ix. To think of adopting expertise in plant structure, functions and solve the problems of environment, ecology, sustainable development and enhancing productivity.

x. Concept and significance of sustainable development and use of the plant resources

PROGRAMME LEARNING OUTCOME

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.

1. Understanding of plant classification systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various life-forms. Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.

2. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and the application of statistics to biological data.

STRUCTURE OF B.Sc. HONOURS BOTANY PROGRAMME UNDER CBCS

Part	Year	Semester (July to November)	Semester (January to May)
Part – I	First Year	Semester I	Semester II
Part – II	Second Year	Semester III	Semester IV
Part – III	Third Year	Semester V	Semester VI

COURSE CREDIT SCHEME – CONSOLIDATED

Course	Theory+ Practical	Theory + Tutorial
		***Credits**
I. Core Course		
(14 Papers)	14X4= 56	14X5=70
Core Course Practical / Tutorial*		
(14 Papers)	14X2=28	14X1=14
II. Elective Course		
(8 Papers)		
A.1. Discipline Specific Elective	4X4=16	4X5=20
(4 Papers)		
A.2. Discipline Specific Elective Practical/ Tutorial*	4 X 2=8	4X1=4
(4 Papers)		
B.1. Generic Elective/ Interdisciplinary	4X4=16	4X5=20
(4 Papers)		
B.2. Generic Elective Practical/ Tutorial*	4 X 2=8	4X1=4
(4 Papers)		

 Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester

III. Ability Enhancement Courses		
1. **Ability Enhancement Compulsory**		
(2 Papers of 2 credit each)	2 X 2=4	2 X 2=4
Environmental Science		
English/MIL Communication		
2. **Ability Enhancement Elective** (Skill Based)		
(Minimum 2)	2 X 2=4	2 X 2=4
(2 Papers of 2 credit each)		
Total credit	**140**	**140**

Institute should evolve a system/policy about ECA/ General Interest/Hobby/Sports/NCC/NSS/related courses on its own.

*** wherever there is a practical there will be no tutorial and vice-versa**

Semester wise Distribution of Courses

Semester	Core Course(14)	Ability Enhancement Compulsory Course (AEC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective: (DSE) (4)	Generic Elective: (GE) (4)
I	1.Microbiology and Phycology 2.Biomolecules and Cell Biology	English/MIL Communication/ Environmental Science			GE-1 (Any one) 1.Biodiversity (Microbes, Fungi, Algae, and Archegoniatae) 2.Plant Anatomy and Embryology
II	3. Mycology and Phytopathology 4. Archegoniatae	English/MIL Communication/ Environmental Science			GE-II 3.Plant Ecology and Taxonomy
III	5. Anatomy of Angiosperms 6. Economic Botany 7. Genetics		SEC-I (Any one) 1. Ethnobotany/ 2. Intellectual Property Rights 3.Plant Diversity and Human Welfare 4. Floriculture		GE-III (Any one) 4.Plant Physiology and Metabolism 5.Environmental Biotechnology
IV	8. Molecular Biology 9. Ecology 10.Plant Systematics		SEC-II (Any one) 5. Biofertilizers 6. Medicinal Botany 7. Mushroom Culture and Technology 8. Nursery and Gardening		GE-IV (Any one) 6.Economic Botany and Biotechnology
V	11.Reproductive Biology of Angiosperms 12.Plant Physiology			DSE-I 1.Analytical Techniques in Plant Sciences DSE-II (any one) 2. Biostatistics 3.Natural Resource Management	
VI	13.Plant Metabolism 14.Plant Biotechnology			DSE-III 4.Industrial and Environmental Microbiology DSE-IV (any one) 5.Bioinformatics 6. Plant Breeding	

Course wise assigned credits:

SEMESTER	COURSE OPTED	COURSE: NAME	Credits
I	Ability Enhancement Compulsory Course-I	English /MIL Communications/ Environmental Science	2
	Core Course-I	Microbiology and Phycology	4
	Core Course-I **Practical**	Microbiology and Phycology- Practical	2
	Core Course-II	Biomolecules and Cell Biology	4
	Core Course-II **Practical**	Biomolecules and Cell Biology-Practical	2
	Generic Elective-I	GE-I (Any one) 1.Biodiversity (Microbes, Algae, Fungi and Archegoniates) 2. Plant Anatomy and Embryology	4
	Generic Elective-I **Practical/Tutorial**	GE-I- Practical	2
II	Ability Enhancement Compulsory Course-II	English /MIL Communications/Environmental Science	2
	Core Course-III	Mycology and Phytopathology	4
	Core Course-III **Practical**	Mycology and Phytopathology- Practical	2
	Core Course-IV	Archegoniatae	4
	Core Course-IV Practical	Archegoniatae- Practical	2
	Generic Elective-II	GE-II 3. Plant Ecology and Taxonomy	4
	Generic Elective-II **Practical**	GE-II – Practical	2
III	Core Course-V	Anatomy of Angiosperms	4
	Core Course-V **Practical**	Anatomy of Angiosperms- Practical	2
	Core Course-VI	Economic Botany	4
	Core Course-VI **Practical**	Economic Botany –Practical	2
	Core Course-VII	Genetics	4
	Core Course-VII **Practical**	Genetics-Practical	2
	Skill Enhancement Course-I	SEC-I (Any one) 1. Ethnobotany 2. Intellectual Property Rights	2
	Generic Elective-III	GE-III (Any one) 4. Plant Physiology and Metabolism 5. Environmental Biotechnology	4
	Generic Elective-III **Practical**	GE-III -Practical	2
IV	Core Course-VIII	Molecular Biology	4
	Core Course-VIII **Practical**	Molecular Biology – Practical	2

	Core Course-IX	Ecology	4
	Core Course-IX **Practical**	Ecology – Practical	2
	Core Course-X	Plant Systematics	4
	Core Course-X **Practical**	Plant Systematics- Practical	2
	Skill Enhancement Course- II	SEC-II (Any one) 3. Biofertilizers 4.Medicinal Botany	2
	Generic Elective-IV	GE-IV Economic Botany and Biotechnology	4
	Generic Elective-IV **Practical**	GE-IV - Practical	2
V	Core Course-XI	Reproductive Biology of Angiosperms	4
	Core Course-XI **Practical**	Reproductive Biology of Angiosperms - Practical	2
	Core Course-XII	Plant Physiology	4
	Core Course-XII **Practical**	Plant Physiology- Practical	2
	Discipline Specific Elective-I	DSE-I Analytical Techniques in Plant Science	4
	Discipline Specific Elective-I **Practical**	DSE-I- Practical	2
	Discipline Specific Elective-II	DSE-II Biostatistics	4
	Discipline Specific Elective-II **Practical/Tutorial**	DSE-II – Practical	2
VI	Core Course-XIII	Plant Metabolism	4
	Core Course-XIII Practical/Tutorial	Plant Metabolism- Practical	2
	Core Course-XIV	Plant Biotechnology	4
	Core Course-XIV **Practical/ Tutorial**	Plant Biotechnology- Practical	2
	Discipline Specific Elective-III	DSE-III Industrial and Environmental Microbiology	4
	Discipline Specific Elective-III **Practical**	DSE-III- Practical	2
	Discipline Specific Elective-IV	DSE-IV Bioinformatics	4
	Discipline Specific Elective-IV **Practical/Tutorial**	DSE-IV Bioinformatics- Practical	2
Total			140

COURSES FOR PROGRAMME

Core Courses

1. Microbiology and Phycology
2. Biomolecules and Cell Biology
3. Mycology and Phytopathology
4. Archegoniatae
5. Anatomy of Angiosperms
6. Economic Botany
7. Genetics
8. Molecular Biology
9. Ecology
10. Plant Systematics
11. Reproductive Biology of Angiosperms
12. Plant Physiology
13. Plant Metabolism
14. Plant Biotechnology

Discipline Specific Electives	
Semester-V	DSE-1. Analytical Techniques in Plant Sciences DSE-2. Biostatistics DSE-3. Natural Resource Management
Semester-VI	DSE-4. Industrial and Environmental Microbiology DSE-5. Bioinformatics DSC-6. Plant Breeding
Generic Electives (Four) Offered to the students of other Departments	
Semester –I GE-I	GE-I (Any one) 1. Biodiversity (Microbes, Algae, Fungi and Archegoniatae) 2. Plant Anatomy and Embryology
Semester –II GE-II	GE-II 3. Plant Ecology and Taxonomy
Semester –III GE-III	GE-III (Any one) 4. Plant Physiology and Metabolism 5. Environmental Biotechnology
Semester –IV GE-IV	GE-IV : 6. Economic Botany and Biotechnology
Skill Enhancement Cources: Elective	
Semester-III	(Any One) 1. Ethnobotany 2. Intellectual Property Rights 3. Plant Diversity and Human Welfare 4. Floriculture
Semester-IV	(Any One) 5. Biofertilizers 6. Medicinal Botany 7. Mushroom Culture and Technology 8. Nursery and Gardening
Ability Enhancement Compulsory Course (AEC).	
AEC-1. English/MIL Communication AEC-2. Environmental Science	

COURSE LEARNING OBJECTIVES

The progamme is designed to equip students with essential knowledge and technical skills to study plants and related subjects in a holistic manner. hteh main aim is to train the learners in all areas of plant biology using appropriate combinations of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

COURSE LEARNING OUTCOMES

1. Students will be able to understand and explain different specializations of Botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, cell and molecular biology of plants.

2. Students will be trained in various analytical techniques of plant biology, use of plants as industrial resources or as support system for human livelihood and will be well versed with the use of transgenic technologies for both basic and applied research in plants.

3. Students will be able to identify various life forms of plants, design and execute experiments related to basic studies on evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology. Students are also familiarized with the use of bioinformatics tools and databases and in the application of statistics to biological data.

4 Students will acquire core competency in the subject Botany and in allied subject areas. They will be able to use the evidence based comparative studies approach to explain the evolution of organism and understand the genetic diversity and its significance.

5. The students will be able to explain various physiological and metabolicprocesses unique to plants. They would be able to elaborate on the concepts of gene, genome and the molecular processes of replication, transcription and translation.

6. They will be able to understand adaptation, development and behavior of different forms of life.The students will get an understanding of functioning of ecosystem and tracing the energy pyramids through nutrient flow.

7. Students will be able to demonstrate the experimental techniques and methods in plant sciences and have innovative research ideas. .

COURSE TEACHING-LEARNING PROCESS

The learning experiences gained for cognitive development in every student. The practical exercises help to develop an important aspect of the teaching-learning process. The important relevant teaching and learning processes involved in this course are;

1. Class lectures
2. Seminars
3. Tutorials
4. Group discussions and Workshops
5. Question framing
6. Short answer type questions
7. Long answer type questions
8. Objective type questions
9. Multiple choice questions
10. Statement, reasoning and explanation
11. Project-based learning
12. Field-based learning
13. Practical component and experiments
14. Quizzes
15. Presentations through Posters and power point
16. Internship in industry and research institutional

THEORY:

1. Lesson plan of each week will be prepared before the commencement of the session and followed during the session.
2. The theory topics are covered in lectures with the help of both conventional (chalk board and Charts) and modern (ICT) methods, including animations. .
3. Emphasis is given on interactive class room environment so as to encourage students ask questions/ doubts/ queries for clarification/explanation and discussion.
4. Students are encouraged to refer to reference books in library to inculcate reading habit for better grasp and understanding on the subject.
5. Emphasis is given to illustrations- neat, well-labelled outline and cellular diagrams/ flowcharts for improving creative skills and to substantiate the text content.
6. On completion of theory syllabus, previous years' question papers are discussed so as to apprise students about the general format of semester exam question papers.
7. Assignment (10), Test (10) and Theory Attendance (5) are components of Internal Assessment Scheme for compilation of Internal Assessment Score of each student out of 25 marks.

Practical:

1. Practical plan of each week will be prepared before the commencement of the session and followed during the session.
2. Every practical session begins with instructions, followed by students doing table work for detailed microscopic plant study.

3. Plant study is done using fixed plant materials, museum and herbarium specimens, photographs and permanent slides.
4. The students are instructed about maintaining practical records, which includes comments and diagrams.
5. Students are asked to submit practical records regularly, on a continuous basis, for checking.
6. On completion of practical syllabus, Practical Exam Guidelines are discussed to apprise students about the formant of Practical exam.
7. As part of Continuous Evaluation guidelines, total score for each student is calculated out of 25 marks, taking into consideration
8. Practical Records (10), Practical Test/ Assessment (10) and Practical Attendance (5)

Assessment Methods

A number of appropriate assessment methods of botany will be used to determine the extent to which students demonstrate desired learning outcomes. Involving students in highlighting the salient features/summary a topic through digital media such as Power Point presentationsand animations enhance their communication skill. Making drawings should be compulsory part of practical record books. A continuous assessment method throughout the programme shall inculcate regular reading habit in the students and provide continuous observation learning abilities and challenges of the students'

Following assessment methodology will be adopted:

• Oral and written examinations
• Closed-book and open-book tests,
• Problem-solving exercises,
• Practical assignments and laboratory reports,
• Observation of practical skills,
• Individual and group project reports,
• Seminar and presentations,
• Interactive sessions.
• Evaluation of answer scripts and discussion on the mistakes committed

KEYWORDS

Plant Sciences, Biology, biodiversity, biotechnology, botany, bryophytes, fungi, algae, mocrobes, bacteria, plant pathology, plant reproduction, anatomy, developmental biology, molecular biology, genetics, systematics, taxonomy, plant physiology, biostatistics, bioinformatics, ecology, biochemistry,

CONTENTS OF COURSES OF THE B.Sc. (Hons.) BOTANY PROGRAMME

Microbiology and Phycology
(BHCC1)
Core Course - (CC) Credit:6

Course Objective (2-3)

To gain knowledge of diversity, life forms, life cycles, morphology and importance of micro-organisms (Bacteria and algae).

Course Learning Outcomes

Students would have understanding of the classification, characteristic features, cell structure and growth and reproduction in viruses, bacteria, and various groups of marine and fresh water algae and their ecological and economic importance.

Unit 1

Introduction to microbial world.

Unit 2

Viruses (7 lectures): Discovery, physiochemical and biological characteristics;classification (Baltimore)General structure with special reference to viroids and prions, General account of replication, DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV). Viral diseases

Unit 3

Bacteria (8 lectures): Discovery, general characteristics, types-archaebacteria, eubacteria, wall-less forms(mycoplasma and spheroplasts), Cell structure, nutritional types, Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction), Bacterial diseases

Unit 4

Applied Microbiology (4 lectures): Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, and as causal organisms of plant diseases.
Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

Unit 5

Algae (7 lectures): General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; Methods of reproduction, classification;
Criteria, system of Fritsch, and evolutionary classification of Lee (only up to groups); significant contributions of important phycologists (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P.Iyengar).

Unit 6

Cyanophyta (6 lectures): Ecology and occurrence, range of thallus organization, cell structure, heterocyst,reproduction.economic importance; role in biotechnology. Morphology and life-cycle of *Nostoc*.

Unit 7

Chlorophyta (5 lectures): General characteristics, occurrence, range of thallus organization, cell structure and reproduction.Morphology and life-cycles of *Chlamydomonas, Volvox, Oedogonium, Coleochaete*.Evolutionary significance of *Prochloron*.

Unit 8

Charophyta (2 lectures): General characteristics; occurrence, morphology, cell structure and life-cycle of *Chara*;evolutionary significance.

Unit 9

Xanthophyta (3 lectures): General characteristics; range of thallus organization;Occurrence, morphology and life-cycleof *Vaucheria*.

Unit 10

Phaeophyta (6 lectures): Characteristics, occurrence, range of thallus organization, cell structure and reproduction.Morphology and life-cycles of *Ectocarpus* and *Fucus*.

Unit 11

Rhodophyta (6 lectures): General characteristics, occurrence, range of thallus organization, cell structure and reproduction.Morphology and life-cycle of *Polysiphonia*.

Unit 12:

Applied Phycology (4 lectures): Role of algae in the environment, agriculture, biotechnology and industry.

Practical

Microbiology

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule.
3. Gram staining.

Phycology

4. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas, Volvox, Oedogonium,Coleochaete, Chara, Vaucheria, Ectocarpus, Fucus* and *Polysiphonia, Procholoron* through electron micrographs, temporary preparations and permanent slides

References

1. Kumar, H.D. (1999). *Introductory Phycology*, 2nd edition. New Delhi, Delhi: Affiliated East-West Press. (Chapter 1, 2 for Unit 5; Chapter 3 for Unit 6; Chapter 12 for Unit 8,9; Chapter 10 for Unit 9; Chapter 11 for Unit 10; Chapter 3 for Unit 11; Chapter 14 for Unit 12).
2. Lee, R.E. (2008). *Phycology*, 4th edition. Cambridge, Cambridge: Cambridge University Press, (Chapter 2 for Unit 6; Chapter 4 for Unit 11; Chapter 5 for Unit 8; Chapter 19 for Unit 9; Chapter 21 for Unit 10; Chapter 23 for Unit 12)
3. Pelczar, M.J. (2001). *Microbiology*, 5th edition. New Delhi, Delhi: Tata McGraw-Hill Co. (Chapter 1 for Unit 1;)
4. Talaro, KP, Talaro A. 2006. *Foundations in Microbiology*. New Delhi,Delhi: McGraw-Hill (Chapter 4 for Unit 3; Chapter 6 for Unit 2)

Additional Resources:

1. Campbell, N.A., Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V., Jackson, R.B. (2008). *Biology*, 8th edition. San Francisco, California: Pearson Benjamin Cummings. (Chapter 26,27 for Unit 1-4; Chapter 28 for Unit 5-11;)
2. Prescott, L.M., Harley J.P., Klein D. A. (2005). *Microbiology*, 6th edition. New Delhi, Delhi: McGraw Hill. (Chapter 3,5 for Unit 3; Chapter 6 for Unit 1)
3. Raven, F.H., Evert, R.F., Eichhorn, S.E. (1992). *Biology of Plants*. New York, NY: W.H. Freeman and Company (Chapter 14 for Unit 6; Chapter 16 for Unit 5; Chapter 17 for Unit 7,8,9,10,11)
4. Tortora, G.J., Funke, B.R., Case. C.L. (2007). *Microbiology*. San Francisco, U.S.A: Pearson Benjamin Cummings,. (Chapter 9, 28 for Unit 4;:Chapter 13 for Unit 2).

Teaching Learning Process

Visual media would be used for teaching. Botany Department, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of the subject and they find the subject interesting. College teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.

Teaching Learning Plan
Week 1: Unit 1
Week 2: Unit 2
Week 3: Unit 3
Week 4: Unit 3
Week 5: Unit3
Week 6: Unit 4
Week 7: Unit 5

Week 8: Unit 5
Week 9: Unit 6
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit 7
Week 13: Unit 8
Week 14: Unit 9
Week 15: Unit 10, Unit 11
Week 16: Unit 12

Assessment Methods

1. Making drawings form the temporary preparations as practical record books
2. Involving students in highlighting the salient features of the genera/ groups through digital media such as power point presentations and animations.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
I	Outcome: Introduction to microbial world.	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
II	General structure with special reference to viroids and prions. General account of replication, DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	General characteristics, types- archaebacteria, eubacteria, wall-less forms. (mycoplasma and spheroplasts). Cell structure, nutritional types, Reproduction- vegetative, asexual and recombination	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Economic importance of bacterian and viruses	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Ecology and occurrence, range of	Class room lectures and	Hands on exercises,

	thallus organization, cell structure, heterocyst, reproduction. economic importance; role in biotechnology. Morphology and life-cycle of Nostoc.	Practical demonstration, experiments	PPT, assignments, tests
VII	Morphology and life-cycles of *Chlamydomonas, Volvox, Oedogonium, Coleochaete.* Evolutionary significance of Prochloron.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	General characteristics; occurrence, morphology, cell structure and life-cycle of *Chara*; evolutionary significance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IX	Morphology and life-cycleof *Vaucheria*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
X	Morphology and life-cycles of *Ectocarpus* and *Fucus*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
XI	Morphology and life-cycle of *Polysiphonia*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
XII	Role of algae in the environment, agriculture, biotechnology and industry.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Bacteria, Viruses, Algae, Cyanobacteria, algal reproduction, viroids, bacterial reproduction

Biomolecules and Cell Biology
(BHCC2)
Core Course - (CC) Credit:6

Course Objective (2-3)

Biomolecules and Cell biology study will help the students to gain knowledge on the activities in which the giant molecules and miniscule structures that inhabit the cellular world of life are engaged. This will provide inside into the organization of cell, its features and regulation at different levels. Through the study of biomolecules (i.e protein, carbohydrate, lipid and nucleic acid) and cell organelles, they will be able to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life.

Course Learning Outcomes

This course will be able to demonstrate foundational knowledge in understanding of:

1. The relationship between the properties of macromolecules, their cellular activities and biological responses
2. Understanding of Cell metabolism, chemical composition, physiochemical and functional organization of organelle
3. Contemporary approaches in modern cell and molecular biology.

Unit 1

Biomolecules (18 lectures): Types and significance of chemical bonds; Structure and properties of water; pH and buffers. **Carbohydrates**: Nomenclature and classification; Role of monosaccharides (glucose, fructose, sugar alcohols – mannitol and sorbitol); Disaccharides (sucrose, maltose, lactose), Oligosaccharides and polysaccharides (structural-cellulose, hemicelluloses, pectin, chitin, mucilage; storage – starch, inulin). **Lipids**: Definition and major classes of storage and structural lipids. Storage lipids: Fatty acids structure and functions, Structural lipid: Phosphoglycerides; Building blocks, General structure, functions and properties. Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers, bilayers.
Proteins: Structure of amino acids; Peptide bonds; Levels of protein structure-primary, secondary, tertiary and quarternary; Isoelectric point; Protein denaturation and biological roles of proteins
Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleic acids

Unit 2

Bioenergenetics (4 lectures): Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as a energy currency molecule.

Unit 3

Enzymes (6 lectures): Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; mechanism of action (activation energy, lock and key hypothesis, induced - fit theroy), enzyme inhibition and factors affecting enzyme activity (in brief).

Unit 4

The cell (2 lectures): Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin ofeukaryotic cell (Endosymbiotic theory).

Unit 5

Cell wall and plasma membrane (4 lectures): 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.

Unit 6

Cell organelles (22 lectures): Nucleus:Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin;nucleolus.

Cytoskeleton:role and structure of microtubules, microfilaments and intermediary filament.

Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.

Endomembrane system: Endoplasmic Reticulum – Structure and function of RER and SER, protein folding, processing in ER, export of proteins and lipids; Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes

Unit 7

Cell division (4 lectures)

Eukaryotic cell cycle, mitosis and meiosis. Regulation of cell cycle

Practical

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo*/*Crinum*.
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Separate chloroplast pigments by paper chromatography.
5. Demonstrate the activity of any two enzymes (Urease, Amylase, Catalase).
6. Study of cell and its organelles with the help of electron micrographs.
7. Study the phenomenon of plasmolysis and deplasmolysis.
8. Study the effect of organic solvent and temperature on membrane permeability.
9. Study different stages of mitosis.

References

1. Cooper, G.M., Hausman, R.E. (2009). *The Cell: A Molecular Approach*, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA. (Chapter 2 for Unit 1,2; Chapter 2 for Unit 2, 3; Chapter 12 for Unit 5; Chapter 9,10,11 for Unit 6; Chapter 14 for Unit 7)
2. Iwasa,J, Marshall , W. (2016). Karps's Cell and Molecular Biology ; Concepts and experiments. New Jersey, U.S.A.: John Wiley & Sons. Chapter 2 for Unit 1; Chapter ,3,for Unit 2; Chapter 3 for Unit 2, 3; Chapter 1 for Unit 4; Chapter 4 for Unit 5; Chapter 5,6,8,9 for Unit 6; Chapter 14 for Unit 7)
3. Nelson, D.L., Cox, M.M. (2008). *Lehninger Principles of Biochemistry*, 5th edition. New York, NY: W.H. Freeman and Company. (Chapter 2,3,4,7,8,10 for Unit 1; Chapter 13 for Unit 2; Chapter 13 for Unit 2; Chapter 6 for Unit 3:)

Additional Resources:

5. Reven, F.H., Evert, R.F., Eichhorn, S.E. (1992). *Biology of Plants.* New York, NY: W.H.Freeman and Company. (Chapter 2 for Unit 1; Chapter 5 for Unit 2; Chapter 24 for Unit 4

Teaching Learning Process

Visual media would help students get a feel of thesubject and they find the subject interesting. College teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.

Teaching Learning Plan

Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VI
Week 13: Unit VI
Week 14: Unit VI
Week 15: Unit VII,

Assessment Methods

Making drawings ma be made a compulsory part of practical record books, We may ponder overmaking students involve in highlighting the salient features of the genera/ groups through digitalmedia such as ppt and animations.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Structure and functions of Carbohydrates, Lipids, Proteins and Nucleic acids	Class room lectures and Practical demonstration, experiments, slides, charts	Hands on exercises, PPT, assignments, tests
II	Redox reactions. ATP: structure, its role as a energy currency molecule	Class room lectures and Practical demonstration, experiments, slides, charts	Hands on exercises, PPT, assignments, tests
III	Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; mechanism of action	Class room lectures and Practical demonstration, experiments , slides, charts	Hands on exercises, PPT, assignments, tests
IV	Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells	Class room lectures and Practical demonstration, experiments , slides, charts	Hands on exercises, PPT, assignments, tests
V	Chemistry, structure and function of Plant Cell Wall. Overview of membrane function; fluid mosaic model; Membrane transport	Class room lectures and Practical demonstration, experiments, slides, charts	Hands on exercises, PPT, assignments, tests
VI	.**Nucleus**:Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin;nucleolus. Chloroplast, mitochondria and peroxisomes: Endoplasmic Reticulum Structural organization; Function;	Class room lectures and Practical demonstration, experiments, slides, charts	Hands on exercises, PPT, assignments, tests
VII	Eukaryotic cell cycle, mitosis and meiosis.	Class room lectures and Practical demonstration, experiments, slides, charts	Hands on exercises, PPT, assignments, tests

Keywords

Proteins, lipids, carbohydrates, nucleic acids,mes, plasma membrane, cytoskeleton, chloroplast, meiosis, mitosis, cell division

Mycology and Phytopathology
(BHCC3)
Core Course - (CC) Credit:6

Course Objective (2-3)

1. To introduce students with various fungal groups and lichens, their ecology, classification, characteristics, reproduction and economic Importance
2. To introduce students with the phytopathology, its concepts and principles\
3. To acquaint with various plant diseases, causal organisms and their control

Course Learning Outcomes

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

1. Understand the world of fungi, lichens and pathogens of plants
2. Understand characteristics the ecological and economic significance of the fungi and lichens
3. Understand the application of mycology in various fields of economic and ecologica
4. Significance
5. Understand the economic and pathological importance of fungi, bacteria and viruses
6. Identify common plant diseases and their control measures

Unit 1
Introduction to true fungi (6 lectures)
Definition, General characteristics; Affinities with plants and animals; Thallus organization;Cell wall composition; Heterokaryosis and parasexuality; Nutrition; Classification.

Unit 2
General account of Chytridiomycetes (1 lecture)

Unit 3
Zygomycota (4 lectures)
General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.

Unit 4
Ascomycota (10 lectures)
General characteristics; Ecology; Life cycle, life cycle and classification with reference to *Saccharomyces*, *Penicillium*, *Alternaria* and *Neurospora* and *Peziza.*

Unit 5

Basidiomycota (8 lectures)

General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), *Ustilago* (loose and covered smut, symptoms only), *Agaricus*; Bioluminescence, Fairy Rings and Mushroom Cultivation.

Unit 6

Mixomycota (Allied Fungi) (3 lectures)

General characterises; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.

Unit 7

Oomycota (4 lectures)

General characteristic; Ecology; Life cycle and classification with reference to *Phytophthora*, *Albugo*.

Unit 8

Symbiotic associations (4 lectures)

Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Economic importance of lichens. ; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Unit 9

Applied Mycology (10 Lectures)

Role of fungi in biotechnology, Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites ; Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.

Unit 10

Phytopathology (10 lectures)

Terms and concepts; General symptoms; Geographical distribution of diseases; Host- Pathogen relationships;disease cycle and environmental relation; Methods of control of plant diseases, and role of quarantine. Bacterial diseases – Citrus canker and angular leaf spot disease of Cotton.Viral diseases – Tobacco Mosaic viruses, vein clearing.

Practical

1. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, asocarps & basidiocarps).
2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus* and Penicillium: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. *Peziza*: sectioning through ascocarp.
5. *Alternaria*: Specimens/photographs and temporary mounts.

6. *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.
7. *Agaricus:* Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*, fairy rings and bioluminescent mushrooms to be shown.
8. Study of phaneroplasmodium from actual specimens and /or photograph. Study of *Stemonitis* sporangia.
9. Albugo: Study of symptoms of plants infected with Albugo; asexual phase study throughsection/ temporary mounts and sexual structures through permanent slides.
10. 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 endo mycorrhiza (Photographs)
11. 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.

References

1. Sethi, I.K. and Walia, S.K. (2018). *Text book of Fungi and Their Allies.* (2nd Edition), Medtech Publishers, Delhi (Chapters 1, 3 for Unit I, Chapter 8 for Unit 2, Chapter 9 for Unit 3, Chapters 10, 12-15,17 for Unit 4, Chapter 18, 19, 22-23 for Unit 5, Chapter 5 for Unit 6, Chapter 7 for Unit 7, Chapters 24, 25 for Unit 8, Chapter 26 for Unit 9, Chapter 27 for Unit 10)
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology*, 4th edition. Singapore, Singapore: John Wiley & Sons. (Chapter 1 for Unit 1, Chapter 2 for Unit 2, Chapter 5 for Unit 3, Chapters 7, 10, 11-13 for Unit 4, Chapters 16, 17, 20, 21 for Unit 5, Chapter 29 for Unit 6, Chapter 23 for Unit 7)
3. Agrios, G.N. (2005). *Plant Pathology*, 5th edition. Cambridge, U.K.: Academic Press. (Chapter 1, 8, 9, 11, 12, 14 for Unit 10)
4. Burchett, Stephen and Burchett, Sarah. (2018). Plant Pathology. New York: Garland Science (Chapter 1,6-8, 10 for Unit 10)

Additional Resources

1. Sharma, P.D. (2011). *Plant Pathology.* Meerut, U.P.: Rastogi Publication. (Chapter 1,7-9, 11,12, 14-16, 18 for Unit 10)
2. Webster, J., Weber, R. (2007). *Introduction to Fungi,* 3rd edition. Cambridge, U.K.: Cambridge University Press. (Chapter 1 for Unit 1, Chapter 2 for Unit 6, Chapter 5 for Unit 7, Chapter 6 for Unit 2, Chapter 7 for Unit 3, Chapter 88, 10-14 for Unit 4, Chapters 18, 19, 22, 23 for Unit 5)

Teaching Learning Process

1. The acquired knowledge in the classroom will be integrated with practical classes to impart a sound understanding of the course.

2. Field visits to enhance the understanding about the ecology of fungi and lichens.
3. More emphasis on physical specimens of fungi and lichens to better comprehend the morphology and other characteristics
4. Plants materials infested with diseases will be utilized for practical classes/ field visits may be planned
5. Students will be motivated to become self-directed learners by being able to monitor and adjust their approach to learning the course.

Weekly Teaching Plan

Week 1: Unit 1
Week 2: Unit 1
Week 3: Unit 2
Week 4: Unit 3
Week 5: Unit 4
Week 6: Unit 5
Week 7: Unit 6
Week 8: Unit 6
Week 9: Unit 7
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit 8
Week 13: Unit 9
Week 14: Unit 10
Week 15: Unit 10,

Assessment Methods

1. Continuous evaluation of the progress of students
2. Field based projects/reports 3. Interactive sessions/ presentations
3. Semester end evaluation of drawings as part of practical record books. Students would be involved in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I	True Fungi- General characteristics; Affinities with plants and animals; Thallus organization;Cell wall composition; Heterokaryosis and parasexuality; Nutrition; Classification	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II	General characteristics; Affinities with plants and animals; Thallus organization;Cell wall composition; Heterokaryosis and parasexuality;	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	Nutrition; Classification		
Unit III	General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV	General characteristics; Ecology; Life cycle, life cycle and classification with reference to *Saccharomyces*, *Penicillium*, *Alternaria* and *Neurospora* and *Peziza.*	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V	General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), *Ustilago* (loose and covered smut, symptoms only), *Agaricus*	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI	Status of Slime molds, Classification; Occurrence; Types of plasmodia	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII	Ecology; Life cycle and classification with reference to *Phytophthora*, *Albugo*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII	Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Economic importance	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X	Host- Pathogen relationships; disease cycle and environmental relation; Methods of control of plant diseases, and role of quarantine. Bacterial diseases – Citrus canker and angular leaf spot disease of Cotton.Viral diseases – Tobacco Mosaic viruses	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Fungi, Ascomycota, *Puccinia*, *Agaricus*, slime molds, symbiotic association, economic importance, Fungal disease, Bacterial disease, TMV.

Archegoniatae
(BHCC4)
Core Course - (CC) Credit:6

Course Objective (2-3)

1. The course aims at making a familiarity with special groups of plants joined together by a common feature of *sexual reproduction involving Archegonia*.
2. Creating an understanding by observation and table study of representative members of phylogenetically important groups should be able to make students learn the process of evolution in a broad sense.
3. Study of *morphology, anatomy, reproduction and developmental changes*therein through typological study should create a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants.

Course Learning Outcomes

The students will be made aware of the group of plants that have given rise to land habit and the flowering plants. Through field study they will be able to see these plants grow in nature and become familiar with the biodiversity. to my knowledge students should create their small digital reports where they can capture the zoomed in and zoomed out pictures as well as videos in case they are able to find some rare structure or phenomenon related to these plants.

Unit 1

The entire team feels that we need to update our concepts of the adaptations that lead to land habit. this should also include the evolution that occurred after land habit get established. There is also need to teach undergrads, APG system of classification for each of the three groups.

Unit 2

Bryophytes: *Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum* and *Funaria, Anthoceros* (Developmental details not to be done). Comparative and evolutionary trends in liverworts, hornworts and mosses. Progressive sterilization of the sporophyte**.** Ecological and economic importance with special reference to *Sphagnum*. Besides economic importance new research in field of bryophytes could be studied such as introduction to importance in biological interventions (whole genome of *Marchantia polymorpha* has been sequenced to elucidate evolution).

Unit 3

Pteridophytes: General characteristics, Recent phylogenetic classification, early land plants (*Cooksoni*a and *Rhynia*). Classification (up to family), 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, stelar evolution. Ecological and economic importance. Recent phylogenetic classification.

Unit 4

Gymnosperms: Recent phylogenetic classification. Concept of double fertilization taking example of *Ephedra* and *Gnetum gnemone.* While teaching *Cycas,* a brief mention of *Ginkgo* may also be made (only similarity between *Cycas* and *Ginkgo* such as motile sperms).Comparison of Cycadales with ferns on one hand and *Gnetum* with angiosperms on the other. *Gnetum* complete typological studies. Comparisons between *Gnetum* and *Ephedra*. *Pinus* with concept of polyembryony and pollination drop. Economic importance and introduction to field study – collection and processing.

Practical

1. *Marchantia*- Morphology of thallus, whole mount of rhizoids & scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).
2. *Riccia* – Morphology of thallus. Vertical section of thallus through sporophyte to give the concept of simple spore producing structure.
3. *Anthoceros*- Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).
4. *Pellia, Porella*- Permanent slides.
5. *Sphagnum*- Morphology of plant, whole mount of leaf (permanent slide only).
6. *Funaria*- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores(temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.
7. *Psilotum*- Study of specimen, transverse section of synangium (permanent slide).
8. *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).
9. *Equisetum*- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
10. *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).
11. *Cycas*- Morphology (coralloid roots, bulbil, 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).
12. *Gnetum*- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide)
13. *Pinus*- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones, transverse section of needle, transverse section of stem, longitudinal/ transverse section of male cone, whole mount of microsporophyll whole mount of microspores(temporary slides), longitudinal section of female cone, and megasporophyll, tangential longitudinal section & radial longitudinal sections stem (permanent slide).
14. Botanical excursion

References

1. Kaur I., Uniyal P.L. (2019).*Text Book of Gymnosperms*. New Delhi, Delhi: Daya Publishing House. (Chapters 1 to 7 for Unit 4)
2. Kaur I., Uniyal P.L.*Text Book of Bryophytes.* New Delhi, Delhi: Daya Publishing House (in Press). (Chapters 1 to 7 for Unit 1 and 2)
3. Parihar, N.S. (1972). *An Introduction to Embryophyta. Vol. II: Pteridophyta*. Allahabad, UP: Central Book Depot. (Chapters 1 to 5 and 10 for Unit 3)
4. Parihar, N.S. (1991). *An Introduction to Embryophyta. Vol. I: Bryophyta*. Allahabad, UP: Central Book Depot. (Chapters 1 to 7, 9 to 10 for Unit 2)

Additional Resources

1. Bhatnagar, S.P., Moitra, A. (1996). *Gymnosperms*. New Delhi, Delhi: New Age International (P) Ltd Publishers. (Chapters 1, 6, 13, 15 and 18 for or Unit 1 and 4)
2. Coulter, J.M., Chamberlain,C.J. (1910). *Morphology of Gymnosperms.* Chicago, University of Chicago Press. (Chapters 5, 6, 9, 11-14, 19 for Unit 4)
3. Puri, P. (1985). *Bryophytes*. New Delhi, Delhi, Atma Ram and Sons. (Chapters 1,4,5,7,10 and 11 for Unit 1 and 2)
4. Schofield, W.B. (1985). *Introduction to bryology*. New York, USA. Macmillan, (Reference book for Unit 2)
5. Chand Publication. (Chapters 1 to 7, 10,14, 15, 18 and 20 for Unit 1 and 2)
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). *Botany For Degree Students Pteridophyta*, New Delhi, Delhi: S. Chand Publication. Delhi, India. (Chapters 1 to 7 for Unit 3)

Teaching Learning Process

Teaching through visual media, would help students get a feel of the subject and they find the subject interesting. Teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.

Teaching Learnig Plan

Week 1: **Unit I** –Introduction to archegoniates, unifying features, APG system of classification
Week 2: **Unit 2**-Bryophytes- general characters, land habit and diversity
Week 3: -Classification (latest in detail of groups in syllabus), three groups in general
Week 4: -Type studies on Liverworts
Week 5: -Type studies on Mosses
Week 6: -Type study Hornworts and economic importance of bryophytes, Comparative account of liverworts, mosses and hornworts
Week 7: **Unit 3**-Pteridophytes- general characters and early land plants (*Cooksonia and Rhynia*)
Week 8: -Type studies: *Psilotum, Selaginella*, apogamy and apospory
Week 9:- Type study of *Equisetum* and *Pteris*
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12:-Heterospory and seed habit, Stellar evolution, Telome theory, Economic Importance
Week 13: **Unit 4-**Gymnosperms-general characters, concept of double fertilization

Week 14: -Life history of *Cycas* (brief mention of *Ginkgo*), *Pinus*
Week 15: -Life history of *Gnetum* and economic importance, gymnosperms vs angiosperms

Assessment Methods

Making drawings on practical record books, and students would be involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Assessment method

Unit No	Coure learning Outcome	Teaching and Learning Activity	Assessment Task
I	Introduction to archegoniates	Class room lectures and ppt	Open discussion
II	Bryophytes-general characters, land habit and diversity	Class room lectures and presentations	Group discussion
III	Classification (latest in detail of groups in syllabus), three groups in general	Class room lectures and Practical demonstration of diversity through slides and specimens	Table representation
IV	Type studies on Liverworts	Class room lectures and Practical on *Marchantia,Riccia*, *Pellia* and *Porella*	Sections, whole mounts, assignments, tests
V	Type studies on Mosses	Class room lectures and Practical on *Sphagnum,Polytrichum* and *Funaria*	Sections whole mounts, assignments, tests
VI	Type study Hornworts	Class room lectures and Practical on Anthoceros	Practical specimen studytests
VII	Pteridophytes- general characters and early land plants (*Cooksonia* and *Rhynia*)	revision	assignments, tests
VIII	Type studies: *Psilotum*, *Selaginella*	Class room lectures and Practical to study the vegetative and reproductive stages	assignments, tests
IX	Type study of *Equisetum* and *Pteris*	Class room lectures and Practical on *Equisetum* and *Pteris*	Hands on excercises, PPT, assignments, tests
X	EXCURSION/ EXAMS	On field study	Digital herbarium
XI	Life history of *Cycas* (brief mention of *Ginkgo*), *Pinus*	Class room lectures and Practical through temporary and permanent slides	Continuous evaluation, PPT, assignments, tests
XII	Life history of *Gnetum* and economic importance, gymnosperms vs angiosperms	Class room lectures and Practical - study of fixed material	Continuous evaluation

Keywords

Phylogenetic system of classification, Comparison of varous groups, Evolutionary trends

Anatomy of Angiosperms
(BHCC5)
Core Course - (CC) Credit:6

Course Objective (2-3)

1. To acquaint the students with internal basic structure and cellular composition of the plant body.
2. To correlate structure with important functions of different plant parts.
3. Study of various tissue systems and their development and functions in plants

Course Learning Outcomes

1. Knowledge of various cells and tissues, meristem, epidermal and vascular tissue system in plants.
2. Various aspects of growth, development of the tissues and differentiation of various plant organs.Knowledge of basic structure and organization of plant parts in angiosperms.
3. Correlation of structure with morphology and functions.

Unit 1

Tissues (12Lectures): Classification of tissues; Simple and complex tissues (no phylogeny); Pits and plasmodesmata; Wall ingrowths and transfer cells; Ergastic substances.

Unit 2

Stem and leaf(12Lectures): 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; Shoot Chimeras; Structure of dicot and monocot leaf, Kranz anatomy; Development of Leaf.

Unit 3

Root (6 Lectures) : Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

Unit 4

Vascular Cambium(7 Lectures): Structure (Axially and radially oriented elements); function and seasonal activity of cambium; Secondary growth in root and stem, Anomalies in secondary growth in stem: Included phloem and Phloem wedges.

Unit 5

Wood (8 Lectures): Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology.

Unit 6

Periderm (3 Lectures): Development and composition of periderm;rhytidome and lenticels.

Unit 7

Adaptive and Protective Systems (8 Lectures): Epidermal tissue system; cuticle; epicuticular waxes;trichomes (uni-and multicellular, glandular and non-glandular, two examples of each); stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

Unit 8

Secretory System (3 Lectures): Hydathodes, cavities, lithocysts and laticifers.

Unit 9: Scope of Plant Anatomy (1 Lecture)

Applications in systematics, forensics and pharmacognosy**.**

Practical

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

1. Apical meristem of root, shoot and vascular cambium.
2. Distribution and types of parenchyma, collenchyma and sclerenchyma.
3. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
4. Wood: ring porous; diffuse porous; tyloses; heartwood and sapwood.
5. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
6. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
7. Root: monocot, dicot, secondary growth.
8. Stem: monocot, dicot - primary and secondary growth; phloem wedges in *Bignonia*, included phloem in *Leptadenia*/*Salvadora*; periderm; lenticels.
9. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
10. Adaptive Anatomy: xerophytes, hydrophytes.
11. Secretory tissues: cavities, lithocysts and laticifers.

References

1. Dickison, W.C. (2000).*Integrative Plant Anatomy*. Cambridge, U.K.: Harcourt Academic Press. (Chapter 1 for Unit 1, Chapter 4 for Unit 4, Chapter 4 for Unit 5, Chapter 4 for Unit 6, Chapters 8 and 11 for Unit 7, Chapter 11 for Unit 8, Chapters 5, 13 and 17 for Unit 9)
2. Esau, K. (1977).*Anatomy of Seed Plants*. New Delhi, Delhi: John Wiley & Sons, Inc. (Chapters 1, 4, 5, 6, 9 and 11 for Unit 1, Chapters 16, 18 and 19 for Unit 2, Chapter 14 for Unit

3, Chapters 10, 15 and 17 for Unit 4, Chapter 8 and 9 for Unit 5, Chapter 12 for Unit 6, Chapter 13 for Unit 7, Chapter 13 for Unit 8)

3. Evert, R.F., Eichhorn, S. E. (2006). *Esau's Plant anatomy: Mersitems, Cells, and tissues of the Plant Body: their structure, function and development*. New Jersey, U.S.: Wiley- Liss. (Chapter 1, 4, 7, 8 and 13 for Unit 1, Chapter 6 for Unit 2, Chapter 12 for Unit 4, Chapter 12 for Unit 5, Chapter 15 for Unit 6, Chapters 9, 16 and 17 for Unit 7, Chapters 16 and 17 for Unit 8)

4. Fahn, A. (1974) Plant Anatomy. Pergmon Press, USA and UK. (Chapters 11 and 12 for Unit 2, Chapter 13 for Unit 3, Chapter 14 for Unit 4, Chapter 1 for Unit 9)

Additional Resources:

1. Mauseth, J.D. (1988). *Plant Anatomy*. San Francisco, California: The Benjammin Cummings Publisher. (Chapter 3,4,5 for Unit 1; Chapter 8 for Unit 4: Chapter 10 for Unit 7: Chapter 11 for Unit 2; Chapter 6 for Unit 2,3: Chapter 9 for Unit 8: Chapter 15 for Unit 5: Chapter 17 for Unit 6).

2. Raven, F.H., Evert, R. F., Eichhorn, S.E. (1992). *Biology of Plants*. New York, NY: W.H. Freeman and Company. Chapter 25 for Unit 3; Chapter 26 for Unit 2; Chapter 27 for Unit 4)

Teaching Learning Process

1. Chalk and blackboard teaching methodology
2. Powerpoint presentations
3. Study of anatomical details through permanent slides/temporary stain mounts/ macerations/ museum specimens with the help of suitable examples

Assessment Methods

Assignments/ Projects

Class tests, Student presentations, Continuous evaluation

Making drawings as part of practical record book. we may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Classification of tissues; Simple and complex tissues	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Organization of shoot apex (Apical cell theory, Types of vascular	Class room lectures and Practical	Hands on excercises, PPT, assignments, tests

	bundles; Structure of dicot and monocot stem, leaf, Kranz anatomy	demonstration, experiments	
Unit III:	Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	function and seasonal activity of cambium; Secondary growth in root and stem, Anomalies in secondary growth in stem	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Development and composition of periderm;rhytidome and lenticels	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	cuticle; epicuticular waxes;trichomes (uni-and multicellular, glandular and non-glandular); stomata; Anatomical adaptations of xerophytes and hydrophytes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Hydathodes, cavities, lithocysts and laticifers.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Applications in systematics, forensics and pharmacognosy**.**	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Tissues, Stem, Leaf, Root, Vascular cambium, Wood, Periderm, Anatomical adaptations, Secondary anomalies. Plant tissue systems, meristems, trichomes,

Economic Botany
(BHCC6)
Core Course - (CC) Credit:6

Course Objective (2-3)

To make the students familiar with economic importance of diverse plants that offer resources to human life. It emphasize the plants used as- food for man, fodder for cattle, feed for poultry, plants having medicinal value and also plant source of huge economic value etc

Course Learning Outcomes

After studying Economic Botany, students would have first hand information of plants used as food, the various kinds of nutrients available in the plants. The dietary requirements of proteins, fats, amino-acids, vitamins etc that can be met by plants. The students will learn to perform the micro-chemical tests to demonstrate various components. The students will learn about the use of fibre plants, beverages, fruits and vegetables that are integral to day to day life of plants. Students will learn to explore the regional diversity in food crops and other plants and their ethno-botanical importance as well.

Unit 1

Origin of Cultivated Plants(4 lectures): Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity (Only conventional plant breeding methods); Importance of germplasm diversity.

Unit 2

Cereals (6 lectures): Wheat and Rice (origin, evolution, morphology, post-harvest processing & uses); Green revolution; Brief account of millets and pseudocereals.

Unit 3

Legumes (3 lectures): General accounts (including chief pulses grown in India); Importance to man and ecosystem.

Unit 4

Fruits (3 lectures): Mango and Citrus (Origin, morphology, anatomy and uses)

Unit 5

Sugars and Starches (5 lectures): Morphology, ratooning, evolution (nobilization) and processing of sugarcane, products and by-products of sugarcane industry; Potato – morphology, tuber anatomy, propagation (conventional and TPS) and uses.

Unit 6

Spices (6 lectures): Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper

Unit 7

Beverages (4 lectures): Tea, Coffee (morphology, processing & uses)

Unit 8

Oils and fats (8 lectures): General description, classification, extraction, their uses and health implications; groundnut, coconut, linseed, mustard (Botanical name, family & uses).

Unit 9

Essential Oils (4 lectures): General account, extraction methods, comparison with fatty oils and otheir uses.

Unit 10

Natural Rubber (3 lectures): Para-rubber: tapping, processing and uses.

Unit 11

Drug-yielding plants (5 lectures): Therapeutic and habit-forming drugs with special reference to *Cinchona*, *Digitalis*, *Papaver* and *Cannabis.*

Unit 12

Tobacco (Morphology, processing, uses and health hazards).**(3 lectures)**

Unit 13

Fibers (6 lectures): Classification based on the origin of fibers; Cotton (origin of tetraploid cotton, morphology, extraction and uses) and Jute (morphology, extraction and uses).

Practicals

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). Millets and Pseudocereals (specimens / photographs and grains)
2. Legumes: Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. Fruits: Mango (habit sketch, L.S. fruit, micro-chemical tests in ripe fruit); Citrus (habit sketch, T.S. hesperidium, W.M. vesicle, micro-chemical tests including test for vitamin C)
4. 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).
5. Spices: Black pepper, Fennel and Clove (habit and sections L.S./T.S.).
6. Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
7. Oils and fats: Coconut- T.S. nut, Mustard–plant specimen, seeds
8. Essential oil-yielding plants: Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and *Eucalyptus* (specimens/photographs).
9. Rubber: specimen, photograph/model of tapping, samples of rubber products.

10. Drug-yielding plants: Specimens of *Cinchona*, *Digitalis*, *Papaver* and *Cannabis* (male & female plant).
11. Tobacco: specimen and products of Tobacco.
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 cellulose and lignin on transverse section of stem and fiber).

References

1. Kochhar, S.L. (2012). *Economic Botany in Tropics*. New Delhi, India: MacMillan & Co. (Chapter 1 for Unit 1; Chapter 3 for Unit 2; Chapter 5 for Unit 3; Chapter 7 for Unit 4; Chapter 4 for Unit 5; Chapter 9 for Unit 6; Chapter 11 for Unit 7; Chapter for Unit 8; Chapter 17 for Unit9; Chapter 14 for Unit 10; Chapter 16 for Unit 11; Chapter 10 for Unit 12; Chapter 2 for Unit 13);
2. Wickens, G.E. (2001). *Economic Botany: Principles & Practices*.The Netherlands: Kluwer Academic Publishers. (Chapter 1,2,3,4,5 for Unit 1; Chapter 14 for Unit 13)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of blackboard teaching and PowerPoint presentations. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers.
Practicals: Specimens along with their products are to be maintained in the museum, and explain to the students. Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have cut the section/perform micro-chemical tests of the material, the observations (temporary preparation/micro-chemical tests) has to be recorded and discussed. Any deviation from the expected trend in results is explained. Making drawings from specimens /temporary preparations in practical record books. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
College teachers can also form a group and prepare e-contents for theory as well as for practicals.
Teaching Learning Plan:
Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit IV
Week 5: Unit V
Week 6: Unit VI
Week 7: Unit VII
Week 8: Unit VIII
Week 9: Unit VIII
Week 10: Mid semester Exam

Week 11: Mid Semester Break
Week 12: Unit IX
Week 13: Unit X
Week 14: Unit XI
Week 15: Unit XII, Unit XIII

Assessment Methods

Theory: The students are continuously evaluated based on a assignments/presentation and class test. After marking, the answer scripts of the test are returned to the students. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation, 10 marks are alloted for test, 10 marks for record, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.
Assessment Methods:

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Origin of Cultivated Plants	Class room lectures and Practical	Hands on exercises, PPT, assignments, tests
II	Cereals: Wheat and Rice	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Legumes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Fruits:Mango and Citrus	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Sugars and Starches Sugarcane, Potato	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Spices: Fennel, saffron, clove and black pepper	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Beverages: Tea and Coffee	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Oils and Fats Groundnut, coconut, linseed, mustard	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IX	Essential oils	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

X	Rubber	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
XI	Drug Yielding Plants *Cinchona*, *Digitalis*, *Papaver* and *Cannabis*	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
XII	Tobacco	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
XIII	Fibers Jute and Cotton	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Cultivated plants, Green revolution, Cereals, Legumes, Starches & Sugars, Spices, Oils & Fats, Drug yielding plants, Natural rubber, Fibres

Genetics
(BHCC7)
Core Course - (CC) Credit:6

Course Objective(2-3)

To have knowledge of Mendelian and non-Mendelian inheritance, Chromosome biology and structure and function of genes.

Course Learning Outcomes

To generate interest among the students in Genetics and make them aware about the importance and opportunities in higher education and research, the first unit should be Introductory dealing with how this area has revolutionized all aspects of our life from its growth from Mendel to Genetic Engineering. Modes of inheritance of traits/ phenotypes and Phenotype-genotype corelation are the basic learning.

Unit 1

Mendelian genetics and its extension (16 L): Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; sex determination (briefly with reference to Humans and Drosophilla); Probability and Pedigree analysis; Incomplete dominance and co- dominance; Multiple allelism; lethal alleles; Epistasis; Pleiotropy; Penetrance and expressivity; Polygenic inheritance; numericals.Basics of epigenetics, DNA Methylation and epigenetic code.

Unit 2

Extra-chromosomal Inheritance (6L): Chloroplast Inheritance: Variegationin Four O` clock plant; Mitochondrial inheritance in yeast; Maternal effect- shell coiling in snails; Infective heredity- Kappa particles in Paramecium.

Unit 3

Linkage, crossing over and chromosome mapping (12L): Linkage and crossing over-Cytological basis of crossing over (eg. Maize); Recombination frequency: two factor and three factor crosses; interference and coincidence; Numericals based on gene mapping; Sex linkage (Drosophilla). QTL mapping and its significance

Unit 4

Variation in Chromosome number and structure (8L): Deletion; Duplication; Inversion; Translocation; Position effect; Euploidy and aneuploidy.

Unit 5

Gene mutations (7L): Mutation types; Molecular basis of mutation; Mutagens- Physical and chemical mutagens (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutation (CLB method); role of Transposon in mutation; DNA repair mechanisms (light dependent repair, excision repair, mismatch repair and SOS repair), Transposable genetic elements and its significance; Bacteria-IS elements, The Tn3 family Eukaryotes L Yeast TY elements, Maize transposones, Drosophila transposones; transposones in human genome; *Alu*, Retro-transposones (LINEs and SINEs)

Unit 6

Fine structure of gene (5L): Classical vs molecular concepts of gene; Cis – Trans complementation test for functional allelism; Structure of phage T4, rII locus.

Unit 7

Population and evolutionary genetics (6L): Allele frequencies, genotype frequencies, Hardy-Weinberg law, role of natural selection, mutation,genetic drift, genetic variation and speciation(modes of speciation and genetics of speciation)

Practical

1. To study male meiosis in *Allium cepa* (two stages to be shown)
2. To understand the genetic interaction involved using the seed mixture given. Genetic ratio to be calculated using Chi square analysis.
3. To do problems based on Hardy-Weinberg`s law.
4. Pedigree analysis
5. To study/list human dominant and recessive traits and to observe the listed physical traits among the students present in the class. Data thus generated may be used for calculating allelic and genotypic frequencies using Hardy- Weinberg's principle.
6. To study the syndromes (Downs, Klinefelter/Turner/Patau/Edwards)
7. To study colour blindness/ hemophilia (Ishihara cards may be used to study colour blindness)
8. Chromosomal aberrations: Complex translocation ring, quadrivalents, lagging chromosomes, diccentric/inversion bridge
9. Xeroderma / Pigmentosum/ Sickle cell anemia

References

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). *Principles of Genetics*, 8th edition. New Delhi, Delhi: John Wiley & sons. (Chapter 1 for Unit 1; Chapter 20 for Unit 2; Chapter 7 for Unit 3; Chapter 18 for Unit 4; Chapter 11 for Unit 5; Chapter 12 for Unit 6; Chapter 22 for Unit 7)
2. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). *Introduction to Genetic Analysis*, 10th edition. New York, NY: W.H. Freeman and Co. (Chapters2-4, 6, 15-19 for Units 1-7).
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*, 10th edition. San Francisco, California: Benjamin Cummings. (Chapters 1,3-6, 8-9, 15, 25 for Units 1-7).

4. Campbell, N.A., Urry,L.A.,, Cain, M.L., Wasserman,S.A., Minorsky, P.V., Reece, J.B. (2018).*Biologys*. Harlow,England : Pearson (Chapters 14 for Unit 1;2; chapter 15 for Unit 3; Chapter 20 for Unit 7)

Additional Resources

1. Hartl, D.L., Ruvolo, M. (2012). *Genetics: Analysis of Genes and Genomes*, 8th edition. New Delhi, Delhi: Jones and Bartlett Learning. (Chapters 4 for Unit 2; chapter 5 for Unit 3; Chapter 1,14 for Unit 5; chapter 17 for Unit 7).
2. Snustad, D.P., Simmons, M.J. (2012). *Principles of Genetics*, 6th edition. New Delhi, Delhi: John Wiley & sons. (Chapters 3-7,13,17,22-23 for Units 1-7)

Teaching Learning Process

Chalk -board method, Visual media, power point presentations, discussion and seminars on a topics are some of the methods for teaching and learning which make the subject interesting. Teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.
Week 1: Unit 1
Week 2: Unit 1
Week 3: Unit 2
Week 4: Unit 2
Week 5: Unit 3
Week 6: Unit 3
Week 7: Unit 4
Week 8: Unit 5
Week 9: Unit 5
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit 5
Week 13: Unit 6I
Week 14: Unit 7
Week 15: Unit 7

Assessment Methods

Making drawings as part of practical record books, we may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit 1:	Mendelism Principles of inheritance;	Activity :Class	Assessment: Hands

	Chromosome theory of inheritance; sex determination; Probability and Pedigree analysis; Incomplete dominance and co-dominance; lethal alleles; Epistasis; Pleiotropy; Polygenic inheritance; numericals. epigenetics, DNA Methylation and	room lectures and Practical demonstration, experiments	on exercises, PPT, assignments, tests
Unit 2:	Chloroplast Inheritance: Variegationin Four O` clock plant; Mitochondrial inheritance in yeast; Maternal effect- shell coiling in snails; Infective heredity- Kappa particles in Paramecium	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 3:	Linkage and crossing over- Cytological basis of crossing over (eg. Maize); Recombination frequency: two factor and three factor crosses; interference and coincidence; Numericals based on gene mapping; Sex linkage (Drosophilla). QTL mapping and its significance	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 4:	Variation in Chromosome number and structure	Class room lectures and Practical demonstration, experiments	Hands on excrcises, PPT, assignments, tests
Unit 5:	Mutation types; Molecular basis of mutation; Mutagens- Physical and chemical mutagens (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutation (CLB method); role of Transposon in mutation; DNA repair mechanisms	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 6:	Classical vs molecular concepts of gene; Cis – Trans complementation test for functional allelism; Structure of phage T4, rII locus.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 7:	Allele frequencies, genotype frequencies, Hardy-Weinberg law, role of natural selection, mutation,genetic drift, genetic variation and speciation(modes of speciation and genetics of speciation)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Inheritance theory, linkage, crossing over, chromosome mapping, cytology, Gene, Gene mutation, Population genetics

Molecular Biology
(BHCC8)
Core Course - (CC) Credit:6

Course Objective (2-3)

To gain the knowledge of structure and functions of DNA and RNA

Course Learning Outcomes

1. Understanding of nucleic acid, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.
2. Processing and modification of RNA and translation process, function and regulation of expression.
3. Application in biotechnology

Unit 1

Nucleic acids as carriers of genetic information (3 lectures)

Historical perspective; Experiments that established nucleic acids (DNA & RNA) as the carrier of genetic information: Griffith's,Hershey & Chase, Avery, McLeod & McCarty and Fraenkel-Conrat 's experiment .

Unit 2.

The Structureand organisation of the genetic material (9 lectures)

DNA Structure: Miescher to Watson and Crick- a historic perspective.DNA structure , salient features of double helix ; Types of DNA: A,B & Z conformations . Genome complexity: Concept of C-value paradox, denaturation and renaturation, C_ot curves; Organization of DNA- in Prokaryotes, Viruses & Eukaryotes. Organelle DNA -- mitochondria and chloroplast DNA; Chromatin structure- Nucleosome, Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin . RNA : types of RNA molecules , structure and function of mRNA, tRNA and rRNA

Unit 3

Central Dogma and Genetic Code 3 lectures

Key experiments establishing-The Central Dogma,Genetic code (salient features & experiments that deciphered the correlation between mRNA codon and amino acid).

Unit 4

The Replication of DNA 9 lectures

Mechanism - initiation, elongation and termination, Kornberg's discovery; Enzymes and other proteins involved in DNA replication; General principles – bidirectional, semiconservative and semi discontinuous replication (Replisome), RNA priming (primase & Primosome); Various modes of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA. Replication of the 5'end of linear chromosome (end replication problem & Telomerase).

Unit 5

Mechanism of Transcription 9 lectures

Transcription in prokaryotes and eukaryotes ; Understanding the steps in process of transcription: Initiation, Elongation and Termination. Enzymes and factors involved in transcription.

Unit 6

Processing and modification of RNA 7 lectures

Split genes-concept of introns and exons, Splicing pathways, group I & group II intron splicing, Spliceosome and assembly of the spliceosome machinery , Alternative splicing, Eukaryotic mRNAprocessing (5' cap, 3' poly A tail) ; Ribozymes, RNA Editing

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Unit 7

Mechanism of Translation 10 lectures

Translationin prokaryotes and eukaryotes ; Understand the steps in process of translation - Initiation, Elongation and Termination. Enzymes and factors involved in translation. Ribosome structure and assembly (in prokaryotes and eukaryotes);charging of tRNA, aminoacyl tRNA synthetases; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

Unit 8

Gene Regulation in prokaryotes and eukaryotes 10 lectures

Basic principles of transcriptional regulation: Positive & negative; Inducible & Repressible; Activators and Repressors ; Prokaryotes: Operon concept & regulation of lactose metabolism (positive and Negative) and tryptophan synthesis (Repression-Derepression and Attenuation) in *E.coli;* Eukaryotes: Gene silencing: Methylation, RNAi, Imprinting.

Practicals

1. Preparation of LB medium and raising *E. coli*
2. DNA isolation from cauliflower heads
3. Quantification of unknown DNA by diphenylamine reagent.
4. Study of experiments establishing nucleic acid as genetic material (Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)through photographs
5. Numericals based on DNA re-association kinetics (melting profiles and C_ot curves)
6. Study of DNA replication through photographs: Modes of replication - Rolling circle, Theta and semi-discontinuous ; Semiconservative model of replication (Messelson and Stahl's experiment); Telomerase assisted end-replication of linear DNA

7. Study of structures of : tRNA (2D and 3D); prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozymes and Alternative splicing
9. Understanding the regulation of lactose (*lac*) operon (positive & negative regulation) and tryptophan (*trp*) operon (Repression and De-repression & Attenuation) through photographs.
10. Understanding the mechanism of RNAi by photographs.

Suggested Readings

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition. 7th edition (Chapter 2 for Unit 1, Chapters 4, 5, 8 for Unit 2, Chapters 2, 16 for Unit 3, Chapter 9 for Unit 4, Chapter 13 for Unit 5, Chapter 14 for Unit 6, Chapter 15 for Unit 7, Chapters 18, 19, 20 for Unit 8)
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc.,U.S.A. 5th edition. (Chapter 9 for Unit 2, Chapter 10 for Unit 4; Chapter 11 for Unit 5,6 ; Chapter 14 for Unit 7; Chapter 21 for Unit 8);
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition. (Chapter 10 for Unit 2; Chapter 13 for Unit 4; Chapter 14 for Unit 7; Chapter 16, 17 for Unit 8)
4. Russell, P. J. (2010). iGenetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition. (Chapter 5 for Unit 3);

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s **for checking.**

Weekly teaching Plan
Week 1: Unit 1
Week 2: Unit 2
Week 3: Unit 2
Week 4: Unit 3
Week 5: Unit 3

Week 6: Unit 4
Week 7: Unit 5
Week 8: Unit 6
Week 9: Unit 6
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit 7
Week 13: Unit 7
Week 14: Unit 8
Week 15: Unit 8

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.
Assessment Task

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit 1:	DNA as the carrier of genetic information (Griffith's, Hershey & Chase,Avery, McLeod & McCarty, Fraenkel-Conrat's experiment	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit2:	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-	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.		
Unit 3:	Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semiconservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, (theta) mode of replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 4:	Central dogma and genetic code (2 lectures) Key experiments establishing-The Central Dogma (), Genetic code (deciphering & salient features)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 5:	Transcription in prokaryotes; Transcription in eukaryotes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 6:	Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I & group II intron splicing, alternative splicing eukaryotic mRNA processing(5' cap, 3' polyA tail); Ribozymes,; RNA editing.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 7:	Mechanism of 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.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 8:	Transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli*. Eukaryotes: transcription factors; Gene silencing: Methylation, RNAi, Imprinting.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Nucleic acids, DNA, RNA, Genetic material, Nucleosome, , DNA replication, Central dogma, genetic code,, transcription, Splicing pathways, RNA editing,, Ribosome, polypeptides

Ecology
(BHCC9)
Core Course - (CC) Credit:6

Course Objective (2-3)

To introduce the students with environmental factors affecting the plants, the basic principles of ecology and phytogeography. To make them understand complex community patterns and processes, and ecosystem functioning.

Course Learning Outcomes

It acquaint the students with complex interrelationship between organisms and environment; make them understand methods to studying vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography. This knowledge is critical in evolving strategies for sustainable natural resource management and biodiversity conservation.

Unit 1

Introduction (4 lectures): Brief History, Basic concepts, Levels of organization, Inter-relationships between the living world and the environment, the components and dynamism, homeostasis (with reference to Ecosystem).

Unit 2

Soil (8 lectures): Importance; Origin; Formation; Composition: Physical, Chemical and Biological components; Soil profile; Role of climate in soil development.

Unit 3

Water (3 lectures): Importance; States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table.

Unit 4

Light, Temperature, Wind andFire (6 lectures): Variations; adaptations of plants to their variation.

Unit 5

Bioticinteractions (2 lectures): Definition; types of biotic interactions

Unit 6

Population ecology (4 lectures): Distribution and characteristics of populations; population growth; population dynamics; Ecological Speciation (Ecads, ecotypes, ecospecies, etc)

Unit 7

Plantcommunities(9 lectures): Concept of ecological amplitude; Habitat (types) and Ecological niche (types); Community characters (analytical and synthetic); Ecotone and edge effect; Methods to studying vegetation; Dynamics of communities; Succession: processes, types (Lithosere, Hydrosere); climax concepts.

Unit 8

Ecosystems (5 lectures): Structure; Types; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids.

Unit 9

Functional aspects ofecosystem **(9 lectures):** Principles and models of energy flow; Production and productivity; Measurement of productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.

Unit 10

Phytogeography (10 lectures): Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Vegetation of Delhi.

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 (pH meter, universal indicator/Lovi bond comparator and pH paper)
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. (a). Study of morphological adaptations of hydrophytes and xerophytes (four each).
   (b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Rootparasite (Orobanche), Epiphytes, Predation (Insectivorous plants).
8. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
11. Field visit to familiarize students with ecology of different sites.

References

1. Odum, E.P. (2005). *Fundamentals of Ecology*. New Delhi, India: Cengage Learning India Pvt. Ltd., 5th edition. (Chapter 3, 4 for Unit 8; Chapter 6 for Unit 6; Chapter 7 for Unit 7; Chapter 10 for Unit 10)
2. Singh, J.S., Singh, S.P., Gupta, S.R. (2014). *Ecology, Environmental Science and Conservation.* New Delhi, India: S. Chand. (Chapter 4 for Unit 2; Chapter 5 for Unit 4; Chapter 8 for Unit 6; Chapter 9 for Unit 5; Chapter 10, 11, 12 for Unit 7; Chapter 13 for Unit 8; Chapter 15, 16 for Unit 9; Chapter 18 for Unit 10)
3. Sharma, P.D. (2015-16). *Ecology and Environment*. Meerut, India: Rastogi Publications. 12th edition.(Chapter 2 for Unit 4; Chapter 3 for Unit 2; Chapter 5 for Unit 5; Chapter 7 for Unit 6; Chapter 8 for Unit 7; Chapter 9 for Unit 8; Chapter 19 for Unit 10)
4. Kormondy, E.J. (2017). *Concepts of Ecology*. India:Pearson India Education Services Pvt. Ltd. 4th edition.(Chapter 7, 8 for Unit 8; Chapter 10, 11 for Unit 6; Chapter 12 for Unit 7; Chapter 14 for Unit 10)

Additional Resources:

1. Ambasht, R.S. and Ambasht, N.K. (2008). *A text book of Plant Ecology*, CBS Publishers & Distributors PVT. LTD. 14th Edition (Chapter 2 for Unit 8; Chapter 3, 7 for Unit 4; Chapter 9 for Unit 6; Chapter 10 for Unit 7; Chapter 11, 17, 18 for Unit 10)
2. Majumdar, R and Kashyap, R (2019). *Practical Manual of Ecology and Environmental Science*, New Delhi, India: Prestige Publishers (chapters 1-11 For Practicals 1 to 10)

Teaching Learning Process

The Class room teaching is integrated with practical classes, and field visit to impart a sound understanding of the course. The theory topics are covered in lectures with the help of blackboard teaching and PowerPoint presentations. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers.
Every practical session begins with detailed instructions, followed by students conducting the experiment/s in the laboratory/college campus. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
College teachers can also form a group andprepare e-contents for theory as well as for practicals.
Field visit is also be organised to familarise the students with local plant species, and to understand community pattern and processes.

Teaching Learning Plan:
Week 1: Unit I
Week 2: Unit II
Week 3: Unit II
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit V

Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit IX
Week 14: Unit IX, Unit X
Week 15: Unit X

Assessment Methods

Theory: The students are continuously evaluated based on a assignments/presentation and class test. After marking, the answer scripts of the test are returned to the students.
In fact, presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks. **Practicals:** For continuous evaluation, 10 marks are alloted for test, 10 marks for record /field report, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Introduction	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Soil	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Water	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Light, Temperature, Wind and Fire	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Biotic Interactions	Class room lectures	Hands on exercises, PPT,

		and Practical demonstration, experiments	assignments, tests
VI	Population Ecology Distribution and characteristics of populations; population growth; population dynamics; Ecological Speciation	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Plant Communities Concept of ecological amplitude; Habitat and Ecological niche; Community characters (analytical and synthetic); Ecotone and edge effect; Methods to studying vegetation; Dynamics of communities; Succession	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Ecosystems Structure; Types; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IX	Functional aspects of ecosystems Principles and models of energy flow; Production and productivity; Measurement of productivity; Ecological efficiencies; Biogeochemical cycles	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
X	Phytogeography Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes; Phytogeographical division of India; Vegetation of Delhi	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Environmental factors, Soil profile, Biotic interactions, Ecological niche, Succession, Ecosystem functions, Homeostasis, Endemism, Phytogeography

Plant Systematics
(BHCC10)
Core Course - (CC) Credit:6

Course Objective (2-3)

To gain the knowledge on the taxonomy, phylogeny of plants

Course Learning Outcomes

Understanding of systematics its importance in bioresource utilization and biodiversity management.Nomenclature pattern, Phylogeny, Classification systems of the plants.

Unit 1
Plant identification, Classification, Nomenclature, Biosystematics (2 lectures)

Unit 2
Identification (6 lectures)
Field inventory; Herbarium Techniques; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual Herbarium; E-flora: Flora, Monographs, Journals; Keys: Single Access and Multi-access.

Unit 3
Systematics-an interdisciplinary science (7 lectures)
Evidence from palynology, cytology, phytochemistry [Alkaloids, Phenolics, Glucosides, terpenes and Semantides (in brief)] and molecular data (cp.DNA, mt-DNA, nuclear DNA, PCR amplification, sequence data analysis)

Unit 4
Taxonomic hierarchy (6 lectures)
Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary)

Unit 5
Botanical nomenclature (10 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 and cultivated plants.

Unit 6
Systems of classification (10 lectures)

Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Benthan and Hooker (up to series) and Engler and Prantl (up to series); Brief references of Angiosperm Phylogeny Group (APG IV) classification.

Unit 7

Numerical taxonomy (8 lectures)

Introduction, Principles, methodology of phenetic approach, (Characters; Variations; OTUs, character weighing and coding; cluster analysis); Phenograms.

Unit 8

Phylogeny of Angiosperms (11 lectures)

Cladistics: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Methodology of Cladistics, Methods of illustrating evolutionary relationships (phylogenetic tree, cladogram) Origin and evolution of angiosperms.

Practical

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formul/e and systematic position according to Bentham and Hooker's system of classification)
Ranunculaceae- *Ranunculus*, *Delphinium*
Brassicaceae- *Brassica*, *Alyssum/ Iberis*
Fabaceace- *Calliandra/Prosopis/ Acacia, Cajanus/Sesbania*, *Cassia*
Myrtaceae- *Eucalyptus*, *Callistemon*
Umbelliferae-*Coriandrum/ Anethum/ Foeniculum*
Asteraceae- *Sonchus/ Launaea, Veronia/ Ageratum, Elipta/ Tridax*
Solanaceae- *Solanum nigrum,Withania sominifera*
Lamiaceae- *Salvia/Ocimum*
Euphorbiaceae-*Euphorbia hirta/ E.milli, Jatropha*
Liliaceae- *Asphodelus/ Lilium/ Allium*
Poaceae- *Triticum/ Hordeum/ Avena/ Poa*
Malvaceae-*Abutilon/ Hibiscus/ Sida*
Caryophyllaceae-*Stellaria/ Dianthus/Spergulla*
Rubiaceae- *Hamelia patens* / *Ixora* / *Oldenlandia* sp
Apocyanaceae- *Catharanthus roseus/Cascabala thevitea/Tabernemontana sp.*
Asclepediaceae- *Calotropis procera*
Moraceae- *Morus alba*
Chenopodiaceae- Chenopodium alba
Cannaceae- *Canna indica*
Ten familes should be selected out of the given list of nineteen families representing the following
Class/ Subclass as mentioned below:
Polypetalae- Any 3 families
Gamopetalae- Any 3 families

Monochlamydeae- Any 2 families
Monocotyledons- Any 2 families
2. Field visit (local)- Subject to grant funds from the University
3. Mounting of a properly dried and pressed specimen of any wild plant on herbarium sheet (to be submitted with the record book).

References

1. Singh, G. (2012). *Plant Systematics: Theory and Practice*, 3rd edition. Oxford and IBH Pvt. Ltd. New Delhi. Chapter 1 for unit 1, chapter 2 for unit 5, chapter 3 for unit 4, chapter 5 for unit 2, chapter 7 for unit 3, chapter 8 & 9 for unit 7 and 8, chapter 10 for unit 6.
2. Simpson, M.G. (2010). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A. chapter 1 for unit 1, chapter 2, 6 &7 for unit 8, chapter 14 for unit 3, chapter 15-18 for unit 2.
3. Stuessy, Tod F. (2009) Plant Taxonomy: The systematic evaluation of comparative data - 2nd edition. Columbia University Press Chapter 5, 6 for unit 1, chapter 19-21 for unit 3, chapter10-11 for unit 4, chapter 4&7 for unit 7, chapter 8 for unit 8.
4. Gupta R.2011 (Ed.) Plant Taxonomy: past, present, and future. New Delhi: The Energy and resources Institute (TERI). chapter 2, for unit 5, chapter 4 for unit 5, chapter 5 for unit 3,chapter 8 for unit 2, chapter 9 for unit7 and 8 ,chapter 11-15 for unit 3.

Additional Resources

5. Stace, C.A (1989) Plant Taxonomy and Biosystematics 2nd edition. Cambridge University Press, NY USA. Chapter 1 and 2 for unit 1, chapter 3 for unit 7, chapter 4 & 5 for unit 3, chapter 9 & 10 for unit 2.
6. Raven, F.H., Evert, R. F., Eichhorn, S.E. (1992). *Biology of Plants.* W.H. Freeman and Company. New York, NY. chapter 20 for unit 8, chapter 12 for unit 1, 2 7 & 8.
7. Walter S. Judd, et.al. 2015 Plant Systematics : A Phylogenetic Approach 4th Edition Sinauer Associates , Oxford University Press.USA .chapter 1 for unit 1, chapter 4 for unit 3, chapter 2 & 8 for unit 8, appendix 1 for unit 5, chapter 3 for unit 6.
8. http://www.mobot.org/MOBOT/research/APweb/. Unit 6 (for APG IV classification)

Teaching Learning Process

Field visits to the forested areas and on the spot Plant identification feature would be very helpful. Visual media should be made available. It is suggested that Botany Department, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of the subject and they find the subject interesting. Even the college teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.
Week 1: Unit I
Week 2: Unit II
Week 3: Unit II
Week 4: Unit Local Field visit
Week 5: Unit III

Week 6: Unit III
Week 7: Unit IV
Week 8: Unit V
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VI
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit VIII

Assessment Methods

Making drawings from the live specimens should compulsory part of practical record books. We may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Plant identification, Classification, Nomenclature, Biosystematics	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Herbarium Techniques; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; E-flora: Flora, Monographs	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Palynology, Cytology, Phytochemistry [Alkaloids, Phenolics, Glucosides, Terpenes and Semantides and Molecular data	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary)	Class room lectures and Practical demonstration, experiments	Hands on excrcises, PPT, assignments, tests
Unit V:	Botanical nomenclature-Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids and	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	cultivated plants		
Unit VI:	Contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Benthan and Hooker (up to series) and Engler and Prantl (up to series); Angiosperm Phylogeny Group (APG IV)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	Numerical taxonomy	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Cladistics: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Methodology of Cladistics, Methods of illustrating evolutionary relationships (phylogenetic tree, cladogram) Origin and evolution of angiosperms.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Plant Taxonomy, plant classification, Flora, plant nomenclature, phylogeny, cladogram

Reproductive Biology of Angiosperms
(BHCC11)
Core Course - (CC) Credit:6

Course Objective (2-3)

To have knowledge of the flowering and fruiting, reproduction processes, role of pollinators, anther, ovule and seed development.

Course Learning Outcomes

Student would have an understanding of

1. Induction of flowering,molecular and genetic aspects of flower development.
2. Anther structure, pollen development, dispersal and pollination
3. Ovule, embryo sac development and fertilization,
4. Endosperm development and its importance
5. Alternative pathways of reproduction and their importance
6. Student would be able to apply this knowledge for conservation of plants, pollinators and fruit development

Unit 1
Introduction (2 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, H. Y. Mohan Ram) and scope of Reproductive Biology.

Unit 2
Anther (4 lectures)
Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance.

Unit 3
Pollen biology (8 lectures)
Micro-gametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system (no details but table to be included); Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Unique features: Pseudomonads, polyads, massulae, pollinia.

Unit 4
Ovule (8 lectures)
Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis

(details of *Polygonum* type); Organization and ultrastructure of mature embryo sac; Female germ Unit

Unit 5

Pollination and fertilization (6 lectures)

Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; structure of pollen tube; double fertilization.

Unit 6

Self incompatibility (8 lectures)

Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Rejection and Recognition reaction, Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intraovarian and in vitro pollination; Modification of stigma surface, parasexual hybridization; Cybrids (in brief with examples) , in vitro fertilization.

Unit 7

Endosperm (4 lectures)

Types (2 examples each), development, structure and functions.

Unit 8

Embryo (6 lectures)

Six types of Embryogeny (no details) ; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia*.

Unit 9

Seed (4 lectures)

Structure, importance and dispersal mechanisms (Adaptations – Autochory, Anemochory, Hydrochory, Zoochory with 2 examples each).

Units 10

Polyembryony and apomixes (6 lectures)

Introduction; Classification (given by Bhojwani and Bhatnagar); Causes and applications.

Unit 11

Germline transformation (4 lectures)

Pollen grain and ovules through pollen tube pathway method

Practical

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.

2. Pollen grains: Fresh pollen showing ornamentation and aperture, psuedomonads, dyads, polyads, pollinia, massulae (slides/photographs,fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test.germination: Calculation of percentage germination in different media using hanging and/or sitting 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 egg apparatus, central cell, antipodals.
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
8. Pollination and Seed dispersal mechanisms (adaptations through photographs / specimens
9. Flourescence Microscopes can be purchased for the colleges.

(a) Study of pollen cytology to see 2-celled and 3-celled pollen grains.
(b) To perform pollen culture.
(c) To isolate protoplast from pollen grains.
(d) To study pollen-pistil interactions (fluorescence microscopes).

References

1. Bhojwani, S.S., Bhatnagar, S.P. Dantu P. K. (2015). *The Embryology of Angiosperms*, 6th edition. New Delhi, Delhi: Vikas Publishing House. (Chapter 1 for Unit 1, Chapters 3 to 15 for unit 2-10, Chapter 17 for Unit 11)
2. Johri, B.M. (1984). *Embryology of Angiosperms.* Netherlands: Springer-Verlag. (Chapters 3, 4 for Unit 4, Chapter 6 for Unit 5, Chapter 7, 8 for Unit 7-8; Chapter 12 for Unit 9)
3. Raghavan, V. (2000). *Developmental Biology of Flowering plants.* Netherlands: Springer (Chapter 13 for Unit 8)
4. Shivanna, K.R. (2003). *Pollen Biology and Biotechnology*. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd. (Chapters 1, 2, 3, 4 for Unit 2-3; Chapter 7 for unit 5, Chapter 9 for Unit 6)

Additional Resources

1. Moza M. K., Bhatnagar A.K. (2007). Plant reproductive biology studies crucial for conservation. Current Science 92:1907. (For Unit 1)
2. Bhat V, Dwivedi K.K., Khurana P, Sopory S. (2005). Apomixis: an enigma with potential applications. Current Science 89: 1879-1893. (For Unit 10).
3. Mohanty D, Chandra A, Tandon R. (2016). Germline transformation for crop improvement. *In:* Raina S. N., Rama Rao S, Rajpal V. R. (Eds.). *Molecular Breeding for Sustainable Crop Improvement (Vol 2)*. Switzerland: Spring International Publishing AG, Cham, (Chapter14: pp 343-395 for Unit 11).

4. Resch T, Touraev A. (2011). Pollen Transformation Technologies. *In: Plant Transformation Technologies. C. Neal Stewart Jr, Alisher Touraev, Vitaly Citovsky, Tzvi Tzfira* (*Eds*). Blackwell Publishing limited. (Chapter 5 for Unit 11)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded and students are encouraged to refer to and read the latest research papers in the fields/topics covered.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained.

Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit V
Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit IX
Week 14: Unit X
Week 15: Unit XI

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. A small project where the students perform hands on experiments in embryology like studying the pollen of different taxa or observing different types of pollination in the field etc are also encouraged

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Scope of Reproductive Biology contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison)	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Micro-gametogenesis; Pollen wall structure, NPC system; Palynology and scope; Pollen wall proteins; Pollen viability, storage and germination	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Ovule Structure; Types; endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (*Polygonum* type); Organization and ultrastructure of mature embryo sac	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; structure of pollen tube; double fertilization.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Methods to overcome self-incompatibility: mixed pollination, bud pollination, stub pollination; Intraovarian and in vitro pollination; Modification of stigma surface, parasexual hybridization;	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	Cybrids		
Unit VII:	Endosperm types, development, structure and functions	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo;	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Seed structure, importance and dispersal mechanisms(Adaptations – Autochory, Anemochory, Hydrochory, Zoochory	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X:	Polyembryony and apomixes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit XI:	Pollen grain and ovules through pollen tube pathway method	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Morphology,Development, flowering, anther, pollen biology, ovule, gametogenesis, Pollination, fertilization, self -incompatibility, endosperm, seed, apomixis, polyembryony

Plant Physiology
(BHCC12)
Core Course - (CC) Credit:6

Course Objective (2-3)

The course aims at making students realize how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.

Course Learning Outcomes

The students are able to correlate morphology, anatomy, cell structure and biochemistry with plant functioning. The link between theory and practical syllabus is established, and the employability of youth would be enhanced. The youth can also begin small-scale enterprises.

Unit 1

Plant water relationship (10 lectures)
Water potential and its components, water absorption by roots, aquaporins, pathway of water movement--symplast, apoplast, transmembrane pathways, root pressure, guttation, ascent of sap--cohesion-tension theory, transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement--starch-sugar hypothesis, proton transport theory, blue light stimulated response.

Unit 2

Mineral nutrition (8 lectures)
Essential and beneficial elements, macro- and micronutrients, methods of study and use of nutrient solutions (ash analysis, hydroponics, aeroponics), criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents (including phytosiderophores).

Unit 3

Nutrient uptake (8 lectures)
Soil as a nutrient reservoir, transport of ions across cell membrane--passive absorption: simple (Fick’s law) and facilitated diffusion (carrier and channel proteins), active absorption, proton ATPase pump, electrochemical gradient, ion flux, uniport, co-transport (symport, antiport), role of mycorrhizae (in brief).

Unit 4

Translocation in the phloem (6 lectures)

Experimental evidence in support of phloem as the site of sugar translocation, composition of phloem sap, aphid stylet technique, Pressure-Flow Model, phloem loading and unloading, source-sink relationship.

Unit 5

Plant growth regulators (16 lectures)

Discovery, chemical nature (basic structure, precursor), bioassay, physiological roles and commercial applications of Auxins, Gibberellins, Cytokinins, Abscisic Acid, Ethylene; brief introduction: mechanism of action of auxins; Brassinosteroids and Jasmonic acid (brief introduction).

Unit 6

Physiology of flowering (6 lectures)

Photoperiodism, concept of florigen, CO-FT Model for long-distance transport of flowering stimulus, ABC model of flowering (in brief), vernalization, seed dormancy (causes and methods to overcome dormancy).

Unit 7

Phytochrome (6 lectures)

Discovery, chemical nature, role of phytochrome in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action. signal transduction

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Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Determination of water potential of given tissue (potato tuber) by falling drop method.
4. Study of the effect of light on the rate of transpiration in excised twig/ leaf.
5. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and a xerophyte.
6. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and a xerophyte (any one surface).
7. To study the phenomenon of seed germination (effect of light and darkness).
8. To study the induction of amylase activity in germinating barley grains.

Demonstration experiments

1. To demonstrate suction due to transpiration.
2. Fruit ripening.
3. Rooting from cuttings.
4. Bolting experiment.
5. To demonstrate the delay of senescence by cytokinins

References

1. Bajracharya, D. (1999). *Experiments in Plant Physiology: A Laboratory Manual*. New Delhi, Delhi: Narosa Publishing House. (For Practicals)
2. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism*. Singapore: Springer Nature, Singapore Pvt. Ltd. (Chapter 1 for Unit 1, Chapter 2 for Unit 2, Chapter 3 for Unit 3, Chapter 6 for Unit 4, Chapters 14 to 21, and 27 for Unit 5, Chapters 25 and 28 for Unit 6, Chapter 13 for Unit 7)
3. Hopkins, W. G., Huner, N. P. A. (2009). *Introduction to Plant Physiology*, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd. (Chapters 1, 2 and 8 for Unit 1, Chapter 4 for Unit 2, Chapter 3 for Unit 3, Chapter 9 for Unit 4, Chapters 18 to 21, 24 and 25 for Unit 5, Chapters 24 to 26 for Unit 6, Chapter 22 for Unit 7)
4. Kochhar, S.L., Gujral, S.K. (2017). *Plant Physiology: Theory and Applications*. New Delhi, Delhi: Foundation Books, Cambridge University Press India Pvt, Ltd. (Chapters 2 to 6 for Unit 1, Chapter 7 for Units 2 and 3, Chapter 13 for Unit 4, Chapter 15 for Unit 5, Chapter 14 for Units 6 and 7)

Additional Resources:
1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). *Plant Physiology and Development*, International 6th edition. New York, NY: Oxford University Press, Sinauer Associates. (Chapters 3, 4 and10 for Unit 1, Chapter 5 for Unit 2, Chapter 6 for Unit 3, Chapter 11 for Unit 4, Chapters 15, 18, 21 and 22 for Unit 5, Chapters 18 and 20 for Unit 6, Chapter 16 for Unit 7)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.

Weekly Teaching Plan
Week 1: Unit I
Week 2: Unit I
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Week 8: Unit V
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit V
Week 14: Unit VI
Week 15: Unit VII
The students are asked to submit their record notebooks to the teacher/s for checking.

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.
Assessment Task
Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Water potential and its components, water absorption by roots, aquaporins, pathway of water movement, root pressure, guttation, ascent of sap, transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement--starch-sugar hypothesis, proton transport theory, blue light stimulated response.	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Essential and beneficial elements, macro- and micronutrients, methods of study and use of nutrient solutions (ash analysis, hydroponics, aeroponics), criteria for	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents		
Unit III:	Soil as a nutrient reservoir, transport of ions across cell membrane--passive absorption: simple (Fick's law) and facilitated diffusion (carrier and channel proteins), active absorption, proton ATPase pump, electrochemical gradient, ion flux, uniport, co-transport (symport, antiport), role of mycorrhizae	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Experimental evidence in support of phloem as the site of sugar translocation, composition of phloem sap, aphid stylet technique, Pressure-Flow Model, phloem loading and unloading, source-sink relationship	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Discovery, chemical nature (basic structure, precursor), bioassay ,physiological roles and commercial applications of Auxins, Gibberellins, Cytokinins, Abscisic Acid, Ethylene; brief introduction: mechanism of action of auxins; Brassinosteroids and Jasmonic acid	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Photoperiodism, concept of florigen, CO-FT Model for long-distance transport of flowering stimulus, ABC model of flowering (in brief), vernalization, seed dormancy	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	Discovery, chemical nature, role of phytochrome in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Movement of water, ascent of sap, transpiration, stomatal movements, mineral nutrients, active and passive transport, translocation, plant growth regulators, photoperiodism, photomorphogenesis, signal transduction

Plant Metabolism
(BHCC13)
Core Course - (CC) Credit:6

Course Objective (2-3)

1. A comprehensive study of different pathways including their biochemistry and to some extent the molecular details.
2. Current understanding of regulation and integration of metabolic processes in plants with reference to crop productivity.
3. Significance of metabolic pathways for metabolic engineering in producing transgenics.
4. To gain the knowledge of physiological and biochemical processes in the plant system

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Course Learning Outcomes

- Concept and significance of metabolic redundancy in plants.
- Students will also be able to learn the similarity and differences in metabolic pathways in animals and plants.
- To have understanding of water and nutrient uptake and movement in plants, role of minerl elements, translocation of sugars, Role of various plant growth regulatoras, phytochrome cytochromes and phototropins, and flowering stimulus.

Unit 1

Concept in Metabolism (4 lectures)

Introduction, anabolic and catabolic pathways, Principles of thermodynamics, coupled reactions

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Unit 2

Enzymes (10 lectures)

Historical Background, structure, nomenclature and classification of enzymes, Mechanism of action (activation energy, lock and key, induced fit model), Michaelis Menten equation, enzyme inhibition (competitive, non-competitive and uncompetitive), factors affecting enzyme activity, role of regulatory enzymes, allosteric regulation and covalent modulation, isozymes and alloenzymes

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Unit 3

Carbon assimilation (14 lectures)

Historical background, concept of light-action and absorption spectra, photosynthetic pigments, role of photosynthetic pigments (chlorophyll and accessory pigments (no structural details), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, photophosphorylation, PSI, PSII, Q cycle, CO_2 reduction, photorespiration, C4 pathways, Crassulacean acid metabolism, factors affecting CO_2 reduction

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Unit 4

Carbohydrate metabolism (2lectures)

Metabolite pool and exchange of metabolites, synthesis and catabolism of sucrose and starch (no structural details)

Unit 5

Carbon Oxidation (10 lectures)

Historical Background of Glycolysis and Krebs cycle, Glycolysis, fate of pyruvate- aerobic and anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of Kerbs cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Unit 6

ATP synthesis (4lectures)

Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyer's conformational model, Racker's experiement, Jagendorf's experiement, role of uncouplers, P/O ratio

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Unit 7

Lipid Metabolism (8 lectures)

Synthesis and breakdown of triglycerides, -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination, -oxidation.

Unit 8

Nitrogen Metabolism (8 lectures)

Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes), Physiology and biochemistry of nitrogen fixation, Ammonia assimilation (GS-GOGAT), reductive amination and transamination.

Practical

1.To study the activity of urease enzyme and effect of substrate concentration and temperature on enzyme activity.
2. To study the activity of catalase enzyme and effect of heavy metal and pH on enzyme activity.
3. To study the activity of peroxidase and tryosinase and effect of inhibitor (phenylthiourea of tryosinase and sodium azide of peroxidase) on any one of the enzymes.
4. Chemical separation of photosynthetic pigments.
5. Experimental demonstration of Hill's reaction.
6. To demonstrate and verify Blackman's law of limiting factors.

7. To compare the rate of respiration in different parts of a plant (at least 3 parts).
8. To study activity of Nitrate reductase in leaves of two plant sources.
9. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
10. Demonstration of fluorescence by isolated chlorophyll pigments.
11. Demonstration of absorption spectrum of photosynthetic pigments.
12. Demonstration of respiratory quotient (RQ).

References

1.Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism*. Singapore: Springer. (chapter 1 for Unit 1, chapter 4 for Unit 2, chapter 5 for Unit 3, chapter 9 for Unit 4; chapter 7 for Unit 7, chapter 8 for Unit 6, chapter 7 for Unit 10, chapter 11 for Unit 8).

2. Hopkins, W.G., Huner, N. (2008). *Introduction of Plant Physiology*, 4th edition. New Jearsey, U.S.: John Wiley and sons. (chapters 1-5, 12, 13 for Unit 3, chapters 2-11 for Unit 5, chapters 1-4 for Unit 6, chapters 1-5 for Unit 8).

3. Jain V.K.(2016) *Fundamentals of Plant Physiology* 18th edition. New Delhi, India: S. Chand & Company Pvt. Ltd. (chapters 1-8 for Unit 2, chapters 1-16 for Unit3, chapters 1,2 for Unit 4, chapters 1-11 for Unit 5, chapters 1-5 for Unit6, chapters 1-4 for Unit 7,chapters 1-5 for Unit 8.

4. Jones, R.,Ougham, H., Thomas,H.,Waaland, S. (2013). *The molecular life of plants*. Chichester, England: Wiley-Blackwell. Salisbury F.B., Ross C.W. (2006) *Plant Physiology* 4th edition. Delhi, India: CBS Publishers and Distributors. (chapters 2,4,6,7 of Unit2, chapters 1,2,3,4,5,6,7,8,9,10,12,13,14,15,16 for Unit3, chapters 2-11 for Unit 4, chapters 1,2,4 for Unit 7, chapters 1-5 for Unit 8).

Additional Resources:
6. Taiz, L., Zeiger, E., MØller, I.M., Murphy, A. (2015). *Plant Physiology and Development*, 6th edition. Massachusetts: Sinauer Associates Inc. Sunderlands (chapters 2-16 for Unit 3, chapters 1,2 for Unit 4, chapters 2-9,11 for Unit 5, chapters 1-5 for Unit 7, chapters 1-3,5 for Unit 8).

5. Nelson, D.L., Cox, M.M. (2017). *Lehninger Principle of Biochemistry*, 7th edition. New York, NY: W.H. Freeman, Macmillan learning.

Teaching Learning Process

The experiments included in the paper are performed individually or in group and are followed by group discussions and interjections. The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years’ question papers, thus preparing the students for the examination.

Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.

Weekly Teaching Plan
Week 1: Unit I
Week 2: Unit II
Week 3: Unit II
Week 4: Unit III
Week 5: Unit III
Week 6: Unit IV
Week 7: Unit V
Week 8: Unit V
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VI
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit VIII

Assessment Methods

Students are continuously assessed during practical class.
Submission of class records is mandatory. This exercise develops scientific skill as well as methods of recording and presenting scientific data.
Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	anabolic and catabolic pathways, Principles of thermodynamics, coupled reactions	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Enzymes mechanism of action (activation energy, lock and key, induced fit model), Michaelis Menten equation, enzyme inhibition, factors affecting enzyme activity, role of regulatory enzymes, allosteric regulation and covalent modulation, isozymes and alloenzymes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	photosynthetic pigments, role of	Class room lectures	Hands on exercises,

	photosynthetic pigments (chlorophyll and accessory pigments (no structural details), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, photophosphorylation, PSI, PSII, Q cycle, CO2 reduction, photorespiration, C4 pathways, Crassulacean acid metabolism, factors affecting CO2 reduction	and Practical demonstration, experiments	PPT, assignments, tests
Unit IV:	Metabolite pool and exchange of metabolites, synthesis and catabolism of sucrose and starch	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Glycolysis, fate of pyruvate- aerobic and anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of Kerbs cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyer's conformational model, Racker's experiement, Jagendorf's experiement, role of uncouplers	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	Synthesis and breakdown of triglycerides, -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination, -oxidation.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes), Physiology and biochemistry of nitrogen fixation, Ammonia assimilation (GS-GOGAT), reductive amination and transamination.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Bioenergetics, Coupled reactions, allosteric regulation, photochemical reaction, Glyoxylate cycle, Electron transport chain, ATP synthase, triglycerides, nitrogenase,Anabolism, catabolism, carbon assimilation, carbon oxidation, Lipid metabolism, nitrogen metabolism,

Plant Biotechnology
(BHCC14)
Core Course - (CC) Credit:6

Course Objective (2-3)

1. To give students new knowledge and widening of the knowledge acquired in other course by handling of classical and modern plant biotechnology processes, including tissue culture for healthy plants, plants with improved characteristics.
2. To explore the use of biotechnology to both generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation.
3. Understanding of biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals (vaccines, antibodies, antibiotics etc.), food industry (transgenic crops with improved qualities (nutraceuticals, industrial enzymes etc.), agriculture (biotic and abiotic stress tolerant plants, disease and pest resistant plants, improved horticultural varieties etc.), ecology (plants role in bioremediation). This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.
4. In the laboratory classes, students will perform some of the techniques currently used to generate information and detect genetic variation.

Course Learning Outcomes

The successful students will be able to:

- Learn the basic concepts, principles and processes in plant biotechnology.
- Have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.
- Use basic biotechnological techniques to explore molecular biology of plants
- Explain how biotechnology is used to for plant improvement and discuss the biosefty concern and ethical issue of that use.

Unit 1

Plant Tissue Culture (12 lectures)

Historical perspective, Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Plasticity andTotipotency; Organogenesis; Embryogenesis (somatic and zygotic);

Unit 2

Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and cybrids; Cryopreservation; Germplasm Conservation).

Unit 3

Recombinant DNA technology (32 lectures)

Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (PUC 18 and pUJC19, pBR322. Ti plasmid, BAC); Lambda phage, Ml 3 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC and briefly PAC,).

Unit 4

Gene Cloning (Recombinant DNA. Bacterial Transformation and selection of recombinant clones, PCR and RT-PCRmediated gene cloning); Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, PCR; Methods of gene transfer- Agrohacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment: Selection of transgenics— selectable marker and reporter genes (Luciferase, GUS, GFP).DNA fingerprinting by RAPD and RFLP;

Unit 5

Applications of Biotechnology (16 lectures)

Engineering plants to overcome abiotic (drought and salt stress) and biotic stress Pest resistant (Bt-cotton) and herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato. Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug)

Unit 6

Molecular farming(Plants as bioreactors)for edible vaccines, antibodies, polymers, biodegradable plastics(PHA), biomass utilization andindustrial enzymes) (- amylase, phytase, lignocelluloses degrading enzymes); Biosatety concerns.

Practical

l. (a) Preparation of Murashige & Skoog’s (MS) medium.
(b) Demonstration of in vitro sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
2. Study of anther. embryo and endosperm culture, micropropagation. somatic embryogenesis & artificial seeds through photographs.
3. Isolation of protoplasts.
4. Construction of restriction map of circular and linear DNA from the data provided.
5. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.

6. Study of steps of genetic engineering for production of *Bt* cotton, Golden rice, FlavrSavr tomato through photographs.
7. Isolation of plasmid DNA.
8. Restriction digestion and gel electrophoresis of plasmid DNA (demonstration/ photograph).
9. Calculate the percentage similarity between different cultivars of a species using RAPD profile. Construct a dendrogram and interpret results.

References

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). *The Embryology of Angiosperms*, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd. (Chapter 17 for Unit 1,2)
2. Bhojwani, S.S., Razdan, M.K., (1996). *Plant Tissue Culture: Theory and Practice. Amsterdam,* Netherlands: Elsevier Science. (Chapters 2,3,4 5, 6, for Unit 1; Chapters 12, 14 for Unit 2; Chapters 14 for Unit 3)
2. Glick, B.R., Pasternak, J..J.(2010). *Molecular Biotechnology: Principles and Applications*. Washington, U.S.: ASM Press. (Chapter 1,3 for Unit 3, 4; Chapter 12,13,14, 20 for Unit 6)
4. Snustad, D.P.,Simmons, M.J. (2010). *Principles of Genetics*, 5th edition. Chichester, England: John Wiley and Sons. (Chapter 16 for Unit 3)

Additional Resources

1. Stewart, C.N. Jr. (2008). *Plant Biotechnology and Genetics: Principles, Techniques and Applications*. New Jearsey, U.S.: John Wiley & Sons Inc. (Chapter 5 for Unit 1,2; Chapter 8 for Unit 3; Chapter 9 for Unit 4; Chapter 17 for Unit 5,6; Chapter 11 for Unit 5)
2. Gupta, R., Rajpal, T. (2012) *Concise Notes on Biotehnology*. New Delhi, Delhi:McGraw Hill Publications.(unit1 2,3, 4 and 6) (chapter 10for unit 1 &2) (chapter 4 for unit 3) (chapter 5 for unit4) (chapter 14 for unit, 6)

Teaching Learning Process

1) Problem oriented learning
2) Individual seminar
3) Presentation and interpretation to other students
4) Discussion of published research articles on the selected topics
5) Practical will introduce the students to a range of tools and techniques of biotechnology

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II

Week 5: Unit III
Week 6: Unit III
Week 7: Unit IV
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit V
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

Assessment must encourage and reinforce learning, enable robust and fair judgments about student performance. It would be fair and equitable to students and give them the opportunity to demonstrate what they have learned. Assessment will be by written class test, assignment, project work, viva for internal assessment and written theory and practical examination for university evaluation.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Plasticity andTotipotency; Organogenesis; Embryogenesis	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and cybrids; Cryopreservation; Germplasm Conservation).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (PUC 18 and pUJC19, pBR322. Ti plasmid, BAC); Lambda phage, Ml 3 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC and briefly PAC,).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Gene Cloning (Recombinant DNA. Bacterial Transformation and selection of recombinant clones, PCR and RT-	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments, tests

	PCRmediated gene cloning); Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, PCR; Methods of gene transfer- Agrohacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment: Selection of transgenics— selectable marker and reporter genes (Luciferase, GUS, GFP).DNA fingerprinting by RAPD and RFLP	experiments	
Unit V:	Engineering plants to overcome abiotic (drought and salt stress) and biotic stress Pest resistant (Bt-cotton) and herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato. Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Molecular farming(Plants as bioreactors)for edible vaccines, antibodies, polymers, biodegradable plastics(PHA), biomass utilization andindustrial enzymes) (- amylase, phytase, lignocelluloses degrading enzymes); Biosafety concerns	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Tissue culture, micropropagation, organogenesis, totipotency, cryopreservation, recombinant DNA technology, Gene cloning , gene transfer, , electroporation microinjection, DNA library, transgenic crops, Humulin, biosafety, edible vaccines,

Analytical Techniques in Plant Sciences
(BHDS1)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

To gain the knowledge on various techniques and instruments used for the study of plant biology

Course Learning Outcomes

Understanding of principles and use of light, confocal transmission and electron microscopy, centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques

Unit 1

Imaging and related techniques (15 lectures)

Principles of microscopy; Light 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.

Unit 2

Cell fractionation (8 lectures)

Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CaCl2 gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3

Radioisotopes (4 lectures)

Use in biological research, auto-radiography, pulse chase experiment.

Unit 4

Spectrophotometry (4 lectures)

Principle and its application in biological research.

Unit 5

Chromatography (8 lectures)

Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6

Characterization of proteins and nucleic acids (6 lectures)

Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE

Practical

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Demonstration of ELISA.
3. To separate nitrogenous bases by paper chromatography.
4. To separate sugars by thin layer chromatography.
5. Isolation of chloroplasts by differential centrifugation.
6. To separate chloroplast pigments by column chromatography.
7. To estimate protein concentration through Lowry’s methods.
8. To separate proteins using PAGE.
9. To separation DNA (marker) using AGE.
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).

References

1. Cooper, G.M., Hausman, R.E. (2009). *The Cell: A Molecular Approach*, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA. (Chapter 1 for Unit 1; 2.
2. Iwasa,J, Marshall , W. (2016). Karps's Cell and Molecular Biology ; Concepts and experiments. New Jersey, U.S.A.: John Wiley & Sons. Chapter 18 for Unit 1,2,3,5,)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.

When the entire syllabus is completed, a few lectures are devoted to discuss the previous years’ question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.

The students are asked to submit their record notebooks to the teacher/s for checking.

Weekly Plan

Week 2: Unit I

Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Instrumentation lab visit
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit VI
Week 14: Unit VI

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.

Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.

An assignment can be given in place of the presentation.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Principles of microscopy; Light 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	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	etching.		
Unit II:	Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CaCl2 gradient, analytical centrifugation, ultracentrifugation, marker enzymes.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Radioisotopes and their Use in biological research, auto-radiography, pulse chase experiment.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Principle and its application in biological research.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Microscopy, Flow cytometry, Chromosome banding, FISH, SCM, Centrifugation, radioisotopes, spectrophotometry, chromatography, electrophoresis, PAGE, mass spectrometry

Bioinformatics
(BHDS4)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

A computer-based approach is now central to biological research. Bioinformatics operates at the intersection of biology and informatics and has a strong mathematical component. Training students in various aspects of Bioinformatics is the objective of this course.

Course Learning Outcomes

With a working knowledge of the practical and theoretical concepts of bioinformatics, you will be well qualified to progress onto advanced graduate study. The portfolio of skills developed on the programme is also suited to academic research or work within the bioinformatics industry as well as range of commercial settings.

Unit 1

Introduction to Bioinformatics (10 lectures)

Computer fundamentals-programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics-Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.

Unit 2

Biological databases (10 lectures)

Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol).

Unit 3

Data Generation and Data Retrieval (8 lectures)

Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)

Unit 4

Basic concepts of Sequence alignment (8 lectures)

Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and BLOSUM), and CLUSTALW.

Unit 5

Phylogenetic analysis (8 lectures)

Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.

Unit 6

Applications of Bioinformatics (16 lectures)

Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

Practical

1. Sequence retrieval (protein and gene) from NCBI.
2. Structure download (protein and DNA) from PDB.
3. Molecular file formats - FASTA, GenBank, Genpept, GCG, CLUSTAL, Swiss-Prot, FIR.
4. Molecular viewer by visualization software.
5. Translate a nucleotide sequence and select the correct reading frame of the polypeptide from the output sequences.
6. Predict the structure of protein from its amino acid sequence.
7. BLAST suite of tools for pairwise alignment.
8. Sequence homology and Gene annotation.
9. Generating phylogenetic tree using PHYLIP, and MAGA X, Clustal W etc with PHYLIP.
10. Gene prediction using GENSCAN and GLIMMER.

References

1. Ghosh, Z., Mallick, B. (2008). *Bioinformatics – Principles and Applications*, 1st edition. New Delhi, Delhi: Oxford University Press.(chapters 1-11 for Unit 1, chapters 1-7 for Unit 2, chapters 1-5 for Unit 3, chapters 1-7 for Unit 4, chapters 1-4 for Unit 5, chapters 1-8 for Unit 6.

2. Knight Regan (2017) *An Introduction to Bioinformatics*, Larsen & Keller Education, United States. (chapters 1-7 for Unit 2, chapters 1-5 for Unit 3).

3. Mount D.W.(2004). *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbour Laboratory Press, New York, USA. (chapters 1-5 for Unit 3,chapters 1-7 of Unit 4, chapters 1-4 for Unit 5) .
4. Sharma, V, Munjal, A, Shankar A. (2018). *A Text Book of Bioinformatics*. Rastogi Publications, Meerut, India. (chapters 1-4 for Unit 2, chapters 1-5 for Unit 3, chapters 1-7 of Unit 4, chapters 1-4 for Unit 5, chapters 1-8 for Unit 6.)

Teaching Learning Process

Multimedia tutorials and hands on training over biological data using world wide web services.
Interactive classroom teaching of mathematical modelings and Computer programs.
Weekly Lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit VI
Week 14: Unit VI

Assessment Methods

Theoretical tests with the help of assignments, project works, presentations, and through practical examinations.
Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.	Class room lectures and Practical demonstration, experiments , gene ration and analysis of data	Hands on exercises, PPT, assignments, tests,
Unit II:	Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB),	Class room lectures and Practical	Hands on exercises, PPT,

	protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol).	demonstration, experiments, generation and analysis of data	assignments, tests
Unit III:	Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit IV:	Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and BLOSUM), and CLUSTALW.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit V:	Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit VI:	Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests

Keywords

Biological Databases, Sequence Alignment, Phylogenetics Analysis, Protein Structure prediction and analysis.

Biostatistics
(BHDS2)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

To have knowledge of analysis of scientific data

Course Learning Outcomes

Understanding of interpreting the scientific data that is generated during scientific experiments. It is the responsibility of biostatisticians and other experts to consider the variables in subjects to understand them, and to make sense of different sources of variation. In essence, the goal of biostatistics is to disentangle the data received and make valid inferences that can be used to solve problems in public health. Biostatistics uses the application of statistical methods to conduct research in the areas of biology, public health, and medicine. Many times, experts in biostatistics collaborate with other scientists and researchers.

Unit 1

Biostatistics - definition - statistical methods - basic principles. Variables -measurements, functions, limitations and uses ofstatistics. (8 lectures)

Unit 2

Collection of data primary and secondary - types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data – sampling methods. (12 lectures)

Unit 3

Measures of central tendency - mean, median, mode, merits & demerits of harmonic and geometric mean - . Measures of dispersion - range, standard deviation, mean deviation, standard error, skewness and kurtosis, quartile deviation –merits and demerits; Co- efficient of variations. (13 lectures)

Unit 4

Correlation - types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression.
(10 lectures)

Unit 5

Statistical inference - hypothesis - simple hypothesis - student’t’ test - chi square test, Ftest.
(10 lectures)

Unit 6

Basic concept of probability, Introduction to bionomial, poisson and Normal distribution; Uses of advance softwares (MS-excel, SPSS, Sigmaplot and R) in modern biostatistics. (6 Lectures)

Practical

1) Classification - tabulation and presentation of data
2) Calculation of mean, mode, median, standard deviation, quartile deviation, standard error and coefficient of variance
3) Calculation of correlation coefficient values by Karl Pearson's and Spearman Rank methods
4) Statistical inference - hypothesis – student 't' test - chi square test
5) Addition and multiple rules of probability
6) One way analysis of variance
7) Uses of software in biostatistics

References

1. Mann, S. P. (2016). Introductory Statistics, 9th edition. Hoboken, NJ, Jone Wiley and Sons Inc. Chapter 1 for Unit 1; Chapter 3 for Unit 2; Chapter 3,7 for Unit 2; Chapter 9,10 for Unit 5; Chapter 3 for Unit 3; Chapter 2 for Unit 2; Chapter 6,7 for Unit 6).
2. Danniel, W.W. (1987). *Biostatistic*. New York,NY: John Wiley Sons. (Chapter 1 for unit 1; Chapter 2-3 for Unit 6; Chapter 5 for Unit 2; Chapter 2 for Unit 3; Chapter 9 for Unit 6; Chapter 9 for Unit 4; Chapter 7, 12 for Unit 5)
3. Khan, I.A., Khanum, A. (2004). *Fundamentals of Biostatistics*, 5th edition. Hyderabad: Ukaaz publications.(Chapter 1 for unit 1; Chapter 2-5 for Unit 2; Chapter 6-8 for Unit 3; Chapter 6,9 for Unit 6; Chapter 11-12 for Unit 4; Chapter 13 and 15 for Unit 5)
4. Zar, J.H. (2014). *Biostatistical Analysis*, 5th edition. London, London: Pearson Publication. Chapter 3 for Unit 3; Chapter 5 for Unit 6; Chapter 17,18,19, 20 for Unit 4; Chapter 22 for Unit 5)

Additional Resources:

5. Pandey, M. (2015). *Biostatistics Basic and Advanced.* New Delhi, Delhi: M V Learning. Chapter 1,2,3,4,5, for Unit 1; Chapter 9,10,11,13 for Unit 2; Chapter 6 for Unit 5; Chapter 4 for Unit 6).
6. Sundarrao, P.S.S., Richards, (1996). *An introduction to Biostatistics*, 3rd edition. Vellore, Tamil Nadu: J. Christian Medical College.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.

The students are asked to submit their record notebooks to the teacher/s for checking.

Weekly Plan

Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit VI
Week 14: Unit VI

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained are scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Biostatistics - definition - statistical methods - basic principles. Variables -measurements, functions, limitations and uses ofstatistics.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Collection of data primary and secondary - types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data – sampling methods.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Measures of central tendency - mean, median, mode, merits & demerits of harmonic and geometric mean - . Measures of dispersion - range, standard deviation, mean deviation, standard error, skewness and kurtosis, quartile deviation –merits and demerits; Co- efficient of variations.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Correlation - types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Statistical inference - hypothesis - simple hypothesis - student’t’ test - chi square test, Ftest.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Basic concept of probability, Introduction to bionomial, poisson and Normal distribution; Uses of advance softwares (MS-excel, SPSS, Sigmaplot and R) in modern biostatistics.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Biological database, Sequence database, ,NCBI, Sequence alignment, melecular Phylogeny QSAR, crop improvement ,

Industrial and Environmental Microbiology
(BHDS3)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

1. To introduce students with the industrial microbiology: concepts, principles, scope and application
2. To introduce students with the environmental microbiology: concepts, principles, scope and application

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Course Learning Outcomes

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

1. Understand how microbiology is applied in manufacturing of industrial products
2. Know about design of bioreactors, factors affecting growth and production
3. Understand the rationale in medium formulation & design for microbial fermentation, sterilization of medium and air
4. Comprehend the different types of fermentation processes
5. Comprehend the techniques and the underlying principles in upstream and down- stream processing
6. Learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
7. Understand various biogeochemical cycles – Carbon and Nitrogen, and microbes involved
8. Understand the basic principles of environment microbiology and application of the same in solving environmental problems – waste water treatment and bioremediation
9. Comprehend the various methods to determine the quality of water

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Unit 1

Scope of microbes in industry and environment; institutes of microbial research (4 lectures)

Unit 2

Bioreactors/Fermenters and fermentation processes (12 lectures)

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous Fermentations; Components of a typical bioreactor, Types of bioreactors: laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Unit 3

Microbial production of industrial products (14 lectures)

Microorganisms involved, microorganisms generally regarded as safe (GRAS), media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; production of industrially important products: enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin)

Unit 4

Microbial enzymes of industrial interest and enzyme immobilization (8 lectures)

Overview of enzymes used for industrial applications, Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes: glucose isomerase and penicillin acylase

Unit 5

Microbes and quality of environment. (6 lectures)

Distribution of microbes in air, soil and water; isolation of microorganisms from soil, air and water.

Unit 6

Microbial flora of water. (10 lectures)

Water pollution: various sources and control measures; role of microbes in sewage and domestic waste water treatment systems. Microorganisms as indicators of water quality: coliforms and fecal coliforms.

Practical

1. Principles and functioning of instruments in microbiology laboratory (autoclave, laminar air flow, incubators, types of fermenters)
2. Preparation of different culture media (Nutrient medium/ Luria Bertani medium/Potato dextrose medium/Czapek Dox medium)
3. Hydrolysis of casein / starch by microorganisms
4. Alcohol production by yeast using sugar/ jaggery
5. Serial dilution method for isolation of microorganisms from water and soil and study of aeromicroflora.
6. Determination of BOD, COD, TDS and TOC of water samples
7. Determination of coliforms in water samples using eosin methylene blue (EMB) medium
8. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations and a report to be submitted.

References

Suggested Readings

1. Pelzar, M.J. Jr., Chan E.C. S., Krieg, N.R. (2010). *Microbiology: An application based approach*. New Delhi, Delhi: McGraw Hill Education Pvt. Ltd., Delhi. (Chapter 25, 27, 28, 29 for Unit Unit 1, 2, 3, 5 & 6)
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). *Microbiology*. San Francisco, SF: Pearson Benjamin Cummings,. 9th edition (Chapter 27 for Unit 6)
3. Stanbury, P.F., Whitaker, A., Hall, S.J. (2016) *Principles of Fermentation Technology***.** Amesterdam, NDL**:**Elsevier Publication (Chapter 4, 5, 7, 10 , 11 for Unit 1 to 6)
4. Patel, A.H. (2008) *Industrial Microbiology*, Bangalore, India: McMillan India Limited (Chapter 2, 3, 5, 7, 11, 12, 14, 20 for Unit 1 to 6)
5. Mohapatra. P.K. (2008). *Textbook of Environmental Microbiology* New Delhi, Delhi, I.K. International Publishing House Pvt.Ltd. (Chapter 1,5,6, 11,12,14 for Unit 5, 6, & 7)

6. Bertrand, Jean-Claude, Caumette, P. , Lebaron, P, Matheron, R., Normand, P., Sime-Ngando, T. (2015) *Environmental Microbiology: Fundamentals and Applications*. Amesterdam, Netherlands, Springer (Chapter 14,16,17 for Unit 5 & 7)
7. Joe, S., Sukesh (2010). *Industrial Microbiology*. New Delhi, Delhi: S.Chand & Company Pvt. Ltd., (Cahpter 1,2,3,,5,13 for Unit 1 to 4)

Additional Sources

8. Casida, J.R. (2016). *Industrial Microbiology*. New, Delhi, Delhi, New Age International Publishers (Chapter 1,2,3,4,7,14,17,25,26 for Unit 1 to 4)
9. Atlas, Bartha. (1997). *Microbial Ecology: Fundamentals and Applications*. San Fransisco, SF. Pearson (Chapter 9, 10, 11, 14 for Unit 5 & 7)
10. Sharma, P.D. (2005)., *Environmental Microbiology*. Meerut, UP: Alpha Science International, Ltd

Teaching Learning Process

i) The acquired knowledge in the classroom will be integrated with practical classes to impart a sound understanding of the course
ii) More emphasis on hands on practical sessions
iii) Visits to various research institutes/industries to understand the application of microbes for commercial productions.
iv)Visits to industries/ research institutions working towards mitigation of various environmental issues through microbial application.
v) Students will be motivated to become self-directed learners by being able to monitor and adjust their approach towards learning of the course.

Teaching Learning Plan

Week 1: Unit I Week 2: Unit I Week 3: Unit II Week 4: Unit II Week 5: Unit III Week 6: Unit III Week 7: Unit III Week 8: Unit IV Week 9: Unit IV Week 10: Mid semester Exam Week 11: Mid Semester Break Week 12: Unit V Week 13: Unit VI Week 14: Unit VI Week 15: Unit VII

Assessment Methods

i. Continuous evaluation of the progress of students
ii. Field based projects/reports
iii. Interactive sessions/ presentations
iv. Semester end evaluation

ASSESSMENT METHOD

Unit No	**Coure learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
I	**Scope of microbes in industry and environment**	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
II	**Bioreactors/Fermenters and fermentation processes** Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous Fermentations; Components of a typical bioreactor, Types of bioreactors: laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.	Class room lectures and Practical demonstration, experiments, industry/institute visit to learn the structure and functioning of various fermenters	Hands on excercises, PPT, assignments, tests, Industry/ institute visit report
III	**Microbial production of industrial products** Microorganisms involved, microorganisms generally regarded as safe (GRAS), media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; production	Class room lectures and Practical demonstration, experiments, industry/institute visit to learn the role of microbes in production of various products	Hands on excercises, PPT, assignments, tests, Industry/ institute visit report

	of industrially important products: enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin)		
IV	**Microbial enzymes of industrial interest and enzyme immobilization** Overview of enzymes used for industrial applications, Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes: glucose isomerase and penicillin acylase**.**	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
V	**Microbes and quality of environment.** Distribution of microbes in air, soil and water; isolation of microorganisms from soil, air and water.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VI	**Microbial flora of water.** Water pollution: various sources and control measures; role of microbes in sewage and domestic waste water treatment systems. Microorganisms as indicators of water quality: coliforms and fecal coliforms.	Class room lectures and Practical demonstration, experiments, visit to a sewage treatment plant to observe the role of microbes	Hands on excercises, PPT, assignments, tests, field visit report
VII	**Microbes in agriculture and remediation of contaminated soils.** Biological fixation (Carbon and Nitrogen); bioremediation of contaminated soils	Class room lectures and Practical demonstration, experiments, field visit	Hands on excercises, PPT, assignments, tests, field visit report

Keywords

Industrial microbiology, environmental microbiology, microbes, bioreactors, fermenters, fermentation, upstream processing, downstream processing, microbial enzymes, enzyme immobilization, aeromicroflora, water pollution, coliform, biological fixation, bioremediation

Natural Resource Management
(BHDS9)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

To introduce the students with various Natural Resources and their management strategies.
To make them aware about the contemporary practices and efforts (national and international) in resources management.

Course Learning Outcomes

It acquaints students with various Natural Resources- their availability, causes of depletion, conservation, sustainable utilization and their management strategies. The students will be able to evolve strategies for sustainable natural resources management. The students will also have the knowledge of national and international initiatives, and policies adopted in natural resources management.

Unit 1

Natural resources (2 lectures)
Definition and types.

Unit 2

Sustainable utilization (8 lectures)
Concept, approaches (economic, ecological and socio-cultural).

Unit 3

Land (8 lectures)
Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation (magnitude of problem and cause) and management strategies; Restoration of degraded lands.

Unit 4

Water (8 lectures)
Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies, Ramsar convention.

Unit 5

Biological Resources (12 lectures)

Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).

Unit 6

Forests (6 lectures)

Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion, Biological Invasion; Management.

Unit 7

Energy (6 lectures)

Renewable and non-renewable sources of energy

Unit 8

Contemporary practices in resource management (8 lectures)

EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.

Unit 9

National and international efforts in resource management and conservation (4 lectures)

Practical

1. Estimation of solid waste generated by a domestic system (biodegradable and non biodegradable) and its impact on land degradation.
2. Analyses for pH, hardness, TDS, Alkalinity, COD and BOD of water samples from various sources.
3. Diversity indices in field based/simulation experiment.
4. Collection of data on forest cover of specific area. Measurement of dominance of woody species by DBH (diameter at breast height) method.
5. Calculation and analysis of ecological footprint (carbon footprint using UN/WWF carbon calculator).

References

1. Vasudevan, N. (2006). *Essentials of Environmental Science*. New Delhi, India: Narosa Publishing House. (Chapter 5 for Unit 1,2,3,4,5,6,7 and 8; (Chapter 6 for Unit 9);
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). *Ecology, Environment and Resource Conservation*.New Delhi, India: Anamaya Publications. (Chapter 25 for Unit 1,2,3,4,5,6,7 and 8; Chapter 30 for Unit 9))

3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). *An Introduction to Sustainable Development*. New Delhi, India: Prentice Hall of India Private Limited.(Chapter 1 for Unit 2, Chapter 13 for Unit 8,9)
Sharma , P D. (2005). *Ecology and Environment*. Meerut, UP: Rastogi Publications (Chapter 16 for 1,2,3,4,5,6,7; Chapter 17 for Unit 8; Chapter 24 for Unit 9),

Teaching Learning Process

Theory: The Class room teaching is integrated with practical classes, and field visit to impart a sound understanding of the course. The theory topics are covered in lectures with the help of blackboard teaching and Power Point presentations. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s in the laboratory/field. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to use online software, graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
College teachers can also form a group and prepare e-contents for theory as well as for practicals. Visit is also be organised to a Natural Ecosystem, any degraded land/Restored site or any Institution/industry.
Teaching Learning Plan:

Week 1: Unit I
Week 2: Unit II
Week 3: Unit II
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit IV
Week 7: Unit V
Week 8: Unit V
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VIII
Week 14: Unit VIII
Week 15: Unit IX

Assessment Methods

Theory: The students are continuously evaluated based on a assignments/presentation and class test. The answer scripts of the test are returned to the students. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Natural Resources	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Sustainable Utilization	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Land Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation (magnitude of problem and cause) and management strategies; Restoration of degraded lands.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Water. Fresh water ; Marine; Estuarine; Wetlands; Threats and management strategies	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Biological Resources Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Forests, Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion (deforestation and biological invasion); Management	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Energy	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Contemporary practices in resource management	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IX	National and international efforts in resource management and conservation	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Land, Water, Biodiversity, Energy, Conservation, Management Strategies

Plant Breeding
(BHDS8)
Discipline Specific Elective - (DSE) Credit:6

Course Objectives

To gain knowledge on commercially important plants, their breeding systems and strategies employed for crop improvement.

Course Learning Outcomes

Student would be able to understand the experimental steps and methods involved in generating new varieties using classical and contemporary breeding practices.

Unit 1:
An introduction to Plant Breeding (10 lectures)
Introduction and objectives. Breeding systems: modes of reproduction in crop plants. **Self-incompatibility, male sterility and apomixis.**Important achievements and undesirable consequences of plant breeding.

Unit 2:
Methods of crop improvement (20 lectures)
Introduction: Centers of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross pollinated and vegetatively propagated plants;, Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.

Unit 3:
Quantitative inheritance (10 lectures)
Concept, mechanism, Monogenic vs polygenic Inheritance, **QTL and QTL Mapping,** Case studies in inheritance of Kernel colour in wheat, Fruit quality in tomato.

Unit 4:
Inbreeding depression and heterosis (10 lectures)
History, genetic basis of inbreeding depression and heterosis; Applications.

Unit 5:
Crop improvement and breeding (10 lectures)

Role of mutations; Polyploidy; Distant hybridization, **Molecular Breeding, Marker assisted selection**, Role of biotechnology in crop improvement.

Practicals (tentative species: Pea, *Brassica*, Chickpea, Wheat*)

1. Introduction to field /controlled pollinations in field and laboratory (temporal details of anthesis, anther dehiscence, stigma receptivity and pollen viability, emasculation, bagging).
2. Analysis of the breeding system of chosen crop species by calculating Pollen:Ovule Ratio
3. Calculation of Index of self-incompatibility (ISI) and Confirmation of Self-Incompatibility.
4. Study of Quantitative and qualitative characters in select crops.
6. Study of Pollinators.
7. Assessment of genetic diversity by using Molecular Markers.

References

1. Acquaah, G. (2007). *Principles of Plant Genetics & Breeding*.New Jearsey, U.S.: Blackwell Publishing. (Chapter 1,2 for Unit 1; Chapter 9 for Unit 5)

3. Singh, B.D. (2005). *Plant Breeding: Principles and Methods*, 7th edition. New Delhi, Delhi: Kalyani Publishers.(Chapter 1 for Unit 1; Chapter 2,3,11-15 for Unit 2; Chapter 4 for Unit 3;: Chapter 18-24, 29 for Unit 5);

2. Chaudhari, H.K. (1984). *Elementary Principles of Plant Breeding*, 2nd edition. New Delhi, Delhi: Oxford – IBH. (Chapter 1 for Unit 1; Chapter 3,4, 5 for Unit 2; Chapter 8,10 for Unit 4, 11)

Teaching Learning Process

The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Field observation
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break

Week 12: Field observation
Week 13: Unit V
Week 14: Unit V

Assessment Methods

The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation. The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	. **Plant Breeding I**ntroduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	**Methods of crop improvement** Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	**Quantitative inheritance, C**oncept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings.Monogenic vs polygenic Inheritance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	**Inbreeding depression and heterosis** History, genetic basis of inbreeding depression and heterosis; Applications.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V	**Crop improvement and breeding,** Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

breeding system , reproduction, pollination, domestication of plants , genetic resources, hybridization, inheritance , inbreeding depression, crop improvement

Biofertilizers
(BHSE3)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To gain the knowledge on the following aspects

1. Eco-friendly fertilizers like Rhizobium, Azospirilium Azotobactor, cyanobacteria and mycorrhizae, their identification, growth multiplication
2. Organic farming and recycling of the organic waste

Course Learning Outcomes

The student would have a deep understanding of ecofriendly fertilizers. They will be able to understand the growth and multiplication conditions of useful microbes such as Rhizobium, cyanobacteria, mycorrhizae, Azotobactor etc, their role in mineral cycling and nutrition to plants. The can also think of the methods of decomposition of biodegradable waste and convert into the compost

Unit 1

General account about the microbes used as biofertilizer – Rhizobium – isolation,identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis. (4 lectures)

Unit 2

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. (8 lectures)

Unit 3

Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation. (4 lectures)

Unit 4

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. (8 lectures)

Unit 5

Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application. (6 lectures)

Practical

1. Isolation of *Anabaena* from *Azolla* leaf
2. Study of Rhizobium from root nodules of leguminous plants by Gram staining method
3. Test for pH, No2, SO4, Cl and organic matter of different composts
4. Observation of mycorrhizae from roots
5. isolation of arbuscular mycorrhizal spores from rhizospheric soil
6. Spots, Specimen /photographs of earthworm, azolla, arbuscules . vesicles
7. Biocontrol photographs -pheromons trap,Trichoderma,, Pseudomonas, , Neem etc, , Identification and application
8. Photographs of biocompost methods,
9. Projects on any topic mentioned in the syllabus, with Rhizobium technology, , AMF technology, Organicfarming, vermicomposting,, biocompost , *Azolla* culture

References

1. Kumaresan, V. (2005). *Biotechnology*. New Delhi, Delhi: Saras Publication. Chapter 39 for Unit 1, Chapter 38 for Unit 3, Chapter 57 for Unit 5)
2. Sathe, T.V. (2004). *Vermiculture and Organic Farming*. New Delhi, Delhi: Daya publishers. (Chapter 1 and 2 for Units 1, 2,3 and 5)
3. Subha Rao, N.S. (2000). *Soil Microbiology*. New Delhi, Delhi: Oxford & IBH Publishers. (Chapter 5 for Unit 2; Chapter 6 for Unit 3; Chapter 8 for Unit 1; Chapter 9 for Unit 4);

Additional Resources:

1. Vayas,S.C, Vayas, S., Modi, H.A. (1998). *Bio-fertilizers and organic Farming*. Nadiad, Gujarat: Akta Prakashan. (Chapters 2,3,4 for Unit 1; Chapter 18 for Unit 2; Chapter 19 for Unit 3; Chapter 20 for Unit 4; Chapter 4,5,6,12,13 for Unit 5)
2. Annonymous (2016) *Proceedings of Workshop on Biofertilizers*. New Delhi. Delhi: Zakir Husain Delhi College (Chapter1 to 9 for Unit 1 to 5)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
strong>Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s for checking.
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit III
Week 7: Field visit
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IV
Week 13: Unit V
Week 14: Unit V
Week 15: Unit V

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.
Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	General account about the microbes used as biofertilizer – Rhizobium – isolation,identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	*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.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	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.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Rhizobium, Azotobacter, inoculum, , cyanobacteria, nitrigen fixation, Azolla,VAM, mycorrhizae

Ethnobotany
(BHSE1)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

To have the knowledge of the plants used by the local communities, tribals, ethenic groups, their nutritive and medicinal value.

Course Learning Outcomes

Students would have an understanding of the treasure, value and usefulness of the the natural products and their efficient use by the local communities as food and medicine and their conservation practices .

Unit 1

Ethnobotany (6Lectures)
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 2

Methodology of Ethnobotanical studies (6lectures)
a) Field work
b) Herbarium
c) Ancient Literature
d) Archaeological findings
e) temples and sacred places.

Unit 3

Role of ethnobotany in modern Medicine (10 lectures) Medicoethnobotanical 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.

Unit 4

Role of ethnobotany in modern medicine with special example of *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 5

Ethnobotany and legal aspects (8 lectures) Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy,

Unit 6

Intellectual Property Rights and Traditional Knowledge.

Practical

Collection , identification and preparation of herbarium of three ethenobotanically important plants with appropriate references

Preparation of crude extract of ethenobotanically important plants with appropriate references (any method to be used)

Project work-documentation, literature survey, and collection of information on ethnobotanically useful plants from traditional healers)

References

1. Gupta , R., Rajpal , T., (2012) Concise R.,(2011) , Plant Taxonomy past Present and Future . TERI Press (Chapter 7 for Unit 8)

3. Gupta , R., Rajpal , T., (2012) Concise Mc Graw Hill Publication (chapter 14 for Unit 8)

3. Jain, S.K. (1995). *Manual of Ethnobotany*. Rajasthan: Scientific Publishers. (Chapter 1,2,3 for Unit 1; Chapter 4 for Unit 2; Chapter 9 for Unit 3; Chapter 14 for Unit 4 ; Chapter 16 for Unit 5)

Teaching Learning Process

To engage students and transform them into active learners the students are updated with latest books and review articles.

The experiments included in the paper are performed individually or in group and are followed by group discussions and interjections

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Local Field Visits
Week 6: Unit II
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Local Institute Visit
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

The students are assessed on the basis of oral presentations and regular class tests.
Students are continuously assed during practical class.
Submission of class records is mandatory. This exercise develops scientific skill as well as methods of recording and presenting scientific data.

Assessment Task

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	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	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Methodology of Ethnobotanical studies- Field work, Herbarium, Ancient Literature, Archaeological findings, temples and sacred places	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Medicoethnobotanical sources in India;Significance of the following plants in ethno botanical	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments, tests

	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.	experiments	
Unit IV:	Role of ethnobotany in modern medicine with special example of *Rauvolfia sepentina, Trichopus zeylanicus, Artemisia,Withania.* Role of ethnic groups in conservation of plant genetic resources.Endangered taxa and forest management (participatory forest management).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Ethnobotany and legal aspects (8 lectures) Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy,	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Intellectual Property Rights and Traditional Knowledge.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Tribals,.minor forest products, intoxicants, beverages, Resins, Field work, Herbarium, sacred groves,. ethnobotanical practices, Azadiractha indica, Ocimum sanctum, Vitex negundo. Gloriosa superba, Indigofera tinctoria.ethnomedicimes , conservation ,Traditional Knowledge.

Floriculture
(BHSE5)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To have knowledge of gardening and cultivation of ornamental plants and knowledge of landscaping, soil condition.

Course Learning Outcomes

Students would be able to identify the ornamental plants, They will have an understanding of cultivation methods, landscaping and making the flower arrangement.

Unit 1

Introduction: History of gardening; Importance and scope of floriculture and landscape gardening. (2 Lectures)

Unit 2

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. (8 lectures)

Unit 3

Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai. (4 lectures)

Unit 4

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. (4 lectures)

Unit 5

Landscaping Places of Public Importance: Landscaping highways and Educational institutions. (4 lectures)

Unit 6

Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold,Rose, Lilium, Orchids). (6 lectures)

Unit 7:
Diseases and Pests of Ornamental Plants.**(2 lectures)**

Practical

1. Study of flower with reference to stamens and gynoecium
2. Study of Soil sterilization process
3. Seed sowing and transplantation methods
4. Garden designing and hedge preparation methods
5. patterns of flower arrangement in vase
6. study of disease and pastes of ornamental plants

References

1. Randhawa, G.S., Mukhopadhyay, A. (1986). *Floriculture in India.* New York, NY: Allied Publishers. (Chapter1,2 for Unit1; Chapter 3 for Unit 2; Chapter4,6,8-16,18, 19, 21-23 for Unit 4, Chapter 24 for Unit 5; Chapter 20 for Unit 6; Chapter 26 for Unit 7)

Teaching Learning Process

The topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Lesson Plan

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Field observation
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break

Week 12: Unit VI
Week 13: Unit VI
Week 14: Unit VII

Assessment Methods

The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks
Unit wise Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	History of gardening; Importance and scope of floriculture and landscape gardening.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	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.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Principles of Garden Designs: English, Italian, French, Persian, Mughal and	Class room lectures and Practical	Hands on exercises, PPT,

	Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India.	demonstration, experiments	assignments, tests
Unit V:	Landscaping Places of Public Importance: Landscaping highways and Educational institutions.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold,Rose, Lilium, Orchids).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII	Diseases and Pests of Ornamental Plants.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Propagation methods, Gardening , transplantation,saplings,Ornamental, cacti , succulents, hedge, fencing lawns, grass, orchids

Intellectual Property Rights
(BHSE2)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To have knowledge of roles regulations, laws and processes og patents, copyright trade marks and concepts of traditional knowledge and protection of plant varieties .

Course Learning Outcomes

Students would have deep understanding of patents copyrights, their importance. Thy can think about the importance of traditional knowledge, bio-prospecting, biopiracy. They would gain the knowledge of farmers rights and the importance on indigenous plant varieties, concept of novelty and biotechnological inventions

Unit 1

Introduction to intellectual property right (IPR) (2 lectures)

Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO).

Unit 2

Patents (3 Lectures)

Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents.Infringement.

Unit 3

Copyrights (3 Lectures)

Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement

Unit 4

Trademarks (3 Lectures)

Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name

Unit 5

Geographical Indications (3 Lectures)

Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position

Unit 6

Protection of Traditional Knowledge (4 Lectures)

Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library.

Unit 7

Industrial Designs (2 Lectures)

Objectives, Rights, Assignments, Infringements, Defences of Design Infringement

Unit 8

Protection of Plant Varieties (2 Lectures)

Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues farmers, Breeders and Researchers.National gene bank, Benefit sharing.Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit 9

Information Technology Related Intellectual Property Rights (4 Lectures)

Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection Unit 10: Biotechnology and Intellectual Property Rights. (4 Lectures) Patenting Biotech Inventions

Practical

1. Patent search
2. Trademark search
3. copyright infringement (Plagiorism checkby Urkundand other available software,
4. Geographical Indicators (i) food- Malabar pepper, Basmati rice, Darjeeling Tea, and Requefort cheese, handlooms, (Kota Doria, , Banarasi Sari, , Muga Silk, Kanchipuram), II- Industry (Mysore agarbatti, Feni Goa, Champagne, (France). IV. Natural resources- (Makrana marbles Two example of each category
5. Biopiracy-neem , turmeric
6. Industrial designs- Jewellery design, chair design, car design, Bottle design, Aircraft design,
7. IPR e diary

References

1. Gupta, R., (2011) , Plant Taxonomy past Present and Future . TERI Press (Chapter 7 for Unit 6)

2.. Gupta , R., Rajpal , T., (2012) ConciseR.,(2011) , Plant Taxonomy past Present and Future . TERI Press (Chapter 7 for Unit 6)
3. Gupta , R., Rajpal , T., (2012) Concise Notes on Biotechnology. Delhi: Mc Graw Hill Publication (chapter 14 for Unit 1)
4. N.K., Acharya.(2001).Text Book on Intellectual Property Rights: (Copyright, Trademark, Patent Design, Geographical Indications, Protection of New Plant Varieties & Farmers Rights and Protection of Biodiversity) . (chapters 1 to 8 for Units 1 to 9)

Additional Resources

1. Gogia, SP. *On Intellectual Property Rights (IPR)*. Hyderabad: Asia Law House.(chapter 1- 6 for Unit 1,6 and 9)
2. Bhandari, M.K. (2017). *Law Relating to Intellectual Property Rights (IPR).* Allahabad: U.P.: Central Law Publications. (Chapters 1-5 for Unit 1-8)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s for checking
Week 2: Unit II
Week 3: Unit III
Week 4: Unit IV
Week 5: Unit V
Week 6: Unit VI
Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit IX
Week 14: Unit IX
Week 15: Unit X

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.

Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents.Infringement.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Copyrights (3 Lectures) Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Geographical Indications, Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	National level, Traditional Knowledge Digital Library.		
Unit VII:	Industrial Designs Rights, Assignments, Infringements, Defences of Design Infringement	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues farmers, Breeders and Researchers.National gene bank, Benefit sharing.Protection of Plant Varieties and Farmers' Rights Act, 2001.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Information Technology Related Intellectual Property Rights Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X	Biotechnology and Intellectual Property Rights. Patenting Biotech Inventions	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Keywords

Patents, IPR, Copyrights,trademarks, geographical indicators, traditional knowledge, industrial design, plant varieties , novelty, biotechnology

Medicinal Botany
(BHSE4)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

1. To introduce students to complementary and alternative medicine and provide them an opportunity
2. To explore uses of plants as medicine ranging from traditional indigenous approach for treating ailments to modern pharmaceuticals
3. To inculcate awareness about the rich diversity of medicinal plants in India.

Course Learning Outcomes

Knowledge Skills

- An appreciation of the contribution of medicinal plants to traditional and modern medicine and the importance of holistic mode of treatment of the Indian traditional systems of medicine.
- To develop an understanding of the constraints in promotion and marketing of medicinal plants.

Professional and Practical Skills

- Transforming the knowledge into skills for promotion of traditional medicine.
- Developing entrepreneurship skills to establish value addition products, botanical extracts and isolation of bioactive compounds.

Unit 1

Scope and importance of medicinal plants in the traditional systems of medicine and modern medicine.Importance of preventive and holistic healing in theIndian traditional systems of medicine.Ayurveda: History, origin, fundamental doctrine and concepts of Panchamahabhutas, Saptadhatus andTridoshasin relation to health and disease.

Unit 2

Therapeutic and pharmaceutical uses of important plants used in the Ayurveda system of medicine. Concept of Rasayanadrugs.Siddha :

Origin, concepts, therapeutic and pharmaceutical uses of important plants used in Siddha system of medicine.Unani : History, concept of Umoor-e-Tabiya(Fundamentals of Physique), therapeutic and pharmaceutical uses of plants used in Unani system of medicine

Unit 3

Nutraceuticals and polyherbalformulations. Plants used for the treatment of hepatic disorders, cardiac diseases,infertility, diabetes, blood pressure, cancer and skin diseases.Role of AYUSH, NMPB and AIIA in thepromotion of medicinal plants.

Unit 4

Adulteration of herbal drugs.Evaluation and Standardization of crude drugs.Fundamentals of Pharmacognosy. Organoleptic,microscopicand phytochemical evaluation of plant drugs.

Unit 5

Conservation of Endangered and Endemic Medicinal plants.Red Data List Criteria. In-situ Conservation : Biosphere Reserves, National Parks, Sacred Groves. Ex-situ conservation :Botanic Gardens, National Gene Banks, Plant cell, tissue, and Organ culture, Cryopreservation. Role of NBPGR, CIMAP, JNTBGRI and RRL.

Unit 6

General aspects of cultivation and propagation of medicinal plants. WHO Guidelines of Good Agricultural and Cultivation Practices (GACP). Objectives of the Nursery,classification and important components ofnursery. Greenhouse technology. Propagation through cuttings, layering, grafting and budding.

Practical

1. Identification and medicinal value of locally available medicinal plants in the field.
2. Study of organoleptic, macroscopic and microscopic parameters of any two plant drugs. Sections and powder microscopic evaluation.
3. Isolation of bioactive compounds in the lab and phytochemical analysis of the crude extract of various parts of medicinal plants.
4. Study of ingredients and medicinal uses of common polyherbal formulations used in the traditional systems of medicine.
5. Project Report based onvisit to PharmaceuticalIndustries and/or Institutes.
6. E-presentations : Traditional Systems of Medicine, Contribution of medicinal plants toalternative and modern medicine, Conservation strategies of medicinal plants,Nutraceuticals, Rasayana drugs, Medicinal plants and non-communicable diseases, Cultivation, marketing and utilisation of medicinal plants.
7. Laboratory Records

References

1. Chaudhry, B. (2019). *A Handbook of Common Medicinal Plants Used in Ayurveda.* Kojo Press, New Delhi. (For Units 1-3).
2. Purohit, Vyas (2008). *Medicinal Plant Cultivation : A Scientific Approach*, 2nd edition. Jodhpur, Rajasthan: Agrobios. (Chapter 1 for Unit 1; Chapter-6 for Unit 6, Chapter 12 for Unit 5).
3. S.B. Gokhale, C.K. Kokate (2009). *Practical Pharmacognosy*. Pune, Maharashtra: Nirali Prakashan. (For Unit 4).
4. Trivedi, P.C. (2006). *Medicinal Plants Traditional Knowledge.* New Delhi, Delhi: I.K. International Publishing House Pvt. Ltd. (Chapter 1 for Unit 4; Chapter 2 and 11 for Unit 3)

Additional Resources:

1. Trivedi, P.C. (2009). *Medicinal Plants. Utilisation and Conservation.* Jaipur, Rajasthan: Aavishkar Publishers. (Chapter 1 and 19 for Unit 5; Chapter 20 for Unit 3).

2.William Charles Evans (2009*) Trease and Evans's Pharmacognosy,* 16th edition. Edinburg, London, Philadelphia, Pennsylvania: Saunders Ltd. (Chapter 1, and Chapters 42-44 for Unit 4).

3. ayush.gov.in (Ministry of AYUSH) (for Unit 1 and 2).

Teaching Learning Process

- To encourage innovation, to link theoretical knowledge with practical training and application of knowledge to find practical solutions to the challenges encountered in the field of traditional medicine.
- To hold regular and structured workshops, seminars, field trips, collaboration with Research institutions, Industry and other Government Organizations, in order to facilitate peer learning and skill enhancement.
- To complement classroom teaching with discussions, presentations, quizzes,interpretation of results, short projects, writing project reports and field exposure.

Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit III
Week 7: Field visit
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit V
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

Continuous Evaluation
(Project/ E-presentation :10 marks, Lab Records :
Attendance in Practicals
Practical Examination :

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Scope and importance of medicinal plants in the traditional systems of medicine and modern medicine.Importance of preventive and holistic healing in theIndian traditional systems of medicine.Ayurveda : History, origin, fundamental doctrine and concepts of Panchamahabhutas, Saptadhatus andTridoshasin relation to health and disease.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Therapeutic and pharmaceutical uses of important plants used in the Ayurveda system of medicine. Concept of	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments,

	Rasayanadrugs. Siddha : Origin, concepts, therapeutic and pharmaceutical uses of important plants used in Siddha system of medicine.Unani : History, concept of Umoor-e-Tabiya(Fundamentals of Physique), therapeutic and pharmaceutical uses of plants used in Unani system of medicine	experiments	tests
Unit III:	Nutraceuticals and polyherbalformulations. Plants used for the treatment of hepatic disorders, cardiac diseases,infertility, diabetes, blood pressure, cancer and skin diseases.Role of AYUSH, NMPB and AIIA in thepromotion of medicinal plants.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Adulteration of herbal drugs. Evaluation and Standardization of crude drugs. Fundamentals of Pharmacognosy. Organoleptic,microscopicand phytochemical evaluation of plant drugs.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Conservation of Endangered and Endemic Medicinal plants. Red Data List Criteria. In-situ Conservation : Biosphere Reserves, National Parks, Sacred Groves. Ex-situ conservation :Botanic Gardens, National Gene Banks, Plant cell, tissue, and Organ culture, Cryopreservation. Role of NBPGR, CIMAP, JNTBGRI and RRL.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	General aspects of cultivation and propagation of medicinal plants. WHO Guidelines of Good Agricultural and Cultivation Practices (GACP). Objectives of the Nursery,classification and important components ofnursery. Greenhouse technology. Propagation through cuttings, layering, grafting and budding	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Keywords :Medicinal plants, Ayurveda, Siddha, Unani,Holistic healing, Phytochemicals, Pharmacognosy, Polyherbals, Conservation, Propagation.

Mushroom Culture Technology
(BHSE8)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

1. Objective of this paper is to make aware student about the mushroom growing techniques.
2. Mushrooms have medicinal and nutritional value students will be make aware of this aspect.
3. National and international market that helps in economy of country students will be make aware about this also as this is low cost input process but benefits/outcomes are high.

Course Learning Outcomes

As mushroom cultivation is a booming field Goverment of India is also supporting this type of work because students can learn the techniques and small scale and large scale industries can be established by the students. Hand on experience will be given to students so they can utilize this training in long run. In small area also they can establish the bussiness..

Unit 1

Introduction, history, Nutritional and medicinal value of edible mushrooms, Poisonous mushrooms, Types of edible mushrooms availablein India: *Volvariella,Volvacea , Pleurotus citrinopileatus, Agaricus bisporus.*

Unit 2

Cultivation technology,Infrastructure substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculationloop, low cost stove, sieves, culture rack, mushroomunit (Thatched house) water sprayer, tray, small polythene bags, Pure culture, Medium psterlization , preperation spawn, multiplication, mushroom bed preperation, paddy straw, sugarcane trash, maize straw, banana leaves, Factors affecting the mushroom bed preperation -- low cost technology, compostingtechnology in mushroom production.

Unit 3

Storage and nutrition,short term storage (Refrigeration upto 24 hours) long term storage (canning, pickels and papads) drying, storage in salt solutions, . Nutrition- proteins, amino acids, mineral elements nutrition- carbohydrates, crude fibre content- vitamins.

Unit 4

Food preperation, Types of food prepared from mushroom. Research centers-National level and Regional level, Cost benefit ratio- Marketing in India and abroad, Export value.

Practical

1. Principle and functioning of instruments used in the various techniques.
2. Preperation of various types of media.
3. Preperation of spawn.
4. Study of poisnous and non poisonous mushroom
5. Study of diseases of mushroom.
6. Nutritional and market value of mushroom
7. Centres of mushroom
8. Techniques for the cultivation of *Agaricus* , *Pleurotus and Ganoderma*
9. *Visit to Institute and* cultivation centre.

References

1. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, vol. I& II. (chapter 1,2, &3 for unit 1.) (chapter 6& 7 for unit 2) (chapter 3& 4 for unit 3) (chapter 16 for unit 4)

Additional Resources

1. Swaminathan , M. (1990). Food and Nutrition. Bappco, Bangalore, Karnataka: The Banglore Printing and Publishing Co. Ltd.(Chapter 1-4 for Unit 1 and 2
2. Tewari, P., Kapoor, S.C.(1998) Mushroom cultivation, Mittal Publications , Delhi.(Chapters1 to for Unit 1 and 2)

Teaching Learning Process

Classroom knowledge of the student will be integrated with hand on experience/practical to make understanding strong. Practicals are designed on hand on experience basis. Visit to Institutes and farm houses will make understanding and awareness better of students. Students will be motivated to start their start up in this field. Teaching and learning will be through group discussions, test, assignments and power point presentations.

Teaching Learnig Plan

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit II
Week 6: Unit II
Week 7: Unit III
Week 8: Unit II
Week 9: Unit III
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit III

Week 13: Unit IV
Week 14: Unit IV
Week 15: Unit IV

Assessment method

Unit No	Coure learning Outcome	Teaching and Learning Activity	Assessment Task
I	Introduction, history, Nutritional and medicinal value of edible mushrooms, poisonous mushrooms. Types of edible mushrooms available in India- *Volvariella voivacea, Pleurotus citrinopileatus, Agaricus bisporus*	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests &Viva voce
II	Cultivation technology, Infra structure substrates (locally available) Polythene bag vessels,Inoculation hook, loop, low cost stove, sieves, culture rack, mushroom unit , (Thatched house) water sprayer, tray, small polythene bag, pure culture, medium sterilization, preparation of spawn, multiplication, Mushroom bed preparation, paddy straw, sugarcane trash,maize straw, banana leaves, Factors affecting the bed preparation,- low cost technology, composting technology in mushroom production	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests & viva voce
III	Storsage and nutrition, short term storage (Refrigeration – upto 24 hours) . Long term storage (canning, pickels ,papads) drying , storagein salt solutions. Nutrition- proteins, amino acids, mineral elements nutrition-carbohydrates, crude fibre content- vitamins.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
IV	Food prepration, Types of food prepared from mushroom, Research centres- National level and Regional level , cost benefit raio – Marketing in Indiaand Abroad, Export value.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests

Assessment Methods

Field based projects will be there regarding growing of various types of mushrooms related to environmental conditions. Field report will be there regarding the visit. Power point presentations. Continuous evaluation of the student.

Keywords

Mushroom cultivation, spawning, culture, media straw paddy , maize polythene bags, trays, soil, dung, casing, *Agaricus, Pleurotus, Volvariella*

Nursery and Gardening
(BHSE7)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To gain knowledge of gardening, cultivation, multiplication, raising of seedlings of ornamental plants

Course Learning Outcomes

Students would have an understanding of
How nursery of the plants is prepared?
How rooting is promoted in the stem cuttings?
How seeds are stored and what are the soil conditions for seed sowing and seedling growth?
How landscaping is designed?

Unit 1

Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.(4 Lectures)

Unit 2

Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion - Seed production technology - seed testing and certification. (6 Lectures)

Unit 3

Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants - green house - mist chamber, shed root, shade house and glass house. (6Lectures)

Unit 4

Gardening: definition, objectives and scope - different types of gardening - landscape and home gardening - parks and its components - plant materials and design - computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting. (8 Lectures)

Unit 5

Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures. **(6 Lectures)**

Practical

1. Breaking of seed dormancy
2. Seed viability tests
3. Preparation of stem cutting, air layering
4. soil layering and manuring
5. compost preparation
6. Diseases and pests of plants

References

1. Paliwal, H.K. (2009). Ornamental Gardening: A User companion. New Delhi, Delhi: National Book Trust of India. (Chapter 2 for Unit 1; Chapter 3 for Unit 3, Chapter 4 for Unit 4)
2.Krishnan P.R., Kalia R.K. Tiwari , JC, Roy N.M. 2014. Plant Nursery Manahgement : Principles and Practices. Jodhpur, Rajasthan, CAZARI (Chapter 1,2,3,4 for Unit 1; Chapter 9,13,15,16,19-22 for Unit 3; Chapter 24, 32 for Unit 5)
3 Agrawal, P.K. (1993). *Hand Book of Seed Technology*. New Delhi, Delhi: Dept. of Agriculture and Cooperation, National Seed Corporation Ltd. (Chapter 2,3,11,12 for Unit 2)
4. Randhawa, G.S., Mukhopadhyay, A. *Floriculture in India*. New Delhi, Delhi: Allied Publishers (Chapter 12 for Unit 1; Chapter 3,11,12 for Unit 2,5; Chapter 3,4,21,23,24 for Unit Chapter 4 for Unit 5)

Additional Resources:

1. Sandhu, M.K. (1989). *Plant Propagation.* Madras, Bangalore: Wile Eastern Ltd. (Chapter 3,4,5 for Unit 2; chapter 5,6,10,11,12, for Unit 3; Chapter 7,14 for Unit 4 ; Chapter 14 for Unit 4)

Teaching Learning Process

Teaching session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.. Field visits and institutional visits will alo be included. The students are asked to submit their record notebooks to the teacher/s for checking.

Weekly Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Field observation
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Field observation
Week 13: Unit V

Week 14: Unit V

Assessment Methods

The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the students will listen to the presentation of each student, and they are also encouraged to ask questions. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions. An assignment can be given in place of the presentation

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion - Seed production technology - seed testing and certification.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants - green house - mist chamber, shed root, shade house and glass house.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Gardening: definition, objectives and scope - different types of gardening - landscape and home gardening - parks and its components - plant materials and design - computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Transplantation seed dormancy, seed viability, vegetative propagation,layring , cutting , rooting medium, hardening , landscaping

Plant Diversity and Human welfare
(BHSE9)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To gain the knowledge of
1. biodiversity and its importance.
2. Agricultural diversity
3. biodiversity loss and biodiversity management

Course Learning Outcomes

The students would be able to judge the value of biodiversity and its role in stabilizing the climate and economy. They would know the causes and consequences of loss of biodiversity and planning of conservation strategies. .

Unit 1

Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at theecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity:Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes. (8 lectures)

Unit 2

Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss, **Management of Plant Biodiversity:** Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication. (8 lectures)

Unit 3

Conservation of Biodiversity: Conservation of genetic diversity, speciesdiversity and ecosystem diversity, *In situ* and *ex situ* conservation, Socialapproaches to conservation, Biodiversity awareness programmes, Sustainable development. (8 lectures)

Unit 4

Role of plants in relation to Human Welfare; a) Importance of forestry their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d) Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses. (6 lectures)

Practical

1. Mapping species diversity
2. mapping of crop diversity
3. Visits of plant conservatories
4. study of wood features
5. Herbarium study of a.Avenue trees,b) Ornamental plantsc Fruits and nuts: Important fruit crops. Wood

References

1. Krishnamurthy, K.V. (2004). *An Advanced Text Book of Biodiversity - Principles and Practices*. New Delhi, Delhi: Oxford and IBH Publications Co. Pvt. Ltd. (Chapter 1 to 5 for Unit 1; Chapter 7 for Unit 2; Chapter 8,9 for Unit 3; Chapter 6 for Unit 4);

2. Kochhar, S.L. (2011). *Economic Botany in Tropics*. New Delhi, India: MacMillan & Co. (Chapter 1 for Unit 4; Chapter 11 for Unit 4; Chapter 7 for Unit 4; Chapter 12 for Unit 4)

Teaching Learning Process

Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking. Field visits will also be arranged

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Field observation
Week 6: Unit III
Week 7: Unit III
Week 8: Unit III
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Field observation

Week 13: Unit IV
Week 14: Unit IV

Assessment Methods

The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the students listen to the presentation of each student, and they will be encouraged to ask questions. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, new information has been added, and lastly on the answers given by students to the questions.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at theecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity:Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss, Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	a) Importance of forestry their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d) Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Genetic diversity, species diversity, crop diversity , biodiversity loss,crop diversity ,value of diversity, IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation, conservation, forestry, fruits, timber

Biodiversity (Microbes, Fungi, Algae and Archegoniates) (BHGE1) Generic Elective - (GE) Credit:6

Course Objective (2-3)

Biodiversity generally refers to the variety and variability of life on earth. Plants are relevant to humans as they provide us with food, shelter, clothing, energy, health, aesthetic beauty, environment and even economy. This paper is relevant to ALL students.

1. Introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi, to various plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms).
2. Information on the Ecological and Economic Importance of Microbes, Fungi and various plant groups to enable students understand and appreciate relevance of Microbes and Plants to environment and human well-being.
3. Insight into the line of Plant Evolution on Earth and the consequent Biodiversity is instrumental in creating Awareness on the threats to biodiversity and sensitize young minds towards the Biodiversity Conservation for sustainable development.

Course Learning Outcomes

1. Combination of Theoretical and Practical components will provide comprehensive information and insight into the fascinating world of Microbes and Plants.
2. Hands on Training will help students learn use of microscope, mounting, section-cutting and staining techniques for the study of plant materials.
3. Making Drawings in Practical Records will enhance understanding morphological and structural details and related functional aspects in diverse plant groups.
4. Use of Illustrations, Photographs, Charts, Permanent Slides, Museum and Herbarium Specimens along with ICT Methods will provide an interesting insight into the beautiful world of microbes and plants.
5. Scope of Biodiversity includes Medicinal field, Industry, Agriculture, Research and Study, Job Opportunities and Environmental Conservation. This paper is both informative and interesting and will enable students to learn about Biodiversity not only as a plant or nature lover, but also for higher academic pursuits, particularly in the field of Biological Sciences, Environment and Biodiversity Conservation.

Unit 1

MICROBES (14 Lectures)

a) **Viruses** – Discovery; General Structure- RNA virus (TMV) and DNA virus (T-phage); Replication-Lytic and Lysogenic Cycle; Economic Importance.

b) **Bacteria** – Discovery; General Characteristics and Cell Structure; Reproduction-Vegetative, Asexual and Genetic Recombination (Conjugation, Transformation and Transduction); Economic Importance.

Unit 2

FUNGI (8 Lectures)

General Characteristics; Outline Classification (Webster); Economic Importance; Thallus Organization and Reproduction in *Rhizopus*, *Penicillium*, *Alternaria* and *Puccinia*.

Unit 3

ALGAE (8 Lectures)

General Characteristics; Outline Classification (Fritsch); Economic Importance; Thallus Organization and Reproduction in *Nostoc*, *Chlamydomonas*, *Vaucheria* and *Ectocarpus*.

Unit 4

ARCHEGONIATAE(30 Lectures)

a) **Bryophytes (10 Lectures)**

General Characteristics; Outline Classification; Ecological and Economic Importance; Morphology, Structure and Reproduction in Marchantia, Anthoceros and Funaria.

b) **Pteridophytes (10 Lectures)**

General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Selaginella*, *Equisetum* and *Pteris*.

c) **Gymnosperms (10 Lectures)**

General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Cycas* and *Pinus*.

Practical

1. **Viruses-** Structure of TMV and T-Phage (EMs/ Models/ Photographs); Lytic and Lysogenic Cycle (Line Drawings/ Photographs).
2. **Bacteria**-Types and Structure (Permanent Slides/ Photographs); EM Bacterium; Binary Fission and Conjugation (Photographs).
3. ***Rhizopus***, ***Penicillium*** and ***Alternaria***- Asexual Stage from Temporary/ Tease Mounts, ***Puccinia***-Black Stem Rust of Wheat and Infected Barberry Leaves (Herbarium Specimens/ Photographs), Tease Mounts of Spores on Wheat, Section of infected portion of Wheat and Barberry (Permanent Slides).
4. ***Chlamydomonas***-E.M., ***Nostoc***, ***Vaucheria*** and ***Ectocarpus***- Study of Vegetative and Reproductive Structures through Temporary Preparations and Permanent Slides.
5. **Bryophytes :*Marchantia***-Morphology of Thallus, W.M. Rhizoids, V.S. Thallus through Gemma Cup, W.M. Gemma (all Temporary Slides), L.S. Sporophyte (Permanent slide).

Anthoceros- Morphology of Thallus, W.M. Rhizoids, L.S./ T.S. Capsule, W.M. Spores, W.M. Pseudoelaters, (all Temporary Slides), L.S. Sporophyte (Permanent slide).***Funaria***- Morphology of Gametophyte bearing Sporophyte, W.M. Rhizoids, W.M. Leaf, W.M. Operculum, W.M. Peristome, W.M. Spores (all Temporary Slides), L.S. Capsule (Permanent Slide).

6. **Pteridophytes:** ***Selaginella***- Morphology, T.S. Stem, W.M. Strobilus, W.M. Microsporophyll and Megasporophyll (all Temporary Slides), L.S. Strobilus (Permanent Slide).

   Equisetum- Morphology, T.S. Stem (Internode), L.S./ T.S. Strobilus, W.M. Sporangiophore, W.M. Spores (Wet and Dry) (all Temporary Slides).

   Pteris- Morphology, V.S. Sporophyll, W.M. Sporangium, W.M. Spores (all Temporary Slides), W.M. Prothallus with Sex Organs (Permanent Slide).

7. **Gymnosperms:** ***Cycas***- Morphology (Coralloid Roots, Leaf, Microsporophyll, Megasporophyll), T.S. Coralloid Root (Permanent Slide), V.S. Leaflet, V.S. Microsporophyll, W.M. Spores (all Temporary Slides), L.S. Ovule (Permanent Slide). ***Pinus***- Morphology (Long and Dwarf Shoots, Male and Female Cones), W.M. Dwarf Shoot, T.S. Needle, L.S/ T.S. Male Cone, W.M. Microsporophyll, W.M. Microspores (all Temporary Slides), L.S Female Cone (Permanent Slide).

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1. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology*. Singapore, Singapore: John Wiley and Sons (Asia). (Chapters 1,4.9.13,18,20 for Unit 2)
2. Kumar, H.D. (1999). *Introductory Phycology*. New Delhi,Delhi: Affiliated East-West. Press Pvt. Ltd. (Chapters 1,3,10,11,12,14 for Unit 3)
3. Kaur, I..D., Uniyal, P.L. (2019).*Text Book of Gymnosperms*. New Delhi,ND: Daya Publishing House, (Chapters 1,2,5, 6 for 4)
4. Parihar, N.S. (1972). *An Introduction to Embryophyta. Vol. II: Pteridophyta*. Allahabad, UP: Central Book depot. Chapters 1, 4, 5,9,for Unit 4)

Additional Resources:

1. Bhatnagar, S.P., Moitra, A. (1996). *Gymnosperms*. New Delhi, ND: New Age International (P) Ltd Publishers. (Chapters 1,6,13 for Unit 4)
2. Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2011). *Biology 9th edition*. San Francisco, SF: Pearson Benjamin Cummings. (Chapters 19,27 for Unit 1¸ Chapter 31 for Unit 2; Chapter for Unit 3)))
3. Parihar, N.S. (1991). *An Introduction to Embryophyta. Vol. I. Bryophyta*. Allahabad, UP: Central Book Depot. (Chapters 1,3,6,9 for Unit 4)
4. Puri, P. (1985) *Bryophytes*. New Delhi, Delhi. Atma Ram and Sons, Delhi (Chapters 1,5,7,10 for Unit 4)
5. Tortora, G.J., Funke, B.R., Case, C.L. (2010). *Microbiology: An Introduction*. San Francisco, SF: Pearson Benjamin Cummings. (Chapters 13, 14 For Unit 1)

6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). *Botany For Degree Students Pteridophyta*. New Delhi, Delhi: S. Chand Publication. (Chapters 1,4, 6, 9 for unit 4)
7. Vashistha, B.R., Sinha, A.K., Kumar, A. (2011). *Botany For Degree Students, Bryophyta.* New Delhi, Delhi: S Chand Publication.(Chapters 1,5,14, 18 for Unit 4)
8. Webster, J. and Weber, R. (2007). *Introduction to Fungi*. Cambridge, Cambridge University Press. Chapters 1,5, 7,22 Unit 2)

Teaching Learning Process

THEORY:

1. The theory topics are covered in lectures with the help of both conventional (chalk board) and modern (ICT) methods, including use of Charts.
2. Emphasis is on interactive class room environment so as to encourage students ask questions/ doubts/ queries for clarification/explanation and discussion.
3. Students are encouraged to refer to reference books in library to inculcate reading habit for better grasp and understanding on the subject.
4. Emphasis is given to illustrations- neat, well-labelled outline and cellular diagrams/ flowcharts for improving creative skills and to substantiate the text content.
5. On completion of theory syllabus, previous years' question papers are discussed so as to apprise students about the general format of semester exam question papers.
6. Assignment (10), Test (10) and Theory Attendance (5) are components of Internal Assessment Scheme for compilation of Internal Assessment Score of each student out of 25 marks.

PRACTICAL:

1. Every practical session begins with instructions, followed by students doing table work for detailed microscopic plant study.
2. Plant study is done using fixed plant materials, museum and herbarium specimens, photographs and permanent slides.
3. The students are instructed about maintaining practical records, which includes comments and diagrams.
4. Students are asked to submit practical records regularly, on a continuous basis, for checking.
5. On completion of practical syllabus, Practical Exam Guidelines are discussed to apprise students about the formant of Practical exam.
6. As part of Continuous Evaluation guidelines, total score for each student is calculated out of 25 marks, taking into consideration Practical Records (10), Practical Test/ Assessment (10) and Practical Attendance (5)Teaching Learning Plan

Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit I
Week 5: Unit II

Week 6: Unit II
Week 7: Unit III
Week 8: Unit III
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IV
Week 13: Unit IV
Week 14: Unit IV
Week 15: Unit IV
Week 16: Unit IV

Assessment Methods

THEORY:

1. Emphasis is given for an interactive classroom environment, with at least few minutes for question-answer session.
2. Assignment topics are given to students for submission of hand written assignments.
3. Test is taken, with both objective and descriptive questions, from a defined portion of syllabus.
4. Assignment (10), Test (10) and Theory Attendance (5) are components of Internal Assessment Scheme for compilation of Internal Assessment Score of each student out of 25 marks.

PRACTICAL:

1. Students are monitored in the practical class w.r.t their performance in table work for detailed plant study.
2. Students are asked to submit practical records regularly, on a continuous basis, for checking.
3. Emphasis is given on neat, labelled diagrams and proper, concise comments in practical records, with properly maintained Index page regularly signed by the teacher.
4. Practical Test/ Assessment is taken to evaluate students performance as per guidelines framed for Continuous Evaluation under C.B.C.S.
5. As part of Continuous Evaluation guidelines, total score for each student is calculated out of 25 marks, taking into consideration Practical Records (10), Practical Test/ Assessment (10) and Practical Attendance (5).

Assessment Method

Unit No		Teaching and Learning Activity	Assessment Task

I	a) V**ruses** – Discovery; General Structure- RNA virus (TMV) and DNA virus (T-phage); Replication-Lytic and Lysogenic Cycle; Economic Importance. b) Ba**cteria** – Discovery; General Characteristics and Cell Structure; Reproduction- Vegetative, Asexual and Genetic Recombination (Conjugation, Transformation and Transduction); Economic Importance.	Class room Lectures and Practical demonstration, Photographs, Class room Lectures and Practical demonstration, Photographs, Experiments	Hands on excercises, Assignments, Tests, Hands on excercises, Assignments, Tests
II	**FUNGI:** General Characteristics; Outline Classification (Webster); Economic Importance; Thallus Organization and Reproduction in *Rhizopus*, *Penicillium*, *Alternaria* and *Puccinia*.	Class room Lectures and Practical demonstration, Type Study	Hands on excercises, Assignments, Tests
III	**ALGAE:** General Characteristics; Outline Classification (Fritsch); Economic Importance; Thallus Organization and Reproduction in *Nostoc*, *Chlamydomonas*, *Vaucheria* and *Ectocarpus*.	Class room Lectures and Practical demonstration, Type Study	Hands on excercises, Assignments, Tests
IV	a) **Bryophytes:** General Characteristics; Outline Classification; Ecological and Economic Importance; Morphology, Structure andReproduction in *Marchantia*, *Anthoceros*and *Funaria*. b) **Pteridophytes:** General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Selaginella*, *Equisetum* and *Pteris*. c) **Gymnosperms :**General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Cycas* and *Pinus*.	Class room Lectures and Practical demonstration, Type Study	Hands on excercises, Assignments, Tests

Keywords

Biodiversity; Microbes; Viruses; Bacteria; Fungi; Algae; Archegoniates; Bryophytes; Pteridophytes; Gymnosperms

Economic Botany and Biotechnology
(BHGE7)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

To gain the knowledge on the economically important of plants, their life cycle, processing, plant part used, application of biotechnology for the production of plant resources and production of new varieties

Course Learning Outcomes

Understanding of morphology,and processing and economic value of plant sources of cereals, legumes,spices, oil,rubber, timber and medicines

Unit 1

Origin of Cultivated Plants (4 lectures)
Concept of centres of origin, their importance with reference to Vavilov's work.

Unit 2

Cereals (4lectures):
Wheat -Origin, morphology, uses

Unit 3

Legumes (6 lectures)
General account with special reference to Gram and soybean

Unit 4

Spices (6 lectures)
General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)

Unit 5

Beverages (4 lectures)
Tea (morphology, processing, uses)

Unit 6

Oils and Fats (4 lectures)
General description with special reference to groundnut

Unit 7

Fibre Yielding Plants (4 lectures)

General 4description with special reference to Cotton (Botanical name, family, part used,morphology and uses)

Unit 8

Introduction to Plant Biotechnology (1 lecture)

Unit 9

Tissue Culture Tchnology (9 lectures)

Introduction; nutrient media; aseptic and culture conditions; developmental pathways: direct and indirect organogenesis and embryogenesis; single cell and protoplast culture.

Unit 10

Recombinant Technology (18 lectures)

Molecular techniques: Blotting techniques (Southern, Northern and Western); PCR; Molecular DNA markers (RAPD, RFLP, SNPs) and DNA fingerprinting in plants.

Genetic Engineering Techniques: Gene cloning vectors (pUC 18, pBR322, BAC, YAC, Ti plasmid); construction of genomic and C-DNA libraries; screening for gene of interest by DNA probe hybridisation, complementation; Insertion of genes into plant tissues (*Agrobacterium* mediated, electroporation, micro-projectile bombardment); selection of recombinants by selectable marker and reporter genes (GUS, luciferase, GFP). Applications: Bt cotton, Roundup ready soybean, Golden rice, Flavr-Savr tomato, edible vaccines, industrial enzyme production, Bioreactors, Applications: Micropropagation, androgenesis, gynogenesis, embryo and endosperm culture, secondary metabolite production, germplasm conservation.

Practical

1. Study of economically important plants : Wheat, Gram, Soybean, Black pepper, Clove Tea, Cotton, Groundnut through specimens, sections and microchemical tests
2. Familiarization with basic equipments in tissue culture.
3. Study through photographs: Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation.
4. Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE.

References

1. Kochhar, S.L. (2011). *Economic Botany in Tropics*. New Delhi, India: MacMillan & Co. (Chapter 1 for Unit 1; Chapter 3 for Unit 2; Chapter 5 for Unit 3; Chapter 9 for Unit 4; Chapter 11 for Unit 5; Chapter 6 for Unit 6; Chapter 2 for Unit 7);

2. Bhojwani, S.S., Razdan, M.K. (1996). *Plant Tissue Culture: Theory and Practice*. Amsterdam, Netherlands: Elsevier Science. (Chapter 3, 4, 5, 6,12 for Unit 9)

3. Glick, B.R., Pasternak, J.J. (2003). *Molecular Biotechnology- Principles and Applications*. Washington, U.S.: ASM Press. (Chapter 1 for Unit 8; Chapter 3 for Unit 10)
4. Gupta , R., Rajpal , T., (2012) Concise Notes on Biotechnology. Delhi: Mc Graw Hill Publication. (Chapter 1 for Unit 8; chapter 8 for Unit 9; chapter 4 for unit 10)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s for checking.
Week 2: Unit II
Week 3: Unit III
Week 4: Unit IV
Week 5: Unit V
Week 6: Unit VI
Week 7: Unit VII
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IX
Week 13: Unit X
Week 14: Unit X
Week 15: Unit X

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and

lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Concept of centres of origin, their importance with reference to Vavilov's work.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Cereals : Wheat -Origin, morphology, uses	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Legumes, general account with special reference to Gram and soybean	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Spices ,general account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Beverages, Tea (morphology, processing, uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Oils and Fats, general description with special reference to groundnut	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	General 4description with special reference to Cotton (Botanical name, family, part used,morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Introduction to Plant Biotechnology	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Nutrient media; aseptic and culture	Class room lectures and	Hands on

	conditions; developmental pathways: direct and indirect organogenesis and embryogenesis; single cell and protoplast culture.	Practical demonstration, experiments	exercises, PPT, assignments, tests
Unit X:	Molecular techniques: Blotting techniques (Southern, Northern and Western); PCR; Molecular DNA markers (RAPD, RFLP, SNPs) and DNA fingerprinting in plants.Gene cloning vectors (pUC 18, pBR322, BAC, YAC, Ti plasmid); construction of genomic and C-DNA libraries; screening for gene of interest by DNA probe hybridisation, complementation; Insertion of genes into plant tissues (*Agrobacterium* mediated, electroporation, micro-projectile bombardment); selection of recombinants by selectable marker and reporter genes (GUS, luciferase, GFP). Applications: Bt cotton, Roundup ready soybean, Golden rice, Flavr-Savr tomato, edible vaccines, industrial enzyme production, Bioreactors Micropropagation, androgenesis, gynogenesis, embryo and endosperm culture, secondary metabolite production, germplasm conservation.	Class room lectures and Practical demonstration, experiments	exercises, PPT, assignments, tests

Keywords

Vavilove, Cultivated plants, , Wheat, Gram , soyabean, spices, Tea, cotton, groundnut, tissue culture, recombinant DNA technology, Molecular markers, RAPD, PCR, ELISA.

Environmental Biotechnology
(BHGE6)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

This course aims to introduce the students to various regional and global concerns regarding the environment, including the natural challenges, various types of environmental contaminants and their sources and effects, environmental changes, and the developments of diverse technologies to detect, study and address these concerns. The course aims to introduce the specific roles of chemical, biological and molecular sciences to identify and address the emerging environmental issues.

Course Learning Outcomes

1. Explain the various global and regional environmental concerns due to natural causes and/or human activities.
2. Investigate some examples of different types of environmental pollution and their impacts.
3. Describe existing and emerging technologies that are important in the area of environmental biotechnology.
4. Demonstrate an awareness of emerging concerns such as climate change, waste management or reductions in fossil fuels, and new technologies for addressing these.
5. Appreciate the scientific, ethical and/or social issues associated with certain applications of biotechnology for alleviating the environmental concerns.
6. Explain national and international legislations, policies and role of public participation in Environmental Protection
7. Students will have an insight on the causes and consequences of environmental pollution, pollutants, They can think about the prevent of degradation of environment and management of pollutants.

Unit 1

Environment - basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management. **(4 lectures)**

Unit 2

An overview of atmosphere, hydrosphere, lithosphere and anthrosphere - environmental problems.Environmental pollution - types of pollution, sources of pollution, measurement of pollution, methods of measurement of pollution, fate of pollutants in the environment, Bioconcentration, bio/geomagnification. **(6 lectures)**

Unit 3

Microbiology of waste water treatment, aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industries. (8 lectures)

Unit 4

Xenobiotic compounds - organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganic (metals, radionuclides, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, decay behavior and degradative plasmids, molecular techniques in bioremediation. **(10 lectures)**

Unit 5

Role of immobilized cells/enzymes in treatment of toxic compounds. Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. **(6 lectures)**

Unit 6

Sustainable Development: Economics and Environment: Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost effectiveness analysis, WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics. **(8 lectures)**

Unit 7:

International Legislations, Policies for Environmental Protection: 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. **(6 lectures)**

Unit 8

National Legislations, Policies for Pollution Management: 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. **(6 lectures)**

Unit 9

Public Participation for Environmental Protection: Environmental movement and people's participation with special references to Gandhamardan, Chilika and Narmada Bachao Andolan, Chipko and Silent valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society. **(6 lectures**

Practical

1. To determine the pH and total hardness of water samples collected from different places (polluted and non-polluted sites).
2. To determine the salinity of water samples (polluted and non-polluted sites)
3. To determine the dissolved oxygen of two water samples
4. To determine alkalinity of water samples.
5. To determine pH and rapid field test of soil samples (Calcium, Magnesium, Nitrate and Chloride).
6. Set-ups- through photograph

    i. Microbial assessment of air (open air plate) and water)
    ii. Interaction of plant seeds with diesel for potential use in remediation of diesel fuel from contaminated soil.
    iii. Growth response of Bacteria on Petroleum Fuel.
    iv. Isolation and characterization of Bacteria from crude petroleum oil contaminated soil.

References

1. Thakur, I.S. (2006). *Environmental Biotechnology*. New Delhi, Delhi. IK International Pvt Ltd (Chapter 1,4, 5 for Unit 1; Chapter 2,7,8 for Unit 2; Chapter 2 for Unit 2 ; Chapter 6 for Unit 3; Chapter 9,10,11 for Unit 4; Chapter 12-17 for Unit 5;
2. Sharma, P.D. (2010) *Ecology and Environment*. Meerut, UP. Rastogi Publications. (Chapters 15 for Unit 2, 7; Chapters 20 for Unit 4, 5; Chapters 21,22 for Unit 9; Chapters 23 for Unit 7,8).
3. Chauhan , B.S 2008. Environmental Studies. New Delhi, Delhi. University Science Press. (Chapters 1 for Unit 1; Chapters 6 for Unit 2; Chapters 7 for Unit 8)
4 Tiwari, M., Khulbe, K., Tiwari, A. 2009. *Environmental Studies*. New Delhi, Delhi, I K International (Chapter 1,2,3,4 for Unit 1; Chapter 2,3 for Unit 2, Chapter 17,35, 36 for Unit 3; Chapter 41, 42 for Unit 4; Chapter 45,46 for Unit 6;, Chapter 55,56,60 for Unit 8; Chapte 61,62,63 for Unit 9).

Additional Resources

1. Barucha ,E.2004. *Textbook of Environmental studies*. New Delhi , Delhi : UGC. (Chapter 1 for Unit 1; Chapter 3,4 for Unit 2; Chapter 6 for Unit 6,8,9):

Teaching Learning Process

To engage students and transform them into active learners the students are updated with latest books and review articles.The experiments included in the paper are performed individually or in group and are followed by group discussions and interjections.
Week 2: Unit II
Week 3: Unit III
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit IV

Week 7: Unit V
Week 8: Unit V
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VIII
Week 14: Unit VIII
Week 15: Unit IX

Assessment Methods

The students are assessed on the basis of oral presentations and regular class tests.

- Students are continuously assed during practical class.
- Submission of class records is mandatory. This exercise develops scientific skill as well as methods of recording and presenting scientific data.

Assessment Task

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Environment - basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	An overview of atmosphere, hydrosphere, lithosphere and anthrosphere - environmental problems.Environmental pollution - types of pollution, sources of pollution, measurement of pollution, methods of measurement of pollution, fate of pollutants in the environment, Bioconcentration, bio/geomagnification.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Microbiology of waste water treatment, aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process -anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industries.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganic (metals, radionuclides, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, decay behavior and	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	degradative plasmids, molecular techniques in bioremediation.		
Unit V:	Role of immobilized cells/enzymes in treatment of toxic compounds. Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Economics and Environment: Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost effectiveness analysis, WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	Policies for Environmental Protection: 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.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Policies for Pollution Management: 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.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Public Participation for Environmental Protection: Environmental movement and people’s participation with special references to Gandhamardan, Chilika and Narmada Bachao Andolan, Chipko and Silent valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Green house effect, anthropogenic activity, pollutants, bioconcentration, geomagnification, Aerobic process, activated sludge, oxidation ponds, oxidation ditch. anaerobic digestion, anaerobic sludge blanket reactors. Water Treatment schemes .metals, bioremediation, biobleaching , policies on environment protection, public movements. contaminants, waste management, xenobiotic compounds, biopesticides, polyaromatic hydrocarbons, biosensors, bio-techniques, Stockholm Conference, Brundtland Report (1987), Ramsar convention 1971.

Plant Anatomy and Embryology
(BHGE2)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

The Objective of this paper is to provide basic knowledge of plant internal architecture and cellular composition and reproduction. This will help them to understand how different plant tissue structures evolve and modify their functions with respect to their environment.

Course Learning Outcomes

Knowledge regarding anatomy equipped the students to identify different types of tissues and make them able to correlate their physiology in a better away. This will also help them to understand how different plant tissue evolve and modify their structure and functions with respect to their environment. Knowledge regarding embryology make them understand how reproduction play significant role in defining population structure, natural diversity and sustainability of ecosystem in a better way.

Unit 1

Meristematic and permanent tissues (8 lectures)
Simple (parenchyma, collenchyma, sclerenchyma) and complex tissues (xylem, phloem), Root and shoot apical meristems (describe theories in brief with special reference to Tunica Corpus and Korper-Kappe theory)

Unit 2

Organs (4 lectures)
Structure of dicot and monocot stem (include types of vascular bundles), root and leaf (including Kranz anatomy).

Unit 3

Secondary Growth (8 lectures)
Vascular cambium: structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood; Ring and diffuse porous wood; Early and late wood)

Unit 4

Adaptive and protective systems (8 lectures)

Epidermis (trichomes and hair), cuticle, stomata: structure and type (Metcalf and Chalk Classification); General account of adaptations in xerophytes and hydrophytes (Examples may be cited from *Nerium*, *Opuntia*, *Hydrilla* and *Nymphaea*).

Unit 5

Introduction to Plant Reproduction (5 lectures)

Modes of reproduction in plants: vegetative options - natural and artificial; introduction and Significance of sexual reproduction. 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, Significance of Reproductive Biology studies.

Unit 6

Structural organization of flower (10 lectures)

Organization of flower; Structure: Anther (No developmental stage) and development of Pollen grains; Ovules:

Structure and types; Embryo sac Types (monosporic, bisporic and tetrasporic) and development (with special reference to *Polygonum* type).

Unit 7

Pollination and fertilization (10 lectures)

Pollination types and adaptations; Double fertilization and triple fusion; Seed: Structure (Dicot and Monocot, No developmental stages) appendages and dispersal mechanisms (– Autochory, Anemochory, Hydrochory, Zoochory with 1 example each) Adaptations (aril, caruncle).

Unit 8:

Embryo and endosperm (10 lectures)

Endosperm types (one example of each type), structure and functions; Dicot and Monocot embryo (Brief account of dicot embryo development); Embryo endosperm relationship (General account).

Practical

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: *Zea mays*; Dicot: *Helianthus*.
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*.
5. Leaf: Dicot and Monocot (only Permanent slides).

6. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem).
7. Structure of anther (young and mature).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac (Permanent slides/photographs).
10. Pollination types and seed dispersal mechanisms (including appendages, aril,caruncle) Photographs/specimens).
11. Dissection of embryo/endosperm from developing seeds.
12. Calculation of percentage of germinated pollen in a given medium.

References

1. Bhojwani, S.S., Bhatnagar, S.P. , Dantu P. K. (2015). *Embryology of Angiosperms*, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd. (chapter 1 for unit 5;chapters 2, 3, 4, 6 and 7 for unit 6; chapters 8, 9 for unit 7; chapters 11, 12 and 15 for unit 8)
2. Dickison,W.C.(2000). *Integrated Plant anatomy*. Cambridge, U.K.: Academic press Inc. (chapter 2 for unit 1; chapter 3 for unit 2; chapter 4 for unit 3; chapters 2 and 8 for unit 4)
3. Fahn, A. (1982). *Plant anatomy*. Oxford, U.K.: Pergamon Press. (chapters 3 to 8 for unit 1; chapters 11 to 13 for unit 2; chapters 13, 14 for unit 3; chapters 10 to 13 for unit 4)
4. Mauseth, J.D. (1988). *Plant Anatomy*. San Francisco, California: The Benjamin/Cummings Publisher. (chapters 3 to 8 for unit 1; chapters 11 to 13 for unit 2; chapters 14, 15 for unit 3; chapter 10 for unit 4)

Additional Resources

1. Evert F. R., Eichhorn S. E. (2008). *Raven Biology of Plants*. 8th Edition. New York, W.H. Freeman and Company Publishers. (chapters 23 to 26 for units 1 to 4, Chapter 19 for units 5 to 8)

Teaching Learning Process

Theory:The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years’ question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.

Teaching Learning Plan

Week 1: Unit I
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Week 3: Unit III
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Week 8: Unit VI
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit VIII

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.
Assessment method

Unit No	Coure learning Outcome	Teaching and Learning Activity	Assessment Task
I	Meristematic and permanent tissues: Simple (parenchyma, collenchyma, sclerenchyma) and complex tissues (xylem, phloem), Root and shoot apical meristems (describe theories in brief with special reference to Tunica Corpus and Korper-	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests

	Kappe theory)		
II	Organs: Structure of dicot and monocot root stem and leaf.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
III	Secondary Growth: Vascular cambium: structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood)	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
IV	Adaptive and protective systems: Epidermis (trichomes and hair), cuticle, stomata: structure and type (Metcalf and Chalk Classification) ; General account of adaptations in xerophytes and hydrophytes (Examples may be cited from *Nerium*, *Opuntia, Hydrilla* and *Nymphaea*).	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
V	Introduction to Reproduction: Modes of reproduction in plants: vegetative options - natural and artificial; introduction and Significance of sexual reproduction.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VI	Structural organization of flower: Organization of flower, Structure; Anther and Pollen (No developmental stage); Ovules: Structure and types; Embryo sac: Types special reference to Polygonum type.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VII	Pollination and fertilization: Pollination mechanisms and adaptations; Double fertilization and triple fusion; Seed: Structure (Dicot and Monocot, No developmental stages) appendages and dispersal mechanisms.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VIII	Embryo and endosperm: Endosperm types (one example of each type), structure and functions; Dicot and Monocot embryo; Embryo endosperm relationship (General account).	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests

Keywords

meristem, secondary growth, Vascular cambium, anther, embryo sac, pollination, double fertilisation, endosperm, reproductive biology.

Plant Ecology and Taxonomy
(BHGE3)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

Objectives: To make students understand ecology and basic ecological concepts, inter-relation between the living world and environment. Also to make them aware about identification, nomenclature and classification.

Course Learning Outcomes

After successful completion of the course the student shall have adequate knowledge about the basic principals of environment and taxonomy.

Unit 1

Introduction (1 lecture)

Inter-relation between the living world and environment

Unit 2

Ecological factors (11 lectures)

Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance.

Unit 3

Plant communities (6 lectures)

Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)

Unit 4

Ecosystem (8 lectures)

Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous

Unit 5

Phytogeography (4 lectures)

Principle biogeographical zones; Endemism (definition and types)

Unit 6

Introduction to plant taxonomy (1 lecture)

Identification, Classification, Nomenclature.

Unit 7

Identification (5 lectures)

Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access

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Unit 8

Taxonomic evidences from palynology, cytology, phytochemistry and molecular data. (6 lectures)

Unit 9

Taxonomic hierarchy (2 lectures)

Ranks, categories and taxonomic groups

Unit 10

Botanical nomenclature (6 lectures)

Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit 11

Classification (6 lectures)

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

Unit 12

Biometrics, numerical taxonomy and cladistics (4 lectures)

Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

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, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.
3 (a) Study of morphological adaptations of hydrophytes and xerophytes (four each).
(b)Study of biotic interactions of the following: Stem parasite (Cuscuta), Root parasite (Orobanche), Epiphytes, Predation (Insectivorous plants)
4. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. \(species to be listed)
5. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer’s frequency distribution law

6. 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):Brassicaceae - Brassica,Alyssum / Iberis; Asteraceae - Sonchus/Launaea, Vernonia/Ageratum,Eclipta/Tridax; Solanaceae -Solanum nigrum, Withania; Lamiaceae -Salvia, Ocimum; Liliaceae - Asphodelus / Lilium / Allium.
7. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted on the herbarium sheet with appropriate label.)

References

1. Kotpal, R.L. , Bali, N.P. (1978). Concepts of Ecology. Jullundur, Punjab, Vishal Publications, (Chapter 1 for Unit 1; Chapter 3,4,56, for Unit 2: Chapter 12,13 for Unit 3. Chapter 7,8 for Unit 4))
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.(Chapter 1 for Unit 1, Chapter 2,3,4 for Unit 2; Chapter 9,10 for Unit 3; Chapter 12,13 for Unit 4; Chapter 15 for Unit 5;
3. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A (Chapter 1, 16 for Unit 6. Chapter 15,17,18 for Unit 7; Chapters 9-12,14, 18-21 for Unit 8; Chapter 1,2 for Unit 9; Chapter 16 for Unit 10; Chapter 7,8 for Unit 11);
4. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi (Chapter 1 for Unit 6; Chapter 5 for Unit 7; Chapter 7 for Unit 8; Chapter 3 for Unit 9; Chapter 2 for Unit 10; Chapter 10 for Unit 11).

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and talk and chalk method. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Week 1: Unit I and part of II
Week 2: Unit II
Week 3: Unit II
Week 4: Unit III
Week 5: Unit III and part of IV
Week 6: Unit IV
Week 7: Unit V
Week 8: Unit V
Week 9: Unit VI and part of VII
Week 10: Unit VII and VIII
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit IX and X
Week 14: Unit XI
Week 15: Unit XII

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s for checking and evaluation

Assessment Methods

Theory: The students are continuously evaluated based on a written assignment, class test and/or presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a Assignment/PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation. The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Unit No	Core learning Outcome	Teaching and Learning Activity	Assessment Task
I	Inter-relation between the living world and environment	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
II	Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
III	Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
IV	Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling;	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests

	Cycling of carbon, nitrogen and Phosphorous		
V	Principle biogeographical zones; Endemism (definition and types)	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VI	Identification, Classification, Nomenclature	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VII	Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VIII	Taxonomic evidences from palynology, cytology, phytochemistry and molecular data	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
IX	Taxonomic hierarchy: Ranks, categories and taxonomic groups	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
X	Botanical nomenclature: Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
XI	Classification: Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (up to series).	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
XII	Biometrics, numerical taxonomy and cladistics: Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests

Keywords

Environment, Soil, Water, Plant communities, Succession, Ecosystem, Phytogeography, Endemism, Plant taxonomy, Taxonomic hierarchy, Botanical Nomenclature, Classification, Biometrics

Plant Physiology and Metabolism
(BHGE5)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

The course aims at making students realize how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.

Course Learning Outcomes

The students are able to correlate morphology, anatomy, cell structure and biochemistry with plant functioning. The link between theory and practical syllabus is established, and the employability of youth would be enhanced. The youth can also begin small-scale enterprises.

Unit 1
Plant-water relations **(8 Lectures)**
Importance of water, water potential and its components, pathway of water movement, ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation, stomatal movements – only ion theory.

Unit 2
Mineral nutrition **(8 Lectures)**
Essential elements, macro- and micronutrients, criteria of essentiality of elements, methods of studying mineral requirement (Hydroponics, Aeroponics), role of essential elements, transport of ions across membrane, active and passive transport, carriers, channels and pumps.

Unit 3
Translocation in phloem **(6 lectures)**
Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading.

Unit 4

Photosynthesis **(10 Lectures)**
Historical contribution of Julius von Sachs, Blackman, Emerson, Engelmann, Hill. Arnon; photosynthetic pigments (chlorophyll a and b, xanthophyll, carotene); photosystem I and II,

reaction centre, antenna molecules; electron transport and mechanism of ATP synthesis, C3 pathway; C4 and CAM plants (in brief, no pathways); photorespiration.

Unit 5

Respiration **(6 Lectures)**

Glycolysis, anaerobic respiration, TCA cycle, oxidative phosphorylation, glyoxylate cycle, RQ.

Unit 6

Enzymes **(4 Lectures)**

Structure and properties, Km (no derivation), mechanism of enzyme catalysis and enzyme inhibition.

Unit 7

Nitrogen metabolism **(6 Lectures)**

Biological nitrogen fixation - nodulation in detail, nitrate and ammonia assimilation, dinitrogenase, NR, NiR, transamination.

Unit 8

Plant growth regulators **(6 Lectures)**

Discovery, physiological roles of auxins, gibberellins, cytokinins and ethylene.

Unit 9

Plant response to light and temperature **(6 Lectures)**

Photoperiodism - discovery (SDP, LDP, day neutral plants); phytochrome (discovery and structure), red and far-red light response on photomorphogenesis (general account), florigen (brief account).

***NO STRUCTURES AND FORMULAE TO BE ASKED IN THE EXAM**

Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of the environmental factor light on transpiration by excised twig.
3.Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. To Study Hill's reaction.
5. To study the activity of catalase and study the effect of pH and enzyme concentration.
6. To study the effect of light intensity on O2evolution in photosynthesis.
7. Comparison of the rate of respiration in any two parts of a plant.

Demonstration experiments

1. Bolting.
2. Effect of auxins on rooting.

3. Suction due to transpiration.
4. Hydroponics (using a photograph).
5. To demonstrate the delay of senescence by cytokinins.
6. To study the phenomenon of seed germination (effect of light and darkness)

References

1. Bajracharya, D. (1999). *Experiments in Plant Physiology: A Laboratory Manual.* New Delhi, Delhi: Narosa Publishing House. (For Practicals)
2. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism.* Singapore: Springer Nature, Singapore Pvt. Ltd. (Chapter 1 for Unit 1, Chapters 2 and 3 for Unit 2, Chapter 6 for Unit 3, Chapter 5 for Unit 4, Chapter 7 for Unit 5, Chapter 4 for Unit 6, Chapter 11 for Unit 7, Chapters 14 to 17, 19, and 27 for Unit 8, Chapters 13 and 25 for Unit 9)
3. Hopkins, W. G., Huner, N. P. A. (2009). *Introduction to Plant Physiology*, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd. (Chapters 1, 2 and 8 for Unit 1, Chapters 3 and 4 for Unit 2, Chapter 9 for Unit 3, Chapters 7 and 8 for Unit 4, Chapter 10 for Unit 5, Chapter 8 for Unit 6, Chapter 11 for Unit 7, Chapters 18 to 21, and 23 for Unit 8, Chapters 22 and 24 for Unit 9)
4. Kochhar, S.L., Gujral, S.K. (2017). *Plant Physiology: Theory and Applications.* New Delhi, Delhi: Foundation Books, imprint of Cambridge University Press India Pvt, Ltd. (Chapters 1 to 6 for Unit 1, Chapter 7 for Unit 2, Chapter 13 for Unit 3, Chapter 9 for Unit 4, Chapter 10 for Unit 5, Chapter 8 for Unit 6, Chapter 11 for Unit 7, Chapter 15 for Unit 8, Chapter 14 for Unit 9)

Additional Resources:

1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). *Plant Physiology and Development* International 6th edition. New York, NY: Oxford University Press, Sinauer Associates. (Chapters 3 and 4 for Unit 1, Chapters 5 and 6 for Unit 2, Chapter 11 for Unit 3, Chapters 7 and 8 for Unit 4, Chapter 12 for Unit 5, Chapter 13 for Unit 7, Chapters 15, 18, 21 and 22 for Unit 8, Chapters 16 and 20 for Unit 9)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.

When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.

The students are asked to submit their record notebooks to the teacher/s for checking.

Weekly lesson Plan

Week 1: Unit I

Week 2: Unit I

Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit IV
Week 7: Unit IV
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VI
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit IX

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Importance of water, water potential and its components, pathway of water movement, ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation, stomatal movements – only ion theory..	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Essential elements, macro- and micronutrients, criteria of essentiality of elements, methods of studying mineral	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments,

	requirement (Hydroponics, Aeroponics), role of essential elements, transport of ions across membrane, active and passive transport, carriers, channels and pumps.	experiments	tests
Unit III:	Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Historical contribution of Julius von Sachs, Blackman, Emerson, Engelmann, Hill. Arnon; photosynthetic pigments (chlorophyll a and b, xanthophyll, carotene); photosystem I and II, reaction centre, antenna molecules; electron transport and mechanism of ATP synthesis, C3 pathway; C4 and CAM plants (in brief, no pathways); photorespiration	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V	Glycolysis, anaerobic respiration, TCA cycle, oxidative phosphorylation, glyoxylate cycle, RQ.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI	Structure and properties, Km (no derivation), mechanism of enzyme catalysis and enzyme inhibition.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII	Biological nitrogen fixation - nodulation in detail, nitrate and ammonia assimilation, dinitrogenase, NR, NiR, transamination.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII	Discovery, physiological roles of auxins, gibberellins, cytokinins and ethylene.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Photoperiodism - discovery (SDP, LDP, day neutral plants); phytochrome (discovery and structure), red and far-red light response on photomorphogenesis (general account), florigen (brief account)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Movement of water, ascent of sap, transpiration, stomatal movements, mineral nutrients, active and passive transport, translocation, enzymes, photosynthesis, respiration, nitrogen metabolism plant growth regulators, photoperiodism, photomorphogenesis

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This work would not have been possible without the help by the Undergraduate Curriculum Committee, who time to time prvided the academic as well as technical guidance during the revision of the courses.

I am especially indebted to Professor K. S. Rao, Head, department of Botany, University of Delhi, who worked actively to provide me with the academic time to pursue the goal of course revision.

I am grateful to all of those with whom I have had the pleasure to work. Each of the convinors and members of working group has provided me extensive personal and professional guidance in the improvement of the contents of the syllabi of Botany programmes. I would especially like to thank Dr. Anuradha Sharma, Hindu College, Dr Vijay Kumar, Shivaji College and Atika Chandra, Maitryie College, who have greatly contributed in the preparation of the course revision groups, preparation of the framework and writing substantial part of the course outcome. Besides that I especially thank the following members who have been more important to me in the pursuit of this project by working as convenors and working members for the revision of the courses of Botany programmes

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दिल्लीविश्वविद्यालय

UNIVERSITY OF DELHI

Bachelor of Science Programme in Life Sciences
(CBCS)

(Botany Component)

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges, Non Collegiate Women's Education Board and School of Open Learning

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Preamble

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its programmes in the best interest of their students and in this endeavour it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes.

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the programme of their choice. The Under-Graduate Programmes will prepare the students for both, academia and employability.

Each programme vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programmes also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each programme prepares students for sustainability and life-long learning.

The new curriculum of B.Sc. Life Sciences offer essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

The University of Delhi hopes the LOCF approach of the B.Sc. Programme in Life Sciences will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

B.Sc. Programme in Life Sciences (CBCS)
(Botany Component)

INTRODUCTION

B.Sc. Programme in Life Sciences is designed to afford a skeletal structure within which the programme can be developed to suit the need of the hour, in keeping with the emergence of new areas of life sciences through interdisciplinary approach. The B.Sc. Programme in Life Sciences programme covers a wide range of basic and applied aspects of botany, zoology and chemistry courses as well as courses of interdisciplinary nature. The core courses that are a part of the programme are designed to build knowledge base in the student, and furthermore, acquaints the students with the applied aspects of this fascinating discipline as well. The student is thus equipped to pursue higher studies, and to apply the skills learnt in the programme to solving practical societal problems. The programme offers a wide range of elective courses of botany, zoology and chemistry. These include skill enhancement courses that prepare the student for an eventual job in academia or industry.

CHOICE BASED CREDIT SYSTEM (CBCS):

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. It offers flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge of all aspects of the field. The Learning outcomes-based curriculum framework is designed around the CBCS and is intended to suit the present day needs of the student interms of securing their path towards higher studies or employment.

The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed.

Design of Program:

The teaching-learning will involve theory classes (Lectures) of one hour duration and practical classes. The curriculum will be delivered through various methods including chalk and talk, power-point presentations, audio, video tools, E-learning/E-content,virtual labs, simulations, field trips/Industry visits, seminars (talks by experts), workshops, projects, models and class discussions. The assessment broadly will comprise of Internal Assessment (Continuous Evaluation) and End Semester Examination. The internal Assessment will be through MCQ, test, assignment, oral presentation, worksheets and short project.

Outline of Choice Based Credit System:

1. Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2.Elective Course: Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/ subject/ domain or nurtures the candidate's proficiency/skill is called an Elective Course.

2.1.Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

2.2 Dissertation/Project: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.

2.3 Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

3. Ability Enhancement Courses (AEC)/Competency Improvement Courses/Skill Development Courses/Foundation Course: The Ability Enhancement (AE) Courses may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC). "AECC" courses are the courses based upon the content that leads to Knowledge enhancement. They ((i) Environmental Science, (ii) English/MIL Communication) are mandatory for all disciplines. AEEC courses are value-based and/or skill-based and are aimed at providing hands-on -training, competencies, skills, etc.

3.1 AE Compulsory Course (AECC): Environmental Science, English Communication/MIL Communication.

3.2 AE Elective Course (AEEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

Project work/Dissertation is considered as a special course involving application of knowledge in solving / analyzing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

LEARNING OUTCOME–BASED APPROACH TO CURRICULUM PLANNING:

The Learning Outcomes-based Curriculum Framework (LOCF) for the B.Sc. degree in Life Sciences is designed to afford a skeletal structure within which the programme can be developed to suit the need of the hour, in keeping with the emergence of new areas of life sciences. The framework is architected to allow for flexibility in programme design and course content development, while at the same time maintaining a basic uniformity in structure in comparison with other universities across the country. The B.Sc. Life Sciences programme covers a wide range of basic and applied aspects of botany, zoology and chemistry courses as well as courses of interdisciplinary nature. The core courses that are a part of the programme are designed to build sound knowledge in the student, and furthermore, acquaints the students with the applied aspects of this fascinating discipline as well. The student is thus equipped to pursue higher studies in an institution of her/his choice, and to apply the skills learnt in the programme to solving practical societal problems. The programme offers a wide range of elective courses to the student. These include skill enhancement courses that prepare the student for an eventual job in academia or industry.

LEARNING OUTCOME BASED CURRICULUM FRAMEWORK

Nature and extent of the B.Sc Programme in Life Sciences

Content: Botany is the broad discipline encompassing various subjects involved with the study of plants. The Programme imparts knowledge on various fields of plant biology through teaching, interactions and practical classes. Present trend has been shifted to frontier areas of plant sciences at the cost of traditional botany. There is need to maintain a balance of the traditional botany and modern science and applied approach. This syllabus has been drafted to enable the learners to prepare them for future employment in various fields including academics as well as competitive exams. Students would gain wide knowledge as follow:

1. Diversity of plants and microbes their habitat, morphology, and reproduction.
2. Genetics and molecular biology of plants
3. Fungi and disease causing microbes and fungi
4. Economic value of plants and their use in Biotechnology

Plants are relevant to humans as they provide us with food, shelter, clothing, energy, health, aesthetic beauty, environment and even economy. This paper is relevant to ALL students. Introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi and to various plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms) and information on the Ecological and Economic Importance of Microbes, Fungi and various plant groups to enable students understand and appreciate relevance of Microbes and Plants to environment and human well-being. Insight into the line of Plant Evolution on Earth and the consequent Biodiversity is instrumental in creating Awareness on the threats to biodiversity and sensitize young minds towards the Biodiversity Conservation for sustainable development. Combination of Theoretical and Practical components will provide comprehensive information and insight into the

1. Fascinating world of Microbes and Plants.
2. Hands on Training will help students learn use of microscope, mounting, section-cutting and staining techniques for the study of plant materials.
3. Making Drawings in Practical Records will enhance understanding morphological and structural details and related functional aspects in diverse plant groups.
4. Use of Illustrations, Photographs, Charts, Permanent Slides, Museum and Herbarium Specimens along with ICT Methods will provide an interesting insight into the beautiful world of microbes and plants.
5. Scope of Biodiversity includes Medicinal field, Industry, Agriculture, Research and Study, Job Opportunities and Environmental Conservation. This paper is both informative and

interesting and will enable students to learn about Biodiversity not only as a plant or nature lover, but also for higher academic pursuits, particularly in the field of Biological Sciences, Environment and Biodiversity Conservation.
6. The relationship between the properties of macromolecules, their cellular activities and biological responses.
7. Understanding of Cell metabolism, chemical composition, physiochemical and functional organization of organelles.
8. Contemporary approaches in modern cell and molecular biology.
9. Understand how plant sciences and microbiology is applied in manufacturing of industrial products
10. Know about design of bioreactors, factors affecting growth and production
11. Comprehend the techniques and the underlying principles in upstream and down- stream processing
12. Learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
13. Understand various biogeochemical cycles – Carbon and Nitrogen, and microbes involved
14. Understand the basic principles of organism and environment interation and application of the same in solving environmental problems – waste water treatment and bioremediation
15. Learn the basic concepts, principles and processes in plant biotechnology.
16. Have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.
17. Use basic biotechnological techniques to explore molecular biology of plants Explain how biotechnology is used to for plant improvement and discuss the biosefty concern and ethical issue of that use.

Aims of B.SC. Programme in Life Sciences

Content: 1. Provide an introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi, including diverse plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms).

2. To enable students to understand and appreciate the relevance of Microbes and Plants to environment (ecological significance) and human well-being (economic importance).

3. Develop an understandingof Evolution of Plant formsand the consequent Biodiversity. These are instrumental in creating awareness on the threats to biodiversity and sensitizestudents towards the Conservation of Biodiversity for sustainable development.

4. To study the organization of cell, cell organelles and biomolecules (i.e protein, carbohydrate, lipid and nucleic acid) to gain knowledge on the activities in which the diverse macro molecules and microscopic structures inhabiting the cellular world of life are engaged. This will enable the students to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life.

5. To introduce students to application of microbes in Industrial production and Environmental remediation strategies.

6. New knowledge and widening of the knowledge acquired in by handling of classical and modern plant biotechnology processes, including tissue culture for healthy plants, plants with improved characteristics.

7. To explore the natural genetic variation in plants and to understand how diverse factors (at the cellular level) contribute to the expression of genotypes and hence to phenotypic variation.

8. Understanding of biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals (vaccines, antibodies, antibiotics etc.), food industry (transgenic crops with improved qualities (nutraceuticals, industrial enzymes etc.), agriculture (biotic and abiotic stress tolerant plants, disease and pest resistant plants, improved horticultural varieties etc.), ecology (plants role in bioremediation). This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.

9. In the laboratory classes, students will perform some of the techniques currently used to generate information and detect genetic variation.

10. Understanding of plant classification systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various plants groups.

11. Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system.

12. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and in the application of statistics to biological data

13. To provide new information, enhance core competency and discovery/inquiry based learning of learners. A botany graduate would be competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.

14. To make students aware of most basic domain-independent knowledge, including critical thinking and communication.

15. To enable the graduate to prepare for national and International competitive examinations for employment.

GRADUATE ATTRIBUTES:

Some of the characteristic attributes ofB.ScProgramme in Life Sciences include:

• Knowledge acquisition: gathers in-depth knowledge of basic and applied areas of Botany, zoology and Chemistry.

• Core subjects laboratory skills: understands various methods of safe handling, culturing and storage of plant and animal specimens and chemicals in the laboratory.

•Interdisciplinary approach: becomes aware of the role of life sciences in interdisciplinary research as well as in daily life.

•Environmental literacy: develops a basic understanding of the principles of life sciences that have environmental implications, and gains an awareness of regulatory requirements and their compliance in biotechnology and microbiological research.

•Scientific logic: develops scientific logic and approaches a problem with critical reasoning.

•Independence in thought: cultivates independent thinking and is able to integrate knowledge from other disciplines and fit that knowledge into the context of loife sciences.

•Team work: understands the importance and strengths of interacting with and working alongside people from diverse backgrounds.

•Global perspective: becomes acquainted with standard international practices and emerging technologies used to study plants, animals and their structural components.

•Communication skills: develops effective communication skills through oral presentations of ongoing developments in the field and the compiling of information in the form of reports.

•Ethics: acquires anawareness of work ethics and ethical issues in scientific research as well as plagiarism policies.

•Self-motivation: develops self-discipline, planning and organization skills, and time management skills.

Qualification description: The qualification description for B.Sc. programme in Life Science include:

•Demonstration of a clear and exhaustive understanding of the basic concepts of Zoology, Botany and Chemistry, and an awareness of the emerging areas of the field.

•Acquisition of in-depth comprehension of the applied aspects of Zoology, botany and chemistry in day-to-day life.

•Enhancement of ability to read, assimilate and discuss scholarly articles and research papers showcasing subject of life sciences as well as interdisciplinary areas of life sciences.

•Sharpening of critical thinking skills facilitating the application of knowledge gained in the field of life sciences in the classroom to the practicalsolving of societal problems.

•Development of intellectual capabilities promoting the ability to formulate and test a hypothesis.

•Acquisition of practical laboratory skills, enabling the accurate design of an experiment and systematic collection of experimental data.

•Exhibition of ability to interpret and quantitatively analyze experimental data and maintain records of the same.

•Development of strong oral and written communication skills promoting the ability to present studies in the field of zoology, botany and chemistry using the concepts and knowledge acquired.

•Demonstration of the ability to work effectively and productively, independently or as part of a team.

QUALIFICATION DESCRIPTORS

For a graduate student in Life Sciences the qualification descriptors may include following:
(i) To show a systematic, extensive, coherent knowledge and understanding of academic subjects and their applications, including critical understanding of the established theories, principles and concepts of a number of advanced and emerging issues in the field of Botany;
(ii) To gain knowledge to produce professionals in the field of plant sciences in research and development, academics (teaching in Schools, Colleges and University), government and public services e.g. conservationist, plant explorer, ecologist, horticulturist, plant biochemist, genetics, nursery manager, molecular biologist, plant pathologist, taxonomist, farming consultant and environmental consultant. Further application of knowledge can enhance productivity of several economically important products. Knowledge of plant sciences is also necessary for the development and management of forests, parks, wastelands and sea wealth
(iii) Display skills and ability to use knowledge efficiently in areas related to specializations and current updates in the subject.
(iv) Provide knowledge about plants, current research, scholarly and professional literature of advanced learning areas of plant sciences
(v) Use knowledge understanding and skills for critical assessment of wide range of ideas and problems in the field of Botany
(vi) Communicate the outcomes of studies in the academic field of Botany through print and digital media.
(vii) Apply one's knowledge and understanding of Botany to new/unfamiliar contexts and to identify problems and solutions in daily life
(viii) Design and apply the knowledge of plant sciences in identifying the problems which can be solved through the use of plants
(ix) To think of adopting expertise in plant structure, functions and solve the problems of environment, ecology, sustainable development and enhancing productivity.
(x) Concept and significance of sustainable development and use of the plant resources

PROGRAM LEARNING OUTCOMES:

• Students of the B.Sc. Life Sciences programme will learn to use scientific logic as they explore a wide range of contemporary subjects spanning various basic and applied aspects life sciences

• Students will appreciate the biological diversity of plant and animals and compounds in them to be able to describe/explain the processes used by microorganisms for their replication, survival, and interaction with their environment, hosts, and host populations. They will become aware of the important role of plant and animals in ecosystem functioning.

•Students will gain knowledge of various biotechnological applications of plants and animals and will learn of industrially important natural products produced by them.

•Students will become familiar with scientific methodology, hypothesis generation and testing, design and execution of experiments. Students will develop the ability to think critically and to read and analyze scientific literature.

•Students will acquire and demonstrate proficiency in good laboratory practices in biological sciences and be able to explain the theoretical basis and practical skills of the tools/technologies commonly used to study this field.

•Students will develop proficiency in the quantitative skills necessary to analyze biologicalproblems (e.g., arithmetic, algebra, and statistical methods as applied to biology)

•Students will develop strong oral and written communication skills through the effective Presentation of experimental results as well as through seminars.

•Graduates of the B.Sc. programme in Life Sciences will make the students to understand and evaluate the impact of new research discoveries in the life sciences, and will be able to stimulate to think on wide range of careers, including biological and medical research in higher education institutions as well as careers in public and global health, scientific writing, environmental organizations, and food, pharmaceuticals and biotechnology industries.

STRUCTURE B.SC. PROGRAMME IN LIFE SCIENCES

Credit Distribution

Course	*Credits	
	Theory+ Practical	Theory+Tutorials
I. Core Course (12 Papers) 04 Courses from each of the 03 disciplines of choice	12X4= 48	12X5=60
Core Course Practical / Tutorial* (12 Practical/ Tutorials*) 04 Courses from each of the 03 Disciplines of choice	12X2=24	12X1=12
II. Elective Course (6 Papers) Two papers from each discipline of choiceincluding paper of interdisciplinary nature.	6x4=24	6X5=30
Elective Course Practical / Tutorials* (6 Practical / Tutorials*) Two Papers from each discipline of choice including paper of interdisciplinary nature •Optional Dissertation or project work in place of one Discipline elective paper (6 credits) in 6^{th} Semester	6 X 2=12	6X1=6
III. Ability Enhancement Courses		
1. Ability Enhancement Compulsory (2 Papers of 2 credits each) Environmental Science English/MIL Communication	2X 2=4	2X2=4
2. Ability Enhancement Elective (Skill Based) (4 Papers of 2 credits each)	4 X 2=8	4 X 2=8
	Total credit= 120	Total credit= 120

Institute should evolve a system/policy about ECA/ General Interest/ Hobby/ Sports/ NCC/ NSS/ related courses on its own.

*wherever there is practical there will be no tutorials and vice -versa

Semester wise distribution of Courses of B.Sc. Life Science under CBCS

[BOTANY COMPONENT]

Semester	Core Course	Ability Enhancement Compulsory Courses	Skill Enhancement Courses SEC 4	Discipline Specific Elective DSE(4)
I	Botany I: CC Biodiversity (Microbes, Algae, Fungi and Archegoniatae) CC Zoology I CC Chemistry I	English/MIL Communication/ Environmental Science		
II	Botany II: CC Plant Ecology and Taxonomy CC Zoology II CC Chemistry II	English/MIL Communication/ Environmental Science		
III	Botany III: CC Plant Anatomy and Embryology CC Zoology III CC Chemistry III		SEC –I 1. Biofertilizers	
IV	Botany IV: CC Plant Physiology and Metabolism CC Zoology III CC Chemistry III		SEC –II 2. Medicinal Botany	
V			3. Ethnobotany	DSE-I Botany (Any one) l.Cell and Molecular Biology 2. Bioinformatics
VI			4. Intellectual Property Right	DSE-II Botany (Any one) 3. Economic Botany and Biotechnology 4. Analytical Techniques in Plant Sciences

Courses for Programme under B.Sc. Life Sciences

Core Courses —Botany

1. Biodiversity (Microbes, Algae, Fungi and Archegoniatae)
2. Plant Ecology and Taxonomy
3. Plant Anatomy and Embryology
4. Plant Physiology and Metabolism

Discipline Specific Electives-Botany (Any two)

Semester V DSE-I	DSE-I (Any one) l.Cell and Molecular Biology 2. Bioinformatics
Semester VI DSL-II	DSE-II (Any one) 3. Economic Botany and Biotechnology 4. Analytical Techniques in Plant Sciences
Ability Enhancement Compulsory Courses	
1. Environmental Science 2. English/M1L Communication	
Skill Enhancement Courses (four)	
Semester III SEC-I	1. Biofertilizers
Semester IV SEC-II	2. Medicinal Botany
Semester V SEC- III	3. Ethnobotany
Semester VI SEC-IV	4. Intellectual Property Right

COURSE LEARNING OBJECTIVES

The progamme is designed to equip students with essential knowledge and technical skills to study plants and related subjects in a holistic manner. hteh main aim is to train the learners in all areas of plant biology using appropriate combinations of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

COURSE LEARNING OUTCOME

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.

1. Understanding of plant classification systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various life-forms. Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.

2. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and the application of statistics to biological data.

TEACHING-LEARNING PROCESS:

The B.Sc. programme in Life Sciences aims to make the student proficient in biology through the transfer of knowledge in the classroom as well as in the laboratory. In the classroom this will be done through blackboard and chalk lectures, charts, powerpoint presentations, and the use of audio-visual resources that are available on the internetsuch as virtual lab. An interactive mode of teaching will be used. The student will be encouraged to participate in discussions and deliver seminars on some topics. A problem-solving approach will be adopted wherever suitable. In the laboratory the student will first learn good laboratory practices and then get hands-on training on basic microbiological techniques and methods. Emphasis on laboratory work is particularly important keeping in mind the practical nature of the subject, and the time devoted to practicals will enable the student to better understand the applications of the different courses. Field exercises and field trips will be organized to nature and industries that will facilitate understanding of students on applied aspects of the subject and enable him to gain exposure to future places/areas of employment.

Assessment methods:

The student will be assessed over the duration of the programme by many different methods. These include short objectives-type quizzes, assignments, written and oral examinations, group discussions and presentations, problem-solving exercises, case study presentations, experimental design planning, execution of experiments, seminars, preparation of reports, and presentation of practical records. The wide range of assessment tasks aim to break the monotony of having a single assessment method

KEYWORDS

Plant Sciences, Biology, biodiversity, biotechnology, botany, bryophytes, fungi, algae, mocrobes, bacteria, plant pathology, plant reproduction, anatomy, developmental biology, molecular biology, genetics, systematics, taxonomy, plant physiology, biostatistics, bioinformatics, ecology, biochemistry,

CONTENTS OF COURSES OF THE PROGRAMME

Biodiversity (Microbes, Fungi, Algae and Archegoniatae)
(LSCC2)
Core Course - (CC) Credit:6

Course Objective (2-3)

This course aims at making a familiarity with special groups of Bacteria, Viruses, Fungi, algae and plants reproduction. Creating an understanding by observation and table study of representative members of phylogenetically important groups should be able to make students learn the process of evolution in a broad sense. Study of morphology, anatomy, reproduction and developmental changes thereinthrough typological study should create a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants. To acquaint the students with external and internal basic structure and cellular composition of the Bacteria, Viruses, Fungi, Bryophytes and Pteridophytes and Gymnosperms.To gain knowledge of diversity, life forms, life cycles, morphology and importance of microoganisms (Bacteria and algae). To introduce students with various fungal groups and lichens, their ecology, classification, characteristics, reproduction and economic importance.

1. To introduce students with the phytopathology, its concepts and principles
2. To acquaint with various plant diseases, causal organisms and their control
3. To correlate structure with important functions of different organs of the organisms.Study of various tissue systems and their development and functions in plants

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Course Learning Outcomes

The students will be made aware of the various groups of organisms, Bacteria, viruses, algae bryophytes, pteridophytes and gymnosperms that have given rise to land habit. Through field study they will be able to see these plants grow in nature and become familiar with the biodiversity. to my knowledge students should create their small digital reports where they can capture the zoomed in and zoomed out pictures as well as videos in case they are able to find some rare structure or phenomenon related to these plants. Students would have understanding of the classification, characteristics features, cell structure and growth and reproduction in viruses, bacteria, and various groups of marine and fresh water algae and their ecological and economic importance.
Upon completion of this course, the students will be able to:

1. Understand the world of fungi, and pathogens of plants
2. Appreciate the characteristics of the fungi
3. Understand the ecological and economic significance of lichen
4. Understand the application of mycology in various fields of economic and ecological significance
5. Understand the economic and pathological importance of fungi, bacteria and viruses
6. Identify common plant diseases and their control measures

Unit 1

MICROBES (14 Lectures)
a) Viruses – Discovery; General Structure- RNA virus (TMV) and DNA virus (Tphage); Replication-Lytic and Lysogenic Cycle; Economic Importance.
b) Bacteria – Discovery; General Characteristics and Cell Structure; Reproduction-Vegetative, Asexual and Genetic Recombination (Conjugation, Transformation and Transduction); Economic Importance.

Unit 2

ALGAE (8 Lectures)
General Characteristics; Outline Classification (Fritsch); Economic Importance; Thallus Organization and Reproduction in Nostoc, Chlamydomonas, Vaucheria and Ectocarpus

Unit 3

FUNGI (8 Lectures)
General Characteristics; Outline Classification (Webster); Economic Importance; Thallus Organization and Reproduction in *Rhizopus, Penicillium, Alternaria and Puccinia*

Unit 4

ARCHEGONIATAE (30 Lectures)
a) Bryophytes (10 Lectures) General Characteristics; Outline Classification; Ecological and Economic Importance; Morphology, Structure and Reproduction in *Marchantia, Anthoceros* and *Funaria*.

Unit 5

b) Pteridophytes (10 Lectures) General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Selaginella*, *Equisetum* and *Pteris*.

Unit 6

c) Gymnosperms (10 Lectures) General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Cycas* and *Pinus.*

Practical

MICROBES

a) Viruses- Structure of TMV and T-Phage (EMs/ Models/ Photographs); Lytic and Lysogenic Cycle (Line Drawings/ Photographs).
b) Bacteria-Types and Structure (Permanent Slides/ Photographs); EM Bacterium; Binary Fission and Conjugation (Photographs).
c) Chlamydomonas-E.M., *Nostoc*, *Vaucheria* and *Ectocarpus*- Study of Vegetative and Reproductive Structures through Temporary Preparations and Permanent Slides.
d) *Rhizopus*, *Penicillium* and *Alternaria*- Asexual Stage from Temporary/ Tease Mounts, *Puccinia*-Black Stem Rust of Wheat and Infected Barberry Leaves (Herbarium

Specimens/ Photographs), Tease Mounts of Spores on Wheat, Section of infected portion of Wheat and Barberry (Permanent Slides).

e) Bryophytes: *Marchantia*-Morphology of Thallus, W.M. Rhizoids, V.S. Thallus through Gemma Cup, W.M. Gemma (all Temporary Slides), L.S. Sporophyte (Permanent slide). *Anthoceros*- Morphology of Thallus, W.M. Rhizoids, L.S./ T.S. Capsule, W.M. Spores, W.M. Pseudoelaters, (all Temporary Slides), L.S. Sporophyte (Permanent slide). *Funaria*- Morphology of Gametophyte bearing Sporophyte, W.M. Rhizoids, W.M. Leaf, W.M. Operculum, W.M. Peristome, W.M. Spores (all Temporary Slides), L.S. Capsule (Permanent Slide).

f) Pteridophytes: *Selaginella*- Morphology, T.S. Stem, W.M. Strobilus, W.M. Microsporophyll and Megasporophyll (all Temporary Slides), L.S. Strobilus (Permanent Slide).*Equisetum*- Morphology, T.S. Stem (Internode), L.S./ T.S. Strobilus, W.M. Sporangiophore, W.M. Spores (Wet and Dry) (all Temporary Slides). *Pteris*- Morphology, V.S. Sporophyll, W.M. Sporangium, W.M. Spores (all Temporary Slides), W.M. Prothallus with Sex Organs (Permanent Slide).

g) Gymnosperms: *Cycas*- Morphology (Coralloid Roots, Leaf, Microsporophyll, Megasporophyll), T.S. Coralloid Root (Permanent Slide), V.S. Leaflet, V.S. Microsporophyll, W.M. Spores (all Temporary Slides), L.S. Ovule (Permanent Slide).*Pinus*- Morphology (Long and Dwarf Shoots, Male and Female Cones), W.M. Dwarf Shoot, T.S. Needle, L.S/ T.S. Male Cone, W.M. Microsporophyll, W.M. Microspores (all Temporary Slides), L.S Female Cone (Permanent Slide).

References

1. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology*. Singapore, Singapore: John Wiley and Sons (Asia). (Chapters 1,4.9.13,18,20 for Unit 2)

2. Kumar, H.D. (1999). *Introductory Phycology*. New Delhi,Delhi: Affiliated East-West. Press Pvt. Ltd. (Chapters 1,3,10,11,12,14 for Unit 3)

3. Kaur, I..D., Uniyal, P.L. (2019).*Text Book of Gymnosperms*. New Delhi,ND: Daya Publishing House, (Chapters 1,2,5, 6 for 4)

4. Parihar, N.S. (1972). *An Introduction to Embryophyta. Vol. II: Pteridophyta*. Allahabad, UP: Central Book depot. Chapters 1, 4, 5,9,for Unit 4)

Additional Resources:

1. Bhatnagar, S.P., Moitra, A. (1996). *Gymnosperms*. New Delhi, ND: New Age International (P) Ltd Publishers. (Chapters 1,6,13 for Unit 4)

2. Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2011). *Biology 9th edition*. San Francisco, SF: Pearson Benjamin Cummings. (Chapters 19,27 for Unit 1¸ Chapter 31 for Unit 2; Chapter for Unit 3)))

3. Parihar, N.S. (1991). *An Introduction to Embryophyta. Vol. I. Bryophyta*. Allahabad, UP: Central Book Depot. (Chapters 1,3,6,9 for Unit 4)

4. Puri, P. (1985) *Bryophytes*. New Delhi, Delhi. Atma Ram and Sons, Delhi (Chapters 1,5,7,10 for Unit 4)

5. Tortora, G.J., Funke, B.R., Case, C.L. (2010). *Microbiology: An Introduction*. San Francisco, SF: Pearson Benjamin Cummings. (Chapters 13, 14 For Unit 1)

6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). *Botany For Degree Students Pteridophyta*. New Delhi, Delhi: S. Chand Publication. (Chapters 1,4, 6, 9 for unit 4)

7. Vashistha, B.R., Sinha, A.K., Kumar, A. (2011). *Botany For Degree Students, Bryophyta*. New Delhi, Delhi: S Chand Publication.(Chapters 1,5,14, 18 for Unit 4)
8. Webster, J. and Weber, R. (2007). *Introduction to Fungi*. Cambridge, Cambridge University Press. Chapters 1,5, 7,22 Unit 2)

Teaching Learning Process

Visual media would be used for teaching. Botany Department, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of the subject and they find the subject interesting. College teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process
Weekly lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit II
Week 7: Unit III
Week 8: Unit III
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IV
Week 13: Unit IV
Week 14: Unit IV

Assessment Methods

Making drawings form the temporary preparations as practical record books. We may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	a) **Viruses** – Discovery; General Structure- RNA virus (TMV) and DNA virus (T-phage); Replication-Lytic and Lysogenic Cycle; Economic Importance. b) **Bacteria**– Discovery; General Characteristics and Cell Structure; Reproduction-Vegetative, Asexual and Genetic Recombination (Conjugation, Transformation and Transduction); Economic Importance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	**FUNGI:** General Characteristics; Outline Classification (Webster); Economic Importance;	Class room lectures and	Hands on exercises, PPT,

	Thallus Organization and Reproduction in *Rhizopus, Penicillium*, *Alternaria* and *Puccinia*.	Practical demonstration, experiments	assignments, tests
Unit III:	**ALGAE:** General Characteristics; Outline Classification (Fritsch); Economic Importance; Thallus Organization and Reproduction in *Nostoc*, *Chlamydomonas*, *Vaucheria* and *Ectocarpus*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	**Bryophytes :**General Characteristics; Outline Classification; Ecological and Economic Importance; Morphology, Structure and Reproduction in *Marchantia*, *Anthoceros* and *Funaria*. b) **Pteridophytes:** General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Selaginella*, *Equisetum* and *Pteris*. c) **Gymnosperms G**eneral Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Cycas* and *Pinus*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Bacteria,Viruses, Algae , Cyanobacteria, algal reproduction, viroids, bacterial reproduction, Fungi, Ascomycota,*Puccinia*,*Agaricus*,slime molds,symbiotic association,economic importance, Fungal disease, Bacterial disease, TMV

Plant Anatomy and Embryology
(LSCL4)
Core Course - (CC) Credit:6

Course Objective (2-3)

The Objective of this paper is to provide basic knowledge of plant internal architecture and cellular composition and reproduction. This will help them to understand how different plant tissue structures evolve and modify their functions with respect to their environment.

Course Learning Outcomes

Knowledge regarding anatomy equipped the students to identify different types of tissues and make them able to correlate their physiology in a better away. This will also help them to understand how different plant tissue evolve and modify their structure and functions with respect to their environment. Knowledge regarding embryology make them understand how reproduction play significant role in defining population structure, natural diversity and sustainability of ecosystem in a better way.

Unit 1

Meristematic and permanent tissues (8 lectures)
Simple (parenchyma, collenchyma, sclerenchyma) and complex tissues (xylem, phloem), Root and shoot apical meristems (describe theories in brief with special reference to Tunica Corpus and Korper-Kappe theory)

Unit 2

Organs (4 lectures)
Structure of dicot and monocot stem (include types of vascular bundles), root and leaf (including Kranz anatomy).

Unit 3

Secondary Growth (8 lectures)
Vascular cambium: structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood; Ring and diffuse porous wood; Early and late wood)

Unit 4

Adaptive and protective systems (8 lectures)

Epidermis (trichomes and hair), cuticle, stomata: structure and type (Metcalf and Chalk Classification); General account of adaptations in xerophytes and hydrophytes (Examples may be cited from *Nerium*, *Opuntia*, *Hydrilla* and *Nymphaea*).

Unit 5

Introduction to Plant Reproduction (5 lectures)
Modes of reproduction in plants: vegetative options - natural and artificial; introduction and Significance of sexual reproduction. 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, Significance of Reproductive Biology studies.

Unit 6

Structural organization of flower (10 lectures)
Organization of flower; Structure: Anther (No developmental stage) and development of Pollen grains; Ovules: Structure and types; Embryo sac Types (monosporic, bisporic and tetrasporic) and development (with special reference to *Polygonum* type).

Unit 7
Pollination and fertilization (10 lectures)
Pollination types and adaptations; Double fertilization and triple fusion; Seed: Structure (Dicot and Monocot, No developmental stages) appendages and dispersal mechanisms (– Autochory, Anemochory, Hydrochory, Zoochory with 1 example each) Adaptations (aril, caruncle).

Unit 8:
Embryo and endosperm (10 lectures)
Endosperm types (one example of each type), structure and functions; Dicot and Monocot embryo (Brief account of dicot embryo development); Embryo endosperm relationship (General account).

Practical

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: *Zea mays*; Dicot: *Helianthus*.
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*.
5. Leaf: Dicot and Monocot (only Permanent slides).
6. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem).
7. Structure of anther (young and mature).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac (Permanent slides/photographs).

10. Pollination types and seed dispersal mechanisms (including appendages, aril,caruncle) Photographs/specimens).
11. Dissection of embryo/endosperm from developing seeds.
12. Calculation of percentage of germinated pollen in a given medium.

References

1. Bhojwani, S.S., Bhatnagar, S.P. , Dantu P. K. (2015). *Embryology of Angiosperms,* 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd. (chapter 1 for unit 5;chapters 2, 3, 4, 6 and 7 for unit 6; chapters 8, 9 for unit 7; chapters 11, 12 and 15 for unit 8)
2. Dickison,W.C.(2000). *Integrated Plant anatomy*. Cambridge, U.K.: Academic press Inc. (chapter 2 for unit 1; chapter 3 for unit 2; chapter 4 for unit 3; chapters 2 and 8 for unit 4)
3. Fahn, A. (1982). *Plant anatomy*. Oxford, U.K.: Pergamon Press. (chapters 3 to 8 for unit 1; chapters 11 to 13 for unit 2; chapters 13, 14 for unit 3; chapters 10 to 13 for unit 4)
4. Mauseth, J.D. (1988). *Plant Anatomy*. San Francisco, California: The Benjamin/Cummings Publisher. (chapters 3 to 8 for unit 1; chapters 11 to 13 for unit 2; chapters 14, 15 for unit 3; chapter 10 for unit 4)

Additional Resources

1. Evert F. R., Eichhorn S. E. (2008). *Raven Biology of Plants*. 8th Edition. New York, W.H. Freeman and Company Publishers. (chapters 23 to 26 for units 1 to 4, Chapter 19 for units 5 to 8)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
Weekly lesson plan
Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit IV

Week 7: Unit V
Week 8: Unit VI
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit VIII

Assessment Methods

Theory:The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher An assignment can be given in place of the presentation. The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals:For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained are scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Meristematic and permanent tissues: Simple (parenchyma, collenchyma, sclerenchyma) and complex tissues (xylem, phloem), Root and shoot apical meristems (describe theories in brief with special reference to Tunica Corpus and Korper-Kappe theory)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Organs: Structure of dicot and monocot root stem and leaf.	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments, tests

		experiments	
III	Secondary Growth: Vascular cambium: structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Adaptive and protective systems: Epidermis (trichomes and hair), cuticle, stomata: structure and type (Metcalf and Chalk Classification); General account of adaptations in xerophytes and hydrophytes (Examples may be cited from *Nerium*, *Opuntia*, *Hydrilla* and *Nymphaea*).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Introduction to Reproduction: Modes of reproduction in plants: vegetative options - natural and artificial; introduction and Significance of sexual reproduction.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Structural organization of flower: Organization of flower, Structure; Anther and Pollen (No developmental stage); Ovules: Structure and types; Embryo sac: Types special reference to *Polygonum* type.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Pollination and fertilization: Pollination mechanisms and adaptations; Double fertilization and triple fusion; Seed: Structure (Dicot and Monocot, No developmental stages) appendages and dispersal mechanisms.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Embryo and endosperm: Endosperm types (one example of each type), structure and functions; Dicot and Monocot embryo; Embryo endosperm relationship (General account).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Meristem, secondary growth, Vascular cambium, anther, embryo sac, pollination, double fertilization, endosperm, reproductive biology.

Plant Ecology and Taxonomy
(LSCC3)
Core Course - (CC) Credit:6

Course Objective (2-3)

To make students understand ecology and basic ecological concepts, interrelation between the living world and environment. Also to make them aware about identification, nomenclature and classification.

Course Learning Outcomes

After successful completion of the course the student shall have adequate knowledge about the basic principals of environment and taxonomy.

Unit 1

Introduction (1 lecture)
Inter-relation between the living world and environment

Unit 2

Ecological factors (11 lectures)
Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance.

Unit 3

Plant communities (6 lectures)

Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)

Unit 4

Ecosystem (8 lectures)
Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous

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Unit 5

Phytogeography (4 lectures)
Principle biogeographical zones; Endemism (definition and types)

Unit 6
Introduction to plant taxonomy (1 lecture)
Identification, Classification, Nomenclature.

Unit 7
Identification (5 lectures)
Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access

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Unit 8
Taxonomic evidences from palynology, cytology, phytochemistry and molecular data. (6 lectures)

Unit 9
Taxonomic hierarchy (2 lectures) Ranks, categories and taxonomic groups

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Unit 10
Botanical nomenclature (6 lectures)
Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit 11
Classification (6 lectures)
Types of classification-artificial, natural and phylogenetic.Bentham and Hooker (up to series), Engler and Prantl (up to series).

Unit 12
Biometrics, numerical taxonomy and cladistics (4 lectures)
Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

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, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.
1. 3 (a) Study of morphological adaptations of hydrophytes and xerophytes (four each).
2. (b)Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*), Epiphytes, Predation (Insectivorous plants)
3. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (species to be listed)
4. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law
5. 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):Brassicaceae - *Brassica*,*Alyssum / Iberis*; Asteraceae -*Sonchus/Launaea*, *Vernonia/Ageratum*, *Eclipta/Tridax*; Solanaceae -*Solanumnigrum*, *Withania*; Lamiaceae -*Salvia*, *Ocimum*; Liliaceae - *Asphodelus / Lilium / Allium*.
6. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted on the herbarium sheet with appropriate label.)

References

1. Kotpal, R.L., Bali, N.P. (1978). *Concepts of Ecology*. Jullundur, Punjab, Vishal Publications, (Chapter 1 for Unit 1; Chapter 3,4,56, for Unit 2: Chapter 12,13 for Unit 3. Chapter 7,8 for Unit 4))
2. Sharma, P.D. (2010). *Ecology and Environment*. 8th edition Meerut, India: Rastogi Publications,..(Chapter 1 for Unit 1, Chapter 2,3,4 for Unit 2; Chapter 9,10 for Unit 3; Chapter 12,13 for Unit 4; Chapter 15 for Unit 5;
3. Simpson, M.G. (2006). *Plant Systematics*. San Diego, CA: Elsevier Academic Press, (Chapter 1, 16 for Unit 6. Chapter 15,17,18 for Unit 7; Chapters 9-12,14, 18-21 for Unit 8; Chapter 1,2 for Unit 9; Chapter 16 for Unit 10; Chapter 7,8 for Unit 11);
4. Singh, G. (2012). *Plant Systematics: Theory and Practice*. New Delhi :Oxford & IBH Pvt. Ltd., (Chapter 1 for Unit 6; Chapter 5 for Unit 7; Chapter 7 for Unit 8; Chapter 3 for Unit 9; Chapter 2 for Unit 10; Chapter 10 for Unit 11).

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and talk and chalk method. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking and evaluation

Teaching Learning Plan

Week 1: Unit I and II
Week 2: Unit II
Week 3: Unit II
Week 4: Unit III
Week 5: Unit III, IV
Week 6: Unit IV
Week 7: Unit V
Week 8: Unit V
Week 9: Unit VI, VII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII, VIII
Week 13: Unit IX, X
Week 14: Unit XI
Week 15: Unit XII

Assessment Methods

Theory: The students are continuously evaluated based on a written assignment, class test and/or presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students. Each student in a class is given a different topic to prepare an Assignment/PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation. The Internal

Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained are scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment method

Unit No	Coure learning Outcome	Teaching and Learning Activity	Assessment Task
I	Inter-relation between the living world and environment	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Plant communities, Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Ecosystem structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Phytogeography, Principle biogeographical zones; Endemism	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Introduction to plant taxonomy, Identification, Classification, Nomenclature.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

VIII	Taxonomic evidences from palynology, cytology, phytochemistry and moleculardata	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Taxonomic hierarchy, Ranks, categories and taxonomic groups	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X	Botanical nomenclature, Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit XI	Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (up to series).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit XII	Biometrics, numerical taxonomy and cladistics, Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Environment, Soil, Water, Plant communities, Succession, Ecosystem, Phytogeography, Endemism, Plant taxonomy, Taxonomic hierarchy, Botanical Nomenclature, Classification, Biometrics

Plant Physiology and Metabolism
(LSCC1)
Core Course - (CC) Credit:6

Course Objective (2-3)

The course aims at making students realize how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.

Course Learning Outcomes

The students are able to correlate morphology, anatomy, cell structure and biochemistry with plant functioning. The link between theory and practical syllabus is established, and the employability of youth would be enhanced. The youth can also begin small-scale enterprises.

Unit 1

Plant-water relations (8 Lectures)
Importance of water, water potential and its components, pathway of water movement, ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation, stomatal movements – only ion theory.

Unit 2

Mineral nutrition (8 Lectures)
Essential elements, macro- and micronutrients, criteria of essentiality of elements, methods of studying mineral requirement (Hydroponics, Aeroponics), role of essential elements, transport of ions across membrane, active and passive transport, carriers, channels and pumps.

Unit 3

Translocation in phloem (6 lectures)
Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading.

Unit 4

Photosynthesis (10 Lectures)
Historical contribution of Julius von Sachs, Blackman, Emerson, Engelmann, Hill.Arnon; photosynthetic pigments (chlorophyll a and b, xanthophyll, carotene); photosystem I and II, reaction center, antenna molecules; electron transport and mechanism of ATP synthesis, C3 pathway; C4 and CAM plants (in brief, no pathways); photorespiration

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Unit 5

Respiration (6 Lectures)
Glycolysis, anaerobic respiration, TCA cycle, oxidative phosphorylation, glyoxylate cycle,RQ.

Unit 6

Enzymes (4 Lectures)
Structure and properties, Km (no derivation), mechanism of enzyme catalysis and enzyme inhibition.

Unit 7

Nitrogen metabolism (6 Lectures)
Biological nitrogen fixation - nodulation in detail, nitrate and ammonia assimilation, dinitrogenase, NR, NiR, transamination.

Unit 8

Plant growth regulators (6 Lectures)
Discovery, physiological roles of auxins, gibberellins, cytokinins and ethylene.

Unit 9

Plant response to light and temperature (6 Lectures)
Photoperiodism - discovery (SDP, LDP, day neutral plants); phytochrome (discovery and structure), red and far-red light response on photomorphogenesis (general account), florigen (brief account).
*NO STRUCTURES AND FORMULAE TO BE ASKED IN THE EXAM

Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of the environmental factor light on transpiration by excised twig.
1. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
3. To Study Hill's reaction.
4. To study the activity of catalase and study the effect of pH and enzyme concentration.
5. To study the effect of light intensity on O2 evolution in photosynthesis.
6. Comparison of the rate of respiration in any two parts of a plant.

Demonstration experiments

1. Bolting.
2. Effect of auxins on rooting.
3. Suction due to transpiration.
4. Hydroponics (using a photograph).
5. To demonstrate the delay of senescence by cytokinins.
6. To study the phenomenon of seed germination (effect of light and darkness)

References

1. Bajracharya, D. (1999). *Experiments in Plant Physiology: A Laboratory Manual*. New Delhi, Delhi: Narosa Publishing House. (For Practicals)
2. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism*. Singapore: Springer Nature, Singapore Pvt. Ltd. (Chapter 1 for Unit 1, Chapters 2 and 3 for Unit 2, Chapter 6 for Unit 3, Chapter 5 for Unit 4, Chapter 7 for Unit 5, Chapter 4 for Unit 6, Chapter 11 for Unit 7, Chapters 14 to 17, 19, and 27 for Unit 8, Chapters 13 and 25 for Unit 9)
3. Hopkins, W. G., Huner, N. P. A. (2009). *Introduction to Plant Physiology*, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd. (Chapters 1, 2 and 8 for Unit 1, Chapters 3 and 4 for Unit 2, Chapter 9 for Unit 3, Chapters 7 and 8 for Unit 4, Chapter 10 for Unit 5, Chapter 8 for Unit 6, Chapter 11 for Unit 7, Chapters 18 to 21, and 23 for Unit 8, Chapters 22 and 24 for Unit 9)
4. Kochhar, S.L., Gujral, S.K. (2017). *Plant Physiology: Theory and Applications*. New Delhi, Delhi: Foundation Books, imprint of Cambridge University Press India Pvt, Ltd. (Chapters 1 to 6 for Unit 1, Chapter 7 for Unit 2, Chapter 13 for Unit 3, Chapter 9 for Unit 4, Chapter 10 for Unit 5, Chapter 8 for Unit 6, Chapter 11 for Unit 7, Chapter 15 for Unit 8, Chapter 14 for Unit 9)

Additional Resources:

1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). *Plant Physiology and Development* International 6th edition. New York, NY: Oxford University Press, Sinauer Associates. (Chapters 3 and 4 for Unit 1, Chapters 5 and 6 for Unit 2, Chapter 11 for Unit 3, Chapters 7 and 8 for Unit 4, Chapter 12 for Unit 5, Chapter 13 for Unit 7, Chapters 15, 18, 21 and 22 for Unit 8, Chapters 16 and 20 for Unit 9)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.

Weekly Plan

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit IV
Week 7: Unit IV
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VI
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit IX

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher An assignment can be given in place of the presentation. The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Importance of water, water potential and its components, pathway of water movement,	Class room lectures and Practical	Hands on exercises, PPT,

	ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation, stomatal movements – only ion theory..	demonstration, experiments	assignments, tests
Unit II:	Essential elements, macro- and micronutrients, criteria of essentiality of elements, methods of studying mineral requirement (Hydroponics, Aeroponics), role of essential elements, transport of ions across membrane, active and passive transport, carriers, channels and pumps.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Historical contribution of Julius von Sachs, Blackman, Emerson, Engelmann, Hill. Arnon; photosynthetic pigments (chlorophyll a and b, xanthophyll, carotene); photosystem I and II, reaction centre, antenna molecules; electron transport and mechanism of ATP synthesis, C3 pathway; C4 and CAM plants (in brief, no pathways); photorespiration	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V	Glycolysis, anaerobic respiration, TCA cycle, oxidative phosphorylation, glyoxylate cycle, RQ.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI	Structure and properties, Km (no derivation), mechanism of enzyme catalysis and enzyme inhibition.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII	Biological nitrogen fixation - nodulation in detail, nitrate and ammonia assimilation, dinitrogenase, NR, NiR, transamination.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII	Discovery, physiological roles of auxins, gibberellins, cytokininsand ethylene.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Photoperiodism - discovery (SDP, LDP, day neutral plants); phytochrome (discovery and structure), red and far-red light response on photomorphogenesis (general account), florigen (brief account)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Movement of water, ascent of sap, transpiration, stomatal movements, mineral nutrients, active and passive transport, translocation, enzymes, photosynthesis, respiration, nitrogen metabolism, plant growth regulators, photoperiodism, photomorphogenesis.

Analytical Techniques in Plant Sciences
(LSDS3)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

To gain the knowledge on various techniques and instruments used for the study of plant biology

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Course Learning Outcomes

Understanding of principles and use various methods, tools and techniques used in plant sciences such as light microscopy, confocal transmission and electron microscopy, centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques

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Unit 1

Imaging and related techniques (15 lectures)
Principles of microscopy; Light 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.

Unit 2

Cell fractionation (8 lectures)
Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, $CaCl_2$ gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3
Radioisotopes (4 lectures)

Use in biological research, auto-radiography, pulse chase experiment.

Unit 4
Spectrophotometry (4 lectures)
Principle and its application in biological research.

Unit 5

Chromatography (8 lectures)
Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ionexchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6

Characterization of proteins and nucleic acids (6 lectures)
Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAG

Practical

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Demonstration of ELISA.
3. To separate nitrogenous bases by paper chromatography.
4. To separate sugars by thin layer chromatography.
5. Isolation of chloroplasts by differential centrifugation.
6. To separate chloroplast pigments by column chromatography.
7. To estimate protein concentration through Lowry's methods.
8. To separate proteins using PAGE.
9. To separation DNA (marker) using AGE.
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).

References

1. Cooper, G.M., Hausman, R.E. (2009). *The Cell: A Molecular Approach*, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA. (Chapter 1 for Unit 1;
2. 2. Iwasa,J, Marshall , W. (2016). Karps's Cell and Molecular Biology ; Concepts and experiments. New Jersey, U.S.A.: John Wiley & Sons. Chapter 18 for Unit 1,2,3,5,)

Teaching Learning Process

1) Lectures and seminars
2) Problem oriented learning
3) Individual seminar
4) Presentation and interpretation to other students
5) Discussion of published research articles on the selected topics
6) Practical will introduce the students to a range of tools and techniques of biotechnology

Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Instrumentation lab visit
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit VI
Week 14: Unit VI

Assessment Methods

Assessment must encourage and reinforce learning. It will enable robust and fair judgments about student performance. It gives the opportunity demonstrate what they have learned.
It will be done through a academic standard procedures. Assessment will be by written class test, assignment, project work, viva for internal assessment and written theory and practical examination for university evaluation.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Unit II:	Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (RasMol, J mol).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and BLOSUM), and CLUSTALW.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Biological Databases, Sequence Alignment, Phylogenetics Analysis, Protein Structure prediction and analysis.

Bioinformatics
(LSDS4)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

A computer-based approach is now central to biological research. Bioinformatics operates at the intersection of biology and informatics and has a strong mathematical component. Training students in various aspects of Bioinformatics is the objective of this course.

Course Learning Outcomes

With a working knowledge of the practical and theoretical concepts of bioinformatics, you will be well qualified to progress onto advanced graduate study. The portfolio of skills developed on the programme is also suited to academic research or work within the bioinformatics industry as well as range of commercial settings.

Unit 1

Introduction to Bioinformatics (10 lectures)

Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.

Unit 2

Biological databases (10 lectures)
Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol).

Unit 3

Data Generation and Data Retrieval (8 lectures)
Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA,

GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)

Unit 4

Basic concepts of Sequence alignment (8 lectures)
Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and BLOSUM), and CLUSTALW.

Unit 5

Phylogenetic analysis (8 lectures)
Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.

Unit 6

Applications of Bioinformatics (16 lectures)
Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

Practical

1. Sequence retrieval (protein and gene) from NCBI.
2. Structure download (protein and DNA) from PDB.
3. Molecular file formats - FASTA, GenBank, Genpept, GCG, CLUSTAL, Swiss-Prot, FIR.
4. Molecular viewer by visualization software.
5. Translate a nucleotide sequence and select the correct reading frame of the polypeptide from the output sequences.
6. Predict the structure of protein from its amino acid sequence.
7. BLAST suite of tools for pairwise alignment.
8. Sequence homology and Gene annotation.
9. Construction of phylogenetic tree.
10. Generating phylogenetic tree using PHYLIP.
11. Gene prediction using GENSCAN and GLIMMER.

References

1. Ghosh, Z., Mallick, B. (2008). *Bioinformatics – Principles and Applications*, 1st edition. New Delhi, Delhi: Oxford University Press.(chapters 1-11 of Unit 1, chapters 1-7 0f Unit 2, chapters 1-5 0f Unit 3,chapters 1-7 of Unit 4, chapters 1-4 of Unit 5, chapters 1-8 of Unit 6.
2. Knight Regan (2017) *An Introduction to Bioinformatics,* Larsen & Keller Education, United States. (chapters 1-7 0f Unit 2, chapters 1-5 0f Unit 3).

3. Mount D.W.(2004). *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbour Laboratory Press, New York, USA. (chapters 1-5 0f Unit 3,chapters 1-7 of Unit 4, chapters 1-4 of Unit 5) .
4. Sharma, V, Munjal, A, Shankar A. (2018). *A Text Book of Bioinformatics*. Rastogi Publications, Meerut, India. (chapters 1-4 0f Unit 2, chapters 1-5 0f Unit 3,chapters 1-7 of Unit 4, chapters 1-4 of Unit 5, chapters 1-8 of Unit 6.)

Teaching Learning Process

Multimedia tutorials and hands on training over biological data using world wide web services.
Interactive classroom teaching of mathematical modelings and Computer programs.
Weekly Lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit VI
Week 14: Unit VI

Assessment Methods

Theoretical tests with the help of assignments, project works, presentations, and through practical examinations.
Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.	Class room lectures and Practical demonstration, experiments , gene ration and analysis of data	Hands on exercises, PPT, assignments, tests,
Unit II:	Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG,	Class room lectures and Practical demonstration, experiments, gener	Hands on exercises, PPT, assignments, tests

	EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol).	ation and analysis of data	
Unit III:	Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit IV:	Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and BLOSUM), and CLUSTALW.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit V:	Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit VI:	Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests

Keywords

Biological Databases, Sequence Alignment, Phylogenetics Analysis, Protein Structure prediction and analysis.

Cell and Molecular Biology
(LSDS2)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

Cell biology study will help the students to gain knowledge on the activities in which the giant molecules and minuscule structures that inhabit the cellular world of life are engaged. This will provide inside into the organization of cell, its features and regulation at different levels. Through the study of biomolecules (i.e. protein, carbohydrate, lipid and nucleic acid) and cell organelles, they will be able to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life. It would help in gaining the knowledge of structure and functions of DNA and RNA

Course Learning Outcomes

This course will be able to demonstrate foundational knowledge in understanding of: The relationship between the properties of macromolecules, their cellular activities and biological responses Understanding of Cell metabolism, chemical composition, physiochemical and functional organization of organelle Contemporary approaches in modern cell and molecular biology.Understanding of nucleic acid, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.Processing and modification of RNA and translation process, function and regulation of expression.Applichation in biotechnology

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Unit 1

Techniques in Biology (8 Lectures)
Principles of microscopy; Light Microscopy; Phase contrast microscopy; Fluorescence microscopy; Confocal microscopy; Sample Preparation for light microscopy; Electron microscopy (EM)- Scanning EM and Scanning Transmission EM (STEM); Sample Preparation for electron microscopy; X-ray diffraction analysis.

Unit 2

Cell as a unit of Life (2 Lectures)
The Cell Theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components.

Unit 3

Cell Organelles (20 Lectures)
Mitochondria:- Structure, marker enzymes, composition; Semiautonomous nature; Symbiont hypothesis; Proteins synthesized within mitochondria; mitochondrial DNA. Chloroplast-Structure, marker enzymes, composition; semiautonomous nature, chloroplast DNA. ER, Golgi body & Lysosomes:-Structures and roles. Peroxisomes and Glyoxisomes:_Structures, composition, functions in animals and plants and biogenesis. Nucleus:- Nuclear Envelope-structure of nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure (brief)

Unit 4

Cell Membrane and Cell Wall (6 Lectures)
The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Faces of the membranes; Selective permeability of the membranes; Cell wall.

Unit 5

Cell Cycle (6 Lectures)
Overview of Cell cycle, Mitosis and Meiosis; Molecular controls.

Unit 6

Genetic material (6 Lectures)
DNA: Miescher to Watson and Crick- historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase bacteriophage experiment, DNA structure, types of DNA, types of genetic material. DNA replication (Prokaryotes and eukaryotes): bidirectional replication, semi—conservative, semi discontinuous RNA priming, 6 (theta) mode of replication, replication of linear, ds-DNA, replicating the 5 end of linear chromosome including replication enzymes.

Unit 7
Transcription (Prokaryotes and Eukaryotes) (6 Lectures) Types of structures of RNA (mRNA, tRNA, rRNA), RNA polymerase- various types; Translation (Prokaryotes and eukaryotes), genetic code.

Unit 8
Regulation of gene expression (6 Lectures) Prokaryotes:Lac operon and Tryptophan operon ; and in Eukaryotes.

Practical

1. To study prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light and electron micrographs.
2. 2.Study of the photomicrographs or cell organdies
3. To study the structure of plant cell through temporary mounts.
4. To study the structure of animal cells by temporary mounts-squamous epithelial cell and nerve cell.
5. Preparation of temporary mounts of striated muscle fiber
6. To prepare temporary stained preparation of mitochondria from striated muscle cells /cheek epithelial cells using vital stain Janus green.
7. Study of mitosis and meiosis (temporary mounts and permanent slides).
8. Study the effect of temperature, organic solvent on semi permeable membrane.
9. Demonstration of dialysis of starch and simple sugar.
10. Study of plasmolysis and deplasmolysis on *Rhoeo* leaf.
11. .11. Measure the cell size (either length or breadth/diameter) by micrometry.
12. Study the structure of nuclear pore complex by photograph (from Gerald Karp) Study of special chromosomes (polytene&lampbrush) either by slides or photographs.
13. Study DNA packaging by micrographs.
14. Preparation of the karyotype and ideogram from given photograph of somatic metaphase chromosome.

References

1. Becker, W.M., Kleinsmith, L.J., Hardin. J., Bertoni, G. P. (2009). *The World of the Cell*, 7th edition. San Francisco, California: Pearson Benjamin Cummings Publishing. (Ch 4 for unit 2, Ch. 21, 22 for unit 7, Ch. 23 for unit 8).
2. Cooper, G.M., Hausman, R.E. (2009). *The Cell: A Molecular Approach*, 5th edition. Sunderland, Massachusetts: Sinauer Associates, MA. (Ch. 9-11 for unit 3, Ch. 13, 14 for unit 4, Ch. 16 for unit 5, Ch. 6 for unit 6, Ch. 7,8 for unit 7).
3. De Robertis, E.D.P., De Robertis, E.M.F. (2006). *Cell and Molecular Biology*, 8th edition. Philadelphia, Pennsylvania: Lippincott Williams and Wilkins. .(Ch3 for unit 1, Ch. 1 for unit 2, Ch. 8-13 for unit 3, Ch. 4 for unit 4, Ch. 14-16 for unit 5, Ch. 22 for unit 8).
4. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*, 6th Edition. New Jersey, U.S.: John Wiley & Sons. Inc.(Ch18 for unit 1, Ch. 1 for unit 2, Ch. 6,9,10,12 for unit 3, Ch. 8,11for unit 4, Ch. 14 for unit 5, Ch. 4, 7 for unit 6, Ch. 6 for unit 7, Ch. 6 for unit 8).

Teaching Learning Process

Visual media would be helpful. Botany Department, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of the subject and they find the subject interesting. College teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.
Weekly lesson Plan

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit IV
Week 7: Unit V
Week 8: Unit VI
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VII
Week 14: Unit VIII

Assessment Methods

Making drawings may be made a compulsory part of practical record books, We may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Principles of microscopy; Light Microscopy; Phase contrast microscopy; Fluorescence microscopy; Confocal microscopy; Sample Preparation for light microscopy; Electron microscopy (EM)- Scanning EM and Scanning Transmission EM (STEM); Sample Preparation for electron microscopy; X-ray diffraction analysis.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	The Cell Theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Mitochondria:- Structure, marker enzymes, composition; Semiautonomous nature; Symbiont hypothesis; Proteins synthesized within mitochondria; mitochondrial DNA. Chloroplast-Structure, marker enzymes, composition; semiautonomous nature,chloroplast DNA. ER, Golgi body & Lysosomes:-Structures and roles. Peroxisomes and Glyoxisomes: Structures, composition, functions in animals and plants and biogenesis. Nucleus:- Nuclear Envelope- structure of	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure		
Unit IV:	The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Faces of the membranes; Selective permeability of the membranes; Cell wall.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V	Overview of Cell cycle, Mitosis and Meiosis; Molecular controls.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI	DNA: Miescher to Watson and Crick- historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase bacteriophage experiment, DNA structure,types of DNA, types of genetic material. DNA replication (Prokaryotes and eukaryotes): bidirectional replication, semi—conservative, semi discontinuous RNA priming, 6 (theta) mode of replication, replication of linear, ds-DNA, replicating the 5 end of linear chromosome including replication enzymes.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII	Types of structures of RNA (mRNA, tRNA, rRNA), RNA polymerase- various types; Translation (Prokaryotes and eukaryotes), genetic code.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII	Regulation of gene expression	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Microscopy,X-ray diffraction, eukaryotic cell, mitochondria, chloroplast, Golgi body, nucleus, chromatin, membrane protein, meiosis,ribosomes,DNA replication,transcription, gene expression

Economic Botany and Biotechnology
(LSDS1)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

To gain the knowledge on the economically important of plants, their life cycle, processing, plant part used, application of biotechnology for the production of plant resources and production of new varieties

Course Learning Outcomes

Understanding of morphology and processing and economic value of plant sources of cereals, legumes,spices, oil,rubber, timber and medicines

Unit 1

Origin of Cultivated Plants (4 lectures)
Concept of centres of origin, their importance with reference to Vavilov's work.

Unit 2

Cereals (4lectures)
Wheat -Origin, morphology, uses

Unit 3

Legumes (6 lectures)
General account with special reference to Gram and soybean

Unit 4

Spices (6 lectures)
General account with special reference to clove and black pepper(Botanical name, family, part used, morphology and uses)

Unit 5

Beverages (4 lectures)
Tea (morphology, processing, uses)

Unit 6

Oils and Fats (4lectures)
General description with special reference to groundnut

Unit 7
Fibre Yielding Plants (4lectures)
General description with special reference to Cotton (Botanical name, family, part used, morphology and uses)

Unit 8
Introduction to Plant Biotechnology (1 lecture)

Unit 9
Tissue Culture Technology (9 lectures)
Introduction; nutrient media; aseptic and culture conditions; developmental pathways: direct and indirect organogenesis and embryogenesis; single cell and protoplast culture.

Unit 10
Recombinant Technology (18 lectures)
Molecular techniques: Blotting techniques (Southern, Northern and Western); PCR; Molecular DNA markers (RAPD, RFLP, SNPs) and DNA fingerprinting in plants, Genetic Engineering Techniques: Gene cloning vectors (pUC 18, pBR322, BAC, YAC, Tiplasmid); construction of genomic and C-DNA libraries; screening for gene of interest by DNA probe hybridisation, complementation; Insertion of genes into plant tissues (Agrobacterium mediated, electroporation, micro-projectile bombardment); selection of recombinants by selectable marker and reporter genes (GUS, luciferase, GFP). Applications: Bt cotton, Roundup ready soybean, Golden rice, Flavr-Savr tomato, edible vaccines, industrial enzyme production, Bioreactors Applications: Micropropagation, androgenesis, gynogenesis, embryo and endosperm culture, secondary metabolite production, germplasm conservation.

Practical

1. Study of economically important plants: Wheat, Gram, Soybean, Black pepper, Clove Tea, Cotton, Groundnut through specimens, sections and micro chemical tests
2. Familiarization with basic equipment’s in tissue culture.
3. Study through photographs: Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation.
4. Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE.

References

1. Kochhar, S.L. (2011). *Economic Botany in Tropics*. New Delhi, India: MacMillan & Co. (Chapter 1 for Unit 1; Chapter 3 for Unit 2; Chapter 5 for Unit 3; Chapter 9 for Unit 4; Chapter 11 for Unit 5; Chapter 6 for Unit 6; Chapter 2 for Unit 7);
2. Bhojwani, S.S., Razdan, M.K. (1996). *Plant Tissue Culture: Theory and Practice*. Amsterdam, Netherlands: Elsevier Science. (Chapter 3, 4, 5, 6,12 for Unit 9)
3. Glick, B.R., Pasternak, J.J. (2003). *Molecular Biotechnology- Principles and Applications*. Washington, U.S.: ASM Press. (Chapter 1 for Unit 8; Chapter 3 for Unit 10)
4. Gupta , R., Rajpal , T., (2012) Concise Notes on Biotechnology. Delhi: Mc Graw Hill Publication. (Chapter 1 for Unit 8; chapter 8 for Unit 9; chapter 4 for unit 10)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
Weekly lesson plan
Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit IV
Week 5: Unit V
Week 6: Unit VI
Week 7: Unit VII
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IX
Week 13: Unit X
Week 14: Unit X
Week 15: Unit X

Assessment Methods

The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Concept of centres of origin, their importance with reference to Vavilov's work.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Cereals : Wheat -Origin, morphology, uses	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Legumes, general account with special reference to Gram and soybean	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Spices ,general account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Beverages, Tea (morphology, processing, uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Oils and Fats, general description with special reference to groundnut	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	General 4description with special reference to Cotton (Botanical name, family, part used,morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Introduction to Plant Biotechnology	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Nutrient media; aseptic and culture conditions; developmental pathways: direct and indirect organogenesis and embryogenesis; single cell and protoplast culture.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X:	Molecular techniques: Blotting techniques (Southern, Northern and Western); PCR; Molecular DNA markers (RAPD, RFLP, SNPs) and	Class room lectures and Practical demonstration, experiments	exercises, PPT, assignments, tests

	DNA fingerprinting in plants.Gene cloning vectors (pUC 18, pBR322, BAC, YAC, Ti plasmid); construction of genomic and C-DNA libraries; screening for gene of interest by DNA probe hybridisation, complementation; Insertion of genes into plant tissues (*Agrobacterium* mediated, electroporation, micro-projectile bombardment); selection of recombinants by selectable marker and reporter genes (GUS, luciferase, GFP). Applications: Bt cotton, Roundup ready soybean, Golden rice, Flavr-Savr tomato, edible vaccines, industrial enzyme production, Bioreactors Micropropagation, androgenesis, gynogenesis, embryo and endosperm culture, secondary metabolite production, germplasm conservation.		

Keywords

Rhizobium, *Azotobacter*, inoculum,cyanobacteria, nitrogen fixation, Azolla,VAM, mycorrhizae

Biofertilizers
(LSSE1)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To gain the knowledge on the following aspects

1. Eco-friendly fertilizers like Rhizobium, Azospirilium Azotobactor, cyanobacteria and mycorrhizae, their identification, growth multiplication
2. Organic farming and recycling of the organic waste

Course Learning Outcomes

The student would have a deep understanding of ecofriendly fertilizers. They will be able to understand the growth and multiplication conditions of useful microbes such as Rhizobium, cyanobacteria, mycorrhizae, Azotobactor etc, their role in mineral cycling and nutrition to plants. The can also think of the methods of decomposition of biodegradable waste and convert into the compost

Unit 1

General account about the microbes used as biofertilizer – Rhizobium – isolation,identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis. (4 lectures)

Unit 2

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. (8 lectures)

Unit 3

Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation. (4 lectures)

Unit 4

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. (8 lectures)

Unit 5

Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application. (6 lectures)

Practical

1. Isolation of *Anabaena* from *Azolla* leaf
2. Study of Rhizobium from root nodules of leguminous plants by Gram staining method
3. Test for pH, No2, SO4, Cl and organic matter of different composts
4. Observation of mycorrhizae from roots
5. isolation of arbuscular mycorrhizal spores from rhizospheric soil
6. Spots, Specimen /photographs of earthworm, Azolla, arbuscules . vesicles
7. Biocontrol photographs -pheromons trap,Trichoderma,, Pseudomonas, , Neem etc, , Identification and application
8. Photographs of biocompost methods,
9. Projects on any topic mentioned in the syllabus, with Rhizobium technology, , AMF technology, Organicfarming, vermicomposting,, biocompost , *Azolla* culture

References

1. Kumaresan, V. (2005). *Biotechnology*. New Delhi, Delhi: Saras Publication. Chapter 39 for Unit 1, Chapter 38 for Unit 3, Chapter 57 for Unit 5)
2. Sathe, T.V. (2004). *Vermiculture and Organic Farming*. New Delhi, Delhi: Daya publishers. (Chapter 1 and 2 for Units 1, 2,3 and 5)
3. Subha Rao, N.S. (2000). *Soil Microbiology*. New Delhi, Delhi: Oxford & IBH Publishers. (Chapter 5 for Unit 2; Chapter 6 for Unit 3; Chapter 8 for Unit 1; Chapter 9 for Unit 4);

Additional Resources:

1. Vayas,S.C, Vayas, S., Modi, H.A. (1998). *Bio-fertilizers and organic Farming*. Nadiad, Gujarat: Akta Prakashan. (Chapters 2,3,4 for Unit 1; Chapter 18 for Unit 2; Chapter 19 for Unit 3; Chapter 20 for Unit 4; Chapter 4,5,6,12,13 for Unit 5)
2. Annonymous (2016) *Proceedings of Workshop on Biofertilizers*. New Delhi. Delhi: Zakir Husain Delhi College (Chapter1 to 9 for Unit 1 to 5)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
strong>Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during

class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit III
Week 7: Field visit
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IV
Week 13: Unit V
Week 14: Unit V
Week 15: Unit V

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment Task

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	General account about the microbes used as biofertilizer – Rhizobium – isolation,identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	*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.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Unit III:	Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	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.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Rhizobium, Azotobacter, inoculum, cyanobacteria, nitrigen fixation, Azolla,VAM, mycorrhizae

Ethnobotany
(LSSE3)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To have the knowledge of the plants used by the local communities, tribals, ethenic groups, their nutritive and medicinal value.

Course Learning Outcomes

Students would have an understanding of the treasure, value and usefulness of the natural products and their efficient use by the local communities as food and medicine and their conservation practices.

Unit 1

Ethnobotany (6Lectures)
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 and c) Resins and oils and miscellaneous uses.

Unit 2

Methodology of Ethnobotanical studies (6 lectures)
a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.

Unit 3

Role of ethnobotany in modern Medicine (10 lectures) Medicoethnobotanical sources in India;Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadiracthaindica* b) *Ocimum sanctum* c) *Vitexnegundo* d) *Gloriosasuperba* e) *Tribulusterrestris* f) *Pongamiapinnata* g) *Cassia auriculata* h) *Indigoferatinctoria*.

Unit 4

Role of ethnobotany in modern medicine with special example of *Rauvolfiasepentina*, *Trichopuszeylanicus*, *Artemisia*,*Withania*.Role of ethnic groups in conservation of plant genetic resources.Endangered taxa and forest management (participatory forest management).

Unit 5

Ethnobotany and legal aspects (8 lectures)
Ethnobotany as a tool to protect interests of ethnic groups.Sharing of wealth concept with few examples from India; Biopiracy.

Unit 6

Intellectual Property Rights and Traditional Knowledge.

Practical

1. Collection, identification and preparation of herbarium of three ethnobotanically important plants with appropriate references
2. Preparation of crude extract of ethnobotanically important plants with appropriate references (any method to be used)
3. Project work-documentation, literature survey, and collection of information on ethnobotanically useful plants from traditional healers)

References

1. Gupta , R., Rajpal , T., (2012) Concise R. (2011). *Plant Taxonomy past Present and Future* . New Delhi, Delhi: TERI Press (Chapter 7 for Unit 8)

3. Gupta , R., Rajpal, T. (2012) *Concise notes on Biotechnology*. New Delhi, Delhi: McGraw Hill Publication (chapter 14 for Unit 8)

3. Jain, S.K. (1995). *Manual of Ethnobotany*. Rajasthan: Scientific Publishers. (Chapter 1,2,3 for Unit 1; Chapter 4 for Unit 2; Chapter 9 for Unit 3; Chapter 14 for Unit 4 ; Chapter 16 for Unit 5)

Teaching Learning Process

To engage students and transform them into active learners the students are updated with latest books and review articles. The experiments included in the paper are performed individually or in group and are followed by group discussions and interjections
Weekly lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Local Field Visits
Week 6: Unit II
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Local Institute Visit
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

The students are assessed on the basis of oral presentations and regular class tests. Students are continuously assessed during practical class. Submission of class records is mandatory. This exercise develops scientific skill as well as methods of recording and presenting scientific data.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	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	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Methodology of Ethnobotanical studies- Field work, Herbarium, Ancient Literature, Archaeological findings, temples and sacred places	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Medicoethnobotanical sources in India;Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadiracthaindica* b) *Ocimum sanctum* c) *Vitex negundo* d) *Gloriosasuperba* e) *Tribulusterrestris* f) *Pongamiapinnata* g) *Cassia auriculata* h) *Indigoferatinctoria*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Role of ethnobotany in modern medicine with special example of *Rauvolfiasepentina*, *Trichopuszeylanicus*, *Artemisia*, *Withania*. Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Ethnobotany and legal aspects (8 lectures). Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Intellectual Property Rights and Traditional Knowledge.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Tribals, minor forest products, beverages, Resins, sacred groves, ethnobotanical practices, *Azadiractha indica*, *Ocimum sanctum*, *Vitex negundo*,*Gloriosa superba*, *Indigofera, tinctoria*. ethnomedicimes, conservation, Traditional Knowledge.

Intellectual Property Right
(LSSE6)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To have knowledge of roles regulations, laws and processes of patents, copyright trademarks and concepts of traditional knowledge and protection of plant varieties.

Course Learning Outcomes

Students would have deep understanding of patents copyrights, their importance. They can think about the importance of traditional knowledge, bio-prospecting, biopiracy. They would gain the knowledge of farmers rights and the importance on indigenous plant varieties, concept of novelty and biotechnological inventions

Unit 1

Introduction to intellectual property right (IPR) (2 lectures)
Concept and kinds.Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO).

Unit 2

Patents (3 Lectures)
Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents.Infringement.

Unit 3

Copyrights (3 Lectures)
Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement

Unit 4

Trademarks (3 Lectures)

Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defenses, Domain name

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Unit 5

Geographical Indications (3 Lectures)
Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position

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Unit 6

Protection of Traditional Knowledge (4 Lectures)
Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio- Prospecting and Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library.

Unit 7
Industrial Designs (2 Lectures) Objectives, Rights, Assignments, Infringements, Defences of Design Infringement

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Unit 8
Protection of Plant Varieties (2 Lectures)
Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues farmers, Breeders and Researchers.National gene bank, Benefit sharing.Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit 9
Information Technology Related Intellectual Property Rights (4 Lectures)
Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection

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Unit 10
Biotechnology and Intellectual Property Rights (4 Lectures): Patenting Biotech Inventions

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Practical

1. Patent search
2. Trademark search
3. copyright infringement (Plagiarism checkby Urkundand other available software,
4. Geographical Indicators

5. food- Malabar pepper, Basmati rice, Darjeeling Tea, and Requefort cheese,
6. handlooms (Kota Doria, Banarasi Sari, Muga Silk, Kanchipuram),
7. Industry (Mysore agarbatti, Feni Goa, ChampagneFrance).
8. Natural resources- Makrana marbles Two example of each category Biopiracy- neem, turmeric
9. Industrial designs- Jewelry design, chair design, car design, Bottle design, Aircraft design,
10. IPR e diary

References

1. Gupta, R. (2011). *Plant Taxonomy past Present and Future*. New Delhi, Delhi: TERI Press (Chapter 7 for Unit 6)
2. Gupta, R., Rajpal, T. (2012). *Concise Notes on Biotechnology*. New Delhi,Delhi: Mc Graw Hill Publication (chapter 14 for Unit 1)
3. Acharya, N.K.(2001). *Text Book on Intellectual Property Rights: (Copyright, Trademark, Patent Design, Geographical Indications, Protection of New Plant Varieties & Farmers Rights and Protection of Biodiversity*. New Delhi S.P Gogia HUF) (chapters 1 to 8 for Units 1 to 9)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
Weekly lesson plan
Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit IV
Week 5: Unit V
Week 6: Unit VI
Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit IX
Week 14: Unit IX

Week 15: Unit X

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents.Infringement.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Copyrights (3 Lectures) Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Geographical Indications (3 Lectures) Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments, tests

	Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library.	experiments	
Unit VII:	Industrial Designs (2 Lectures) Objectives, Rights, Assignments, Infringements, Defences of Design Infringement	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues farmers, Breeders and Researchers.National gene bank, Benefit sharing.Protection of Plant Varieties and Farmers' Rights Act, 2001.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Information Technology Related Intellectual Property Rights Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
	Biotechnology and Intellectual Property Rights. Patenting Biotech Inventions	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Patents, IPR, Copyrights,trademarks, geographical indicators, traditional knowledge, industrial design, plant varieties, novelty, biotechnology.

Medicinal Botany
(LSSE2)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To introduce students to complementary and alternative medicine and provide them an opportunity
To explore uses of plants as medicine ranging from traditional indigenous approach for treating ailments to modern pharmaceuticals
To inculcate awareness about the rich diversity of medicinal plants in India.

Course Learning Outcomes

Knowledge Skills
· An appreciation of the contribution of medicinal plants to traditional and modern medicine and the importance of holistic mode of treatment of the Indian traditional systems of medicine.
· To develop an understanding of the constraints in promotion and marketing of medicinal plants.
Professional and Practical Skills
· Transforming the knowledge into skills for promotion of traditional medicines.
· Developing entrepreneurship skills to establish value addition products, botanical extracts and isolation of bioactive compounds.

Unit 1

Scope and importance of medicinal plants in the traditional systems of medicine and modern medicine.Importance of preventive and holistic healing in the Indian traditional systems of medicine.Ayurveda: History, origin, fundamental doctrine and concepts of Panchamahabhutas, Saptadhatus andTridoshasin relation to health and disease.

Unit 2

Therapeutic and pharmaceutical uses of important plants used in the Ayurveda system of medicine. Concept of Rasayanadrugs. Siddha Origin, concepts, therapeutic and pharmaceutical uses of important plants used in Siddha system of medicine.Unani: History, concept of Umoor-e-Tabiya(Fundamentals of Physique), therapeutic and pharmaceutical uses of plants used in Unani system of medicine

Unit 3

Nutraceuticals and polyherbalformulations. Plants used for the treatment of hepatic disorders, cardiac diseases,infertility, diabetes, blood pressure, cancer and skin diseases.Role of AYUSH, NMPB and AIIA in thepromotion of medicinal plants.

Unit 4

Adulteration of herbal drugs.Evaluation and Standardization of crude drugs.Fundamentals of Pharmacognosy.Organoleptic,microscopicand phytochemical evaluation of plant drugs.

Unit 5

Conservation of Endangered and Endemic Medicinal plants.Red Data List Criteria. In situ Conservation: Biosphere Reserves, National Parks, Sacred Groves. Ex-situ conservation:Botanic Gardens, National Gene Banks, Plant cell, tissue, and Organ culture, Cryopreservation. Role of NBPGR, CIMAP, JNTBGRI and RRL

Unit 6

General aspects of cultivation and propagation of medicinal plants. WHO Guidelines of Good Agricultural and Cultivation Practices (GACP). Objectives of the Nursery,classification and important components ofnursery.Greenhouse technology.Propagation through cuttings, layering, grafting and budding.

Practical

1. Identification and medicinal value of locally available medicinal plants in the field.
2. Study of organoleptic, macroscopic and microscopic parameters of any two plant drugs. Sections and powder microscopic evaluation.
3. Isolation of bioactive compounds in the lab and phytochemical analysis of the crude extract of various parts of medicinal plants.
4. Study of ingredients and medicinal uses of common polyherbal formulations used in the traditional systems of medicine.
5. Project Report based onvisit to PharmaceuticalIndustries and/or Institutes.
6. E-presentations : Traditional Systems of Medicine, Contribution of medicinal plants toalternative and modern medicine, Conservation strategies of medicinal plants,Nutraceuticals, Rasayana drugs, Medicinal plants and non-communicable diseases, Cultivation, marketing and utilisation of medicinal plants.
7. Laboratory Records

References

1. Chaudhry, B. (2019). *A Handbook of Common Medicinal Plants Used in Ayurveda*. Kojo Press, New Delhi. (For Units 1-3).

2. Purohit, Vyas (2008). *Medicinal Plant Cultivation : A Scientific Approach*, 2nd edition. Jodhpur, Rajasthan: Agrobios. (Chapter 1 for Unit 1; Chapter-6 for Unit 6, Chapter 12 for Unit 5).
3. S.B. Gokhale, C.K. Kokate (2009). *Practical Pharmacognosy*. Pune, Maharashtra: Nirali Prakashan. (For Unit 4).
4. Trivedi, P.C. (2006). *Medicinal Plants Traditional Knowledge.* New Delhi, Delhi: I.K. International Publishing House Pvt. Ltd. (Chapter 1 for Unit 4; Chapter 2 and 11 for Unit 3)

Additional Resources:
1. Trivedi, P.C. (2009). *Medicinal Plants. Utilisation and Conservation.* Jaipur, Rajasthan: Aavishkar Publishers. (Chapter 1 and 19 for Unit 5; Chapter 20 for Unit 3).
2. Evans, W. (2009*). Trease and Evans's Pharmacognosy*, 16th edition. Edinburg, London, Philadelphia, Pennsylvania: Saunders Ltd. (Chapter 1, 42-44 for Unit 4).
3. Ayush.gov.in (Ministry of AYUSH) (for Unit 1 and 2).

Teaching Learning Process

To encourage innovation, to link theoretical knowledge with practical training and application of knowledge to find practical solutions to the challenges encountered in the field of traditional medicine. To hold regular and structured workshops, seminars, field trips, collaboration with Research institutions, Industry and other Government Organizations, in order to facilitate peer learning and skill enhancement. To complement classroom teaching with discussions, presentations, quizzes, interpretation of results, short projects, writing project reports and field exposure.
Weekly lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit III
Week 7: Field visit
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit V
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

Continuous Evaluation
(Project/ E-presentation:10 marks, Lab Records :
Attendance in Practicals
Practical Examination:

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Scope and importance of medicinal plants in the traditional systems of medicine and modern medicine.Importance of preventive and holistic healing in theIndian traditional systems of medicine.Ayurveda: History, origin, fundamental doctrine and concepts of Panchamahabhutas, Saptadhatus andTridoshasin relation to health and disease.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Therapeutic and pharmaceutical uses of important plants used in the Ayurveda system of medicine. Concept of Rasayanadrugs. Siddha : Origin, concepts, therapeutic and pharmaceutical uses of important plants used in Siddha system of medicine.Unani : History, concept of Umoor-e-Tabiya (Fundamentals of Physique), therapeutic and pharmaceutical uses of plants used in Unani system of medicine	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Nutraceuticals and polyherbalformulations. Plants used for the treatment of hepatic disorders, cardiac diseases,infertility, diabetes, blood pressure, cancer and skin diseases.Role of AYUSH, NMPB and AIIA in thepromotion of medicinal plants.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Adulteration of herbal drugs. Evaluation and Standardization of crude drugs. Fundamentals of Pharmacognosy. Organoleptic,microscopicand phytochemical evaluation of plant drugs.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Conservation of Endangered and Endemic Medicinal plants. Red Data List Criteria. In-situ Conservation: Biosphere Reserves, National Parks, Sacred Groves. Ex-situ conservation: Botanic Gardens, National Gene Banks, Plant cell, tissue, and Organ culture, Cryopreservation. Role of NBPGR, CIMAP, JNTBGRI and RRL.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	General aspects of cultivation and propagation of medicinal plants. WHO Guidelines of Good Agricultural and Cultivation Practices (GACP). Objectives of the Nursery,classification and important components ofnursery. Greenhouse technology. Propagation through cuttings, layering, grafting and budding	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Medicinal plants, Ayurveda, Siddha, Unani, Holistic healing, Phytochemicals, Pharmacognosy, Polyherbals, Conservation, Propagation, Nursery and Gardening

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दिल्लीविश्वविद्यालय

UNIVERSITY OF DELHI

Bachelor of Science Programme in Applied Life Sciences with Agrochemicals and Pest Management

(Botany Component)

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges, Non Collegiate Women's Education Board and School of Open Learning

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Preamble

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its programmes in the best interest of their students and in this endeavour it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes.

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the programme of their choice. The Under-Graduate Programmes will prepare the students for both, academia and employability.

Each programme vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programmes also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each programme prepares students for sustainability and life-long learning.

The new curriculum of B.Sc. Programme in Applied Life Sciences with Agrochemicals and Pest Management offer essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

The University of Delhi hopes the LOCF approach of the B.Sc. Programme Applied Life Sciences with Agrochemicals and Pest Management will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

B.Sc. Programme Applied Life Sciences with Agrochemicals and Pest Management

(CBCS)

(Botany Component)

INTRODUCTION

The Learning outcomes-based curriculum framework is designed around the Choice-Based Credit System (CBCS) and is intended to suit the present day needs of the student in terms of securing their path towards higher studies or employment. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. The uniform grading system will also enable potential employers in assessing the performance of the candidates. The Choice-Based Credit System (CBCS) provides an opportunity for the students to choose courses from the prescribed courses comprising of:

1. Core Course: compulsory course studied by a candidate as a core requirement is termed as a Core course.
2. Elective Course: A course which can be chosen from a pool of courses and which may be very specific or specialized subject of study which enables an exposure to some other discipline/ subject is called an Elective Course.

2.1 Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective.

2.2 Dissertation/ Project: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.

3. Ability Enhancement Courses (AEC)/Competency Improvement Courses/Skill Development Courses/Foundation Course: The Ability Enhancement (AE) Courses may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC). “AECC” courses are the courses based upon the content that leads to Knowledge enhancement. They ((i) Environmental Science, (ii) English/MIL Communication) are mandatory for all disciplines. AEEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.

3.1 AE Compulsory Course (AECC): Environmental Science, English Communication/MIL Communication.

3.2 AE Elective Course (AEEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

Project work/Dissertation is considered as a special course involving application of knowledge in solving / analyzing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

Programme Duration and Design:

The B.Sc. Programme with Agrochemical and Pest Management (ACPM) will be of three years duration. Each year will be called an academic year and will be divided into two semesters. Thus there will be a total of six semesters. Each semester will consist of sixteen weeks. The teaching-learning will involve theory classes (Lectures) of one hour duration and practical classes. The curriculum will be delivered through various methods including chalk and talk, power point presentations, audio, video tools, E-learning/E-content, virtual labs, simulations, fieldtrips/Industry visits, seminars (talks by experts), workshops, projects, models and class discussions. Assessment will be based on continuous evaluation (class test, presentation, group discussion, quiz, assignment etc.) and end of semester examination. Each theory paper will be of 100 marks out of which 25% marks are reserved for internal assessment while a practical paper will be of 50 marks comprising 50% internal assessment.

LEARNING OUTCOME BASED CURRICULUM FRAMEWORK

Nature and Extent of the Programme B.Sc. Applied Life Sciences with Agrochemicals and Pest Management

The programme includes Core Courses and Elective Courses. The Core Courses are all compulsory courses. There are three types of Elective Courses – Discipline Specific Elective (DSE), Skill Enhancement Courses (SEC) and Ability Enhancement Courses (AEC). The Core and DSE are six credit courses; the SEC are four credit courses and AEC are two credit courses. A student has to study a minimum of 128 credits to get a degree in B.Sc. Programme with Agrochemical and Pest Management (ACPM). To acquire a B.Sc. Programme with Agrochemical and Pest Management (ACPM) degree, the student will study twelve Core Courses, six Discipline Specific Elective Courses, four Skill Enhancement Courses and two Ability Enhancement courses.

The student will study four Core Courses from each discipline in Semesters I, II, III and IV; two Discipline Specific Elective Courses from each discipline in Semesters V and VI; one Skill Enhancement Course in Semester III, IV, V and VI. And two compulsory Ability Enhancement Courses are Environmental Sciences and English Communication and the student will study one each in Semesters I and II.

Aims of Bachelor's degree programme in (CBCS)

The Learning Outcomes-based Curriculum Framework (LOCF) for the B.Sc. Programme Agrochemicals and Pest Management is designed to allow the flexibility in programme design and course content development, while at the same time maintaining a basic uniformity in the structure in comparison with other Universities across the country. The B.Sc. Programme ACPM covers a wide range of basic and applied courses in the fields of Botany, Zoology and Chemistry covering the areas like Agricultural Botany, Immunology, Molecular Biology, Inorganic Chemistry, Organic Chemistry, Physical Chemistry and many more. The core courses that are a part of the programme are designed to build a strong knowledge base in the fields already mentioned so that the student gets acquainted with the all aspects of this interesting course. The student is thus equipped to pursue higher studies in an institution of her/his choice, and to apply the skills learnt in the programme in solving the practical problems. The programme also offers a wide range of elective and skill enhancement courses to the student. The well-designed papers and the exhaustive training in the diverse fields help them to explore prospect in the higher studies and the jobs in academia or industry.

GRADUATE ATTRIBUTES IN SUBJECT

1. Communication skills: Develops effective communication skills through oral presentations of on-going developments in the field and the compiling of information in the form of reports.
2. Cooperation/Team work: Understands the importance and strengths of interacting with and working alongside people from diverse backgrounds with a meaningful contribution to team ethos and goals.
3. Moral and ethical awareness/reasoning: Awareness of ethical issues: Is aware of what constitutes unethical behaviour-plagiarism, fabrication and misrepresentation or manipulation of data.
4. Ethics: Acquires an awareness of work ethics and ethical issues in scientific research as well as plagiarism policies.
5. Self-directed learning: Self-motivation: Develops self-discipline, planning and organization skills, and time management skills.
6. Research-related skills: Is inquisitive about processes and phenomena happening during experiments in laboratories and seeks answers through the research path.
7. Knowledge acquisition: Gathers in-depth knowledge of basic and applied areas of ACPM
8. Laboratory skills: Understands and becomes conversant with various methods of safer handling of chemicals, biological specimens and various scientific equipments.
9. Interdisciplinary approach: Becomes aware of the synchronization of the main scientific fields viz. Chemistry, Botany and Zoology and its application in the daily life.
10. Environmental literacy: Develops a basic understanding of the Chemistry, Botany and Zoology principles that have environmental implications, gains an awareness of environmental safety like safer handling of chemicals in the laboratories, their safe disposal and replacement of harsh chemicals with the safer and environmental friendly options.

11. Scientific logic: Develops a scientific logic and approaches a problem with critical reasoning.

QUALIFICATION DESCRIPTION

The qualification description for B.Sc. Programme in Agrochemicals and Pest Management includes:

- Demonstration of a comprehensive knowledge of the basic concepts, principles and theories of the fields- Chemistry, Botany, Zoology, Agriculture & Pest management and an awareness of the emerging areas/topics of these fields.
- Enhancement of ability to read, assimilate and discuss scholarly articles and research papers of the mentioned diverse fields of sciences with a sense of interdisciplinary scenario.
- Acquisition of practical laboratory skills, enabling the systematic collection of experimental data of all the three fields and correlating them to accurately design an experiment.
- Ability to analyse and interpret experimental data and maintain records of the same.
- Development of literature searching and information management skills.
- Development of strong oral and written communication skills promoting the ability to present the studies in all the three fields by using the concepts and knowledge acquired.
- Development of awareness of the role of Chemistry, Botany, Zoology, Agriculture & Pest management in contemporary societal and global issues, including areas such as sustainability and green chemistry and environmental science.
- Demonstration of the ability to work effectively and productively, independently or as part of a team.
- Development of competence in intellectual, practical and transferable skills (Communication and Interpersonal skills) necessary for employment as a professional scientist.

PROGRAMME LEARNING OUTCOME IN COURSE

Students of B.Sc. programme in Agrochemicals and Pest Management (ACPM) are designed to develop in depth knowledge of the core concepts and principles of Agrochemical and Pest Management. Undergraduates pursuing this programme of study go through laboratory work that specifically develops their quantitative and qualitative skills, provides opportunities for critical thinking and team work and exposes them to techniques useful for applied areas of scientific study.

- Knowledge, Width and Depth: Students acquire sound theoretical knowledge and understanding of the fundamental concepts, principles and processes in Agrochemical and Pest Management. Depth in understanding is the outcome of transactional effectiveness and treatment of specialized course contents. Width results from the choice of electives that students are offered.
- Instrumental technique: A much valued learning outcome of this programme is the laboratory skills that students develop during the course. The techniques gained through hands- on

methods opens a choice of joining the industrial laboratory work force after graduation. The programme also provides an ample training in handling basic chemical and biological laboratory instruments and their use in the interfacial scientific determinations. Undergraduates on completion of this programme can cross branches to join pharmaceutical, material testing besides agrochemicals, pest management labs.

- Communication: Communication is a highly desirable attribute to possess. Opportunities to enhance student's ability to write methodical, logical and precise reports are inherent to the structure of the programme. Techniques that effectively communicate scientific content to large audiences are acquired through oral and poster presentations and regular laboratory report writing.
- Capacity Enhancement: Modern day scientific environment requires students to possess ability to think independently as well as be able to work productively in groups. This requires some degree of balancing. The ACPM course is designed to take care of this important aspect of student development through effective teaching learning process.
- Portable Skills: Besides communication skills, the programme develops a range of portable or transferable skills in students that they can carry with them to their new work environment after completion of ACPM programme. These are problem solving, information retrieval skills and organizational skills. These are valued across work environments.

STRUCTURE OF B.Sc. PROGRAMME (APPLIED LIFE SCIENCES WITH AGRO-CHEMICALS AND PEST MANAGEMENT)

Credit Distribution for the programme

Course	Credits	
	Theory+ Practical	Theory+Tutorials I.
I. Core Course (12 Papers) 04 Courses from each of the 03 disciplines of choice	12X4= 48	12X5=60
Core Course Practical / Tutorial* (12 Practical/ Tutorials*) 04 Courses from each of the 03 Disciplines of choice	12 X2=24	12X1=12
II. Elective Course (6 Papers) Two papers from each discipline of choice including paper of interdisciplinary nature.	6x4=24	6X5=30
Elective Course Practical / Tutorials* (6 Practical / Tutorials*) Two Papers from each discipline of choice including paper of interdisciplinary nature	6 X 2=12	6X1=6

- Optional Dissertation or project work in place of one Discipline elective paper (6 credits) in 6th Semester

III. Ability Enhancement Courses		
1. Ability Enhancement Compulsory (2 Papers of 2 credits each) Environmental Science, English/MIL Communication	2 X 2=4	2X2=4

2. Ability Enhancement Elective 4 X 2=8 4 X 2=8
(Skill Based)
(4 Papers of 2 credits each) __________________ __________________
Total credit= 120 Total credit= 120

Institute should evolve a system/policy about ECA/ General Interest/Hobby/Sports/NCC/NSS/related courses on its own.

*wherever there is practical there will be no tutorials and vice -versa

SEMESTER WISE COURSES OFFERED UNDER B.Sc. PROGRAMME (APPLIED LIFE SCIENCES WITH AGRO-CHEMICALS AND PEST MANAGEMENT)

Semester Core Course (12) Ability Enhancement Course (AEC) (2) Skill Enhc. Course (SEC) (4) Discipline Specific Elective (DSE) (6)

Semester	Course opted	Course Name
I	Ability enhancement compulsory course	Environmental Science / English Communication
	Core course Botany –I	Biology of life forms: Plants Credits- L=4
	Core course Botany –I, Practical	Biology of life forms: Plants Credits-, P=2
	Core course Zoology- I	
	Core course Zoology- I, Practical	
	Core course Chemistry- I	
	Core course Chemistry- I, Practical	
II	Ability enhancement compulsory course	Environmental Science / English Communication
	Core course Botany –II	Agricultural Botany and Weed science Credits- L=4
	Core course Botany –II, Practical	Agricultural Botany and Weed science Credits- P=2
	Core course Zoology- II	
	Core course Zoology- II, Practical	
	Core Course Chemistry- II	
	Core Course Chemistry- II, Practical	
III	Core course Botany –III	Fundamentals of Plant Systematics and Ecology, Credits - L=4
	Core course Botany –III, Practical	Fundamentals of Plant Systematics and Ecology, Credits - P=2
	Core course Zoology- III	
	Core course Zoology- III, Practical	
	Core course Chemistry- III	
	Core course Chemistry- III, Practical	
	SEC -1	
IV	Core course Botany –IV	Developmental Biology: Plants

		Credits- L=4
	Core course Botany –IV, Practical	Developmental Biology: Plants Credits- P=2
	Core course Zoology- IV	
	Core course Zoology- IV, Practical	
	Core course Chemistry- IV	
	Core course Chemistry- IV, Practical	
	SEC -2	
V	Discipline Specific Elective Botany –I	Any two 1.Genetics and Plant Biotechnology 2. Plants regulators and Economic Botany 3. Dissertation
	Discipline Specific Elective Botany –I, Practical	
	Discipline Specific Elective Zoology –I	
	Discipline Specific Elective Zoology –I, Practical	
	Discipline Specific Elective Chemistry –I	
	Discipline Specific Elective Chemistry –I, Practical	
	SEC -3	
VI	Discipline Specific Elective Botany –II	Any two 1.Genetics and Plant Biotechnology 2. Plants regulators and Economic Botany 3. Dissertation
	Discipline Specific Elective Botany –II, Practical	
	Discipline Specific Elective Zoology –II	
	Discipline Specific Elective Zoology –II, Practical	
	Discipline Specific Elective Chemistry –II	
	Discipline Specific Elective Chemistry –II, Practical	
	SEC -4	

(L=Lecture, P=Practical Core Courses –12 papers)

Credits: 12x 6 = 72

Details of Courses of Botany component

Core Courses –Botany

1. Biology of life forms: Plants
2. Agricultural Botany and Weed science
3. Fundamentals of Plant Systematics and Ecology

4. Developmental Biology: Plants

Discipline Specific Electives-Botany (Any two)

1. Genetics and Plant Biotechnology
2. Plants regulators and Economic Botany
3. Dissertation

Ability Enhancement Compulsory Courses

1. English Communication
2. Environmental Science

Skill Enhancement Courses (any four)- Botany

1. Medicinal Plants and IPR (Intellectual Property Rights)
2. Plants Quarantine
3. Plant health diagnostics and Management
4. Plants regulators and Economic Botany

COURSE LEARNING OBJECTIVES

The progamme is designed to equip students with essential knowledge and technical skills to study plants and related subjects in a holistic manner. hteh main aim is to train the learners in all areas of plant biology using appropriate combinations of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

COURSE LEARNING OUTCOME

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.

1. Understanding of plant classification systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various life-forms. Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.

2. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and the application of statistics to biological data.

TEACHING-LEARNING PROCESS

B.Sc. programme in Agrochemicals and Pest Management (ACPM) aims to make the student proficient in theoretical background and practical training in all aspects of ACPM. It also helps them to develop an appreciation of the importance of ACPM in different contexts through the exposure to the spectrum of the knowledgeable and facts in this field. For this, an exhaustive training in the classroom and laboratory is given.

In the classroom, this will be done through the lectures delivered using both conventional methods and smart technology. The protocol may vary from using blackboard/ whiteboard to the power-point presentations with the inclusion of the information from internet viz. animations. So the different pedagogies such as problem-based learning, peer-led instruction, and technology-aided instruction (blended learning) are adopted wherever suitable. Like in the interactive mode of teaching, the student will be encouraged to participate in discussions and deliver presentations on the relevant topics.

In the laboratory, the student will first learn good laboratory practices and then get hands-on training on basic techniques and methods adopted for simple synthesis and characterization of agrochemicals. The student will participate in field trips to industries that give an insight to the future areas of the employment.

ASSESSMENT METHODS

The student will be assessed over the duration of the programme by many different methods. These include short objectives-type quizzes, assignments, written and oral examinations, group discussions and presentations, problem-solving exercises, case study presentations, experimental design planning, execution of experiments, seminars, preparation of reports, and presentation of practical records. The wide range of assessment tasks aim to break the monotony of having a single assessment method.

KEYWORDS

Plant Sciences, Biology, biodiversity, biotechnology, botany, bryophytes, fungi, algae, mocrobes, bacteria, plant pathology, plant reproduction, anatomy, developmental biology, molecular biology, genetics, systematics, taxonomy, plant physiology, biostatistics, bioinformatics, ecology, biochemistry,

Contents of Courses of the B.Sc. Programme in Applied Life Sciences with Agrochemicals and Pest Management

Agricultural Botany and Weed Science
(APLSC2)

Core Course - (CC) Credit: 6

Course Objective (2-3)

To gain the knowledge on

1. Requirement of the conditions for seed germination, plant growth and development
2. Role of growth hormones in plant development and flowering
3. Weed control methods

Course Learning Outcomes

After completion of this course the students would be able to

1. How the quality of seeds are judged and how to create suitable conditions for the seed germination.
2. How the growth, flowering and fruiting in plants are managed through the application of hormones
3. How the weeds are managed in commercial crops?

Unit 1

Agricultural Botany

Seed Physiology - Seed dormancy, types, factors causing dormancy, mechanism and methods for breaking seed dormancy, seed viability, seed vigour, hormonal regulation of seed dormancy and germination (Lectures: 8)

Unit 2

Physiology of Growth and Yield - Principal of growth analysis, source-sink relationship, factors affecting growth, dry matter partitioning and yield, crop simulations and modeling, use of controlled environment for plant growth and development studies, concept of phytotronics. (Lectures: 8)

Unit 3

Chemical Regulation of Growth and Development - Role of hormones in plant growth and development, commercial applications of growth regulators, growth retardant and its usefulness. (Lectures: 8)

Unit 4

Reproductive Physiology and Senescence - Photoperiodism, flowering response, photo perception, critical photoperiod, photo-induction, phytochrome and its role in flowering, hormonal regulation, vernalization, physiology of fruit ripening, senescence, regulation of senescence.(Lectures: 10)

Unit 5

Weed Science

Biology of Weeds - Ecology of weeds, competition, reproduction of weeds. Seed biology.(Lectures: 6)

Unit 6

Weed Management Practices - Mechanical Practices, Cultural Practices, Biological control. (Lectures: 8)

Unit 7

Chemical Weed Control - Herbicide classification, Selectivity of herbicides, absorption and translocation of herbicides, Mode of action of herbicides, Detoxification mechanisms of herbicides.Weed resistance to herbicides. (Lectures: 8)

Unit 8

Weed Control Methods: Weed control in wheat, rice and vegetable crops. Control of five abnoxious weeds. (Lectures: 4)

Practical

1. To study opening and closing of stomata.
2. To determine stomatal index of the given leaf.
3. To study the effect of ethylene on shelf life of cut flowers.

4. To study the effect of cytokinin on leaf senescence.
5. To study effect of heavy metals on growth and development.
6. To test the viability of weed seeds.
7. To evaluate the allelopathic effects of weeds on germination of crop seeds.
8. To evaluate effect of herbicides on seed germination and seedling growth of weeds.

References

1. Ashton, F. M., Monaco, T. J. (2002). Weed Science: Principles and Practices. New Jersey, U.S.: John Wiley and Sons. Inc. (Chapter 2 and 8 for Unit5,7 respectively)
2. Hopkins, W.G. (1995). Introduction to plant physiology. Jersey, U.S.: John Wiley and Sons. Inc. (Chapter 26 for Unit 1, Chapters 16,17 18,19,20,21 for Unit 3,Chapters 22, 24, 25,26 for Unit 4,)
3. Mandal, R.C. (1990). Weeds, weedicides and weed control: Principle and Practice. New Delhi, Delhi: Agro Botanical Publishers (Chapter 1 for Unit 5, Chapter 2, 3 for Unit 8, Chapter 7, 9 for unit 8).
4. Rao, V. S. (1999). Principles of Weed Science. Oxford and IBH Publishers, New Delhi (Chapter 2 for Unit 5, Chapter 3,4, 5, 15 for Unit 6, Chapter 2,6,7,8, 13 for Unit 7, Chapter 3,4,5,13,14,15,17, 18 for Unit 8)

Additional Resources:

1. Subramanian,S. (2017). All about weed control. New Delhi, Delhi: Kalayani publishers (Chapters 1,2,3, 9 for Unit 5, Chapter 18 for Unit 6, Chapter 11 for Unit 7, Chapter 19,20, 21 for Unit 8)
2. Taiz, L., Zeiger, E. (2006). Plant Physiology, 5th edition. Sunderland, Massachusetts:Sinauer Associates, Inc. .(Chapter 16,17, 26 for Unit1,2 and 4, Chapter 19,20,21,22 for Unit 3, Chapter 16 for Unit 2)

Teaching Learning Process

Teaching and Learning Process: Theoretical knowledge will be imparted through lectures and power-point presentations. Practical sessions would help students identify the plants, their economically important parts. Project and field work will help students gain experimential knowledge and some skills help in extraction of resources.

Teaching Learning Plan
Week 1: Unit I
Week 2: Unit II

Week 3: Unit II
Week 4: Unit III
Week 5: Unit III,
Week 6: Unit IV
Week 7: Unit IV
Week 8: Unit V
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit VIII

Assessment Methods

Assessment Methods: Group discussions, Multiple choice questions, Written examination including project work presentation.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Seed Physiology - Seed dormancy, types, factors causing dormancy, mechanism and methods for breaking seed dormancy, seed viability, seed vigour, hormonal regulation of seed dormancy and germination	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Physiology of Growth and Yield - Principal of growth analysis, source-sink relationship, factors affecting growth, dry matter partitioning and yield, crop simulations and modeling, use of controlled environment for plant growth and development studies, concept of phytotronics.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Chemical Regulation of Growth and Development - Role of hormones in	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments,

	plant growth and development, commercial applications of growth regulators, growth retardant and its usefulness.	experiments	tests
IV	Reproductive Physiology and Senescence - Photoperiodism, flowering response, photoperception, critical photoperiod, photo-induction, phytochrome and its role in flowering, hormonal regulation, vernalization, physiology of fruit ripening, senescence, regulation of senescence.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Weed Science Biology of Weeds - Ecology of weeds, competition, reproduction of weeds. Seed biology.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Weed Management Practices - Mechanical Practices, Cultural Practices, Biological control.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Chemical Weed Control - Herbicide classification, Selectivity of herbicides, absorption and translocation of herbicides, Mode of action of herbicides, Detoxification mechanisms of herbicides. Weed resistance to herbicides.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Weed control in wheat, rice and vegetable crops. Control of five abnoxious weeds.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Seed dormancy, seed viability, hormonal regulation, source sink, crop simulation, phytotronics, flowering ,phytochrome, vernalization, weed, photoperiodism

Biology of Life Forms: Plants
(APLSC1)
Core Course - (CC) Credit:6

Course Objective (2-3)

1. Introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi, to various plant groups (Algae and Archegoniates- Bryophytes, Pteridophytes and Gymnosperms).
2. Information on the Ecological and Economic Importance of Microbes, Fungi and various plant groups to enable students understand and appreciate relevance of Microbes and Plants to environment and human well-being.
3. Insight into the line of Plant Evolution on Earth and the consequent Biodiversity is instrumental in creating Awareness on the threats to biodiversity and sensitize young minds towards the Biodiversity Conservation for sustainable development.

Course Learning Outcomes

1. Combination of Theoretical and Practical components will provide comprehensive information and insight into the fascinating world of Microbes and Plants.
2. Hands on Training will help students learn use of microscope, mounting, section-cutting and staining techniques for the study of plant materials.
3. Making Drawings in Practical Records will enhance understanding morphological and structural details and related functional aspects in diverse plant groups.
4. Scope of Biodiversity includes Medicinal field, Industry, Agriculture, Research and Study, Job Opportunities and Environmental Conservation. This paper is both informative and interesting and will enable students to learn about Biodiversity not only as a plant or nature lover, but also for higher academic pursuits, particularly in the field of Biological Sciences, Environment and Biodiversity Conservation.

Unit 1

Classifying the diversity of life: Kingdoms of Life –Eubacteria, Archaea and Eukaryotes
(4 Lectures)

Unit 2

Viruses: Discovery; Physiochemical and biological characteristics; Classification; Replication,Lytic and Lysogenic cycle; Structure of DNA virus (bacteriophage T4), RNA virus(TMV), economic importance. (6 Lectures)

Unit 3

Bacteria: Discovery of bacteria; Ecology and distribution; General structure; Comparison of Archaea and Eubacteria; Wall-less forms (L-forms, Mycoplasma, Protoplasts and Sphaeroplasts) Nutrition; Reproduction–vegetative, asexual and recombination; Economic importance. (8Lectures)

Unit 4

Algae: Diagnostic features of identification; morphology, reproduction and classification with special reference to *Nostoc*, *Volvox*, and Spirogyra. Economic importance of Algae. (10 Lectures)

Unit 5

Fungi: Diagnostic features of identification; morphology, reproduction and classification with special reference to *Rhizopus*, *Penicillium*, *Agaricus*and*Alternaria*; Lichens (a general account), and economic importance of lichens and fungi. (10 Lectures)

Unit 6

Archegoniate: Characteristic features of identification, classification and reproduction of Bryophytes and Pteridophytes with special reference to *Marchantia*, *Funaria*, and *Pteris*; economic importance of bryophytes and pteridophytes. (12 Lectures)

Unit 7
Gymnosperms: Characteristic features, classification, study of vegetative structures and reproduction of gymnosperms, economic importance of gymnosperms. *Pinus*: detailed account. (5 Lectures)

Unit 8
Angiosperms: Diagnostic features, Structure of flower, inflorescence, and fruits. (5 Lectures)

Practical

1. Viruses: EM of TMV and Bacteriophage, study specimens of virus infected plants (any two)
2. Bacteria: Types through permanent slides/photographs, specimens of infected plants (any two).
1. Algae: Study of vegetative and reproductive structures of (a) *Nostoc* (b) *Volvox* (c) *Spirogyra* through temporary preparations and permanent slides.
2. Fungi: Study of vegetative and reproductive structures of (a) *Rhizopus*, (b) *Penicillium*, (c) *Alternaria* and (d) *Agaricus* through temporary preparations and permanent slides/specimen/photographs.
3. Study of growth forms of Lichens (crustose, foliose and fruticose)
4. Bryophytes: Study of (a) *Marchantia* morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides), (b) *Funaria*: detailed study and classification from W.M. rhizoids, leaf, operculum, peristome, spores and permanent slides of archegonia, antheridia and capsule.
5. Pteridophytes: Study of (through temporary/permanent slides) and classification of *Pteris:* detailed study of T. S. of rachis, V.S. of sporophyll and W.M. of sporangium.
6. Gymnosperms: Study of *Pinus* from specimens and permanent slides only.
7. Angiosperms: Study of flower morphology, types of inflorescence (any 5 types) and fruit type (any 5 types) through specimen or photographs.

References

1. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology*, 4th edition. Singapore, John Wiley and Sons (Asia). (Chapter 1 for Unit 5)
2. Kumar, H.D. (1999). *Introductory Phycology*, 2nd edition. Delhi, Delhi: Affiliated East-West. Press Pvt. Ltd. (Chapters 12,3 for Unit 4)
3. Kaur I.D. Uniyal, P.L. (2019). *Text Book of Gymnosperms.* New Delhi, Delhi: Daya Publishing House. (Chapter 1,5, 6 for Unit 7)
4. Parihar, N.S. (1991). *An introduction to Embryophyta. Vol. I. Bryophyta*. Prayagraj: U.P.: Central Book Depot. (Chapter 1,3,9 for Unit 6)

Additional Resources:

1. Parihar, N.S. (1991). *An introduction to Embryophyta. Vol. II. Pteridophytes*. Prayagraj: U.P.: Central Book Depot. (Chapter 1,8 for Unit 6)
2. Pelczar, M.J. (2001). *Microbiology*, 5th edition. New Delhi, Delhi: Tata McGraw-Hill Co. (Chapter 3 for Unit 1;)
3. Tortora, G.J., Funke, B.R., Case. C.L. (2007). *Microbiology*. San Francisco, U.S.A: Pearson Benjamin Cummings,. (Chapter 13 for Unit 2; Chapter 11 for Unit 3)
4. Raven, P.H., Evert, RF., Eichhorn, S.E. (1999). *Biology of Plants*. New York, NY: W.H.Freeman and Company Worth Publishers. (Chapter 13,16 for Unit 1,; Chapter 14 for Unit 1; Chapter 17 for Unit 4; Chapter 18,19 for Unit 5; Chapter 20 for Unit 7)
5. Sethi, I.K. and Walia, S.K. (2018). *Text book of Fungi and Their Allies.* (2nd Edition), Medtech Publishers, Delhi (Chapter 9, 24,25 for Unit 3)

6. Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). *Pteridophyta*. New Delhi, Delhi: S. Chand & Co Ltd. (Chapter 1 and 8)

Teaching Learning Process

1. The theory topics are covered in lectures with the help of both conventional (chalk board) and modern (ICT) methods, including use of Charts.
2. Emphasis is on interactive class room environment so as to encourage students ask questions/ doubts/ queries for clarification/explanation and discussion.
3. Students are encouraged to refer to reference books in library to inculcate reading habit for better grasp and understanding on the subject.
4. Emphasis is given to illustrations- neat, well-labelled outline and cellular diagrams/ flowcharts for improving creative skills and to substantiate the text content.
5. On completion of theory syllabus, previous years' question papers are discussed so as to apprise students about the general format of semester exam question papers.
6. Assignment (10), Test (10) and Theory Attendance (5) are components of Internal Assessment Scheme for compilation of Internal Assessment Score of each student out of 25 marks.

PRACTICAL:

1. Plant study is done using fixed plant materials, museum and herbarium specimens, photographs and permanent slides.
2. The students are instructed about maintaining practical records, which includes comments and diagrams.
3. Students are asked to submit practical records regularly, on a continuous basis, for checking.
4. Practical Exam Guidelines are discussed to apprise students about the formant of Practical exam.
5. As part of Continuous Evaluation guidelines, total score for each student is calculated out of 25 marks, taking into consideration Practical Records (10), Practical Test/ Assessment (10) and Practical Attendance (5).

Weekly lesson plan

Week 1: Unit I
Week 2: Unit II
Week 3: Unit II
Week 4: Unit III
Week 5: Unit III,
Week 6: Unit IV
Week 7: Unit IV
Week 8: Unit V
Week 9: Unit V
Week 10: Mid semester Exam

Week 11: Mid Semester Break
Week 12: Unit VI
Week 13: Unit VI
Week 14: Unit VII
Week 15: Unit VIII

Assessment Methods

Emphasis is given for an interactive classroom environment, with at least few minutes for question-answer session.

1. Assignment topics are given to students for submission of hand written assignments.
2. Test is taken, with both objective and descriptive questions, from a defined portion of syllabus.
3. Assignment (10), Test (10) and Theory Attendance (5) are components of Internal Assessment Scheme for compilation of Internal Assessment Score of each student out of 25 marks.
4. Students are monitored in the practical class w.r.t their performance in table work for detailed plant study.
5. Students are asked to submit practical records regularly, on a continuous basis, for checking.
6. Emphasis is given on neat, labelled diagrams and proper, concise comments in practical records, with properly maintained Index page regularly signed by the teacher.
7. Practical Test/ Assessment is taken to evaluate students' performance as per guidelines framed for Continuous Evaluation under C.B.C.S.
8. As part of Continuous Evaluation guidelines, total score for each student is calculated out of 25 marks, taking into consideration Practical Records (10), Practical Test/ Assessment (10) and Practical Attendance (5).

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Classifying the diversity of life: Kingdoms of Life –Eubacteria, Archaea and Eukaryotes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Viruses: Physiochemical and biological characteristics; Classification; Replication, Lytic and Lysogenic cycle; Structure of DNA virus (bacteriophage T4), RNA virus (TMV), economic importance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Bacteria; Ecology and distribution; General structure; Comparison of	Class room lectures and Practical	Hands on exercises, PPT, assignments, tests

	Archaea and Eubacteria; Wall-less forms (L-forms, Mycoplasma, protoplasts and Sphaeroplasts) Nutrition; Reproduction–vegetative, asexual and recombination; Economic importance.	demonstration, experiments	
IV	Diagnostic features of identification; morphology, reproduction and classification with special reference to *Nostoc*, V*olvox*, and *Spirogyra*. Economic importance of Algae.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Diagnostic features of identification; morphology, reproduction and classification with special reference to *Rhizopus, Penicillium, Agaricus* and *Alternaria*; Lichens description, economic importance lichens and fungi.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Characteristic features of identification, classification and reproduction of Bryophytes and Pteridophytes with special reference to *Marchantia*, *Funaria* , and *Pteris* ; economic importance of bryophytes and pteridophytes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Characteristic features, classification, study of vegetative structures and reproduction of gymnosperms, economic importance of gymnosperms. *Pinus*: detailed account.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Angiosperms: Diagnostic features, Structure of flower, inflorescence, and fruits.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Biodiversity; Microbes; Viruses; Bacteria; Fungi; Algae; Archegoniates; Bryophytes; Pteridophytes; Gymnosperms

Developmental Biology: Plants
(APLSC4)
Core Course - (CC) Credit:6

Course Objective (2-3)

- To acquaint the students with internal basic structure and cellular composition of the plant body.
- To correlate structure with important functions of different plant parts.
- Study of various tissue systems and their development and functions in plants
- To have knowledge of the flowering and fruiting, reproduction process, role of pollinators, ovule and seed development.

Course Learning Outcomes

Knowledge of various cells and tissues, meristem, epidermal and vascular tissue system in plants.Various aspects of growth, development of the tissues and differentiation of various plant organs. Knowledge of basic structure and organization of plant parts in angiosperms. Correlation of structure with morphology and functions.

1. Pollen development, dispersal and pollination
2. Ovule development and fertilization,
3. Endosperm development and its importance
4. alternation pathways of reproduction

Unit 1

Meristematic and permanent tissue: (10 Lectures)
Meristems and derivatives- structural organization of shoot and root apices; permanent tissue: simple and complex tissues.

Unit 2

Dermal system (4 Lectures)
Epidermis, cuticle, stomata, trichomes and glands

Unit 3

Organs (6 Lectures)
Structure of dicot and monocot root, stem and leaf.

Unit 4

Secondary Growth (10Lectures)
Vascular cambium – structure and function, Secondary growth in root and stem, periderm.

Unit 5

Structural organization of flower (1Lecture)

Unit 6

Anther: (8 Lectures)
structure and development, microsporogenesis, pollen development; structure of pollen wall.

Unit 7

Ovule: (8Lectures)
Structure and types, megasporogenesis and megagametogenesis, mature embryo sac

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Unit 8

Pollination and fertilization: (6 Lectures)
Pollination mechanisms and adaptations; double fertilization; sexual incompatibility- basic concepts

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Unit 9

Endosperm and embryo: (5Lectures)
Types and function of endosperm, embryogenesis, Dicot and monocot embryo

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Unit 10

Seed development basic concepts (2 Lectures)

Practical

1. Study of root and shoot apex through permanent slides and photographs.

2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: Zea mays; Dicot: Helianthus; Secondary: Helianthus (only Permanent slides).
4. Root: Monocot: Zea mays; Dicot: Helianthus; Secondary: Helianthus (only Permanent slides).
5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Structure of anther (young and mature).
7. Calculation of percentage of germinated pollen in a given medium.
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: Mature embryo sac (photographs).Ultrastructure of mature egg apparatus cells through electron micrographs
10. Dissection of embryo and endosperm from developing seeds.

References

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). *Embryology of Angiosperms*, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd. (Chapter 2 for Unit 5: Chapter 3 for Unit 6; Chapter 8 for Unit 8; Chapter 11,12 for Unit 9; Chapter 15 for Unit 10)
2. Mauseth, J.D. (1988). *Plant Anatomy*. San Francisco, California: The Benjamin/Cummings Publisher. (Chapter 3-9 for Unit 1 ; Chapter 10 for Unit 2 ; Chapter 11-13 for Unit 3 ; Chapter 1-18 for Unit 4 ; Chapter19 for Unit 5, 6, 10)
3. Evert, R. F.(2006). *Esau's Plant Anatomy: Meristems, Cells, And Tissues of the Plant Body: Their Structure, Function, and Development*. New Jersey, U.S.: John Wiley & Sons, Inc., Hoboken. (Chapter 5 for Unit 1 : Chapter 9 for Unit 2 : Chapter 6 for Unit 3 : Chapter 12 for Unit 4:
4. Vasishtha, P.C. (1985) Plant Anatomy. Jallandhar, Punjab: Pradeep Publications. (Chapter 6 for Unit 1; Chapter 11,12,15 for Unit 3; Chapter 13 for Unit 4: Chapter 18 for Unit 5,6,7,8,9,10)

Additional Resources:

5. Bendre and Kumar (2004). *A Textbook Of Practical Botany. Vol II.* Meerut, U.P.: Rastogi publications. (Chapter 6 for Unit 6; Chapter 5 for Unit 7; Chapters 11-14 for practical 1 -10)

Teaching Learning Process

Chalk and blackboard teaching methodology
Powerpoint presentations

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

Weekly lesson plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit V
Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit VIII
Week 14: Unit IX
Week 15: Unit X

Assessment Methods

Assignments/ Projects
Class tests
Student presentations
Continuous evaluation
Making drawings as a part of practical record books.we may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Meristems and derivatives- structural organization of shoot and root apices; permanent tissue: simple and complex tissues.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Epidermis, cuticle, stomata, trichomes and glands	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Structure of dicot and monocot root, stem and leaf.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Secondary Growth Vascular cambium – structure and function,	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments, tests

	Secondary growth in root and stem, periderm.	experiments	
V	Structural organization of flower	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Anther: structure and development, microsporogenesis, pollen development; structure of pollen wall.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Ovule: structure and types, megasporogenesis and megagametogenesis, mature embryo sac	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Pollination and fertilization Pollination mechanisms and adaptations; double fertilization; sexual incompatibilitybasic Concepts	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Endosperm and embryo: Types and function of endosperm, embryogenesis, Dicot and monocot embryo	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X	Seed development basic concepts	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Tissues, Stem, Leaf, Root, Vascular cambium, Wood, Periderm, Anatomical adaptations, Secondary anomalies. Plant tissue systems, meristems, trichomes,flowering development, anther, plooen biology, ovule , gametogenesis, Pollination, fertilization, self -incompatibility, endosperm, seed, apomixix, polyembryony

Fundamentals of Plant Systematics and Ecology
(APLSC3)
Core Course - (CC) Credit:6

Course Objective(2-3)

To make students understand ecology and basic ecological concepts, inter-relation between the living world and environment. Also to make them aware about identification, nomenclature and classification.

Course Learning Outcomes

After successful completion of the course the student shall have adequate knowledge about the basic principals of environment and taxonomy. They will be able to identify the plants and their resources and the ecological conditions for the growth and development of the plants

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Unit 1

SECTION A: Systematics
Aims, fundamental components of systematics description, identification, nomenclature, phylogeny, classification: artificial, natural and phylogenetic, biosystematics. (5 Lectures)

Unit 2

Systematics in Practices: Herbarium- Methods and their roles, role of computers and internet resources in identification; Keys, floras, monographs, manuals and journals. (8 Lectures)

Unit 3

Taxonomic Hierarchy- Concept of taxa, categories and hierarchy. (4 Lectures)

Unit 4

Botanical Nomenclature- principles and rules; ranks and names, type method; author citation; valid publication; rejection of names, principle of priority and its limitations; names of hybrids and cultivars. (9 Lectures)

Unit 5

System of classification: An outline of Bentham and Hooker's and Engler and Prantl's systems of classification and their merits and Demerits. APG-III (brief introduction only) (6 Lectures)

Unit 6

SECTION B: Ecology
Introduction to ecology, level of organization (2 Lecture)

Unit 7
Ecological factors (10 Lectures)
Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes.

Unit 8
Biotic interactions (2 Lectures)

Unit 9
Plant communities (6 Lectures)
Characters; Ecotone and edge effect; Succession; Processes and types.

Unit 10
Ecosystem (8 Lectures) Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; biogeochemical cycling; carbon, nitrogen and Phosphorous cycle.

Practical

1. Study of herbarium technique (Mounting of a properly dried and pressed specimen of any wild plant on sheet with complete herbarium label).
2. Taxonomic study of characters of 2 plants from each of the following families:
    (a) Malvaceae
    (b) Solanaceae,
    (c) Asteraceae
    (d) Fabaceace

   Classification according to the system of Bentham and Hooker.
3. Use of internet in identification of plants.
4. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
5. Determination of pH, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.
6. (a)Study of morphological adaptations of hydrophytes and xerophytes (four each).
   (b)Study of biotic interactions of the following: Stem parasite (Cuscuta), Symbiotic interaction: Root nodules, Epiphytes, Predation (Insectivorous plants)

7. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (Species to be listed)
8. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law

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References

1. Singh, G (2004). *Plant Systematics — Theory and Practice.* 2nd edition. New Delhi, Delhi: Oxford & IBH Publishing Co. Pvt. Ltd. (Chapter 1,2 for Unit 1; Chapter 5 for Unit 2; Chapter 3 for Unit 3: Chapter 4 for Unit 4; Chapter 10 for Unit 5)
2. Stuessy, T.F. (2009). *Plant Taxonomy; The systematic Evaluation of comparative Data*. Columbia, CB: Columbia Univ Press (Chapter 1,2 for Unit 1; Chapter 10 for Unit 3; Chapter 2 for Unit 4)
3. Sharma, P.D. (2010). *Ecology and Environment*, 12th edition. Meerut, U.P.: Rastogi Publications. (Chapter 1 for Unit 6; Chapter 3,4 for Unit 7; Chapter 4 for Unit 8; Chapter 8 for Unit 9; Chapter 10 for Unit 10).

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and talk and chalk method. Students are encouraged to ask questions. The reading list has been suitably upgraded. A few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment. The students are asked to submit their record notebooks to the teacher/s for checking and evaluation
Weekly lesson plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit V
Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit VIII

Week 14: Unit IX
Week 15: Unit X

Assessment Methods

Theory: The students are continuously evaluated based on a written assignment, class test and/or presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.

Each student in a class is given a different topic to prepare a Assignment/PowerPoint presentation. All the students listen to the presentation of each student, and they are also encouraged to ask questions. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions. The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained are scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Systematics Aims, fundamental components of systematics description, identification, nomenclature,phylogeny, classification: artificial, natural and phylogenetic, biosystematics.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Herbarium- Methods and their roles, role of computers andinternet resources in identification; Keys, floras, monographs, manuals and journals.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Taxonomic Hierarchy- Concept of taxa, categories and hierarchy.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Botanical Nomenclature- principles and rules; ranks and names, type method; authorcitation; valid publication; rejection of names, principle of priority and its limitations;names of hybrids and	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	cultivars		
V	System of classification: An outline of Bentham and Hooker's and Engler and Prantl'ssystems of classification and their merits and Demerits. APG-III	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Introduction to ecology, level of organization	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Soil: Origin, formation, composition, soil profile. Water: States of water in theenvironment, precipitation types. Light and temperature: Variation Optimal and limitingfactors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Biotic interactions	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Plant communities Characters; Ecotone and edge effect; Succession; Processes and types.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X	Ecosystem Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; biogeochemical cycling;carbon, nitrogen and Phosphorous cycle.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

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Keywords

Environment, Soil, Water, Plant communities, Succession, Ecosystem, Phytogeography, Endemism, Plant taxonomy, Taxonomic hierarchy, Botanical Nomenclature, Classification, Biometrics

Dissertation
(APLSD3)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)
To enhance the learning habit through the reading of literature and preparing of a manuscript

Course Learning Outcomes
Students would gain the skill of understanding the conclusion of scientific data. The will bve able to analyze the data and have a gain good writing , presentation and communication skills,

Teaching Learning Process
Students will learn through the reading of the relevant literature, books article and research papers. They will analyze the data. Preparation of the dissertation will acquaint the student the writing and preparation of manuscript
Week 1: Selection of topics
Week 2: Literature survey
Week 3: Literature survey
Week 4: Preparation of subtopics
Week 5: Content writing
Week 6: Content writing
Week 7: Content writing
Week 8: Discussion
Week 9: Content writing
Week 10: Mid semester Presentation
Week 11: Mid Semester Break
Week 12: Checking of the manuscript
Week 13: Checking of the manuscript
Week 14: Editing of the manuscript
Week 15: Submission and presentation

Assessment Methods
Student will be assessed on the basis of the
1.Quality and coherence of content in the dissertation,
2.Originality of the content
3.Language quality, and Writing skill
4.Quality of conclusion and Novelty
5.Presentation of the dissertation

Keywords
Dissertation, project, article, manuscript reference, material and methods, results, discussion conclusion

Genetics and Plant Biotechnology
(APLSD1)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

To have knowledge of Mendelian and non-Mendelian inheritance, Chromosome biology and structure and function of genes. To have understanding of structure and functions of DNA and RNA, models of DNA replication, prokaryotic and eukaryotic genome-structure, Central dogma and genetic code, transcription and gene silencing. Acquaintance of RNA processing and translation, protein synthesis and gene functions. Such knowledge is applied in the field of biotechnology

To give students new knowledge and widening of the knowledge acquired in other course by handling of classical and modern plant biotechnology processes, including tissue culture for healthy plants, plants with improved characteristics. This course explores the use of biotechnology to both generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation.

Understanding of biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals (vaccines, antibodies, antibiotics etc.), food industry (transgenic crops with improved qualities (nutraceuticals, industrial enzymes etc.), agriculture (biotic and abiotic stress tolerant plants, disease and pest resistant plants, improved horticultural varieties etc.), ecology (plants role in bioremediation). This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.

Course Learning Outcomes

To generate interest among the students in Genetics and make them aware about the importance and opportunities in higher education and research, the first unit should be Introductory dealing with how this area has revolutionised all aspects of our life from its growth from Mendel to Genetic Engineering. The first unit may include brief introduction of: Definition, Application of this field in Food production, Medicines, Industries, Bioinformatics, Genomics, Proteomics, Transcriptomics, System Biology to Personalised medicines.

The successful students will be able to learn the basic concepts, principles and processes in plant biotechnology. They will have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.
Use basic biotechnological techniques to explore molecular biology of plants

Explain how biotechnology is used to for plant improvement and discuss the biosafety concern and ethical issue of that use.

Unit 1

Transmission Genetics: Mendel’s laws of inheritance, allelic and non-allelic interactions, modified dihybrid ratios, polygenic inheritance, multiple alleles, extra nuclear inheritance. (10 Lectures)

Unit 2

Physical and Molecular Organization of Genetic Material — chromosomes, chromosome morphology, karyotype, idiogram, polytene and lampbrush chromosomes, nucleosome, DNA/RNA as genetic material, Watson and Crick’s model, RNA types. (10 Lectures)

Unit 3

Mutations — spontaneous and induced mutations, mechanism of mutation, genomic mutations (aneuploidy, eupolyploidy), chromosomal aberrations. (10 Lectures)

Unit 4

Linkage and Crossing Over — complete and incomplete linkage, two-point and three point test cross, cytological basis of crossing over, Molecular basis of recombination; sex-linked inheritance. (6 Lectures)

Unit 5

Recombinant DNA Technology: Basics; Agrobacterium mediated gene transfer (4 Lectures)

Unit 6

GM plants: resistance to pathogens & pests, stress tolerance, golden rice, BT-cotton, flavor savor tomato. (8 Lectures)

Unit 7

Microbial and Industrial Biotechnology: production of antibiotics, alcohol, single cell proteins, enzymes, (4 Lectures)

Unit 8

Gene therapy, DNA Fingerprinting. (3 Lectures)

Unit 9

Ethics and Biosafety: public perception of biotechnology, ethical and biosafety issues. (5 Lectures)

Practical

1. Study of gene interaction/deviations from the Mendelian ratios using seed Samples in ratio of 9:7, 9:4:3, 9:6:1and 12:3:1.
2. To study of the karyotype of person with Down's, Turner's and Klinefelter's Syndrome.
3. Study of the organization of T-DNA and eukaryotic chromosome (through illustration).
4. Study of salivary gland and lampbrush chromosomes.
5. Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE.
6. Study of GM plants (Golden rice, Bt-cotton and flavor savor tomato)

References

1. Glick, B.R., Pasternak, J.J. (2003). *Molecular Biotechnology- Principles and Applications*. Washington, U.S.: ASM Press. (Chapter 3,13,14,16,18,19,20,22,23 for Unit 5, Unit 6, Unit 7 and Unit 9)
2. Snustad, D.P., Simmons, M.J. (2012). *Principles of Genetics,* 6th edition. New Jersey, U.S.: John Wiley and Sons Inc. (Chapter 3,4,5,6,7,9,11,13,16 for Unit 1, Unit 2, Unit 3, Unit 4 and Unit 8)
3. Tortora, G.J., Funke, B.R., Case. C.L. (2007). *Microbiology,* 9th edition. San Francisco, California: Pearson Benjamin Cummings. (Chapter 28 for Unit 7).

Additional Resources

1. Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino M.A. (2012). *Concepts of Genetics*, 10th edition. San Francisco, California: Pearson Education Inc. (Chapter 3,4,8,9,22 for Unit 1, Unit 3 and Unit 9)
2. Prescott, L.M., Harley J.P., Klein, D.A. (2002). *Microbiology*, 5th edition. New York: The Mac-Graw Hills Inc. (Chapter 41,42 for Unit 7)

3. Willey, J.M., Sherwood L., Woolverton J. (2017). *Prescott's Microbiology*, 10th edition. New York: The Mac-Graw Hills Inc. (Chapter 41,42 for Unit 7)
4. Russell, P.J. (2010). *iGenetics-A Molecular Approach*. 3rd edition. San Fransisco CA: Pearson Education Inc. (Chapter 10 for Unit 8)
5. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). *Principles of Genetics*, 8th edition. Canada: John Wiley and Sons, Inc. (Chapter 2,4,7.11,18 and 19 for Unit 1, Unit3 and Unit4)
6. Pierce, B.P. (2012). *Genetics- A Conceptual Approach*, 4th edition. New York, England: W. H. Freeman and Company. (Chapter 3,5,7,9,10,11,12,14,18,21 for Unit 1, Unit 2, Unit 3 and Unit 4)

Teaching Learning Process

1) Problem oriented learning
2) Individual seminar
3) Presentation and interpretation to other students
4) Discussion of published research articles on the selected topics
5) Practical will introduce the students to a range of tools and techniques of biotechnology

Weekly lesson plan
Week 1: Unit I
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Week 8: Unit VI
Week 9: Unit VII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VIII
Week 14: Unit VIII
Week 15: Unit IX

Assessment Methods

Assessment will be by written class test, assignment, project work, viva for internal assessment and written theory and practical examination for university evaluation.
Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task

I	Transmission Genetics: Mendel's laws of inheritance, allelic and non-allelic interactions, modified dihybrid ratios, polygenic inheritance, multiple alleles, extra nuclear inheritance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Physical and Molecular Organization of Genetic Material — chromosomes, chromosome morphology, karyotype, idiogram, polytene and lampbrush chromosomes, nucleosome, DNA/RNA as genetic material, Watson and Crick's model, RNA types.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Mutations — spontaneous and induced mutations, mechanism of mutation, genomic mutations (aneuploidy, eupolyploidy), chromosomal aberrations.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Linkage and Crossing Over — complete and incomplete linkage, two-point and three point test cross, cytological basis of crossing over, Molecular basis of recombination; sex-linked inheritance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Recombinant DNA Technology: Basics; Agrobacterium mediated gene transfer	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	GM plants: resistance to pathogens & pests, stress tolerance, golden rice, BT-cotton, flavor savor tomato.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Microbial and Industrial Biotechnology: production of antibiotics, alcohol, single cell proteins, enzymes,	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Gene therapy, DNA Fingerprinting.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Ethics and Biosafety: public perception of biotechnology, ethical and biosafety issues.		

Keywords

Inheritance theory, linkage, crossing over, chromosome mapping, cytology, Gene, Gene mutation, Population genetics

Plant Regulators and Economic Botany
(APLSD2)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

The course aims at making students realize how plants functions are regulated by the hormones, and plant growth and development are influenced

To gain the knowledge on the economically important of plants, their life cycle, processing, plant part used, application of biotechnology for the production of plant resources and production of new varieties

Course Learning Outcomes

Understanding of the role of growth regulators in plant growth and development. The will be apply this knowledge for desired seed germination, plant growth , initiation of flowering and fruiting.

Understanding of morphology,and processing and economic value of plant sources of cereals, legumes,spices, oil, rubber, timber and medicines. Student would have an ability to estimate the value of plants and can apply this knowledge for sustainable use of plant resources, conservation and management.

Unit 1

Chemical Regulation of Growth and Development (5 lectures)
Role of hormones in plant growth and development, commercial applications of growth regulators, growth retardant and its usefulness.

Unit 2

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid. (20 lectures)

Unit 3

Origin of Cultivated Plants (4 Lectures)

Concept of centres of origin, their importance with reference to Vavilov’s work

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Unit 4

Cereals (4 Lectures)
Wheat -Origin, morphology, uses

Unit 5

Legumes (4Lectures)
General account with special reference to Gram and soybean

Unit 6

Spices (6 Lectures)
General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)

Unit 7

Beverages (4Lectures)
Tea (morphology, processing, uses)

Unit 8

Oils and Fats (5 Lectures)
General description with special reference to groundnut

Unit 9

Fibre Yielding Plants (8 Lectures)
General description with special reference to Cotton and Jute (Botanical name, family, part used, morphology and uses)

Practical

1. To study the role of ABA in leaf senescence
2. To study the role of ethylene in fruit ripening.
3. To study the effect of gibberellins in bolting of floral axis.(through photograph)

4. To study and comments (Botanical name, family, part used, morphology and uses) of economically important plants through specimens, sections and micro chemical tests:
   a. Wheat,
   b. Gram,
   c. Soybean,
   d. Black pepper & Clove,
   e. Tea,
   f. Cotton & Jute,
   g. Groundnut.

References

1. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism.* Singapore: Springer. (chapter 14 for Unit 1, chapter 15,16,17,19,19,20 ,21 for Unit 2).
2. Hopkins, W.G., Huner, N. (2008). *Introduction of Plant Physiology*, 4th edition. New Jearsey, U.S.: John Wiley and sons. (Chapters 18 to 21, 24 and 25 for Unit 1 and 2)
3. Kochhar, S.L. (2011). *Economic Botany in the Tropics.* 4th edition. New Delhi, Delhi: MacMillan Publishers India Ltd. (Chapters 1for Unit 3; Chapters 3 for Unit 4; Chapters 5for Unit 5; Chapters 9for Unit 6; Chapters 11for Unit 7)
4. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). *Plant Physiology and Development*. 6th edition. Suderland, Massachusetts: Sinauer Associates Inc. Chapters 15, 18, 21 and 22 for Unit 1 and 2)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
Weekly lesson plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III

Week 6: Unit IV
Week 7: Unit V
Week 8: Unit VI
Week 9: Unit VII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit VIII
Week 14: Unit X
Week 15: Unit IX

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained are scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Chemical Regulation of Growth and Development (5 lectures) Role of hormones in plant growth and development, commercial applications of growth regulators, growth retardant and its usefulness.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	Jasmonic acid.		
III	Origin of Cultivated Plants, Concept of centres of origin, their importance with reference to Vavilov's work	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Wheat -Origin, morphology, uses	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	General account with special reference to Gram and soybean	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Tea (morphology, processing, uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	General description with special reference to groundnut	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	General description with special reference to Cotton and Jute (Botanical name, family, part used, morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Plant growth regulators, photoperiodism, photomorphogenesis, Vavilov, Cultivated plants, , Wheat, Gram , soyabean, spices, Tea, cotton, groundnut,

Medicinal Plants and Intellectual Property Rights
(APLSS1)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To introduce students to complementary and alternative medicine and provide them an opportunity

To explore uses of plants as medicine ranging from traditional indigenous approach for treating ailments to modern pharmaceuticals

To inculcate awareness about the rich diversity of medicinal plants in India.

To have knowledge of roles regulations, laws and processes of patents, copyright trademarks and concepts of traditional knowledge and protection of plant varieties

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Course Learning Outcomes

Knowledge Skills

An appreciation of the contribution of medicinal plants to traditional and modern medicine and the importance of holistic mode of treatment of the Indian traditional systems of medicine.

To develop an understanding of the constraints in promotion and marketing of medicinal plants.

Professional and Practical Skills

Transforming the knowledge into skills for promotion of traditional medicine.

Developing entrepreneurship skills to establish value addition products, botanical extracts and isolation of bioactive compounds.

Students would have deep understanding of patents copyrights, their importance. Thy can think about the importance of traditional knowledge, bio-prospecting, biopiracy. They would gain the knowledge of farmers rights and the importance on indigenous plant varieties, concept of novelty and biotechnological inventions

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Unit 1

History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences (2 lectures)

Unit 2

Ethnobotany and Folk medicines. Applications of Ethnobotany (2 lectures)

Unit 3

Medicinal plants: Botanical names, vernacular names, Morphology of the plant part of medicinal importance and uses with reference to*Cinchona, Digitalis, Papaver, Withania, Rauwolfia, Artemisi*a, and*Cannabis*

Unit 4

Introduction to intellectual property right (IPR) Concept and kinds.Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO). (2 lectures)

Unit 5

Patents: Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents. Infringement; Copyrights: Works protected under copyright law, Rights, Transfer of Copyright, Infringement;Trademarks ,introduction, Types, Rights, Protection of goodwill, Infringement (6 Lectures)

Unit 6

Concept of Traditional Knowledge, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level. (3 Lectures)

Unit 7

Industrial Designs, Geographical Indications (only brief introduction) (2 Lectures)

Unit 8

Protection of Plant Varieties Plant Varieties Protection-Objectives, Justification, International Position, Plant varieties protection in India.Rights of farmers, Breeders and Researchers.National gene bank, Benefit sharing.Protection of Plant Varieties and Farmers' Rights Act, 2001. (3 Lectures)

Unit 9

Biotechnology and Intellectual Property Rights. Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues (4 Lectures)

Practical

1. Study of the medicinal plants with their botanical names, vernacular names, family, plant parts used, active ingredients and uses. For Example; *Withaniasomnifera*, *Ocimumscantum*, *Azadirachtaindica*, *Plactranthusamboinicus*, *Raulfiaserpintena*, *Digitilis spp.*, *Cinchona spp.*, *Papaversomniferum*, *Artemisia annua*, *Cannabis sativa* etc.
2. Patent procedure in India.
3. Literature survey of some Ethnobotanical journals.
4. Questionnaire for collecting information on Ethnobotany.
5. Field survey and collection of information on ethnobotanical uses from traditional healers (any two).
6. To study trademark and logo survey of any five brands which uses plants or their product as their logo or trade mark.
7. Submission of five herbarium plants of medicinal importance.
8. Biopiracy (Neem/turmeric)

References

1. Acharya, N.K. (2001). *Text Book on Intellectual Property Rights: (copyright, Trademark, Patent Design, Geographical Indications, Protection of New Plant Varieties & Farmers Rights and Protection of Biodiversity).* (Chapter -1, 2, 3, 4, 5,7, 8, 9 and 11 for Unit 4, Unit 5 and Unit 8).
2. Bhandari. M.K. (2017) Law Relating to Intellectual Property Rights (IPR). Prayagraj, U.P.: Central Law Publications. (Chapter-1, 2, 3, 4, 5, 6 and 7 for Unit 4, Unit 5, Unit 7, Unit 8)
3. Gokhale, S.B. Kokate, C.K. (2009). *Practical Pharmacognosy*. Pune, Maharashtra: Nirali Prakashan.
4. Purohit and Vyas (2008). *Medicinal Plant Cultivation: A Scientific Approach*, 2nd edition. Jodhpur, Rajasthan: Agrobios. (Chapter 1 and 2 for Unit 1 and Unit 3)

Additional Resources:

1. Trivedi, P.C. (2006). *Medicinal Plants Traditional Knowledge*. New Delhi, Delhi: I.K. International Publishing House Pvt. Ltd. (Chapter 9 and 14 for Unit 2)
2. Trivedi, P.C. (2009). *Medicinal Plants. Utilisation and Conservation.* Jaipur, Rajasthan: Aavishkar Publishers. (Chapter 9 and 11 for Unit 1 and Unit 2)
3. William C. E. (2010). *Trease and Evans's Pharmacognosy*. 16th Edition. Nottingham, England: Saunders Ltd. (Chapter 1, 2 and 3 for Unit 1 and Unit 3)
4. Singh B.D. (2009) Biotechnology expanding horizons. Kalyani publishers, 2nd Edition. (Chapter 21 and 22 for Unit 4, 5 and 9)

Teaching Learning Process

To encourage innovation, to link theoretical knowledge with practical training and application of knowledge to find practical solutions to the challenges encountered in the field of traditional medicine.

To hold regular and structured workshops, seminars, field trips, collaboration with Research institutions, Industry and other Government Organizations, in order to facilitate peer learning and skill enhancement.

To complement classroom teaching with discussions, presentations, quizzes,interpretation of results, short projects, writing project reports and field exposure.
Weekly lesson plan
Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit V
Week 7: Unit VI
Week 8: Unit VI
Week 9: Unit VII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit VIII
Week 14: Unit IX
Week 15: Unit IX

Assessment Methods

Continuous Evaluation
(Project/ E-presentation:10 marks, Lab Records :
Attendance in Practicals
Practical Examination:

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Ethnobotany and Folk medicines. Applications of Ethnobotany	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Medicinal plants: Botanical names, vernacular names, Morphology of the plant part of medicinal importance and uses with refrence to Cinchona, Digitalis, Papaver, Withania, Rauwolfia, Artemisi a, andCannabis	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Introduction to intellectual property right (IPR) Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Patents: Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents. Infringement; Copyrights: Works protected under copyright law, Rights, Transfer of Copyright, Infringement;Trademarks ,introduction, Types, Rights, Protection of goodwill, Infringement	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Concept of Traditional Knowledge, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Industrial Designs, Geographical Indications (only brief introduction)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Protection of Plant Varieties Plant Varieties Protection-Objectives,	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments, tests

	Justification, International Position, Plant varieties protection in India. Rights of farmers, Breeders and Researchers.National gene bank, Benefit haring.Protection of Plant Varieties and Farmers' Rights Act, 2001.	experiments	
Unit IX	Biotechnology and Intellectual Property Rights. Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Medicinal plants, Ayurveda, Siddha, Unani,Holistic healing, Phytochemicals, Pharmacognosy, Polyherbals, Conservation, Propagation.Patents, IPR, Copyrights,trademarks, geographical indicators, traditional knowledge, industrial design, plant varieties, novelty, biotechnology

Plant Health Diagnostics and Management
(APLSS3)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

1. To introduce students with various pathogenic fungi, bactaria and viruses
2. To introduce students with the phytopathology, its concepts and principles
3. To acquaint with various plant diseases, causal organisms and their control

Course Learning Outcomes

On completion of his course the students will develop an

1. Understanding of the various fungal bacterial and virus disease of the plants
2. Understanding and identification of symptoms of plant disease
3. ability to develop the strategy to prevent and control of plant diseases

Unit 1

Plant Pathology (10 lectures)
Importance, concepts and types of plant disease symptoms, causes and classification of diseases.assessment, Diagnosis, Identification of casual organism by Koch postulates, principles of plant disease control,

Unit 2

Histo-chemical and Serological methods of studying plant pathogens, Modern techniques in analysis of plant diseases.

Unit 3

Plant disease Epidemiology, dissemination factors affecting the development of epidemics, Disease forecasting. Plant disease epidemic assessment. Transmission and Control of Plant Diseases

Unit 4

Causal organism, symptomatology, disease cycle, prevention and control of the following fungal diseases:-

White rust of crucifers
Late blight of potato
Downy mildews
Powdery mildews
Rusts of wheat
Smut of wheat and barley

Unit 5

Bacterial Diseases (4 lectures)- Causal organism, symptomatology, prevention and control of the following
Citrus canker
Angular leaf spots of cotton

Unit 6

Viral Diseases – (4 lectures) -Causal organism symptomatology, prevention and control of the following viral diseases
Tobacco mosaic
Yellow mosaic of soybean

Practical

1. Photographs:
   - (i) Powdery scab/Apple scab
   - (ii) Tuber Rot
   - (iii) Black wart of Potato
   - (iv) Chlorosis
   - (v) Disease Forcasting

2. *Albugo* – Specimen/Photograph showing symptoms of white rust of crucifers and hypertrophy. Study of asexual stage through section/temporary mount.
3. *Phytopthora* – Specimen/Photograph showing symptoms of Late blight of potato. Temporary tease mount of infected potato leaf and permanent slides/photographs to study asexual stage.
4. *Peronospora* – Specimen/Photograph showing symptoms of Downy mildew on pea or any other crucifers. Temporary tease mount of infected leaf and photographs to study asexual stage.
5. *Erysiphae* – Specimen/Photographs showing symptoms of Powdery mildew of pea. Temporary tease mount of infected leaf and permanent slides/Photographs to study asexual and sexual stages.

6. *Puccinia* – Specimen of Black stem rust of wheat and infected Barberry leaves. Sections/Mounts of spores on wheat and permanent slides/Photographs of both the hosts.
7. *Ustilago* – Specimen of Loose smut of wheat and Covered smut of Barley. Temporary mount of smut teliospores.
8. Herbarium specimens/Photographs of
9. A: Bacterial diseases
   (i) Citrus canker
   (ii) Angular leaf spot of cotton
10. B: Viral diseases
   (i) Tobacco mosaic disease
   (ii) Yellow vein mosaic of bhindi

References

1. 2. Sharma, P.D..(2014). *Plant Pathology*. Meerut, Rastogi Publications.(chapter1 for Unit 1; chapters 7 and 8 for Unit 3; chapters 13,14,15,16 for Unit 4; chapter 18 for Unit 6)
2. Singh R. S. (2018). *Plant Diseases.* 10^{th} Edition New Delhi, Medtech.(chapter 4 for Unit 5)

Teaching Learning Process

To engage students and transform them into active learners the students are updated with latest books and review articles.

The experiments included in the paper are performed individually or in group and are followed by group discussions and interjections.
Weekly lesson plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit III
Week 7: Unit IV
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit V
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

The students are assessed on the basis of oral presentations and regular class tests. Students are continuously assed during practical class. Submission of class records is mandatory. This exercise develops scientific skill as well as methods of recording and presenting scientific data.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Plant Pathology (10 lectures) Importance, concepts and types of plant disease symptoms, causes and classification of diseases. assessment, Diagnosis, Identification of casual organism by Koch postulates, principles of plant disease control	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Histo-chemical and Serological methods of studying plant pathogens, Moderntechniques in analysis of plant diseases.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Plant disease Epidemiology, dissemination factors affecting the development ofepidemics, Disease forecasting. Plant disease epidemic assessment. Transmission andControl of Plant Diseases	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Causal organism, symptomatology, disease cycle, prevention and control of the followingfungal diseases:- White rust of crucifers, Late blight of potato, Downy mildews, Powdery mildews, Rusts of wheat, Smut of wheat and barley	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Bacterial Diseases - Causal organism, symptomatology, prevention and control of the following Citrus canker Angular leaf spots of cotton	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Viral Diseases – -Causal organism symptomatology, prevention and controlof the following viral diseases Tobacco mosaic, Yellow mosaic of soybean	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Plant disease, causal organisms, serological methods, plant pathogens, epidemiology,, rust, smut, blight, powdery mildews, citrus canker, symptomatology, tobacco mosaic.

Plant Quarantine
(APLSS2)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

To acquaint the students with the Plant Quarantine Information System (PQIS)

To have the knowledge of export and import policies of Germplasm, Transgenic or Genetically Modified Organisms and live organism

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Course Learning Outcomes

Students would have deep understanding of
1. Plant Quarantine Order and Amendments, and Issuance of the export and Import Permit,
2. Procedures of Plant quarantine inspection for clearance
3. The need of quarantine of Germplasm, Transgenic or Genetically Modified Organisms, live insects and microbial cultures, plants and plant products.
4. The laws associated with various acts of plant quarantine

Unit 1

Plant quarantine: Introduction to Plant Quarantine Information System (PQIS) and objective (3 lectures)

Unit 2

Imports: Plant Quarantine Order and Amendments, Issuance of the Import Permit, Import inspection and clearance, Procedures of PEQ inspection, Time schedules for clearance, Permits required for import of Germplasm, Transgenic or Genetically Modified Organisms, live insects and microbial cultures, plants and plant products, Requirement of Import of Wood and Timber: Special conditions of Import Special conditions for import of plant species. (8 lectures)

Unit 3

Exports: Export inspection and certification procedure: Time schedules for clearance, Fees and Charges, Circular issued to Export Certification Authorities. (5 lectures)

Unit 4

Post-entry Quarantine: Appeal and Revision, Power of Relaxation, issuance of import permit, import inspection, inspection authorities Fees and charges, commodities not requiring Plant Quarantine clearance (4 lectures)

Unit 5

Phytosanitary: Phytosanitary Agreement, national standards for phytosanitary measures, accredit treatment facilities, Quarantine Disinfestation Treatment (5 lectures)

Unit 6

Laws: The Destructive Insects and Pests Act, 1914 and amendments, The Plant Quarantine Order 2003 - Amendments, International Plant Protection Convention, WTO-SPS Agreement, International Standards on Phytosanitary Measures (ISPMs) (5 lectures)

Practical

1. Learning of various techniques (conventional and modern)for the detection identification of parasite, saprophytes, microorganisms, pests
2. Dry seed examination , soaked examination, incubation test
3. Learning of various techniques of salvaging of infested/ infected/ contaminated germplasm Mechanical cleaning, hot water treatment, alcohol wash
4. Steps involved for processing of Quarantine Order
5. Visit of Plant quarantine station and preparation of report
6. Preparation of report and certificate with the help of case studies
7. Inspection report , photosanitary certificate , import permit , clearance certificate

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References

1. Muthaiyan, M.C. (2009). *Principles and Practices of Plant Quarantine.* Lucknow, U.P.: Allied publishers private limited. (Chapter 1 for Unit 1; chapter 2 for Unit 6)
2. Ebbels, D.L. (2003). *Principles of Health and Quarantine*, Bristol, UK; CABI Publishing (Chapter for Unit 2,3; Chapter 2 for Unit 5)

Teaching Learning Process

To engage students and transform them into active learners the students are updated with latest books and review articles.

The experiments included in the paper are performed individually or in group and are followed by group discussions and interjections.

Weekly lesson plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IV
Week 13: Unit V
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

The students are assessed on the basis of oral presentations and regular class tests.

Students are continuously assessed during practical class.

Submission of class records is mandatory. This exercise develops scientific skill as well as methods of recording and presenting scientific data.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Plant quarantine: Introduction to Plant Quarantine Information System (PQIS) and Objective	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Unit 2 Imports: Plant Quarantine Order and Amendments, Issuance of the Import Permit, Import inspection and clearance,	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	Procedures of PEQ inspection, Time schedules for clearance, Permits required for import of Germplasm, Transgenic or Genetically Modified Organisms, live insects and microbial cultures, plants and plant products, Requirement of Import of Wood and Timber: Special conditions of Import Special conditions for import of plant species. (8 lectures)		
III	Exports: Export inspection and certification procedure: Time schedules for clearance, Fees and Charges, Circular issued to Export Certification Authorities.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Post-entry Quarantine: Appeal and Revision, Power of Relaxation, issuance of import permit, import inspection, inspection authorities Fees and charges, commodities not requiring Plant Quarantine clearance	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Phytosanitary: Phytosanitary Agreement, national standards for phytosanitary	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Laws: The Destructive Insects and Pests Act, 1914 and amendments, The Plant Quarantine Order 2003 - Amendments, International Plant Protection Convention, WTOSPS Agreement, International Standards on Phytosanitary Measures (ISPMs)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

PQIS,Import permit, import inspection, Germplasm, transgenic, genetically modified organisms,Import of species,Post-entry, Quarantine, Phytosanitary, Destructive Insects and Pests Act, Plant Protection Convention, WTO-SPS Agreement

Plant Regulators and Economic Botany
(APLSS4)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

The course aims at making students realize how plants functions are regulated by the hormones, and plant growth and development are influenced

To gain the knowledge on the economically important of plants, their life cycle, processing, plant part used, application of biotechnology for the production of plant resources and production of new varieties

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Course Learning Outcomes

Students will have an understanding of the role of growth regulators in plant growth and development. They will be apply this knowledge for desired seed germination, plant growth, initiation of flowering and fruiting.

Understanding of morphology,and processing and economic value of plant sources of cereals, legumes,spices, oil, rubber, timber and medicines. Student would have an ability to estimate the value of plants and can apply this knowledge for sustainable use of plant resources, conservation and management.

Unit 1

Chemical Regulation of Growth and Development (5 lectures)
Role of hormones in plant growth and development, commercial applications of growth regulators, growth retardant and its usefulness.

Unit 2

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid. (20 lectures)

Unit 3

Origin of Cultivated Plants (4 Lectures)

Concept of centres of origin, their importance with reference to Vavilov’s work

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Unit 4

Cereals (4 Lectures)
Wheat -Origin, morphology, uses

Unit 5

Legumes (4Lectures)
General account with special reference to Gram and soybean

Unit 6

Spices (6 Lectures)
General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)

Unit 7

Beverages (4Lectures)
Tea (morphology, processing, uses)

Unit 8

Oils and Fats (5 Lectures)
General description with special reference to groundnut

Unit 9

Fibre Yielding Plants (8 Lectures)
General description with special reference to Cotton and Jute (Botanical name, family, part used, morphology and uses)

Practical

1. To study the role of ABA in leaf senescence
2. To study the role of ethylene in fruit ripening.

3. To study the effect of gibberellins in bolting of floral axis.(through photograph)
4. To study and comments (Botanical name, family, part used, morphology and uses) of economically important plants through specimens, sections and micro chemical tests:
   a. Wheat,
   b. Gram,
   c. Soybean,
   d. Black pepper & Clove,
   e. Tea,
   f. Cotton & Jute,
   g. Groundnut.

References

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Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.

Weekly lesson plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III

Week 6: Unit IV
Week 7: Unit V
Week 8: Unit VI
Week 9: Unit VII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit VIII
Week 14: Unit X
Week 15: Unit IX

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained are scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Chemical Regulation of Growth and Development (5 lectures) Role of hormones in plant growth and development, commercial applications of growth regulators, growth retardant and its usefulness.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Chemical nature (basic structure), bioassay and physiological roles of Auxin,Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

III	Origin of Cultivated Plants, Concept of centres of origin, their importance with reference to Vavilov's work	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Wheat -Origin, morphology, uses	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	General account with special reference to Gram and soybean	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	General account with special reference to clove and black pepper (Botanical name,family, part used, morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Tea (morphology, processing, uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	General description with special reference to groundnut	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	General description with special reference to Cotton and Jute (Botanical name, family,part used, morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Plant growth regulators, photoperiodism, photomorphogenesisVavilov, Cultivated plants, Wheat, Gram ,soyabean, spices, Tea, cotton, groundnut,

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