MANIPUR UNIVERSITY

Draft Syllabus for
Bachelor of Science in Botany
2022

Preamble

Higher Education system in the country and all over the world have undergone paradigm shift in the both qualitative and quantitative aspects. Over the past decades the higher education system of our country has undergone substantial structural and functional changes. These changes have gained momentum with the introduction of Choice Based Credit System (CBCS) with learning outcome based curriculum to maximize the benefits. The National Education Policy 2020 stressed on developing overall personality of students by incorporating humanitarian and constitutional values, creativity and critical thinking, harnessing innovation, use of modern technology and interaction with various stakeholders. The new policy recognizes that the pedagogy should evolve to make education more experiential, holistic, integrated, learner-centric, flexible and developing skill sets to make the student face the challenges of the future. The new policy also envisages the refinement and improvement in the Learning Outcome Based Curriculum Framework.

The current Undergraduate Curriculum Framework 2022 for the Botany underlines the perspective, philosophical basis and contemporary realities of higher education as enshrined in the National Education Policy 2020. This new framework will definitely help the teachers of the discipline to visualize the curriculum more specifically in terms of the learning outcomes expected from the students at the end of the instructional process.

The hallmark of the higher education is to develop an integrated personality of the individual and the educational system provides all knowledge and skills to the learner for this. Keeping in this line, sustained and continued endeavour efforts are exemplified in successive revision of undergraduate curricular framework over the decades, keeping pace with the emerging trends in higher education. The new curriculum is attended to keep pace with the emerging trends in higher education in the new millennium and its critical importance in empowering the youth for the future and equipping the youths with the prevailing priorities of optimum skill sets through innovative and practical oriented teaching-learning processes.

Introduction

Botany is the broad discipline encompassing various subjects involved with the study of plants. With the changing outlook in scientific world and development of molecular biology and computational biology, emphasis has been shifted to modern science at the cost of traditional botany. However, there is need to balance the traditional botany and upcoming modern computational and applied approach.

Considering these various facets of learning, adequate balance of topics in botany is arranged displaying latest APG IV based phylogenetic systematics of plants covering higher plants, lower plants, aquatic plants, nature/ field study, functional aspects of various cellular processes of plants, molecular genetics and modern tools i.e. tissue culture, genetic engineering and computational studies that are required to be introduced at undergraduate level.

This syllabus has been drafted to enable the students to equip for national level competitive exams that they may attempt in future. To ensure implementation of a holistic pedagogical model, several allied disciplines are covered/introduced in this syllabus, including Chemistry, Mathematics and a number of generic, and ability enhancement electives. In addition, employability of B.Sc. Botany graduate is given due importance such that their core competency in the subject matter, both theoretical and practical, is ensured. To expand the employability of graduates, a number of skill development courses are also introduced in this syllabus.

Aims of Bachelor's Degree Programs in B.Sc. Botany

1. To gain knowledge of diversity, life forms, life cycles, morphology and importance of viruses, bacteria, fungi and to introduce students about the concepts and principles of plant pathology, causal organisms of plant diseases and their control.
2. To gain knowledge of diversity, life forms, life cycles, morphology and importance of algae, bryophytes, pteridophytes and gymnosperms along with proficiency in the experimental techniques of analysis of these plant groups.
3. To enable students to understand and appreciate the relevance of Microbes and Plants to environment and sustainable development.
4. To develop an understanding of Evolution of Plant forms and the consequent Biodiversity developed. These are instrumental in creating awareness on the threats to biodiversity and sensitize students towards the Conservation of Biodiversity for sustainable development.
5. To 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 and cell organelles, they will be able to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life.

6. To introduce students to application of microbes and plants in Industrial application and Environmental remediation strategies.
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. To provide insight of physiological and biochemical processes in the plant systems with emphasis on different pathways, regulation and integration of metabolic processes with their role in crop productivity, and understanding of metabolic engineering.
9. To make the students familiar with economic importance of diverse plants that offer resources to human life and to emphasize the use of plants as food, medicine and for other utilities with huge economic value etc.
10. To give students knowledge on classical and modern plant biotechnology processes, role of biotechnology on global food security and commercial gains in biotechnology and agriculture, and also to familiarize with biotechnological tools
11. To understand biotechnological processes and its applicative value in pharmaceuticals, food industry, agriculture, ecology to modify plant responses and properties for global food security, human welfare and conservation of biodiversity.
12. 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.
13. 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.
14. 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
15. 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.
16. To make students aware of most basic domain-independent knowledge, including critical thinking and communication.
17. To enable the graduate to prepare for national and International competitive examinations for employment.

Attributes of a Botany Graduate

- **Core competency**: The botany graduates are expected to know the fundamental concepts of botany and plant science that reflect the latest understanding of the field. The core competency is dynamic in nature and requires frequent and time-bound revisions.

- **Communication skills:** Botany graduates are expected to possess minimum standards of communication skills expected of a science graduate. They are expected to read and understand documents with in-depth analyses and logical arguments. Graduates are expected to be well-versed in speaking and communicating their idea/finding/concepts to wider audience
- **Critical thinking**: Botany graduates are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientific arguments.
- **Psychological skills**: Graduates are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Psychological skills may include feedback loops, self-compassion, self-reflection, goal-setting, interpersonal relationships, and emotional management.
- **Problem-solving**: Graduates are expected to be equipped with problem solving philosophical approaches that are pertinent across the disciplines;
- **Analytical reasoning**: Graduates are expected to formulate cogent arguments and spot logical flaws, inconsistencies, circular reasoning etc in fallacious arguments.
- **Research-skills**: Graduates are expected to be keenly observant about what is going on in the natural surroundings to awake their curiosity. Graduates are expected to design a scientific experiment through statistical hypothesis testing and other a priori reasoning including logical deduction.
- **Teamwork**: Graduates are expected to be team players, with productive cooperations involving members from diverse socio-cultural backgrounds.
- **Digital Literacy**: Graduates are expected to be digitally literate for them to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.
- **Moral and ethical awareness**: Graduates are expected to be responsible citizen of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough to distinguish what construes as illegal and crime in Indian constitution. Emphasis be given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and so on.
- **Leadership readiness**: Graduates 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 charismatic inspiring leader and so on.

Qualification Descriptors

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

- 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;

- 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;
- Display skills and ability to use knowledge efficiently in areas related to specializations and current updates in the subject;
- Provide knowledge about plants, current research, scholarly and professional literature of advanced learning areas of plant sciences;
- Use knowledge understanding and skills for critical assessment of wide range of ideas and problems in the field of Botany;
- Communicate the outcomes of studies in the academic field of Botany through print and digital media;
- Apply one's knowledge and understanding of Botany to new/unfamiliar contexts and to identify problems and solutions in daily life;
- Design and apply the knowledge of plant sciences in identifying the problems which can be solved through the use of plants;
- To think of adopting expertise in plant structure, functions and solve the problems of environment, ecology, sustainable development and enhancing productivity;
- Concept and significance of sustainable development and use of the plant resources.

Programme Learning Outcome

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

- **Core competency**: Students will acquire core competency in the subject Botany, and in allied subject areas.
  - The student will be able to identify major groups of plants and compare the characteristics of lower (e.g. algae and fungi) and higher (angiosperms and gymnosperms) plants.
  - Students will be able to use the evidence based comparative botany approach to explain the evolution of organism and understand the genetic diversity on the earth.
  - The students will be able to explain various plant processes and functions, metabolism, concepts of gene, genome and how organism's function is influenced at the cell, tissue and organ level.
  - Students will be able to understand adaptation, development and behaviour of different forms of life.
  - The understanding of networked life on earth and tracing the energy pyramids through nutrient flow is expected from the students.

- Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Botany.
- **Analytical ability**: The students will be able to demonstrate the knowledge in understanding research and addressing practical problems.
    - Application of various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyze the data to decipher the degree to which their scientific work supports their hypothesis.
- **Critical Thinking and problem solving ability**: An increased understanding of fundamental concepts and their applications of scientific principles is expected at the end of this course. Students will become critical thinker and acquire problem solving capabilities.
- **Digitally equipped**: Students will acquire digital skills and integrate the fundamental concepts with modern tools.
- **Ethical and Psychological strengthening**: Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.
- **Team Player**: Students will learn team workmanship in order to serve efficiently institutions, industry and society.
- **Independent Learner**: Apart from the subject specific skills, generic skills, especially in botany, the program outcome would lead to gain knowledge and skills for further higher studies, competitive examinations and employment. Learning outcomes based curriculum would ensure equal academic standards across the country and broader picture of their competencies. The Bachelor program in Botany and Botany honours may be mono-disciplinary or multidisciplinary.

Eligibility Criteria

The general feeder category for entry into Semester I – B.Sc. Botany (Honours) is the Secondary School Leaving Certificate obtained after successfully completing Grade 12. A programme of study leading to entry into the first year of the Bachelor's degree is open to those students who have met the entrance requirements, including specified levels of attainment at the secondary level of education mentioned in the programme admission regulations.

Admission to the Bachelor degree programme of study will depend on the evaluation of documentary evidence (including the academic record) of the applicant's ability to undertake and complete a Bachelor's degree programme which is specified in the UGC Guidelines for Multiple Entry and Exit Scheme in Academic Programmes Offered in Higher Education.

General Information

1. A student who pursues three years undergraduate degree programme in B.Sc. Botany will earn at least 140 credits in that discipline (from 18 CCs and at least 2 DSEs of that discipline) and shall be awarded Degree in Botany, if he/she exits after completion of VI semester.
2. If a student wishes to pursue four years Honours Degree, he/she shall undergo for VII and VIII Semesters.
3. Dissertation or Academic Project in the 4th year shall commence from VII semester and conclude in VIII semester.
4. Exit options will be provided to students to avail the comfort of the flexibility of semester-wise academic load and to learn at his/her own pace. However, the mandatory number of credits has to be secured for the purpose of award of Certificate/Diploma/ Appropriate Bachelor's Degree in the field of Botany, to a student who chooses to exit at the end of even semesters.
5. For award of single discipline specific Honours degree in B.Sc. (Honours) Botany, Core Courses shall be from the Botany only.
6. There shall be a pool of DSEs from which a student may choose a course of study. Each of the DSE courses shall contain two components: Theory and Practical/Tutorial. To pursue B.Sc. (Honours) Botany, DSEs chosen should be from a pool of DSEs of Botany.
7. An elective course chosen generally from an unrelated discipline/subject, with an intention to seek a wide exposure is called a Generic Elective. Generic Electives shall be a pool of courses which is meant to provide multidisciplinary or interdisciplinary education to students. GEs shall consist of a pool of courses offered by various disciplines of study (excluding the GEs offered by the parent discipline), in groups of odd and even semesters, from which a student can choose.
8. A student who pursues four-year undergraduate degree programme shall be awarded Bachelor's Degree in Botany Honours after completion of the VIII semester.

Course Structure

Semester I

Core Courses		
Course code	**Title of the paper**	**Credit**
BOTC-101	Viruses, Bacteria, Fungi and Plant Pathology	4
BOTC-102(P)	Viruses, Bacteria, Fungi and Plant Pathology (Practical)	2
BOTC-103	Algae, Bryophytes, Pteridophytes and Gymnosperms	4
BOTC-104(P)	Algae, Bryophytes, Pteridophytes and Gymnosperms (Practical)	2
Ability Enhancement Compulsory Courses (AECC)		
	English/MIL	4
Skill Enhancement Courses (SEC) to be opted one course		
BOTS-105	Biofertilizers	2
BOTS-106(P)	Biofertilizers (Practical)	2
BOTS-107	Mushroom Cultivation	2
BOTS-108(P)	Mushroom Cultivation(Practical)	2
BOTS-109	Fermentation Technology	2
BOTS-110(P)	Fermentation Technology (Practical)	2
Value Addition Courses (VAC) two courses to be opted from central pool		
	Theory/Practical	2
	Theory/Practical	2
Total Credit		**24**

Semester II

Core Courses		
Course code	**Title of the paper**	**Credit**
BOTC-201	Plant Systematics	4
BOTC-202(P)	Plant Systematics (Practical)	2
BOTC-203	Biomolecules and Cell Biology	4
BOTC-204(P)	Biomolecules and Cell Biology (Practical)	2
Ability Enhancement Compulsory Courses (AECC)		
	Environmental Science	4
Skill Enhancement Courses (SEC) to be opted one course		
BOTS-205	Botanical Garden and Landscaping	2
BOTS-206(P)	Botanical Garden and Landscaping (Practical)	2
BOTS-207	Nursery and Gardening	2
BOTS-208(P)	Nursery and Gardening (Practical)	2

BOTS-209	Floriculture	2
BOTS-210(P)	Floriculture (Practical)	2
Value Addition Courses (VAC) two courses to be opted from central pool		
	Theory/Practical	2
	Theory/Practical	2
Total Credit		**24**

Exit option after first year: Bachelor's Certificate in Botany (Level 5) on completion of 46 credits

Semester III

Core Courses		
Course code	**Title of the paper**	**Credit**
BOTC-301	Plant Metabolism	4
BOTC-302(P)	Plant Metabolism (Practical)	2
BOTC-303	Ecology and Phytogeography	4
BOTC-304(P)	Ecology and Phytogeography (Practical)	2
BOTC-305	Genetics and Cytogenetics	4
BOTC-306(P)	Genetics and Cytogenetics (Practical)	2
Generic Elective Course (GEC) one course to be opted from other discipline		
	Theory with Practical/Theory without Practical	4+2/6
Value Addition Courses (VAC) one course to be opted from central pool		
	Theory/Practical	2
Total Credit		**26**

Semester IV

Core Courses		
Course code	**Title of the paper**	**Credit**
BOTC-401	Economic Botany and Plant Resource Utilization	4
BOTC-402(P)	Economic Botany and Plant Resource Utilization (Practical)	2
BOTC-403	Molecular Biology	4
BOTC-404(P)	Molecular Biology (Practical)	2
BOTC-405	Plant Morphology and Anatomy	4
BOTC-406(P)	Plant Morphology and Anatomy (Practical)	2
Generic Elective Course (GEC) one course to be opted from other discipline		
	Theory with Practical/Theory without Practical	4+2/6
Value Addition Courses (VAC) one course to be opted from central pool		
	Theory/Practical	2
Total Credit		**26**

Exit option after second year: Bachelor's Diploma in Botany (Level 6) on completion of 96 credits

Semester V

Core Courses		
Course code	**Title of the paper**	**Credit**
BOTC-501	Reproductive Biology of Angiosperms	4
BOTC-502(P)	Reproductive Biology of Angiosperms (Practical)	2
BOTC-503	Plant Physiology	4
BOTC-504(P)	Plant Physiology (Practical)	2
Discipline Specific Elective Course (DSE) to be opted one course		
BOTD-505	Stress Physiology	4
BOTD-506(P)	Stress Physiology (Practical)	2
BOTD-507	Plant Breeding	4
BOTD-508(P)	Plant Breeding(Practical)	2
BOTD-509	Plant Pathology	4
BOTD-510(P)	Plant Pathology (Practical)	2
Generic Elective Course (GEC) one course to be opted from other discipline		
	Theory with Practical/Theory without Practical	4+2/6
Value Addition Courses (VAC) one course to be opted from central pool		
	Theory/Practical	2
Total Credit		**26**

Semester VI

Core Courses		
Course code	**Title of the paper**	**Credit**
BOTC-601	Biostatistics and Bioinformatics	4
BOTC-602(P)	Biostatistics and Bioinformatics (Practical)	2
BOTC-603	Plant Biotechnology	4
BOTC-604(P)	Plant Biotechnology (Practical)	2
Discipline Specific Elective Course (DSE) to be opted one course		
BOTD-605	Microbiology	4
BOTD-606(P)	Microbiology (Practical)	2
BOTD-607	Biodiversity Conservation	4

BOTD-608(P)	Biodiversity Conservation (Practical)	2
BOTD-609	Post-Harvest Technology	4
BOTD-610(P)	Post-Harvest Technology (Practical)	2
Generic Elective Course (GEC) one course to be opted from other discipline		
	Theory with Practical/Theory without Practical	4+2/6
Value Addition Courses (VAC) one course to be opted from central pool		
	Theory/Practical	2
Total Credit		**26**

Exit option after third year: Bachelor's Degree in Botany (Level 7) on completion of 140 credits

Semester VII

Core Courses		
Course code	**Title of the paper**	**Credit**
BOTC-701	Molecular Systematics	4
BOTC-702(P)	Molecular Systematics (Practical)	2
BOTC-703	Advanced Plant Physiology	4
BOTC-704(P)	Advanced Plant Physiology (Practical)	2
Discipline Specific Elective Course (DSE) to be opted one course		
BOTD-705	Tools and Techniques in Plant Research	4
BOTD-706(P)	Tools and Techniques in Plant Research (Practical)	2
Generic Elective Course (GEC) to be opted one course from other discipline		
	Theory with Practical/Theory without Practical	4+2/6
Total Credit		**24**

Semester VIII

Core Courses		
Course code	**Title of the paper**	**Credit**
BOTC-801	Applied Microbiology	4
BOTC-802(P)	Applied Microbiology (Practical)	2
BOTC-803	Advanced Ecology	4
BOTC-804(P)	Advanced Ecology (Practical)	2
Discipline Specific Elective Course (DSE) to be opted one course		
BOTD-805	Research Project /Dissertation	6
Generic Elective Course (GEC) to be opted one course from other discipline		
	Theory with Practical/Theory without Practical	4+2/6
Total Credit		**24**

Exit option after fourth year: Bachelor's Degree in Botany Honours (Level 8) on completion of 182 credits

I. Core Courses (Compulsory Courses)

1. Viruses, Bacteria, Fungi and Plant Pathology
2. Algae, Bryophyta, Pteridophyta and Gymnosperm
3. Plant Systematics
4. Biomolecules and Cell Biology
5. Plant Metabolism
6. Ecology and Phytogeography
7. Genetics and Cytogenetics
8. Economic Botany and Plant Resource Utilization
9. Molecular Biology
10. Plant Morphology and Anatomy
11. Reproductive Biology of Angiosperms
12. Plant Physiology
13. Biostatistics and Bioinformatics
14. Plant Biotechnology
15. Molecular Systematics
16. Advanced Plant Physiology
17. Applied Microbiology
18. Advanced Ecology

II. Ability Enhancement Compulsory Courses (AECC)

A. Semester I

1. English/MIL

B. Semester II

1. Environmental Science

III. Discipline Specific Elective Course (DSEC) (to be opted one course each in Semester V, VI, VII and VIII)

A. Semester V

1. Stress Physiology
2. Plant Breeding
3. Plant Pathology

B. Semester VI

1. Microbiology
2. Biodiversity Conservation
3. Post-Harvest Technology

C. Semester VII

1. Tools and Techniques in Plant Research

D. Semester VIII

1. Research Project/Dissertation

IV. Generic Elective Courses (GEC) to be offered to candidates of other discipline

Semester III (To be opted one course)		
Course Code	**Title of the Paper**	**Credit**
BOTG-301 BOTG-302(P)	Algal Biotechnology Algal Biotechnology (Practical)	4 2
BOTG-303 BOTG-304(P)	Intellectual Property Rights Intellectual Property Rights (Practical)	4 2
BOTG-305 BOTG-306(P)	Medicinal and Aromatic Plants Medicinal and Aromatic Plants (Practical)	4 2
Semester IV(To be opted one course)		
Course Code	Title of the Paper	Credit
BOTG-401 BOTG-402(P)	Seed Technology Seed Technology (Practical)	4 2
BOTG-403 BOTG-404(P)	Food Science Food Science (Practical)	4 2
BOTG-405 BOTG-406(P)	Industrial Microbiology Industrial Microbiology (Practical)	4 2
Semester V (To be opted one course)		
Course Code	**Title of the Paper**	**Credit**
BOTG-501 BOTG-502(P)	Environmental Monitoring and Management Environmental Monitoring and Management (Practical)	4 2
BOTG-503 BOTG-504(P)	Global Climate Change Global Climate Change (Practical)	4 2
BOTG-505 BOTG-506(P)	Environmental Toxicity Environmental Toxicity (Practical)	4 2
Semester VI (To be opted one course)		
Course Code	**Title of the Paper**	**Credit**
BOTG-601 BOTG-602(P)	Biodiversity Biodiversity (Practical)	4 2
BOTG-603 BOTG-604(P)	Plant Taxonomy and Ecology Plant Taxonomy and Ecology (Practical)	4 2

BOTG-605 BOTG-606(P)	Phytochemistry Phytochemistry (Practical)	4 2
	Semester VII	
Course Code	**Title of the Paper**	**Credit**
BOTG-701 BOTG-702(P)	Plant Diversity and Conservation Plant Diversity and Conservation (Practical)	4 2
BOTG-703 BOTG-704(P)	Integrated Plant Disease Management Integrated Plant Disease Management (Practical)	4 2
	Semester VIII	
Course Code	**Title of the Paper**	**Credit**
BOTG-801 BOTG-802(P)	Ethnobotany and Indian Traditional Knowledge (ITK) Ethnobotany and Indian Traditional Knowledge (ITK) (Practical)	4 2
BOTG-803 BOTG-804(P)	Plant Resource and Sustainable Management Plant Resource and Sustainable Management (Practical)	4 2

V. Skill Enhancement Courses (SEC) (to be opted one course each in Semester I and Semester II)

A. Semester I

1. Biofertilizers
2. Mushroom Cultivation
3. Fermentation Technology

B. Semester II

1. Botanical Garden and Landscaping
2. Nursery and Gardening
3. Floriculture

VI. Value Added Course (VAC) (To be opted two courses each in Semester I and Semester II and one course each in Semester III, IV, V and VI)

List of Value Added Courses will be provided as central pool.

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 (LECTURE):

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. Total marks for each course shall be based on internal assessment (25%) and semester end examination (75%). Test/Assignment/Seminar/Field Work/Project Work/Case Study (20%) and Attendance (5%) are components of Internal Assessment Scheme for compilation of Internal Assessment Score of each student.

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 presentations and 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

LINKAGE

The course learning outcomes in the Semester I will link with the core courses and other courses as stated below.

Semester I					
Programme Outcome	**CC1** **BOTC-101; BOTC-102(P)**	**CC2** **BOTC-103; BOTC-104(P)**	**SEC1** **BOTS-105; BOTS-106(P)**	**SEC2** **BOTS-107; BOTS-108(P)**	**SEC3** **BOTS-109; BOTS-110(P)**

Core competency	✓	✓			
Critical Thinking	✓	✓			
Analytical Reasoning	✓	✓	✓	✓	✓
Research Skills	✓	✓	✓	✓	✓
Teamwork	✓	✓	✓	✓	✓
Additional Knowledge Enhancement			✓	✓	✓
Exposure beyond discipline			✓	✓	✓
Digital Literacy			✓	✓	✓
Moral and Ethical awareness	✓	✓	✓	✓	✓

Course Content

Semester – I

Core Course – Viruses, Bacteria, Fungi and Plant Pathology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-101**		**BOTC-102(P)**	

Course Objective

To gain knowledge of diversity, life forms, life cycles, morphology and importance of viruses, bacteria, fungi and to introduce students about the concepts and principles of plant pathology, causal organisms of plant diseases and their control.

Learning outcomes

On completion of this course, the students will gain knowledge on and will be able to:

1. Characteristics, diversity, nutrition and importance of microbes
2. Classify viruses, bacteria, fungi and lichens based on their characteristics and structures
3. Replication of viruses
4. Bacterial reproduction and genetic recombination
5. Reproduction and life cycle of representative species of different groups of fungi
6. Develop critical understanding of plant diseases and their remediation

Paper Code: BOTC-101
Paper Title: Viruses, Bacteria, Fungi and Plant Pathology (Theory)
Credit: 4

Unit I: Viruses **12 Lectures**
History, nature, biochemical composition and structural organization (helical and icosahedral symmetry) of viruses; Classification (Baltimore); Nomenclature of plant viruses; Genome organization and replication of tobacco mosaic virus (TMV) and bacteriophage (T-phage); Lytic and lysogenic cycle, Symptoms and transmission of plant viral diseases; Structure, properties and importance of viroids and prions.

Unit II: Bacteria **15 Lectures**
Overview of cell structure and function in the prokaryotes (Bacteria and Archaea); Classification of prokaryotes based on cell structure (Archaea, Gram-positive and Gram-negative bacteria, Mollicutes); Metabolic diversity of bacteria (phototrophy, chemolithotrophy, autotrophy, heterotrophy, fermentation); Bacterial cell division and microbial growth; Bacterial genome and plasmids; Reproduction and genetic recombination; Microbial growth control; Bacterial culture and staining; Economic importance of bacteria.

Unit III: Fungi **18 Lectures**
General characteristics; Thallus organisation; Cell wall composition; Nutrition; Classification; Reproduction in fungi; Economic importance of fungi; Characteristics and life cycles of the following fungal species: Chytridiomycota – *Synchytrium, Allomyces*; Oomycota - *Phytopthora, Albugo*; Zygomycota – *Rhizopus, Mucor*; Ascomycota - *Saccharomyces, Neruspora,*; Basidiomycota - *Puccinia, Agaricus*; Deuteromycota (mitosporic fungi) - *Fusarium*.*Aspergillus*.

Myxomycota - General characterises; Status of slime molds; Occurrence; Classification.

Lichens: Classification; Thallus organization; Reproduction; Physiology and economic importance.

Mycorrhiza – Ectomycorrhiza and endomycorrhiza and their significance.

Unit IV: Plant Pathology **15 Lectures**
History of plant pathology; Terms and concepts; Plant disease symptoms; Host- Pathogen relationships; Disease cycle and environmental relation; Methods of control of plant diseases; Plant quarantine; Fungal diseases – late blight of potato, brown leaf spot of rice, black rust of wheat; Bacterial diseases– citrus canker, angular leaf spot disease of cotton and bacterial blight of rice; Viral diseases – tobacco mosaic virus, vein clearing and tomato yellow leaf curl viruses.

Paper Code: BOTC-102(P)
Paper Title: Viruses, Bacteria, Fungi and Plant Pathology (Practical)
Credit: 2

1. Electron micrographs/Models of viruses – T4 and TMV, Line drawings/ Photographs of lytic and lysogenic cycle.
2. Collection and study of herbarium samples of virus plant diseases.
3. Types of bacteria from temporary/permanent slides/photographs. Electron micrographs or charts of bacterial binary fission, endospore, conjugation.
4. Gram-staining of root nodule bacterium (*Rhizobium*) and curd (*Lactobacillus*).
5. *Rhizopus* and *Mucor*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
6. *Saccharomyces* and *Aspergillus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
7. *Alternaria* and *Fusarium*: Preparation of temporary mount.
8. *Puccinia*: preparation of temporary mount of different spores on wheat.
9. *Agaricus*: sectioning of gills.
10. Study of morphology and anatomy of lichens (crustose, foliose and fruticose) through temporary mounts/permanent slides.
11. Collection of herbarium specimens and study of pathological characteristics through temporary mounts/permanent slides of bacterial diseases (citrus canker, angular leaf spot of cotton); Viral diseases (TMV, vein clearing); Fungal diseases (larly blight of potato/ white rust of crucifers, black stem rust of wheat and brown leaf spot of rice).

Suggested readings

1. Agrios, G.N. 1997. Plant Pathology, 4th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. 1996. Introductory Mycology. 4th edition.John Wiley & Sons (Asia) Singapore.
3. Pandey. B.P. 2014 Modern Practical Botany, (Vol-I) S. Chand and Company Pvt. Ltd., New Delhi.
4. Pelczar, M.J. 2001. Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
5. Sarbhoy, A.K. 2006. Text Book of Mycology, ICAR Publications, New Delhi.
6. Sethi, I.K. and Walia, S.K. 2011. Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
7. Sharma, P.D. 2011. Plant Pathology, Rastogi Publication, Meerut, India.
8. Sharma T.A., Dubey, R.C. and Maheshwari, D.K. 1999. A Text Book of Microbiology. S Chand and Co, New Delhi
9. Singh, R. P. 2007. Microbial Taxonomy and Culture Techniques, Kalyani Publication, New Delhi.
10. Webster, J. and Weber, R. 2007. Introduction to Fungi. 3rd edition. Cambridge University Press, Cambridge.
11. Wiley, J.M, Sherwood, L.M. and Woolverton, C.J. 2013. Prescott's Microbiology. 9th Edition. McGraw Hill International.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Field-based learning
10. Substantial laboratory-based practical component and experiments
11. Games
12. Technology-enabled learning
13. Internship in industry, and research establishments

Teaching Learning Plan:

- Week 1 : Lecture
- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Highlighting the salient features of the genera/ groups through digital media such as power point presentations and animations

Unit	Particulars	Teaching and	Assessment Task

No.		Learning Activity	
I	Virus	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Bacteria	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Fungi	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Plant Pathology	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Core Course - Algae, Bryophytes, Pteridophytes and Gymnosperms

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-103**		**BOTC-104(P)**	

Course Objective

To gain knowledge of diversity, life forms, life cycles, morphology and importance of algae, bryophytes, pteridophytes and gymnosperms along with proficiency in the experimental techniques of analysis of these plant groups.

Learning outcomes

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

1. Understand the classification, characteristic features, reproduction, life cycle patterns, biodiversity and economic importance of various groups of marine and fresh water algae.
2. Demonstrate an understanding of Bryophytes, Pteridophytes and Gymnosperms
3. Develop critical understanding on morphology, anatomy and reproduction of Bryophytes, Pteridophytes and Gymnosperms
4. Understanding of plant evolution and their transition to land habitat.
5. Demonstrate proficiency in the experimental techniques and methods of appropriate analysis of Algae, Bryophytes, Pteridophytes, Gymnosperms

Paper Code: BOTC-103
Paper Title: Algae, Bryophytes, Pteridophytes and Gymnosperms (Theory)
Credit: 4

Unit I: Algae **15 Lectures**

Characteristic features, range of thallus organization, cell structure and components, pigment system, reserve food materials, reproduction and classification proposed by Fritsch and Lee. Thallus structures, reproduction and life cycle of Cyanophyta (*Nostoc*, *Oscillatoria*, *Spirulina*); Chlorophyta (*Chlamydomonas, Volvox, Oedogonium, Coleochaete*); Charophyta (*Chara*); Xanthophyta (*Vaucheria*); Phaeophyta (*Ectocarpus*); Rhodophyta (*Polysiphonia*) and the economic importance of Algae.

Unit II: Bryophyta **15 Lectures**

Comparative and evolutionary trends in liverworts, hornworts and mosses. Progressive sterilization of the sporophytes, general characters, classification, structure of gametophytes and sporophytes, method of reproduction and life cycle of *Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum, Funaria.*

Unit III: Pteridophytes **12 Lectures**

General characteristics and classification, early land plant (*Cooksonia and Rhynia*), reproduction and life cycle of *Psilotum, Lycopodium, Selaginella, Equisetum, Pteris,*

Marsilea. Apogamy and Apospory, Heterospory and Seed habit, Telome theory, Stellar evolution, Ecological and economic importance.

Unit IV: Gymnosperms **18 Lectures**

Characteristic features and classification of Gymnosperms, morphology, reproduction and life cycle and economic importance of *Cycas, Pinus, Gnetum, Ephedra* and *Ginkgo.* Polyembryony and pollination drop with special reference to *Pinus.* Economic importance of Gymnosperms.

Palaeobotany: Geological time scale and dominant fossil flora of different ages, Fossil formation and types of fossilizations.

Paper Code: BOTC-104(P)
Paper Title: Algae, Bryophytes, Pteridophytes and Gymnosperm (Practical)
Credit: 2

1. Study of vegetative and reproductive structures of *Nostoc, Chalamydomonas, Volvox, Oedogonium, Chara, Vaucheria, Ectocarpus, Fucus* and *Polysiphonia* through temporary preparation and permanent slides.

2. Microscopic study of morphology and reproductive structure of *Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum, Funaria* through temporary and permanent slides.

3. Microscopic study of morphology and reproductive structure of *Psilotum, Lycopodium, Selaginella, Equisetum, Pteris* through temporary and permanent slides.

4. Study of morphology and microscopic reproductive structure of *Cycas, Pinus, Gnetum, Ephedra, Taxus*through temporary and permanent slides. Examination of available specimens/slides of fossil plants.

Suggested readings

1. Bhatnagar S.P., Moitra, A. 1996. Gymnosperms. New Age International Publishers, New Delhi, India
2. Kaur I., Uniyal P.L. 2020. Text Book of Bryophytes. New Delhi, Delhi: Daya Publishing House.
3. Kaur I., Uniyal P.L. 2019. Text Book of Gymnosperms. Daya Publishing House, New Delhi.
4. Kumar, H.D. 1999. Introductory Phycology, 2nd edition. New Delhi: Affiliated East-West Press.
5. Lee, R.E. 2008. Phycology, 4th edition. Cambridge University Press.
6. Pandey S.N., Misra, S.P., Trivedi, P.S. 1983. A Textbook of Botany Vol. 2. Bryophyta,Pteridophyta, Gymnosperms and Palaeobotany. Vikas Publishing House Pvt. Ltd., New Delhi.
7. Parihar, N.S. 1972. An Introduction to Embryophyta. Vol.II: Pteridophyta. Allahabad, UP: Central Book Deport.
8. Parihar, N.S. 1991. An Introduction to Embryophyta. Vol. I: Bryophyta. Allahabad, UP: Central Book Deport.
9. Vashistha P.C., Sinha A.K., Kumar A. 2010. Pteridophyta. S. Chand. Delhi, India.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
    - Long answer
    - Short answer
7. Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
8. Practical
9. Field-based learning
10. Substantial laboratory-based practical component and experiments
11. Games
12. Technology-enabled learning
13. Internship in industry, and research establishments

Teaching Learning Plan:

- Week 1 : Lecture
- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Herbarium preparation and specimen collection
3. Highlighting the salient features of the genera/ groups through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Algae	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Bryophyte	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Pteridophyte	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Gynosperm	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Skill Enhancement Course – Biofertilizers (Practical based course)

	L	T	P	Total
Credit	**2**	**0**	**2**	**4**
Paper Codes	**BOTS-105**		**BOTS-106(P)**	

Course Objective

To gain knowledge on eco-friendly fertilizers like Rhizobium, Azospirilium Azotobactor, cyanobacteria and mycorrhizae, their identification, growth multiplication and practical application of Organic farming and recycling of the organic waste.

Learning outcomes

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

1. Identification, growth, multiplication of eco-friendly fertilizers like *Rhizobium, Azospirilium, Azotobactor*, cyanobacteria, mycorrhizae, etc. their role in mineral cycling and nutrition to plants.
2. Organic farming and recycling of the organic waste
3. The student would have a deep understanding of ecofriendly fertilizers.
4. Methods of decomposition of biodegradable waste and convert into the compost

Paper Code: BOTS-105
Paper Title: Biofertilizers (Theory)
Credit: 2

Unit I **8 Lectures**
Introduction, types and importance of bio-fertilizers in agriculture, organic farming system and biocontrol of plant diseases; History of bio-fertilizers production; Micro-organisms used in bio-fertilizer production- *Rhizobium, Azobacter, Azospirillum,* Cyanobacteria, Mycorrhiza, Actinomycorrhiza.

Unit II **8 Lectures**
Classification of biological nitrogen fixation; factors influencing nitrogen fixation; Rhizobia, process of nodule formation, role of Nif and Nod gene in biological nitrogen fixation; *Azolla* and *Anabaena* association, cyanobacteria in rice cultivation. Actnmycorrhizal symbiosis

Unit III **7 Lectures**
Mycorrhizal association: type, colonization of mycorrhiza and contribution in nutrient uptake. taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield–its influence on growth and yield of crop plants.

Unit IV **7 Lectures**
Strategies of Mass multiplication and packaging; Quality standard for bio-fertilizers; Different methods of application of bio-fertilizers, Methods of quality control assessment in respect of bio-fertilizers; Registration of bio-fertilizers.

Paper Code: BOTS-106(P)
Paper Title: Biofertilizers (Practical)
Credit: 2

1. Study of bacteria and cyanobacteria (used in biofertilizers) from temporary mounts /permanent slides.
2. Study of *Rhizobium* from root nodules of leguminous plants by Gram staining method
3. Morphological study and isolation of *Anabaena* from *Azolla* leaf
4. Observation of different mycorrhizae from temporary mounts/permanent slides of mycorrhizal roots
5. Familiarity of different commercial biofertilizer formulations
6. Methods for field application of biofertilizers
7. Quality control of bio-fertilizers: ISI standards specified and estimating the viable bacterial count in carrier based bio-fertilizers,
8. Preparation of proposal of bio-fertilizers production unit

Suggested readings

1. Anonymous 2016. Proceedings of Workshop on Biofertilizers.New Delhi. Delhi: Zakir Husain Delhi College
2. Kumaresan, V. 2005. Biotechnology.New Delhi, Delhi: Saras Publication.
3. Sathe, T.V. 2004. Vermiculture and Organic Farming.New Delhi, Delhi: Daya publishers.
4. Subha Rao, N.S. 2000. Soil Microbiology.New Delhi, Delhi: Oxford & IBH Publishers.
5. Subba Rao, N.S. 1993. Biofertilizers in Agriculture and Forestry. Oxford and IBH. Publ. Co., New Delhi.
6. Vayas,S.C, Vayas, S., Modi, H.A. 1998. Bio-fertilizers and organic Farming. Nadiad, Gujarat: Akta Prakashan

Teaching Learning Process

Classroom lecture should be integrated with practical based learning and experience of the teachers. Practicals are designed on hand on experience basis. Visit to Institutes and farm houses are recommended to make better understanding and field based experience. 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 Learning Plan

- Week 1: Lecture/practical
- Week 2: Lecture/practical
- Week 3: Lecture/practical
- Week 4: Lecture/practical
- Week 5: Lecture/practical
- Week 6: Lecture/practical/Field-based studies

- Week 7: Lecture/practical
- Week 8: Lecture/practical
- Week 9: Lecture/practical
- Week 10: Mid semester Exam
- Week 11: Lecture/practical
- Week 12: Lecture/practical
- Week 13 : Lecture/practical
- Week 14 : Lecture/practical
- Week 15 : Lecture/practical

Assessment Methods

- Field based projects should be mandatory to have understanding of various types of biofertilizers in various environmental conditions.
- Field report should be prepared to highlight the visit.
- Power point presentations are recommended.
- Continuous evaluation of the student should be done.

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce

Skill Enhancement Course – Mushroom Cultivation (Practical based course)

	L	T	P	Total
Credit	**2**	**0**	**2**	**4**
Paper Codes	**BOTS-107**		**BOTS-108(P)**	

Course Objective

To make student aware about the mushroom growing techniques, appreciation of medicinal and nutritional values, economic importance of mushrooms and economical and marketing aspects of mushroom cultivation.

Learning outcomes

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

1. Identify various types and categories of mushrooms.
2. Demonstrate various types of mushroom cultivating technologies.
3. Value the economic factors associated with mushroom cultivation
4. Device new methods and strategies to contribute to mushroom production.

Paper Code: BOTS-107
Paper Title: Mushroom Cultivation (Theory)
Credit: 2

Unit I: **7 lectures**

Introduction, History. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms; Types of edible mushrooms available in India (with local emphasis)-*Volvariella volvacea, Pleurotus* spp., *Agaricus bisporus, Schizophyllum commune, Auricularia* spp., *Lentinulaedodes*, *Ganoderma* spp.

Unit II: **9 lectures**

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

Unit III: **7 lectures**

Cultivation methods for *Pleurotus*, *Volvareilla*, *Lentinula* and *Agaricus;*Methods of harvesting, processing, grading and packing; Short-term storage (Refrigeration – up to 24 hours); Long term storage (canning, pickels, papads), drying, storage in salt solutions; Use of spent mushroom in vermin-composting and in organic farming.

Unit IV: **7 lectures**

Disease control and pest management: types of diseases and pests of mushrooms and their control methods; Mushroom Research Centres- National level and Regional level. Marketing and cost economics of mushroom culture- Cost benefit ratio; Marketing in India and abroad; Export Value.

Paper Code: BOTS-108(P)
Paper Title: Mushroom Cultivation (Practical)
Credit: 2

1. Principle and functioning of instruments used in the various techniques.
2. Preparation of various types of media.
3. Preparation of spawn.
4. Study of edible and poisonous mushrooms
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 Institutes and cultivation centres.

Suggested Readings

1. Bahl, N. 2015. Hand book of Mushrooms, IV Edition, Oxford & IBH Publishing Co Ltd., New Delhi
2. Kannaiyan, S. and Ramasamy, K. 1980. A Hand Book of Edible Mushroom. Today & Tomorrows printers & publishers, New Delhi
3. Marimuthu, T., Krishnamoorthy, A.S., Sivaprakasam, K. and Jayarajan. R. 1991. Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
4. Swaminathan, M. 1990. Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
5. Tewari, P. and Kapoor, S.C.,1988. Mushroom cultivation, Mittal Publications, Delhi.

Teaching Learning Process

Classroom lecture should be integrated with practical based learning and experience of the teachers. Practicals are designed on hand on experience basis. Visit to Institutes and farm houses are recommended to make better understanding and field based experience. 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 Learning Plan

- Week 1: Lecture/practical
- Week 2: Lecture/practical
- Week 3: Lecture/practical
- Week 4: Lecture/practical

- Week 5: Lecture/practical
- Week 6: Lecture/practical/Field-based studies
- Week 7: Lecture/practical
- Week 8: Lecture/practical
- Week 9: Lecture/practical
- Week 10: Mid semester Exam
- Week 11: Lecture/practical
- Week 12: Lecture/practical
- Week 13 : Lecture/practical
- Week 14 : Lecture/practical
- Week 15 : Lecture/practical

Assessment Methods

- Field based projects should be mandatory to have understanding of various types of mushrooms related to environmental conditions.
- Field report should be prepared to highlight the visit.
- Power point presentations are recommended.
- Continuous evaluation of the student should be done.

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce

Skill Enhancement Course - Fermentation Technology

	L	T	P	Total
Credit	**2**	**0**	**2**	**4**
Paper Codes	**BOTS-109**		**BOTS-110(P)**	

Course Objective

To provide knowledge about the various aspects of the fermentation technology and application for fermentative production.

Learning outcomes

On completion of this course, the students will gain knowledge and able to:

1. Understand the design of various reactors used in Industries.
2. Comprehend the criteria for selection of media for microbial growth
3. Develop knowledge about methods for strain improvement and preservation of cultures.
4. Gain better perspective about upstream as well as downstream processing involved in fermentation industries

Paper Code: BOTS-109
Paper Title: Fermentation Technology (Theory)
Credit: 2

Unit I **8 Lectures**
History, Scope and Development of Fermentation technology; Isolation and screening of industrially important microorganisms − primary and secondary screening; Maintenance of Strains; Strain improvement: Mutant selection and Recombinant DNA technology

Unit II **6 Lectures**
Natural and Synthetic media; Basic components of a media (Carbon sources; Nitrogen sources; Vitamins; Minerals; Anti-foaming agents); Role of buffers in media; Process of aeration, and agitation.

Unit III **8 Lectures**
Basic designs of Fermentor; Type of fermentors: Waldhof, Tower, Deepjet, Cyclone column, Packed tower and airlift fermenter; Scale up study and Product development; Down-stream processing and Product recovery; Regulation and safety

Unit IV **6 Lectures**
Production of alcohol; Organic acid − Citric acid; Antibiotic − Penicillin, Amino acid − Glutamic acid; Vitamin − B1; Single Cell Protein (SCP).

Paper Code: BOTS-110(P)
Paper Title: Fermentation Technology (Practical)
Credit: 2

1. Isolation of antibiotic producing microorganisms from soil
2. Isolation of enzyme producing microorganisms from soil
3. Isolation of organic acid producing microorganisms from soil
4. Production of Alcohol
5. Production of Citric acid

Suggested readings

1. Bryce, E.M., Demain, T.C., Allman. A.R. 2006. Fermentation Microbiology and Biotechnology. Second Edition. CRC Press, USA.
2. Chen, H. 2013. Modern Solid State Fermentation: Theory and Practice. Springer Press, Germany
3. Lancini, G., Lorenzetti, R. 2014. Biotechnology of Antibiotics and other Bioactive Microbial Metabolites. Springer publications, Germany.
4. Peppler, H.J., Perlman, D. 2014. Microbial Technology: Fermentation Technology. Academic Press.
5. Smith, J.E. 2009. Biotechnology. Cambridge University Press.UK.
6. Stanbury, P.F., Whitaker, A., Hall, S.J., 2016. Principles of Fermentation Technology. Butterworth-Heinemann Press. UK.
7. Todaro, C.M., Henry C. Vogel, H.C., 2014. Fermentation and Biochemical Engineering Handbook. William Andrew Press. Norwich, NY.

Teaching Learning Process

Classroom lecture should be integrated with practical based learning and experience of the teachers. Practicals are designed on hand on experience basis. Visit to Institutes and industrial units are recommended to make better understanding and field based experience. 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 Learning Plan

- Week 1: Lecture/practical
- Week 2: Lecture/practical
- Week 3: Lecture/practical
- Week 4: Lecture/practical
- Week 5: Lecture/practical
- Week 6: Lecture/practical/Field-based studies
- Week 7: Lecture/practical
- Week 8: Lecture/practical
- Week 9: Lecture/practical
- Week 10: Mid semester Exam
- Week 11: Lecture/practical
- Week 12: Lecture/practical

- Week 13 : Lecture/practical
- Week 14 : Lecture/practical
- Week 15 : Lecture/practical

Assessment Methods

- Field based projects should be mandatory to have understanding of technology and applications of the discipline concerned
- Field report should be prepared to highlight the visit.
- Power point presentations are recommended.
- Continuous evaluation of the student should be done.

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests, viva-voce

Semester II

Core Course – Plant Systematics

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-201**		**BOTC-202(P)**	

Course Objective

To gain the knowledge on the taxonomy and phylogeny of plants

Learning Outcomes

Students understand plant classifications, phylogeny and identification with nomenclatural rules

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

Paper code: BOTC-201
Paper Title: Plant Systematics (Theory)
Credit: 4

Unit I: Plant systematics **15 lectures**

Introduction to systematics; Plant identification, Classification, Nomenclature.
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). Field inventory; Importance of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: intended (yolked) and bracketed keys. Phenetics vs. Cladistics.

Unit II: Botanical Nomenclature and System of Classification **15 lectures**

Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.

System of classification: Natural system of classification (Bentham and hooker), Takhtajan classification of Angiosperms, Principles of Angiosperm Phylogeny Group (APG IV) classification.

Unit III: Biometrics, Numerical Taxonomy and Cladistics 15 lectures

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

Unit IV: Taxonomic hierarchy and Phylogenetic Systematics 15 lectures

Taxonomic Hierarchy: Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concepts (biological, morphological, evolutionary).

Phylogenetic Systematics: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, paraphyly, polyphyly, clades. synapomorphy, symplesiomorphy, apomorphy. Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

Paper code: BOTC-202(P)
Paper Title: Plant Systematics (Practical)
Credit: 2

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 families should be selected out of the given list of nineteen families with available seasonal species of genus indicated in parenthesis.

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).

Suggested readings

1. Gupta R.2011 (Ed.) Plant Taxonomy: past, present, and future. New Delhi: The Energy and resources Institute (TERI).
2. Hall, B.G. 2011. Phylogenetic Trees Made Easy: A How-To Manual. Sinauer Associates, Inc. USA
3. Raven, F.H., Evert, R. F., Eichhorn, S.E. 1992. Biology of Plants. W.H. Freeman and Company. New York, NY.
4. Simpson, M.G. 2010. Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
5. Singh, G. 2012. Plant Systematics: Theory and Practice, 3rd edition. Oxford and IBH Pvt. Ltd. New Delhi.
6. Stace, C.A 1989 Plant Taxonomy and Biosystematics 2nd edition. Cambridge University Press, NY USA.
7. Stuessy, Tod F. 2009 Plant Taxonomy: The systematic evaluation of comparative data - 2nd edition. Columbia University Press
8. Walter S. Judd, et.al. 2015 Plant Systematics : A Phylogenetic Approach 4th Edition Sinauer Associates , Oxford University Press. USA.
9. http://www.mobot.org/MOBOT/research/APweb/
10. Any local/state/regional flora published by BSI or any other agency

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
8. Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
9. Practical
10. Field-based learning
11. Substantial laboratory-based practical component and experiments
12. Games
13. Technology-enabled learning

14. Internship in industry, and research establishments

Teaching Learning Plan:

Week 1 : Lecture

- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Herbarium preparation and specimen collection
3. Highlighting the salient features of the genera/ groups through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Plant systematics	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Botanical Nomenclature and System of Classification	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Biometrics, Numerical Taxonomy and Cladistics	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Taxonomic hierarchy and Phylogenetic Systematics	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Core Course – Biomolecules and Cell Biology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-203**		**BOTC-204(P)**	

Course Objective

To 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 and cell organelles, they will be able to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life.

Learning outcomes:

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

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

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

Paper Code: BOTC – 203
Paper Title: Biomolecules and Cell Biology (Theory)
Credit: 4

Unit I: Bioenergetics and Enzymes **15 lectures**

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule. Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theroy), Michaelis – Menten equation, Lineweaver–Burk equation, and factors affecting enzyme activity (in brief).

Unit II: Biomolecules **15 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; Fatty acids structure and functions; Structural lipid: Triacylglycerols structure, functions and properties Phosphoglycerides.Proteins: Structure of amino acids;

Levels of protein structure-primary, secondary, tertiary and quaternary; Protein denaturation and biological roles of proteins. Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

Unit III: Cell Biology - I **15 lectures**

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Plant and animal cells; Origin of eukaryotic cell (Endosymbiotic theory). Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis. Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus. Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle - checkpoints and regulation; role of protein kinases.

Unit IV: Cell Biology – II **15 lecturers**

Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament; Intracellular trafficking. Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast. Lysosomes and Vacuoles. Endomembrane system: Endoplasmic Reticulum – Types and Structure. Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi ApparatusSignal Transduction: Receptors and primary and secondary signal transduction

Paper Code: BOTC – 204(P)
Paper Title: Biomolecules and Cell Biology (Practical)
Credit: 2

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/ Rheo/ Crinum
3. Demonstration of the phenomenon of protoplasmic streaming in Hydrilla leaf.
4. Separate chloroplast pigments by paper chromatography.
5. Study of cell and its organelles with the help of electron micrographs.
6. Study the phenomenon of plasmolysis and deplasmolysis.
7. Demonstrate the activity of any two enzymes (Urease, Amylase, and Catalase).
8. Study the effect of organic solvent and temperature on membrane permeability.
9. Study different stages of mitosis and meiosis.
10. Separation of protein by Electrophoresis. (Only demonstration to class by the instructor).

Suggested readings

1. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K., Walter, P. 2014. Molecular Biology of Cell. 6th Edition. WW. Norton & Co.
2. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
3. Berg, J.M., Tymoczko, J.L. and Stryer, L. 2011. Biochemistry, W.H.Freeman and Company
4. Campbell, M.K. 2012. Biochemistry, 7th ed., Published by Cengage Learning.
5. Campbell, P.N. and Smith, A.D. 2011. Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
6. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
7. Cooper., G.M. 2015. The cell: A Molecular Approach. 7th Edition. Sinauer Associates.
8. Hardin, J., Becker, G., Skliensmith, L.J. 2012. Becker's World of the Cell. 8th edition.Pearson Education Inc. U.S.A
9. Iwasa,J, Marshall , W. 2016. Karps's Cell and Molecular Biology; Concepts and experiments.
10. Karp, G. 2010. Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
11. Nelson, D.L. and Cox, M.M. 2008. Lehninger Principles of Biochemistry, 5th Edition. W.H. Freeman and Company.
12. Reven, F.H., Evert, R.F., Eichhorn, S.E. 1992. Biology of Plants. New York, NY: W.H.Freeman and Company.
13. Tymoczko, J.L., Berg, J.M. and Stryer, L. 2012. Biochemistry: A short course, 2nd ed., W.H.Freeman.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Field-based learning
10. Substantial laboratory-based practical component and experiments

11. Games
12. Technology-enabled learning
13. Internship in industry, and research establishments

Teaching Learning Plan:

- Week 1 : Lecture
- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
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- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings and illustrations may be made a compulsory part of practical record books
2. Testing the salient features of the biomolecules and cellular components through digital media such as ppt and animations.

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Bioenergetics and Enzymes	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Biomolecules	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Cell Biology - I	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Cell Biology - II	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Skill Enhancement Course – Botanical Garden and Landscaping

	L	T	P	Total
Credit	**2**	**0**	**2**	**4**
Paper Codes	**BOTS-205**		**BOTS-206(P)**	

Course Objective

To gain knowledge of botanical garden, aesthetic planning and outdoor and indoor landscaping

Learning Outcomes

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

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

Paper code: BOTS-205

Paper Title: Botanical Garden and Landscaping (Theory)

Credit: 2

Course Content

Unit I **8 lectures**

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

Unit II **7 lectures**

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

Unit III **8 lectures**

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

Unit IV **7 lectures**

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

indoorscaping Exposure to CAD (Computer Aided Designing)

Paper code: BOTS-206(P)
Paper Title: Botanical Garden and Landscaping (Practical)
Credit: 2

1. Field trips: Field visit to regional/national Botanical Garden.
2. Identification of trees, shrubs and other herbaceous vegetation,
3. Prepare beds for growing nursery for herbs, shrubs and trees.
4. Count the number of types of animals, birds, and insects in the garden
5. Identification of pathogenic and non-pathogenic diseases of garden plants and grasses
6. More Practical may be added depending on the local habitats and available facilities
7. Try to grow herbs hydroponically

References

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

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

- Week 1 : Lecture
- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture

- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
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- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Highlighting the properties of the organisms in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Skill Enhancement Course - Nursery and Gardening

	L	T	P	Total
Credit	**2**	**0**	**2**	**4**
Paper Codes	**BOTS-207**		**BOTS-208(P)**	

Course Objective

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

Learning outcomes:

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

1. Understand the process of sowing seeds in nursery
2. List the various resources required for the development of nursery
3. Distinguish among the different forms of sowing and growing plants
4. Analyse the process of Vegetative propagation
5. Appreciate the diversity of plants and selection of gardening
6. Examine the cultivation of different vegetables and growth of plants in nursery and Gardening

Paper code: BOTS-207
Paper Title: Nursery and Gardening (Theory)
Credit: 2

Course Content

Unit I **7 lectures**

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

Unit II **7 lectures**

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.

Unit III **8 lectures**

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 glasshouse.

Unit IV **8 lectures**

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. Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures.

Paper code: BOTS-208(P)
Paper Title: Nursery and Gardening (Practical)
Credit: 2

1. To study the process of sowing seeds in nursery
2. To list the various resources required for the development of nursery
3. To study the different forms of sowing and growing plants
4. To study the process of Vegetative propagation
5. Listing of garden plants
6. To study computer applications in landscaping
7. To examine the cultivation of different vegetables and growth of plants in nursery
8. To study cold storage models for vegetables
9. To visit nearby local Nursery and record the plant list

Suggested readings

1. Bose T.K. & Mukherjee, D. (1972). Gardening in India, Oxford & IBH Publishing Co., New Delhi.
2. Sandhu, M.K. (1989) Plant Propagation, Wile Eastern Ltd., Bengaluru.
3. Kumar, N. (1997) Introduction to Horticulture, Rajalakshmi Publications, Nagercoil. Edmond Musser & Andres, Fundamentals of Horticulture, McGraw Hill Book Co., New Delhi.
4. Agrawal, P.K. (1993). Hand Book of Seed Technology, Dept. of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi.
5. Janick Jules (1979). Horticultural Science. (3rd Ed.), W.H. Freeman and Co., SanFrancisco, USA.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions

- Assertion and reasoning

8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

- Week 1 : Lecture
- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
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- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Highlighting the properties of the organisms in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Skill Enhancement Course – Floriculture

	L	T	P	Total
Credit	**2**	**0**	**2**	**4**
Paper Codes	**BOTS-209**		**BOTS-210(P)**	

Course Objective

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

Learning outcomes:

After completing this course the learner will be able to;

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

Paper code: BOTS-209
Paper Title: Floriculture (Theory)
Credit: 2

Course Content

Unit-I **8 lectures**

Introduction: History of gardening; Importance and scope of floriculture and landscape gardening.

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

Unit-II **6 lectures**

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

Unit-III **8 lectures**

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.

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

Unit-VI **8 lectures**

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

Paper code: BOTS-210(P)
Paper Title: Floriculture (Practical)
Credit: 2

1. Identification of commercially important floricultural crops.
2. Preparation of flower bed.
3. Seed sowing and transplantation methods.
4. Propagation by cutting, layering, budding and grafting.
5. Patterns of flower arrangement in vase.
6. Use of chemicals and other compounds for prolonging the vase life of cut flowers.
7. Drying and preservation of flowers.
8. Study of disease and pastes of ornamental plants.
9. Garden designing and hedge preparation methods.
10. Field visit to flower gardens.

Suggested readings

1. Randhawa, G.S., Mukhopadhyay, A. (1986). Floriculture in India. New York, NY: Allied Publishers.
2. Adams, C., M. Early and J. Brrok (2011).Principles of Horticulture. Routledge, U.K.
3. A.K.Singh.2006. Flower crops, cultivation andmanagement. New India publishing agency, Pitampura, New Delhi.
4. T.K. Bose, L.P. Yadav, P. Patil, P. Das and V.A. Partha Sarthy. 2003. Commercial Flowers. Partha Sankar Basu, Nayaudyog, 206, Bidhan Sarani, Kolkata.
5. S.K. Bhattacharjee and L.C. De. 2003. Advanced Commercial Floriculture. Aavishkar Publishers,Distributors, Jaipur.
6. Dewasish Choudhary and Amal Mehta. 2010. Flower crops cultivation and management. Oxford book company Jaipur, India. Randhawa,
7. G.S. Amitabha Mukhopadhyay, 2004. Floriculture in India.Allied Publishers Pvt. Ltd.
8. Arora, J.S. 2006. Introductory Ornamental Horticulture.Kalyani Publishers, Ludhiana.
9. Bhattacharjee, S.K. Advanced Commercial Floriculture. Aavishkar Publishers Distributors, Jaipur.
10. Sheela, V.L. 2008. Flower for trade. New India Publishing Agency, Pitampura, New Delhi-110088.
11. Abhinov Kumar. 2000. Production Technology of Ornamental Crops, Medicinal Plants and Landscaping. Kalyani Publishers, New Delhi.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation

6. Subjective type
    - Long answer
    - Short answer
7. Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

- Week 1 : Lecture
- Week 2: Lecture
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- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Highlighting the properties of the organisms in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures,	Hands on

		demonstrations and Practical	exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Semester- III

Core Course – Plant Metabolism

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-301**		**BOTC-302(P)**	

Course Objective

To provide insight of physiological and biochemical processes in the plant systems with emphasis on different pathways, regulation and integration of metabolic processes with their role in crop productivity, and understanding of metabolic engineering.

Learning outcomes

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

1. Differentiate anabolic and catabolic pathways of metabolism
2. Learn the similarity and differences in metabolic pathways in animals and plants.
3. Recognize the importance of Carbon fixation and assimilation in plants.
4. Explain the ATP-Synthesis
5. Interpret the Biological nitrogen fixation in metabolism
6. Grasp the concept of signal reception and transduction in a cell

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

Paper Code: BOTC - 301
Paper Title: Plant Metabolism (Theory)
Credit: 4

Unit I: Concept of Metabolism and Photosynthetic pigments **10 lectures**

Introduction, anabolic and catabolic pathways, regulation of metabolism; enzyme inhibition (competitive, non-competitive and uncompetitive); role of regulatory enzymes (allosteric regulation and covalent modulation, isozymes and alloenzymes); Historical background, role of photosynthetic pigments (chlorophylls and accessory pigments - No structural details), antenna molecules and reaction centres,

Unit II: Carbon Assimilation, Metabolism and Oxidation **20 lectures**

Photochemical reactions, PSI, PSII, photosynthetic electron transport, photophosphorylation, Q cycle, CO_2 Reduction/Carbon Assimilation: C3, C4 and CAM pathways; photorespiration; Factors affecting CO_2 reduction. Synthesis and catabolism of sucrose and starch. Carbon Oxidation: Glycolysis and its regulation, fate of pyruvate- aerobic and anaerobic respiration and fermentation, oxidative decarboxylation of pyruvate, TCA cycle, oxidative pentose phosphate pathway, amphibolic role, anaplerotic reactions, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Unit III: ATP-Synthesis **12 lectures**

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

Unit IV: Lipid and Nitrogen Metabolism, Mechanism of Signal Transduction **18 lectures**

Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, α oxidation. 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. Receptor – ligand interactions; Secondary messenger concept, Calcium-calmodulin, MAP kinase cascade.

Paper Code: BOTC-302 (P)
Paper Title: Plant Metabolism (Practical)
Credit: 2

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

Suggested readings

1. Bhatla, S.C., Lal, M.A. 2018. Plant Physiology, Development and Metabolism. Singapore: Springer.
2. Buchanan, B., Gruissem W., Jones, R.L. (Eds) 2015 Biochemistry and Molecular Biology of Plants. Second Edition. Paper back. Wiley-Blackwell.
3. Harborne, J.B. 1973. Phytochemical Methods. John Wiley & Sons. New York Hopkins, W.G. and Huner, A. 2008. Introduction to Plant Physiology. 4th edition. John Wiley and Sons.U.S.A.
4. Heldt, H.W., B. Piechulla, B. 2019. Plant Biochemistry. 4th Edition. Paperback. Academic Press.
5. Jain V.K.2016. Fundamentals of Plant Physiology 18th edition. New Delhi, India: S. Chand & Company Pvt. Ltd.
6. Jones, R.,Ougham, H., Thomas,H.,Waaland, S. 2013. The molecular life of plants. Chichester, England: Wiley-Blackwell.Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A 2015. Plant Physiology and Development. 6th edition. Sinauer Associates Inc. USA.
7. Nelson, D.L., Cox, M.M. 2017. Lehninger Principle of Biochemistry, 7th edition. New York, NY: W.H. Freeman, Macmillan learning.
8. Salisbury F.B., Ross C.W. 2006. Plant Physiology 4th edition. Delhi, India: CBS Publishers and Distributors.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

- Week 1 : Lecture
- Week 2: Lecture
- Week 3: Lecture

- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings and recording experimental findings as practical record books
2. Highlighting the experimental models and results through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Concept of Metabolism and Photosynthetic pigments	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Carbon Assimilation, Metabolism and Oxidation	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	ATP-Synthesis	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Lipid and Nitrogen Metabolism, Mechanism of Signal Transduction	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

CoreCourse – Ecology and Phytogeography

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-303**		**BOTC-304(P)**	

Course Objective

To gain knowledge on ecology and basic ecological concepts, inter-relation between the living world and environment and also to make students them aware about hytogeographical regions.

Learning Outcomes

On completion of this course, students will gain knowledge and will be able to:

1. Understand the complex interrelationship between organisms and environment
2. Acquire knowledge on different methods for vegetation analysis
3. Evaluate community patterns and processes including ecosystem functions
4. Understand evolving strategies for sustainable natural resource management and biodiversity conservation.
5. Attain knowledge on principles of phytogeography and plant endemism
6. Gain practical knowledge on different instruments used for analyzing soil & climate variables
7. Conduct qualitative and quantitative analysis for different parameters of both soil and water

Paper Code: BOTC-303
Paper Title: Ecology and Phytogeography (Theory)
Credit: 4

Unit I: Introduction **15 lectures**

Brief History, Basic concepts; Levels of organization; Inter- relationships between the living world and the environment; Ecosystem dynamics and homeostasis; Soil formation, types and profile development, physical and chemical properties of soil.

Unit II: Population ecology and plant adaptations **15 lectures**

Distribution and characteristics of populations; Population growth and dynamics; Ecological Speciation (Ecads, ecotypes, ecospecies, etc.); Mortality natality; r and k selection; Types of biotic interactions, Inter and intra-specific competition

Unit III: Ecosystem and plant communities **20 lectures**

Structure; Types; Processes; Trophic organization; Food chains and Food webs; Ecological pyramids; Principles and modes of energy flow, Production and productivity, biogeochemical cycling; Ecological efficiencies; Concept of ecological amplitude; Habitat and Ecological niche; Community characters; Ecotone and edge effect; Methods to studying vegetation; Concepts of plant succession and climax.

Unit IV: Phytogeography **10 lectures**

Phytogeographic regions of the world and India; Static and dynamic phytogeography; Continental drift; Theory of tolerance; Endemism; Major terrestrial biomes; Vegetation of N.E. India with special reference to Manipur.

Paper Code: BOTC-304(P)
Paper Title: Ecology and Phytogeography (Practical)
Credit: 2

1. Familiarization of instruments used to measure microclimatic variables: Soil moister meter, conductivity meter, maximum and minimum thermometer, anemometer, hygrometer, rain gauge, lux meter etc.
2. Determination of pH of soil and water samples
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency of soil samples by field testing kits.
4. Determination of soil organic matter rapid titration method.
5. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
6. Study of morphological adaptations of hydrophytes and xerophytes.
7. Determination of minimal quadrat size for the study of herbaceous vegetation by species area curve method.
8. Quantitative analysis of herbaceous vegetation for frequency and comparison with Raunkiaer's frequency distribution.
9. Quantitative analysis of herbaceous vegetation for density and abundance
10. Field visit to familiarize students with different biomes, ecosystems and vegetation.

Suggested readings

1. Ambasht, R.S, and Ambasht, N.K. 2008. A text book of Plant Ecology, CBS Publishers & Distributors PVT. LTD. 14th Edition.
2. Kormondy, E.J. 2017. Concepts of Ecology. India:Pearson India Education Services Pvt. Ltd. 4th edition.
3. Majumdar, R. and Kashyap, R. 2019. Practical Manual of Ecology and Environmental Science, New Delhi, India: Prestige Publishers.Odum, E.P. 2005. Fundamentals of Ecology. New Delhi, India: engage Learning India Pvt. Ltd., 5th edition.
4. Sharma, P.D. 2015. Ecology and Environment. Meerut, India: Rastogi Publications. 12th edition.
5. Singh, J.S., Singh, S.P., Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. New Delhi, India: S. Chand.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops

4. Peer teaching and learning
5. Question preparation
6. Subjective type
    - Long answer
    - Short answer
7. Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
8. Practical
9. Field-based learning
10. Substantial laboratory-based practical component and experiments
11. Games
12. Technology-enabled learning
13. Internship in industry, and research establishments

Teaching Learning Plan:

- Week 1 : Lecture
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- Week 4: Lecture
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- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

3. Drawings and recordings from the temporary preparations and experiments as practical record books
4. Highlighting the salient features of experimental model and results, genera/ groups through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Introduction	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Population ecology and plant adaptations	Class room lectures, demonstrations and	Hands on exercises, PPT,

		Practical	assignments, tests
III	Ecosystem and plant communities	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Phytogeography	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

CoreCourse – Genetics and Cytogenetics

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-305**		**BOTC-306(P)**	

Course Objective

To gain knowledge on Mendel's laws of inheritance, chromosome theory of inheritance, gene structure, gene interaction, recessive and dominant traits, extra-nuclear inheritance, linkage and crossing over, chromosome mapping, gene mapping, variation in chromosome number, euploidy, aneuploidy, amphiploidy, mutation, sex determination and sex chromosomes, genetic variation and speciation.

Learning outcomes

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

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

Paper Code: BOTC-305

Paper Title: Genetics and Cytogenetics (Theory)
Credit: 4

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

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

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

Determining non-Mendelian Inheritance; Maternal effects and cytoplasmic inheritance; Chloroplast mutation: Variegation in Four O'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in Paramecium. Linkage and crossing over; Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Linkage and Gene mapping, and numericals based on gene mapping;

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

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

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

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

Paper Code: BOTC-306(P)
Paper Title: Genetics and Cytogenetics (Practical)
Credit: 2

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

Suggested readings

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

Teaching Learning Process

15. Class lectures
16. Seminars
17. Group discussions and Workshops
18. Peer teaching and learning
19. Question preparation
20. Subjective type
    - Long answer
    - Short answer
21. Objective type
22. Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
23. Practical
24. Field-based learning
25. Substantial laboratory-based practical component and experiments
26. Games
27. Technology-enabled learning
28. Internship in industry, and research establishments

Teaching Learning Plan:

- Week 1: Lecture
- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Principles of genetics and Biology of Inheritance	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Extra-nuclear Inheritance, Linkage, crossing over and chromosome mapping	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Variation in Chromosome Number and Structure, Mutations	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Fine Structure of Gene, Gene Interaction, Population and Evolutionary Genetic	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course – Algal Biotechnology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-301**		**BOTG-302(P)**	

Course objective

To gain knowledge on algae based biotechnology for agricultural production and other application

Learning outcomes

On completion of this course, the students will gain knowledge and able to:

1. Identification of important algal species
2. Commercial utility of algae, cultivation and production of algal biomass
3. Importance of algae as biofertilizers

Paper Code: BOTG-301
Paper Title: Algal Biotechnology (Theory)
Credit: 4

Unit I **12 Lectures**

Introduction to algal biotechnology: Resource potential of algae; commercial utility of algae. Algae as a source of food and feed; Algae as a source of pigments, fine chemicals, fuel and bio-fertilizers.Distribution of economically important algae in India.

Unit II **15 Lectures**

Uses of the following algae: *Spirulina, Dunaliella, Haematococcus, Chlorella, Scenedesmus, Botryococcus, Porphyridium, Hypnea. Gracilaria, Gelidium, Gelidiella, Kappaphycus, Grateloupia, Sargassum, Turbinaria, Cystoseira, Laminaria, Macrocystis, Porphyra, Caulerpa* and *Ulva*.Algal production systems; Strain selection; Algal growth curve; Culture media; indoor cultivation methods and scaling up.Measurement of algal growth.Large-scale cultivation of algae.Evaporation and uniform dispersal of nutrients; Harvesting and drying of algae.

Unit III **15 Lectures**

Algal production systems; Strain selection; Algal growth curve; Culture media; indoor cultivation methods and scaling up.Measurement of algal growth.Large-scale cultivation of algae. Evaporation and uniform dispersal of nutrients; Harvesting algae. Drying.

Unit IV **18 Lectures**

Algal immobilization and its applications; Blue-green algal bio-fertilizer. Liquid seaweed fertilizer: Method of preparation and application. Biodiesel from algae: algae producing biodiesel; Advantages over other sources of biodiesel; Cultivation and extraction methods. Phycoremediation.Role of algae in nanobiotechnology.Algal culture collection centers in India and abroad and their importance; Centers pursuing algal research in India and their field of interest.

Generic Elective Course
Paper Code: BOTG-302(P)
Paper Title: Algal Biotechnology (Practical)
Credit: 2

1. Morphological study of the following algal forms - *Anabaena*, *Chlorella*, *Volvox*, *Chara*, *Ectocarpus*, *Sargassum*, *Polysiphonia* and *Gracilaria*.
2. Algal Biotechnology: Cultivation of algae in - Chu 10 medium (Demonstration only).
3. Study of economically important products obtained from algae
4. Field visit / trip to collect algal specimens - algae herbaria (5 numbers) to be submitted.
5. Visit to algal biotechnology laboratories.

Suggested readings

1. Barsanti, Laura and Paolo Gualtieri 2005 Algae-Anatomy, Biochemistry and Biotechnology. Taylor & Francis, London, New York.
2. Becker, E.W. 1994 Microalgae-Biotechnology and microbiology. Cambridge University Press.

3. Chandramohan, D. 2007. Prospects of Biodiesel from marine microorganisms. Proceedings of the National Workshop on BIODIESEL, Organised by School of Energy, Environment & Natural Resources, Madurai Kamaraj University, Madurai and Ahimsa Agri division, Chennai, 17th and 18th October, 2007.
4. Trivedi, P.C. 2001 Algal Biotechnology. Pointer publishers, Jaipur, India.
5. Venkataraman, L.V. and E.W. Becker 1985. Biotechnology and Utilization of Algae – The Indian Experience. Dept. Science and Technology, New Delhi and Central Food Research Institute, Mysore, India.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical

15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings form the temporary preparations as practical record books
2. Highlighting the properties of the organisms in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course - Intellectual Property Rights

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-303**		**BOTG-304 (P)**	

Course objective

To provide knowledge on roles regulations, laws and processes of patents, copyright trademarks and concepts of traditional knowledge and protection of plant varieties

Learning outcomes:

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

1. Understand the concept of IPR and their importance
2. Differentiate between various agreements of IPR
3. Compare copyrights, patents and Geographical Indicators
4. Think about the importance of traditional knowledge, bio-prospecting, bio piracy.
5. Examine various legal and cyber issues related to IPR
6. Gain the knowledge of farmer rights and the importance on indigenous plant varieties, concept of novelty and biotechnological inventions

Paper Code: BOTG-303
Paper Title: Intellectual Property Rights (Theory)
Credit: 4

Unit I: Introduction to Intellectual Property Right (IPR) 15 lectures
IPR - Concept and kinds, Copyright Act and IPR, Economic importance. IPR in India and world: Genesis and scope, IPR and WTO (TRIPS, WIPO). Objectives, Rights, Major International Instruments concerning Intellectual Property Rights: Paris Convention, 1883, the Berne Convention, 1886, the Universal Copyright Convention, 1952, the WIPO Convention, 1967,the Patent Act 1970 and its amendments, the TRIPS Agreement, 1994.

Unit II: Patents, Copyrights, Trademarks and Geographical Indications 15 lectures
Procedure of obtaining patents, working of patents. Infringement of patents, Copyrights: work protected under copyright laws, Rights, Transfer of Copyright, and Infringement. Trademarks: Objectives of trademarks, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name; Geographical Indications: Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position

Unit III: Protection of Traditional Knowledge and Plant Varieties 15 lectures
Objective, Concept of Traditional Knowledge, Holders, Issues concerning, 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, Traditional Knowledge Digital Library; Plant varieties – objectives, justification, Plant varieties protection in India, Rights of farmers, National gene bank; Benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit IV: Information Technology Related IPR 15 lectures
Computer Software and Intellectual Property, Database and Data Protection, Protection of Semiconductor chips, Domain Name Protection.Patenting Biotech Inventions: Objective, Applications, Concept of Novelty; Concept of inventive step, Microorganisms, and Moral Issues in Patenting Biotechnological inventions.

Paper Code: BOTG-304(P)
Paper Title: Intellectual Property Rights (Practical)
Credit: 2

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

Recommended Books:

1. Gopalakrishnan, N.S. and Agitha, T.G. (2009). Principles of Intellectual Property Eastern Book Company, Lucknow.
2. David Kitchin Q.C., Llewelyn, D., Mellor, J., Meade, R., Thomas Moody-Stuart, and D. Keeling, Jacob, R. (2005). Kerly's Law of Trade Marks and Trade Names (14th Edition) Thomson, Sweet & Maxweel.
3. Parulekar, A. and D' Souza, S. (2006). Indian Patents Law – Legal & Business Implications; Macmillan India Ltd.
4. Wadehra, B.L. (2000). Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India.
5. Narayanan, P. (2010). Law of Copyright and Industrial Designs; Eastern law House, Delhi.
6. 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)
7. Gogia, SP. On Intellectual Property Rights (IPR). Hyderabad: Asia Law House
8. Bhandari, M.K. (2017). Law Relating to Intellectual Property Rights (IPR). Allahabad: U.P.: Central Law Publications.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type

- Long answer
- Short answer

7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
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12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
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9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Introduction to Intellectual Property Right (IPR)	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Patents, Copyrights, Trademarks and Geographical Indications	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Protection of Traditional Knowledge and Plant Varieties	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Information Technology Related IPR	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course – Medicinal and Aromatic Plants

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**

Paper Codes	BOTG-305		BOTG-306 (P)	

Course Objective

To provide knowledge of medicinal and aromatic plants- their diversity, conservation, propagation, plantation, harvesting, active ingredients, extraction, storage, role in traditional health care system, marketing, importance as industrial crops, etc.

Learning outcomes:

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

1. Identify important medicinal and aromatic plants
2. Apply techniques of conservation and propagation of medicinal and aromatic plants
3. Setup process of harvesting, drying and storage of medicinal herbs
4. Comprehend the extraction methods of essential oils from aromatic plants
5. Propose new strategies to enhance growth of medicinal herbs considering the practical issues pertinent to India.

Paper Code: BOTG-305
Paper Title: Medicinal and Aromatic Plants (Theory)
Credit: 4

Unit I: Introduction to Medicinal and Aromatic Plants 15 Lectures

Definition, History, Importance and future prospects of Medicinal and Aromatic Plants (MAPs), MAPs resources and diversity in India and Manipur, Medicinal Plants – past and present status in world and India.MAPs as industrial crops - constraints and remedial measures, MAPs in Local and Traditional health care systems in India – Ayurveda, Siddha and Unani (Definition, history, origin and scope), MAPs as Non-timber forest products (NTFPs).

Unit II: Propagation, Collection and Conservation 15 Lectures

Survey and assessment of MAPs, Collection and processing of MAPs, Sustainability and threats to MAPs; concept of sustainable harvesting and management of MAPs; Conservation of Endemic and endangered MAPs, In situ conservation(Biosphere reserves, sacred groves, National Parks); Ex situ conservation(Botanic Gardens, Ethno medicinal plant Gardens); Propagation of Medicinal Plants - Objectives of the nursery, sowing, pricking, use of green house for nursery production, propagation through cuttings, layering, RET species and their conservation.

Unit III: Value and Utilisation of MAPs 15 Lectures

Value and uses: Introduction and Use pattern of Medicinal and Aromatic Plants, Present scenario of MAPs based industry in India, MAPs based small scale industries in Manipur, Types of MAPs based consumer products present in Manipur market, Uses and Status of MAPs in Manipur. Utilization of MAPs as - raw materials, Ayurveda products, allopathic medicine, aroma therapy, essential oil and extracts, Industrial use of MAPs (Food, flavors, perfumes, cosmetics, spices and condiments, pharmaceuticals), Domestication potentiality of MAPs, Extraction methods Parts used for medicine of commercially valuable plants

Unit IV: Selected Medicinal and Aromatic Plants 15 Lectures

Study of medicinal with respect to their Botanical name, vernacular name, parts used, active ingredients and uses -

Medicinal plants: Periwinkle, *Rauvolfia*, *Dioscorea*, *Withania*, Belladona*, Cinchona*, Foxglove (*Digitalis*), *Tinospora*, Nux-vomica, *Solanum sps, Adhatoda sps. Artemesia, Aloe vera.*Turmeric

Study of aromatic plants with respect to their Botanical name, vernacular name, parts used, active ingredients; Extraction Methods, storage and utilisation of essential oils.

Aromatic Plants: Citronella and Lemon grass, Khus Khus grass (Vetiver), sweet flag (bach), Jasmine, Roses, Lavender, Eucalyptus, Ginger, *Mentha sps,* Camphor plant, Sandalwood, Patchouli (*Pogostemon*); Extraction Methods, storage and utilisation of essential oils.

Paper Code: BOTG-306(P)
Paper Title: Medicinal and Aromatic Plants (Practical)
Credit: 2

1. Collection and Identification of medicinal and aromatic plant found locally in Manipur and preparation of herbarium specimens.
2. Study of less known aromatic plants used in Manipur as foods and Sample collection of these plants.
3. Simple tests for the presence of alkaloids in plants.
4. Organoleptic study of some drug plants – Ginger, *Adhatoda, Rauvolfia, Cinchon*a, Turmeric, Mints. *Solanum* spp.
4. Study of medicinal and aromatic plants - propagation techniques – harvesting and oil extraction of aromatic plants.
5. Study of locally prepared herbal tea, shampoo, face wash, any other lotions for different uses and medicine (Ingredients, method of preparation, doses storage),
6. Field visit, collection and preparation of herbarium specimens.
7. Visit to a commercial unit of essential oil extraction facility

Suggested readings

1. S.K. Bhattacharjee (2004). Hand Book of Aromatic Plants. Pointer Publishers, Jaipur.
2. S.K. Bhattacharjee (2020). Handbook of Medicinal Plants.Pointer Publishers, Jaipur.
3. L.D. Kapoor (2005). Handbook of Ayurvedic Medicinal Plants.CRC Press.
4. S.L. Kochhar (2007). Economic Botany in the Tropics.MacMillan India.
5. V.V. Sivarajan, V. V. and I. Balachandran (1994).Ayurvedic Drugs and their Plant Sources.Oxford & IBH.
5. Godagama Shantha (2004). The Handbook of Ayurveda.North Atlantic Books.
6. Thakur, R. S., Puri, H. S. and Husain, A. (1989). *Major medicinal plants of India*.Central Institute of Medicinal and Aromatic Plants, Lucknow, India.
7. Kala, C.P. (2010). Medicinal Plants of Uttarakhand: Diversity, Livelihood and Conservation. Biotech Books, Delhi.
8. Trivedi, P.C. (2009). Indian Medicinal Plants.Aavishkar Publishers & Distributors.
9. Samant, S.S., Dhar, U. and Palni, L. M. S. (1998). Medicinal Plants of Indian Himalaya: diversity distribution potential values. G. B. Pant Institute of Himalayan Environment and Development, Almora.
10. Kirtikar, K.R. and Basu, B.D. (1999). Indian Medicinal Plants (Vol 1- 4).International Book Distributors.
11. Sharma, R. (2013). Agro Techniques of Medicinal Plants. Daya Publishing House, Delhi.

12. Akerele, O., Heywood, V. and Synge, H. (1991). The Conservation of Medicinal Plants. Cambridge University Press.
13. Jain, S.K. and Jain, Vartika. (eds.) (2017). Methods and Approaches in Ethnobotany: Concepts, Practices and Prospects. Deep Publications, Delhi.
14. Kapoor, L. D. (2001). *Handbook of Ayurvedic medicinal plants.*Boca Raton, FL: CRC Press.
15. Saroya, A.S. (2017). Ethnobotany.ICAR publication.
16. Sharma, R. (2003). Medicinal Plants of India-An Encyclopaedia. Delhi: Daya Publishing House.
17. Thakur, R. S., H. S. Puri, and Husain, A. (1989). *Major medicinal plants of India*.Central Institute of Medicinal and Aromatic Plants, Lucknow, India.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical

12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings form the temporary preparations as practical record books
2. Collection and preparation of herbaria
3. Highlighting the properties of the important species in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Introduction to Medicinal and Aromatic Plants	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Propagation, Collection and Conservation	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Value and Utilisation of MAPs	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Selected Medicinal and Aromatic Plants	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Semester- IV

Core Course - Economic Botany and Plant Resource Utilization

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-401**		**BOTC-402(P)**	

Course objectives

To make the students familiar with economic importance of diverse plants that offer resources to human life and to emphasize the use of plants as food, medicine and for other utilities with huge economic value etc.

Learning outcomes

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

1. Understand the core concept of Economic Botany and its relationship with environment and society
2. Develop first-hand information of plants used as food, the various kinds of nutrients available in the plants
3. Understand the dietary requirements of proteins, fats, amino-acids, vitamins etc that can be met by plants
4. Learn to perform the micro-chemical tests to demonstrate various components.
5. Learn about the use of fiber plants, beverages, fruits and vegetables that are integral to day to day life of plants
6. Learn to explore the regional diversity in food crops and other plants and their ethno-botanical importance as well.

Core Course
Paper Code: BOTC-401
Paper Title: Economic Botany and Plant Resource Utilization (Theory)
Credit: 4

Unit I: Origin and Conservation of Cultivated Plants 15 lectures

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

Unit II: Botany, Utilization of Plant Wealth (Cereals and Millets, Fruits, Pulses and Legumes, Sources of Sugars and Starches) 15 lectures

Origin, evolution and biosystematics, morphology, and uses of some selected crops: Cereals-wheat, rice, maize, sorghum, pearl millet and minor millets.
Fruits: Citrus and pineapple (origin, morphology, anatomy and uses).
Pulses: Origin, morphology, uses, importance to man and ecosystem of pulses (pigeon pea, chickpea, black gram, greengram, cowpea, soyabean, pea, lentil, horsegram), and legumes (lab-lab bean, ricebean, winged bean, French bean, lima bean, sword bean). Morphology and processing of sugarcane, products and by-products.Morphology, propagation and uses of potato, sweet potato and tapioca.

Unit III: Botany, Utilization of Plant Wealth (Spices, Beverages, Oil Seeds Fats and Essential Oils) 15 lectures

Spices: Listing of important spices (cardamom, cinnamon, tejpat, anise, cumin, tamarind, asafoetida, fenugreek, fennel, coriander), their botanical name, family and part used. Origin, distribution, ecology, botany, cultivation practices, processing of economic plant part,

product, main chemical constituents, and economic importance of the major spices, namely turmeric, ginger, capsicum, black pepper, coriander.

Beverages: tea and coffee: History, origin, growing countries, botany, cultivation practices, common diseases and pests, major chemical constituents, processing and quality control of economic product.

Oil seeds and fats: General description, classification, extraction and uses of groundnut, coconut, linseed, soybean, mustard. Essential oils: General description, uses extraction / distillation of essential oil, chemical constituents of major essential oil yielding aromatic plants, namely rose, geranium, lemongrass/citronella, menthol mint, basil, lavender, eucalyptus, clove, camphor and sandal wood.

Unit IV: Botany, Utilization and Processing of Plant Wealth (Aromatic Plants, Drug-yielding and Medicinal Plants, Timber Plants) 15lectures

Drug-yielding and medicinal plants: fumitories and masticatories: processing, therapeutic uses, and health hazards of habit-forming drugs, botany and cultivation / regulatory practices of such drug yielding plants with special reference to papaver, cannabis and tobacco.

Major medicinal plants : Botany, uses, cultivation and processing of major medicinal plants, namely: ashwagandha, bhuvati, asparagus, ghrita kumari (*Aloe vera*), quinghao (*Artemisia annua*), isabgol, senna, amla (*Phyllanthus*), *Stevia*, sarpagandha (*Rauvolfia*), *Atropa*, *Digitalis*, licorice, ningthoukhongli (*Tinospora*).
Natural Rubber: Pararubber: tapping, processing and uses.
Timber plants and Fibres: General account and botany of the tree, wood structure and quality characteristics, and timber processing with special reference to *Dipterocarpus*, teak and pine. General account of the fiber yielding plants, classification based on the origin of fibers, extraction, processing, morphology and uses of fibers, with special reference to cotton, sunhemp, flax.
Pharmacognosy: Aims and objectives, definition, preparation of drugs for commercial market.

Core Course
Paper Code: BOTC 402(P)
Paper Title: Economic Botany and Plant Resource Utilization (Practical)
Credit: 2

1. Cereals: Wheat (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests) Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. Legumes: Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. Sources of sugars and starches: Sugarcane (habit sketch; cane juice- micro-chemical tests), Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains, micro-chemical tests).
4. Spices: Black pepper, Fennel, *Curcuma* and Clove (habit and sections).

5. Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. Sources of oils and fats: Coconut- T.S. nut, Mustard–plant specimen, seeds; tests for fats in crushed seeds.
7. Essential oil-yielding plants: Habit sketch of *Rosa* and *Cymbopogon* spp., Mint, Basil, Eucalyptus (specimens/photographs).
8. Rubber: specimen, photograph/model of tapping, samples of rubber products.
9. Drug-yielding plants: Specimens of *Artemisia*, *Phyllanthus*, *Papaver* and *Cannabis*.
10. Tobacco: specimen and products of Tobacco.
11. Woods: *Tectona*, *Pinus*: Specimen, Section of young stem.

Suggested Readings

1. Chrispeels, M.J. and Sadava, D.E. 1994. Plants, Genes and Agriculture. Jones & Bartlett Publishers.
2. Kochhar, S.L. 2012. Economic Botany in Tropics. New Delhi, India: MacMillan & Co.
3. Lim, T.K. 2012. Edible Medicinal and Non-Medicinal Plants. Springer Dordrecht Heidelberg London New York
4. Sambamurty, AVSS and Subrahmanyam, N.S. 2008. A Textbook of Modern Economic Botany. 1st Edition, Paperback . CBS Publishers & Distributors Pvt.Ltd.; 1st edition
5. Wickens, G.E. 2001. Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practicum, and project-based learning
9. Field-based learning
10. Substantial laboratory-based practical component and experiments
11. Open-ended project work,
12. Games
13. Technology-enabled learning
14. Internship in industry, and research establishments

Teaching Learning Plan:

- Week 1 : Lecture
- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

3. Drawings and illustrations may be made a compulsory part of practical record books
4. Highlighting the salient features of plant products through digital media such as ppt and animations.

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Origin and conservation of Cultivated Plants	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Botany, Utilization of Plant Wealth (Cereals and Millets, Fruits, Pulses and Legumes, Sources of Sugars and Starches)	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Botany, Utilization of Plant Wealth (Spices, Beverages, Oil seeds fats and Essential oils)	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Botany, Utilization and Processing of Plant Wealth (Aromatic Plants, Drug-yielding and	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

	Medicinal plants, Timber plants)		

Core Course – Molecular Biology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-403**		**BOTC-404(P)**	

Course Objective

To gain the knowledge of structure and functions of DNA and RNA and insights into biotechnological application in plant, animal and microbes.

Learning outcomes

On completion of this course, the students will gain knowledge and able to:

1. Develop an understanding of nucleic acid, organization of DNA in prokaryotes and eukaryotes, DNA replication mechanism, genetic code and transcription process.
2. Understand the mechanisms involved in processing and modification of RNA and translation process, function and regulation of expression.
3. Gain insights into the application in biotechnology in plant, animal and microbial sciences

Paper Code: BOTC-403
Paper Title: Molecular Biology (Theory)
Credit: 4

Unit I **12 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 II **15 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, *Cot* 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 III **18 Lectures**

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

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 IV **15 Lectures**

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

Paper Code: BOTC-404(P)
Paper Title: Molecular Biology (Practical)
Credit: 2

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. Numerical based on DNA re-association kinetics (melting profiles and *Cot* 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

Suggested readings

1. Klug, W.S., Cummings, M.R., Spencer, C.A. 2009. Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
2. Russell, P. J. 2010. iGenetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
3. Snustad, D.P. and Simmons, M.J. 2010. Principles of Genetics. John Wiley and Sons Inc.,U.S.A. 5th edition
4. 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

Teaching Learning Process

1. Class lectures

2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings form the temporary preparations as practical record books
2. Highlighting the properties of the molecules through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and	Hands on exercises, PPT,

		Practical	assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Core Course – Plant Morphology and Anatomy

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-405**		**BOTC-406(P)**	

Course Objective

To provide basic knowledge of plant external and internal architecture and cellular composition, their evolution and modification of their functions with respect to their environment.

Learning outcomes

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

1. Develop an understanding of concepts and fundamentals of plant morphology and anatomy
2. Use various morphological terminologies while describing a plant
3. Understand the Knowledge of various cells and tissues, meristem, epidermal and vascular tissue system in plants.
4. Develop critical understanding on the evolution of concept of organization of shoot and root apex.
5. Correlate the anatomical structure with morphology and functions.
6. Analyze the composition of different parts of plants and their relationships
7. Evaluate the adaptive and protective systems of plants

Paper Code: BOTC – 405
Paper Title: Plant Morphology and Anatomy (Theory)
Credit: 4

Unit I: Morphology of vegetative organs **15 lectures**

Importance of plant morphology, Parts of an angiospermic. Morphology and characteristic of root, Types of root system, Regions of the root, Modifications of root, Morphology and characteristic of stem, Forms of stem, Bud and its modifications, Habit of the plant: parasitic, mycoheterotropic and epiphytic plants, Modifications of stem, Types of branching,

Functions of stem Morphology of leaf, Parts of a leaf, types of leaves, types of stipules and their modifications, leaf blade w.r.t. apex, margin, and shape, Venation, Simple and compound leaves, Modifications of leaves, Phyllotaxy Functions of leaves,

Unit II: Morphology of reproductive organs **15 lectures**

inflorescence: Definition, Classification of inflorescences - Racemose and its types and Cymose and its types, Flower as a modified shoot, structure of flower, types of flower, thalamus, bracts, Symmetry of the flower, Calyx and its modifications, Forms of corolla Androecium: Parts of stamen, cohesion of stamens, adhesion of stamens, length of stamens; Gynoecium: Parts of carpel, simple and compound gynoecium, cohesion of carpels, placentation and its types; Fruit: Definition, Parts of fruit, Classification of fruits, Dispersal of seeds and fruits; Seed: Definition, Parts of dicotyledonous and monocotyledonous seeds, Seed germination and its types.

Unit III: Internal organization and primary plant body **15 lectures**

Tissues: Definition, classification of tissues – Meristem, Simple and complex tissues, Pits and plasmodesmata; Wall ingrowths and transfer cells; Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cyto-histological zonation); Types of vascular bundles; Structure of dicot and monocot stem.Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, KorperKappe theory); Quiescent centre; Structure of dicot and monocot root; Mechanical tissues and their distribution. Root- stem Transition.

Unit IV: Secondary growth and protective and adaptive system **15 lectures**

Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Anomalous secondary growth; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Hard and Soft wood Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm, rhytidome and lenticels. Epidermal tissue system: cuticle, trichomes (uni-and multicellular, glandular and non-glandular, two examples of each); stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes. Applications of anatomy in systematics, forensics and Pharmacognosy

Paper Code: BOTC – 406(P)
Paper Title: Plant Morphology and Anatomy (Practical)
Credit: 2

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

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

Recommended Books

1. Bhattacharya H., Ghosh. 2017. A Textbook of Botany, Vol I – IV, NCBA, Kolkata
2. Dickison, W.C. 2000. Integrative Plant Anatomy. Harcourt Academic Press, USA.
3. Evert, R.F. 2006. Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc Fahn, A. 1974. Plant Anatomy. Pergmon Press, USA.
4. Mauseth, J.D. 1988. Plant Anatomy. The Benjammin/Cummings Publisher, USA.
5. Mitra, J.N. D. Mitra, D., S.K. Chowdhuri, S.K. 2017. Studies in Botany Vol. 1 and 2, Moulik Library, Kolkata.
6. Pandey, B.P. 2001. Plant Anatomy, S. Chand Publishing, New Delhi
7. Vasistha, P.C. 2000. Plant Anatomy, Pradeep Publications, Jalandhar.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
    - Long answer

- Short answer

7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings form the temporary preparations as practical record books
2. Highlighting the properties of the cellular details and tissues through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Morphology of vegetative organs	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Morphology of reproductive organs	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Internal organization and primary plant body	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Secondary growth and protective and	Class room lectures, demonstrations and	Hands on exercises, PPT,

	adaptive system	Practical	assignments, tests

Generic Elective Course - Seed Technology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-401**		**BOTG-402(P)**	

Course Objective
To provide knowledge on seed development, processing and various tools associated with seed technology and their application

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

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

Paper Code: BOTG-401
Paper Title: Seed Technology (Theory)
Credit: 4

Unit I **15 lectures**
Theory of seed development and morphology, Principles of seed production in agricultural crops, seed production in vegetables, fruits, flowers, forage and fodder crops. Seed dormancy: possible reasons and methods of breaking of dormancy.

Unit II **15 lectures**
Concept of seed processing, diversity in seed storage and viability issues, Methods of testing of seed viability. Behaviour of seed germination and concept of speed of germination/seed vigour, design of experiments for evaluation of seed related traits.

Unit III **18 lectures**
Methods used for seed testing, ISTA (International Seed Testing Association) Rules procedure of seed certification and quality control, basis outlines of seed pathology and seed entomology.

Unit IV **12 lectures**
Economics of seed production and marketing, seed production in medicinal and aromatic plants, Concept of hybrid seed and production

Paper Code: BOTG-402(P)
Paper Title: Seed Technology (Practical)
Credit: 2

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

Suggested readings

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

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture

2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings form the temporary preparations as practical record books
2. Highlighting the properties of seed types and production technology in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course - Food Science

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-403**		**BOTC-404(P)**	

Course Objective

To gain knowledge on nutritional components on food, food processing and food preservation techniques

Learning outcomes

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

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

Paper Code: BOTG-403
Paper Title: Food Science (Theory)
Credit: 4

Unit I **12 lectures**

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

Unit II **15 lectures**

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

Unit III **18 lectures**

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

Unit IV **15 lectures**

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

Paper Title: Food Science (Practical)
Paper Code: BOTG-404(P)

Credit: 2

1. Non-thermal and thermal methods of food preservations
2. Meat and Poultry processing technology
3. Post-harvest technology at small scale
4. Food drying
5. Fermentation technology
6. Project work
7. Industrial visit
8. Fruit and vegetables processing
9. Determination of
    a. Moisture of food samples
    b. Protein
    c. Ash
    d. Fat
    e. Sugars- reducing and non-reducing

Suggested readings

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

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
    - Long answer
    - Short answer

7. Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
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5. Week 5: Lecture/Practical
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10. Week 10: Mid semester Exam
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12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings form the temporary preparations as practical record books
2. Highlighting the properties of food products and technology in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course – Industrial Microbiology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-405**		**BOTC-406(P)**	

Course Objective

To introduce students with the industrial microbiology: concepts, principles, scope and application

Learning outcomes

On completion of this course, the students will gain knowledge and 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

Paper Code: BOTG-405
Paper Title: Industrial Microbiology (Theory)
Credit: 4

Unit I **18 Lectures**

Scope of microbes in industry and environment; institutes of microbial research. 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 II **15 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 III **12 Lectures**

Production of industrially important products: enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin). Microbial fermentations, antibiotics, vaccines. Microbes in bioremediation

Unit IV **15 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

Generic Elective Course
Paper Code: BOTG-406(P)
Paper Title: Industrial Microbiology (Practical)
Credit: 2

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. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations and a report to be submitted.

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.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). *Microbiology*. San Francisco, SF: Pearson Benjamin Cummings,. 9th edition
3. Stanbury, P.F., Whitaker, A., Hall, S.J. (2016) *Principles of Fermentation Technology***.** Amesterdam, NDL**:**Elsevier Publication
4. Patel, A.H. (2008) *Industrial Microbiology*, Bangalore, India: McMillan India Limited
5. Mohapatra. P.K. (2008). *Textbook of Environmental Microbiology* New Delhi, Delhi, I.K. International Publishing House Pvt.Ltd.
6. Bertrand, Jean-Claude, Caumette, P. , Lebaron, P, Matheron, R., Normand, P., Sime-Ngando, T. (2015) *Environmental Microbiology: Fundamentals and Applications*. Amesterdam, Netherlands, Springer
7. Joe, S., Sukesh (2010). *Industrial Microbiology*. New Delhi, Delhi: S.Chand & Company Pvt. Ltd.,
8. Casida, J.R. (2016). *Industrial Microbiology.* New, Delhi, Delhi, New Age International Publishers

9. Atlas, Bartha. (1997). *Microbial Ecology: Fundamentals and Applications*. San Fransisco, SF. Pearson
10. Sharma, P.D. (2005).,*Environmental Microbiology*. Meerut, UP: Alpha Science International, Ltd

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
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Teaching Learning Plan:

1. Week 1 : Lecture
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13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings form the temporary preparations as practical record books

2. Highlighting the properties of the industrially important micro-organisms and microbial products in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Semester V

Core Course - Reproductive Biology of Angiosperms

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-501**		**BOTC-502(P)**	

Course Objective

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

Learning outcomes:

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

1. Recall the history of reproductive biology of angiosperms and recognize the importance of genetic and molecular aspects of flower development
2. Understand structure and functions of anther wall and pollen wall
3. Evaluate the special structures of ovule
4. Solve self-incompatibility in pollination and fertilization and relate between embryos, endosperm and seed
5. Comprehend the causes of polyembryony and apomixes with its classification

Paper Code: BOTC - 501
Paper Title: Reproductive Biology of Angiosperms (Theory)
Credit: 4

Unit I: Historical Perspective and Reproduction in Plants **6 lectures**

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

Unit II: Male and Female Gametophyte Development 18 lectures

Anther and pollen biology: Anther wall: Structure and functions, micro-sporogenesis, Micro-gametogenesis; Pollen wall structure, MGU (male germ unit), NPC system (no details but table to be included); Palynology and scope (a brief account); Pollen wall proteins; Pollen viability. Unique features: Pseudomonads, polyads, massulae, pollinia. Ovule:Types of ovules; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– mega-sporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of Polygonum type); Organization and ultrastructure of mature embryo sac.

Unit III: Pollination, Fertilization and Self-Incompatibility 18 lectures

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

Unit IV: Embryo, Endosperm and Seed, Polyembryony and Apomixes 18 lectures

Structure and types of embryo; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Endosperm: types, structure and development; Embryo-endosperm relationship; Nutrition of embryo; Seed structure, importance and dispersal mechanisms. (Adaptations – Autochory, Anemochory, Hydrochory, Zoochory with 2 examples each). Polyembryony and apomixes: Introduction; Classification; Causes and applications.

Paper Code: BOTC – 502(P)
Paper Title: Reproductive Biology of Angiosperms (Practical)
Credit: 2

1. Anther: Wall structure; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bi-celled and dehisced anther stages through slides/micrographs,
2. Pollen grains: Fresh and acetolyzed pollen grrains showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test. Demonstration of pollen germination using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/ campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special

structures: Endothelium, obturator, hypostase, caruncle and aril through permanent slides/ specimens/ photographs.

4. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature embryo sac.
5. Intra-ovarian pollination; Test tube pollination through photographs.
6. Pollination and Seed dispersal mechanisms (adaptations through photographs / specimens
7. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria. Embryogenesis: Study of development of dicot embryo through permanent slides and Study of suspensor through electron micrographs.
8. Embryogenesis: Study of development of dicot embryo through permanent slides and Study of suspensor through electron micrographs.
9. Dissection of developing seeds for embryos at various developmental stages

Recommended Books:

1. Bhojwani, S.S., Bhatnagar, S.P. Dantu P. K. 2015. The Embryology of Angiosperms, 6th Edition, Vikas Publishing House, New Delhi, Delhi:
2. Johri, B.M. l 1984. Embryology of Angiosperms, Springer-Verlag, Netherlands
3. Pandey, A.K. 1997. Introduction to Embryology of Angiosperms. CBS Publishers & Distributors, New Delhi.
4. Raghavan, V. 2000. Developmental Biology of Flowering plants, Springer, Netherlands Shivanna, K.R. 2003. Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
5. Shivanna, K.R. 2003. Pollen Biology and Biotechnology. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments

10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
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12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

3. Drawings and descriptions from the temporary preparations and laboratory experiments as practical record books
4. Highlighting the properties of floral parts, process of pollination, types of embryo and seed development in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Historical perspective and reproduction in plants	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Male and female gametophyte development	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Pollination, fertilization and self-incompatibility	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Embryo, endosperm and seed, polyembryony and apomixes	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Core Course – Plant Physiology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-503**		**BOTC-504(P)**	

Course Objective

To provide knowledge on functions of plant particularly 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.

Learning outcomes:

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

1. Understand water relation of plants with respect to various physiological processes.
2. Explain chemical properties and deficiency symptoms of mineral elements in plants
3. Realize the roles of hormones in plant growth and development and their applications in agriculture and horticulture
4. Understand the role of light in various developmental processes such as flowering, germination and dormancy.
5. Understand transport mechanisms and translocation in the phloem,
6. Appreciate the commercial applications of plant physiology

Paper Code: BOTC – 503
Core Course: Plant Physiology (Theory)
Credit: 4

Unit I: Plant water relationship **15 lectures**

Diffusion, Osmosis, Imbibition and Plasmolysis; Water potential and its components, water absorption by roots, aquaporins, pathway of water movement--symplast, apoplast, transmembrane pathways, root pressure, guttation, Ascent of sap – Vital and Physical theories (cohesion-tension theory), Transpiration - Types and factors affecting transpiration, antitranspirants, mechanism of stomatal opening - starch-sugar hypothesis, proton transport theory, blue light stimulated response.

Unit II: Mineral nutrition and uptake **15 lectures**

Soil - components, types and source of plant nutrients, 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). Transport of ions across cell membrane--passive absorption: simple (Fick's law) and facilitated diffusion (carrier and

channel proteins), active absorption, uniport, co-transport (symport, antiport), role of mycorrhizae (in brief). Experimental evidence in support of phloem as the site of sugar translocation, source-sink relationship, Pressure-Flow Model, phloem loading and unloading

Unit III: Plant growth regulators **15 lectures**

A brief description on Growth, development and differentiation; Discovery, chemical nature (basic structure, precursor), bioassay, physiological roles of Auxins, Gibberellins, Cytokinins, Abscisic Acid, Ethylene; Applications of Phytohormones in agriculture and horticulture; mechanism of action of auxins; Roles of Polyamines, Brassinosteroids,and Jasmonic acid (brief introduction); Senescence and its types, Introduction of Programmed cell death(PCD).

Unit IV: Physiology of flowering and photomorphogenesis **15 lectures**

Photoperiodism – Discovery and definition, SDP, LDP and DNP, Critical photoperiod, flowering stimulus, 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); Discovery, chemical nature and photo reversibility of Phytochrome, role of phytochrome in flowering and tropisms, low energy responses (LER) and high irradiance responses (HIR), mode of action. Circadian rhythms in plants (exogenous factors and physioloical mechanism).Tropic and nastic movements.

Paper Code: BOTC – 504(P)
Core Course: Plant Physiology (Practical)
Credit: 2

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 compare the rate of transpiration from both the surfaces of a dorsiventral leaf.
8. To determine transpiration – Absorption ratio in a plant.
9. Analysis of plant ash for presence of mineral elements (Ca, Mg, Fe, Cu, P, S, Mo)
10. To study the phenomenon of seed germination (effect of light and darkness).
11. To study the induction of amylase activity in germinating barley grains.

Recommended Books

1. Bajracharya, D. 1999. Experiments in Plant Physiology: A Laboratory Manual. New Delhi, Delhi: Narosa Publishing House.
2. Bhatla, S.C., Lal, M.A. 2018. Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.

3. Buchanan, B.B. and Gruissem, W. 2015. Biochemistry and molecular biology of plants. Willy Blackwell ASPB USA.
4. Hopkins, W. G., Huner, N. P. A.(2009. Introduction to Plant Physiology, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.
5. Jain, V.K 2017. Fundamentals of Plant Physiology, S Chand Publishing, New Delhi Kochhar, S.L., Gujral, S.K. 2017. Plant Physiology: Theory and Applications. New Delhi, Delhi: Foundation Books, Cambridge University Press India Pvt, Ltd.
6. Mukherji, S., Ghosh, A.K.nd A. K., 2006. Plant Physiology, New Central Book Agency (P) Limited, Kolkata Pandey, S.N. Sinha, B.K. 2006. Plant Physiology, Vikas Publishing House Pvt Ltd. New Delhi.
7. Srivastava, H.N. 2005. Plant Physiology, Predeep Publications, Jalandhar.
8. 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.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
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5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical

9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from the temporary preparations and laboratory experiments as practical record books
2. Highlighting the physiological processes in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Plant water relationship	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Mineral nutrition and uptake	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Plant growth regulators	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Physiology of flowering and photomorphogenesis	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Discipline Specific Elective Course – Stress Physiology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTD-505**		**BOTD-506(P)**	

Learning outcomes:

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

1. Develop the understanding of concept of stress, stress factors and resistance mechanisms.
2. Explain different types of stress with examples.

3. Develop the ability for critical appraisal of various physiological mechanisms that protect the plant from environmental stress i.e. adaptation, avoidance and tolerance.
4. Analyse the role of production and scavenging mechanisms

Paper Code: BOTD - 505
Paper Title: Stress Physiology (Theory)
Credit: 4

Unit I: Concept of Plant Stress and Strain **12 lectures**
Stress and Strain terminology; Abiotic and Biotic Stress; Stress and stress factors, Resistance Mechanisms; Tolerance, Acclimation and avoidance.

Unit II: Abiotic and Biotic Stress Factors **18 lectures**
Water stress; Salinity stress, High light stress; UV and Ionizing radiation injury: Temperature stress; mechanism of tolerance, Hypersensitive reaction; Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates. Signal transduction and various mechanisms of acquiring resistance. Pyrethroids, isoprenoids and allelopathy.

Unit III: Stress Sensing Mechanisms in Plants **14 lectures**
Signalling: Hormonal, Calcium modulation, Phospholipid signaling.

Unit IV: Developmental and Physiological Mechanisms that Protect Plants Against Environmental Stress **16 lectures**
Adaptation in plants; Changes in root:shoot ratio; Aerenchyma development; Osmotic adjustment; Compatible solute production.
Reactive oxygen species: Production and scavenging mechanisms of ROS.

Paper Code: BOTD – 506(P)
Paper Title: Stress Physiology (Practical)
Credit: 2

1. Determination of osmotic potential and RWC in plant tissue.
2. Effect of light/Temperature on pigment oxidation.
3. Determination of oxidative damage in tissue using TBARS method.
4. Morphological and anatomical variations in plants under stress (such as number of stomata/chl-a/b ratio and anatomical variations).
5. Stress induced organic solute Proline as a physiological marker of stress.
6. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.
7. Superoxide activity in seedlings in the absence and presence of salt stress.
8. Zymographic analysis of peroxidase, superoxide dismutase, and catalase.ive estimation and zymographic analysis of glutathione reductase.

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

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. 4th edition. John Wiley and Sons., U.S.A.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A. (2015). Plant Physiology and Development. 6th edition. Sinauer Associates Inc., USA.
3. Singh D.P. (2003). Stress Physiology. New Age

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
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4. Week 4: Lecture
5. Week 5: Lecture/Practical
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8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical

15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from the temporary preparations and laboratory experiments as practical record books
2. Highlighting the properties of stress related biomolecules and mechanisms of stress sensing and protection in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Concept of plant stress and strain	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Abiotic and biotic stress factors	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Stress sensing mechanisms in plants	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Developmental and physiological mechanisms that protect plants against environmental stress	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Discipline Specific Elective Course – Plant Breeding

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTD-507**		**BOTD-508(P)**	

Course Objective

To study on the principles and methods of plant breeding and crop improvement

Learning outcomes:

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

Understand the experimental steps and methods involved in generating new varieties using classical and contemporary breeding practices.

Paper Code: BOTD - 507

Paper Title: Plant Breeding (Theory)

Credit: 4

Unit I: 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 II: Methods of Crop Improvement **20 lectures**

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.

Unit III: Quantitative Inheritance **10 lectures**

Concept, mechanism, Monogenicvs polygenic Inheritance, QTL and QTL Mapping**,** Case studies in inheritance of Kernel colour in wheat, Fruit quality in tomato.

Unit IV: Inbreeding Depression and Heterosis **10 lectures**

History, genetic basis of inbreeding depression and heterosis; Applications.

Crop Improvement and Breeding **10 lectures**

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

Paper Code: BOTD – 508(P)

Paper Title: Plant Breeding (Practical)

Credit: 2

1. Introduction to field /controlled pollinations in field and laboratory (temporal details of anthesis, anther dehiscence, stigma receptivity and pollen viability, emasculation, bagging in tentative species: pea, *Brassica*, chickpea, wheat).
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.

Suggested Readings

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

Teaching Learning Process

1. Class lectures
2. Seminars

3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
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3. Week 3: Lecture
4. Week 4: Lecture
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9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from the temporary preparations and laboratory/field experiments as practical record books
2. Highlighting the methods of crop improvement and principles of plant breeding in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Introduction to plant breeding	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Methods of crop	Class room lectures,	Hands on

	improvement	demonstrations and Practical	exercises, PPT, assignments, tests
III	Quantitative inheritance	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Inbreeding depression and heterosis Crop improvement and breeding	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Discipline Specific Elective Course – Plant Pathology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTD-509**		**BOTD-510(P)**	

Course Objective

To study on the concepts of plant pathology and plant diseases and practices of plant disease management

Learning outcomes:

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

1. Understand the concept of plant pathology and its related terminologies and disease causing organisms.
2. Identification of important crop diseases, crop disease management using chemical pesticides and other practices.

Paper Code: BOTD - 509
Paper Title: Plant Pathology (Theory)
Credit: 4

Unit-I: Basic Concept of Plant Pathology **15 Lectures**

Introduction to the science of phytopathology, its objectives, scope and historical background.Classification of plant diseases, symptoms, signs, and related terminology.Definitions of terminology - bacteria, fungi, viruses, viroids, phytoplasmas, fastidious vascular bacteria, parasites, pathogens, biotrophs, hemibiotrophs, necrotrophs.Pathogenicity, pathogenesis, virulence, infection, inoculum, invasion, colonization, inoculum potential, symptoms, incubation period.

Unit-II: Plant Pathogens and Crop Diseases **15 Lectures**

Plant pathogens: fungi, bacteria, viruses, phytoplasma, protozoa, algae and parasitic flowering plants-their characteristics. Important diseases of rice, maize, wheat, pulses (pea, broad bean, ground nut), sugarcane, vegetables (cabbage, mustard, potato, tomato) and fruit crops (banana, citrus, pineapple). Post-harvest and storage diseases.

Unit-III: Chemical Methods for Disease Control **15 Lectures**

Principles and methods of plant disease management.Chemical methods of disease management: Fungicides- classification, chemical groups of fungicides, inorganic, organic, systemic and contact fungicides, antibiotics. Methods of application of fungicides - seed, soil, foliar spray, post-harvest treatment and root feeding. Botanicals for plant disease control. Integrated plant disease management.

Unit-IV: Alternative Methods for Disease Control **15 Lectures**

Regulatory method, plant quarantine, inspection, rules and regulations. Cultural practices for plant disease management: sanitation, hot weather ploughing, soil amendments, crop rotation, time of sowing, seed rate and plant density, irrigation and drainage. Physical methods of plant disease control. Biological control and biopesticides.Role of biotechnology in plant disease management- tissue culture and transgenic plants.

Paper Code: BOTD – 510(P)

Paper Title: Plant Pathology (Practical)

Credit: 2

1. Methods of sterilization.
2. Preparation of common culture media for fungi and bacteria.
3. Pure culture technique.
4. Common symptoms of plant diseases caused by fungi, bacteria and viruses.
5. Field identification and laboratory examination of common crop diseases.
6. Familiarization with different groups of fungicides.
7. Preparation of fungicidal spray solutions- methods of application of fungicides - spraying and soil drenching.
8. Seed treatment with systemic and contact fungicides.
9. Preparation and application of botanicals.
10. Familiarization with plant protection equipment.
11. Field visits, survey and collection of disease samples.

Suggested Readings

1. N.G. Ravichandra, 2013. Fundamentals of Plant Pathology. PHI Hall of India, NewDelhi
2. R.S. Mehrohtra and A. Agarwal, 2003.Plant Pathology.Oxford & IBH, New Delhi.
3. A.V.S.S. Sambhamurthy, 2020. A Textbook of Plant Pathology.Dreamtech Press, New Delhi.
4. R.S.Singh, 2002. Introduction to Principles of Plant Pathology.Oxford & IBH, New Delhi.
5. Alexopoulos, C.J. Mims, C.W. and Blackwell, M. 1996. Introduction to Mycology. Wiley Eastern Ltd., New York.
6. Mandahar,C.L. 1987. Introduction to Plant Viruses. Chand and Co. Pvt. Ltd., New Delhi.
7. Mehrotra, R.S. and Aneja, K.R. 1990. . An Introduction to Mycology. New Age International (P) Ltd., New Delhi.
8. Singh, R.S. 1982. Plant Pathogens - The Fungi. Oxford and IBH Publishing Co., New Delhi.
9. Singh, R.S. 1989. Plant Pathogens - The Prokaryotes .Oxford and IBH Publishing Co., NewDelhi.
10. Dhingra and Sinclair 1993. Basic Plant Pathology Methods.CBS, Publishers & Distributors, New Delhi.
11. Agrios, G.N. 2005. Plant Pathology.5th Edition.Academic press, New York.
12. Y.L. Nene and P.N. Thapliyal, 1993.Fungicides in Plant Disease Control.Oxford & IBH, New Delhi.
13. J. Palti, 1981. Cultural Practices and Infectious Crop Diseases. Springer-Verlag, New York.
14. R.S. Singh, 1998. Plant Diseases.Oxford & IBH, New Delhi.
15. G. Rangaswami, 1999. Diseases of Crop Plants in India.Prentice Hall of India. New Delhi.

Teaching Learning Process

13. Class lectures
14. Seminars
15. Group discussions and Workshops
16. Peer teaching and learning
17. Question preparation
18. Subjective type
    - Long answer
    - Short answer
19. Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
20. Practical
21. Substantial laboratory-based practical component and experiments
22. Games
23. Technology-enabled learning
24. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from the temporary preparations and laboratory/field experiments as practical record books
2. Highlighting the disease symptoms, pathogens, disease cycles and control methods of crop diseases in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Basic concept of plant pathology	Class room lectures, demonstrations and	Hands on exercises, PPT,

		Practical	assignments, tests
II	Plant pathogens and crop diseases	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Chemical methods for disease control	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Alternative methods for disease control	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course – Environmental Monitoring and Management

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-501**		**BOTG-502(P)**	

Course Objective

To study on the concepts of environmental monitoring and management and various legal issues related with the environment

Learning Outcome

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

1. Understand the fundamental concepts of environmental monitoring and management
2. Analyze the different methods of air, water, and soil quality monitoring process
3. Examine different environmental management systems and trade related intellectual properties (TRIPs), intellectual property rights (IPRs).
4. Evaluate the status of environmental education and public awareness along with their implications

Paper Code: BOTG-501
Paper Title: Environmental Monitoring and Management (Theory)
Credit: 4

UNIT I: Environment Pollution, Assessment and Monitoring **15 lectures**

Ambient Air quality standards, dispersion of air pollutants, air sampling and analysis and control of air pollution. Water quality monitoring: Wastewater characterization. Methods for Measurement of water pollution.Sources, effects, monitoring and controlling measures of soil pollution. Noise standards and limit values. Measurement and analysis of sound, effects of noise on health, measures to control noise pollution. Thermal Pollution: Definition and

sources, chemical and biological effects of thermal pollution, effects on water quality. Control of thermal pollution.Sources of marine pollution and its control.Effects of pollutants on human beings, plants, and animals.

UNIT II: Drinking Water Standards Parameters **15 lectures**

Water Characteristics, Indian standard and international standards for drinking water.Physical parameters (Color, taste-odor, Turbidity, suspended solids, Temperature. Chemical parameters (TDS Alkalinity, Hardness, salts, acids and alkalis, chlorides, fluorides, proteins, carbohydrates, organics, fats oil & grease, Hazen units, NTU, BOD, COD, DO, TDS, Trace metals, Heavy metals, tests on quality parameters Plate counts and most probable number (MPN). Sewage and wastewater treatments systems: A. Primary treatment methods B. Secondary treatment methods and C. Tertiary treatment methods.

UNIT Ill: Wastewater Treatment Technologies **15 lectures**

Aerobic Biological Treatment Processes: Suspended growth and attached growth wastewater treatments. Process fundamentals methods of aeration, design considerations, Operational difficulties. Description, design and operation of aerobic treatment systems: Activated Sludge process- Trickling Filters, RBC. Aerated lagoons, Waste stabilization ponds. Anaerobic Biological Treatment Processes: Anaerobic digestion, Design of anaerobic digesters, Description, design and operation of attached and suspended growth processes: Anaerobic.

UNIT IV: Solid Waste Management **15 lectures**

Municipal Solid Waste Management: Common components in MSW, Chemical and Physical properties of MS, Key Technologies for SWM (collection, handling, transformation, landfills, incinerators, composting), Sources of biomedical wastes, Hazardous biomedical waste. Waste segregation and labeling, Handling, Collection, Storage and transportation management: Sources, characteristics and categories of hazardous wastes. To know the assessment of Hazardous materials.Hazardous waste collection and transportation of hazardous waste treatment technologies.

Paper Code: BOTG-502(P)
Paper Title: Environmental Monitoring and Management (Practical)
Credit: 2

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Estimation of hardness and dissolved oxygen, TDS etc. content in water samples.
3. Comparative anatomical studies of leaves from polluted and less polluted areas.
4. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
5. Making compost from kitchen waste /vermicomposting.
6. Visits to pollution testing centres/stations to understand the pollutants & their emission levels from vehicles.

Suggested Readings

1. Gabriel Bitton. Wastewater Microbiology. 3rd edition, A John Wiley & Sons, INC. Publication. ISBN: 0-471-65071-4.
2. Metcalf and Eddy Inc. (1979) Waste water Engineering treatment, Disposal, Reuse. Tata McGraw Hill Publication. Co. Ltd.
3. Soli J. Arceivala. Wastewater treatment for pollution control. 2nd edition, Tata McGraw Hill Publishing Company Limited. ISBN: 0-07-463002-4.
4. Environmental Pollution and Control, by Dr H.S. Bhatia - Galgotia Publication (P) Ltd
5. Abbasi, S. A, and E. Ramasami. (1999). Biotechnological Methods of Pollution Control, University Press, Hyderabad.
6. Wadhwa Y. (2009). Air Pollution: Causes and Control. Cyber Tech Publications, ND.
7. Sharma, B. K and Kaur, H. (1994). Water Pollution. Krishna PrakashamMandir, Meerut.
8. Wanger K.D, (1998). Environmental Management. W.B. Saunders Co. Philadelphia, USA.
9. Mahajan S.P. (1998). Pollution control in process industries, Tata McGraw Hill, ND.
10. Kreith, F. (Editor in Chief), Handbook of Solid Waste Management. McGraw-Hill, Inc. (1994).
11. Freeman, H. M., Standard Handbook of Hazardous Waste Treatment and Disposal McGraw-Hill, Inc. (1997).

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture

3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
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10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from laboratory/field experiments as practical record books
2. Highlighting the importance of environmental pollution, types pollutants and methods of environmental management in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Environment pollution, assessment and monitoring	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Drinking water standards parameters	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Wastewater treatment technologies	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Solid waste management	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course – Global Climate Change

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-503**		**BOTG-504(P)**	

Course Objective

To study the concept and various issues associated global climate change and their mitigation processes

Learning Outcome

After completing this course the learner will be able to;

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

Paper Code: BOTG-503
Paper Title: Global Climate Change (Theory)
Credit: 4

UNIT-l: 15 lectures

Global warming: History and future; Major greenhouse gases; Ozone depletion and UV radiation effects; Ozone layer; Role of ozone in environment; Ozone depleting gases; Green House Effect; future climatic predictions.

UNIT-Il: 15 lectures

Temperature profile of the atmosphere; Laps rates; Temperature inversion; Effects of inversion on pollution dispersion; Possible effects and consequences of global warming on weather & climate; Polar ice caps; glaciers and sea level rise; Range of distribution & Phenology of organisms.

UNIT-III: 15 lectures

Factors responsible for global warming and Climate change; Change of Temperature in the environment; role of fossil fuels in global warming and climate change; Impact of human activities on global climate change; Major impacts on forests; Pollution control laws; United Nation Framework Convention on Climate Change, IPCC, Kyoto Protocol, WTO and Environment.

UNIT-IV: 15 lectures

Economic and Ecological impacts of climate change; Global and regional strategies to combat global warming and climate change; Action around the world; Climate change mitigation programs in India.

Paper Code: BOTG-504(P)
Paper Title: Global Climate Change (Practical)
Credit: 2

1. Assignments for Review articles on global warming and climate change
2. Presentations on burning issues on global warming and climate change
3. Field visits to realize man-made activities which accelerates global warming and climate change

Suggested readings

1. Gosain, A.K. and Rao,S. 2003. Climate change and India: Vulnerability Assessment and Adaptation. Eds. Shukla,P.R. Universities Press Pvt. Ltd.Hyderabad.
2. Saha,T.K. 2008. Ecology and Environmental Biology. Books and Allied (P) Ltd. Kolkata..
3. Lakshmipathy,M., S.R.Ramanan, R.Sathyanathan and I.S.Sudarsahn. 2009. Proceedings of the National Conference on Effect of climate change and sustainable resource management RM University, Kattankallathur.
4. Rao,M.N, Datar,M.Y. and Reddy,S. 1997. Vermicomposting-A Technological option for solid waste management Ujjain, India.
5. Houghton,J. 2005. Global warming: The Complete Briefing. Cambridge: Cambridge University Press.Cambridge.
6. Claussen E, Cochran VA & Davis DP. 2001. *Climate Change: Science, Strategies and Solutions.* Pew Centre on Global Climate Change, USA.
7. Committee on Abrupt Climate Change. 2002. *Abrupt climate change: Inevitable Surprises.* National Research Council, Ocean Studies Board, National Academics Press, Washington.
8. Koskela J, Buck A &Teissier du Cros E. 2007. *Climate Change and Forest Genetic Diversity: Implications for Sustainable Forest Management in Europe.* 2007. Biodiversity International, Rome, Italy.
9. Anonymous 2006. Report of the National Forest Commission. Govt. of India, New Delhi.
10. Claussen E, Cochran VA & Davis DP. 2001. Climate Change: Science, Strategies and Solutions. Pew Centre on Global Climate Change, USA.
11. Committee on Abrupt Climate Change. 2002. Abrupt climate change: Inevitable Surprises. National Research Council, Ocean Studies Board, National Academics Press, Washington.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
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5. Question preparation
6. Subjective type
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   - Short answer

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    - Multiple choice questions
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8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
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Teaching Learning Plan:

1. Week 1 : Lecture
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10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and records of field studies as practical record books
2. Highlighting the importance of causes and impact of global climate change in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course – Environmental Toxicity

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-505**		**BOTG-506(P)**	

Course Objective

To provide knowledge on pollutants causing environmental toxicity, risks and effects associated with toxicity.

Learning Outcome

After completing this course the learner will be able to:

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

Paper Code: BOTG-505
Paper Title: Environmental Toxicity (Theory)
Credit: 4

UNIT-I: 15 Lectures

Principles of toxicology; Introduction; Classification of toxic agents; Toxic responses; Mechanisms of toxicity; Reaction of the toxicant with target molecules; Distribution and fate of toxic substances.

UNIT-II: 15 lectures

Factors influencing toxicity; Abiotic and biotic factors; Interaction of chemicals; Bioaccumulation and biomagnification; Biochemical effects of Carbon monoxide, Nitrogen oxide, Sulphur dioxide, Ozone & PAN.

UNIT-III: 15 lectures

Risk assessment: Introduction, definition; Hazard identification ; Risk characterization, Dose-response assessment and Exposure assessment; Ecotoxicological monitoring and tests; Effects of toxic chemicals on human health, animals & plants

UNIT-IV: 15 lectures

Production of mycotoxins in general; Fungal toxins; Bacterial toxins; Exo and endo toxins; Viral toxins; Algal toxins; Teratogen; Carcinogen and mutagens; Chemistry of Toxicology; Pesticides; Heavy metals: Cadmium, Mercury, Lead, Chromium, Zinc; Remedial measures of ecologically toxic materials from different environments.

Paper Code: BOTG-506 (P)

Paper Title: Environmental Toxicity (Practical)
Credit: 2

1. Assignments and review articles on ecotoxicology
2. Deliberations of seminars on ecotoxicants, their toxic effects on ecosystem and organisms and effective remedial measures.
3. Field visit to realize toxicants at waste disposal sites, municipality sewage & drainage, incineration sites and mining sites.

Suggested Readings

1. Trivedy, R. K 1994. Encyclopedia of Environmental Pollution and Control. Enviromedia publications, Karad.
2. Stake, M. Y. Mido, M.S. Sethi, S.A. Iqbal, H. Yasuhisa, S. Taguchi.1997. environmental Toxicology, Discovery publishing house, New Delhi.
3. De, A. K. 1986. Environmental Chemistry, Willey Eastern Limited, New Delhi.
4. Timbrel. 1989. Elements Toxicology, British Council Library.
5. Casseret, L. J and Doull, I. 1982. Toxicology. The basic science of Poisons. Macmillan publishers, New York.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture

5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and records of field studies as practical record books
2. Highlighting different toxic agents in environment and food and their hazards to the environment and human health in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Semester VI

Core Course - Biostatistics and Bioinformatics

	L	T	P	Total

Credit	4	0	2	6
Paper Codes	BOTC-601		BOTC-602(P)	

Course Objective

To provide knowledge of botanical data analysis and also to provide knowledge and imparting training on computer-based approach to biological research.

Learning outcomes

On completion of this course, the students will gain knowledge and able to:

1. Understand subject matter and relevance of statistics and bioinformatics to biological sciences.
2. Understand the classification and structuring of biological data.
3. Understand the construction of histogram and frequency distribution table.
4. Understand the numerical calculation, procedure of location and variability of data.
5. Understand the logic behind probability and probability distribution models in biology.
6. Understand the importance of hardware and software tools in accessing and retrieving biological data through internet.
7. Understand the relevance and development of bioinformatics in biology.
8. Know the use of basic tools involve in understanding bioinformatics.
9. Know the importance of biological databases in sequencing nucleic acid and proteins.

Paper Code: BOTC-601
Paper Title: Biostatistics and Bioinformatics (Theory)
Credit: 4

Unit 1: 15 lectures

Introduction to biostatistics, history and its relevance in biology, Variability in biology, Variable types, Sample and population, sampling units, sampling methods, classification of data, Construction of frequency distribution table and histogram, numerical measures of location and variability, Ecological and statistical population.

Unit 2: 15 lectures

General introduction to probability, probability distribution, normal distribution. Basic concepts of sampling distribution and standard error; Introduction to test of significance: chi –square and t –test.

Unit 3: 15 lectures

Basics of bioinformatics and phylogenetic analysis: Scope of bioinformatics; Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular phylogeny, Basics of computational tools, computer aided Drug Design; General introduction to protein sequencing.

Unit 4: 15 lectures

General introduction to databases: Nucleic acid databases (Genbank, EMBL), Protein databases (Swiss-Prot, PDB), Phylogenetic analysis: similarity, method of alignment (BLAST and FASTA), Phylogenetic tree and analysis, Application of bioinformatics.

Paper Code: BOTC-602(P)
Paper Title: Biostatistics and Bioinformatics (Practical)
Credit: 2

1. Biostatistics:
    a. Computation of central location of sample data generated from biological experiment,
    b. Calculation of variability measures,
    c. Calculation of basic probability related to biological phenomena,
    d. Calculation of chi-square statistics.
2. Bioinformatics:
    a. Sequence retrieval (protein and gene) from NCBI.
    b. Structure download (protein and DNA) from PDB.
    c. Molecular file formats - FASTA, GenBank, Genpept, GCG, CLUSTAL, Swiss-Prot, FIR.
    d. Molecular viewer by visualization software.

Suggested readings:

1. Buehler, L.K., Rashidi, H.R. (Ed). 2005. Bioinformatics Basics, CRC Press; 2nd edition
2. Eason, G., Coles, C.W., Gettindy G. 1980. Mathematics and statistics for the biosciences, John Wiley and sons, New York.
3. Freund, J.E. 1994. Modern elementary statistics ,6th edition Prentice Hall,New Jersey.
4. Health, D. 1995. An introduction to experimental design and statistics for biology. UCL Press Ltd, University college, London.
5. Hughes, A.J., Grawoig, D.E. 1971. Statistics ; A foundation for analysis Addison-Wesley Educational Publishers Inc
6. Lesk, A.M. 2014. Introduction to bioinformatics .4th edition. Oxford University Press UK,1-440
7. Lohar, P.S. 2015.Bioinformatics, MJP Publishers, Chennai
8. Murthy, C.S.V. 2008. Bioinformatics : Himalaya Publishing House Pvt. Ltd. Mumbai
9. Pansey, V.G., Sukhatme, P.V. 1995. Statistical Methods for Agricultural Workers, ICAR, New Delhi
10. Ramsden, J., 2009, Computational Biology - Bioinformatics: An introduction 2nd edition, Springer,1-271
11. Rastogi, S.C., Mendiratta, N., Rastogi, P. 2013. Bioinformatics-Methods and Applications, PHI Learning Private Limited, Delhi
12. Sharma, V., Munjal, A. and Shanker, A. 2008. A Text Book of Bioinformatics , Rastogi Publications , Meerut

13. Sokal, R.R., Rohls, F.J. 1995. Biometry the principle and practice of statistics in biological research, 3rd edition, W.H. Freeman and company, New York.
14. Xiong, J. 2007. Essential Bioinformatics, Cambridge University Press.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

5. Laboratory and computer based practical data as practical record books
6. Highlighting the steps and algorithms in digital media such as power point presentations and animations

Unit	Particulars	Teaching and	Assessment Task

No.		Learning Activity	
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Core Course – Plant Biotechnology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-603**		**BOTC-604(P)**	

Course Objective

To give students knowledge on classical and modern plant biotechnology processes, role of biotechnology on global food security and commercial gains in biotechnology and agriculture, and also to familiarize with biotechnological tools

Learning outcomes

On completion of this course, the students will gain knowledge and able to:

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

Paper Code: BOTC-603
Paper Title: Plant Biotechnology (Theory)
Credit: 4

Unit I: **12 Lectures**

Historical perspective of plant tissue culture, Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Plasticity and Totipotency; Organogenesis; Embryogenesis (somatic and zygotic).Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and cybrids; Cryopreservation; Germplasm Conservation).

Unit II: 15 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 III: 18 Lectures

Gene Cloning (Recombinant DNA. Bacterial Transformation and selection of recombinant clones, PCR and RT-PCR mediated 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- Agrobacterium-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 IV: 15 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)

Paper Code: BOTC-604(P)
Paper Title: Plant Biotechnology (Practical)
Credit: 2

1. (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, micro-propagation. 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, micro-projectile 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.

Suggested readings

1. Bhojwani, S.S., Bhatnagar, S.P. 2011. *The Embryology of Angiosperms*, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
2. Bhojwani, S.S., Razdan, M.K., 1996. *Plant Tissue Culture: Theory and Practice. Amsterdam,* Netherlands: Elsevier Science.
3. Glick, B.R., Pasternak, J.J. 2010. *Molecular Biotechnology: Principles and Applications*. Washington, U.S.: ASM Press.
4. Gupta, R., Rajpal, T. 2012. *Concise Notes on Biotechnology*. New Delhi, Delhi: McGraw Hill Publications.
5. Snustad, D.P., Simmons, M.J. 2010. *Principles of Genetics*, 5th edition. Chichester, England: John Wiley and Sons.
6. Stewart, C.N. Jr. 2008. *Plant Biotechnology and Genetics: Principles, Techniques and Applications*. New Jearsey, U.S.: John Wiley & Sons Inc.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture

5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from the temporary preparations and laboratory experiments as practical record books
2. Highlighting the techniques and steps in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Discipline Specific Elective Course - Microbiology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTD-605**		**BOTD-606(P)**	

Course Objective

To gain knowledge of history, diversity, morphology, reproduction economical application of microorganisms.

Learning outcomes

On completion of this course, the students will gain knowledge and able to:

1. Learn the contributions of various scientists in the field of microbiology.
2. Have the ability of understanding of nomenclature system of microorganisms and their diversity.
3. Use basic microbiological and microscopic techniques to explore various microbes.
4. Explain the types of culture media used for cultivation and conservation of microbial samples.

Paper Code: BOTD-605
Paper Title: Microbiology (Theory)
Credit: 4

Unit I: 18 Lectures

Development of microbiology as a discipline.Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A. Waksman. Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner. Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility.

Unit II: 12 Lectures

Difference between prokaryotic and eukaryotic microorganisms General characteristics of different groups: Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.
Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures;

Unit III: 15 Lectures

Cultivation of anaerobic bacteria, and accessing non-culturable bacteria; Metagenomics and microbiome analysis. Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluoresence Microscope, Confocal microscopy, Scanning and Transmission Electron Microscope

Unit IV: **15 Lectures**

Nutritional requirements in bacteria and nutritional categories; Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation Chemical methods of microbial control: disinfectants, types and mode of action

Paper Code: BOTD-606(P)
Paper Title: Microbiology (Practical)
Credit: 2

2. Microbiology Good Laboratory Practices and Biosafety.
3. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory.
4. Preparation of culture media for bacterial cultivation.
5. Sterilization of medium using Autoclave and assessment for sterility
6. Sterilization of glassware using Hot Air Oven and assessment for sterility
7. Sterilization of heat sensitive material by membrane filtration and assessment for sterility
8. Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air.
9. Study of *Rhizopus, Penicillium,Aspergillus* using temporary mounts

Suggested readings

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.
2. Cappucino J and Sherman N. 2010. Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
3. Madigan MT, Martinko JM, Dunlap PV and Clark DP. 2014. Brock Biology of Microorganisms. 14th edition. Pearson International Edition
4. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
5. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5thedition. McMillan.
6. Tortora GJ, Funke BR and Case CL. 2008. Microbiology: An Introduction. 9th edition. Pearson Education
7. Wiley JM, Sherwood LM and Woolverton CJ. 2013. Prescott's Microbiology. 9th Edition. McGraw Hill International.

Teaching Learning Process

1. Class lectures
2. Seminars

3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from the temporary preparations, microbiological instruments and laboratory experiments as practical record books
2. Highlighting the properties of the organisms in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures,	Hands on

		demonstrations and Practical	exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Discipline Specific Elective Course – Biodiversity Conservation

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTD-607**		**BOTD-608(P)**	

Course Objective

To appreciate the value of biodiversity, function and role and methods of biodiversity conservation

Learning outcomes:

On completion of this course, the students will gain knowledge and able to:

1. Judge the value of biodiversity
2. Understand the role of biodiversity in stabilizing the climate and economy
3. Know the causes and consequences of loss of biodiversity and planning of conservation strategies

Paper code: BOTD-607
Paper Title: Biodiversity Conservation (Theory)
Credit: 4

Unit 1: Plant Diversity and its Scope **15 lectures**

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.

Unit 2: Loss of Biodiversity **20 lectures**

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.

Unit 3:Conservation of Biodiversity **10 lectures**

Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development.

Unit 4: Role of Plants in Relation to Human Welfare **15 lectures**

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.

Paper Code: BOTD-608(P)
Paper Title: Biodiversity Conservation (Practical)
Credit: 2

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 plants, c) Fruits and nuts, d) Timber plants
6. Procedure of *ex situ* conservation methods
7. Procedure of *in situ* conservation methods

Suggested readings

1. Krishnamurthy, K.V. (2004). *An Advanced Text Book of Biodiversity - Principles and Practices.* New Delhi, Delhi: Oxford and IBH Publications Co. Pvt. Ltd.
2. Samit Ray and Arun K. Ray (2012). Biodiversity and Biotechnology. New Central Book Agency (P) Ltd. London. Hyderabad, Delhi, Kolkata, Pune, Guwahati.

Teaching Learning Process

13. Class lectures
14. Seminars
15. Group discussions and Workshops
16. Peer teaching and learning
17. Question preparation
18. Subjective type
    - Long answer
    - Short answer
19. Objective type

- Multiple choice questions
- One answer/two answer type questions
- Assertion and reasoning

20. Practical
21. Substantial laboratory-based practical component and experiments
22. Games
23. Technology-enabled learning
24. Internship in industry, and research establishments

Teaching Learning Plan:

16. Week 1 : Lecture
17. Week 2: Lecture
18. Week 3: Lecture
19. Week 4: Lecture
20. Week 5: Lecture/Practical
21. Week 6: Lecture/Practical
22. Week 7: Lecture/Practical
23. Week 8: Lecture/Practical
24. Week 9: Lecture/Practical
25. Week 10: Mid semester Exam
26. Week 11: Lecture/Practical
27. Week 12: Lecture/Practical/Field-based learning
28. Week 13: Lecture/Practical
29. Week 14: Lecture/Practical
30. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from the temporary preparations, herbarium, etc. as practical record books
2. Highlighting the properties of the organisms in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Plant diversity and its scope	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Loss of biodiversity	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Conservation of biodiversity	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Role of plants in relation to human welfare	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Discipline Specific Elective Course – Post Harvest Technology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTD-609**		**BOTD-610(P)**	

Course Objective
To inculcate the knowledge of post-harvest losses and their management practices

Learning outcomes
On completion of this course, the students will gain knowledge and able to:

1. Comprehend Engineering Properties / various post-harvest process on agriculture produce and its applications
2. Determine various properties & parameters of Agriculture Produce.
3. Evaluate Engineering Properties / Management of storage structures and losses during storage agricultural produce.

Paper Code: BOTD-609
Paper Title: Post-Harvest Technology (Theory)
Credit: 4

Unit I: Introduction to Post-harvest Technology 12 Lectures
Introduction to post harvest technology of agricultural produce; Status of Production, Losses, Need, Scope and Importance. Introduction to various post-harvest operations such as Primary Processing Operation Vs. Secondary Operation, Operations like Harvesting, Handling cleaning, grading, sorting, drying, storage, milling, size reduction, expelling, extraction, blending, heat treatment, separation, material handling (transportation, conveying, elevating), washing; their functions and use in the post-harvest processing.

Unit II: Post-harvest Drying 15 Lectures
Introduction, importance of drying, principles of drying and factors affecting drying, types of drying methods i.e., sun drying & artificial drying by mechanical means – Psychometric Chart, Moisture content representation, equilibrium moisture content, determination of moisture content by direct and indirect methods. Drying Characteristics, Introduction to various grain drying systems - solar drying system, batch drying system, continuous flow drying system.Precautions during drying.

Unit III: Post-harvest Storage 18 Lectures

Introduction, need and importance, general principles of storage. Temperature and moisture changes during storage i.e., influence of moisture content, relative humidity, temperature, fungi etc. on stored product. Fungi, insect and other organism / Infections associated with stored grains. Familiarization with the various types of storage structures.Deep and shallow bins. Traditional and modem storage structures. Management of storage structures.Losses during storage and their control, space requirement of bag storage structure.

Unit IV: Management of Post-harvest Losses 15 Lectures

Methods of Harvesting and Post-harvest losses in fruits and vegetables, Handling of Fruits and Vegetables.Introduction to the storage of fruits and vegetables.Need and importance of storage.Principle of storage of fruits and vegetables.Recommended storage operation conditions for some important fruits and vegetables and their storage life. Post harvest treatment to increase shelf life i.e., freezing, chilling, dehydration, canning, thermal processing. Introduction to Packaging of fruits and vegetables and types of packaging.Concept of modified atmosphere packaging.

Paper Code: BOTD-610(P)
Paper Title: Post-Harvest Technology (Practical)
Credit: 2

1. Determination of physical properties of agricultural materials e.g., size, shape, density and angle of repose of Cereals, Pulses and Oil Seeds Change in Specific Gravity, TSS, Acid of Fruits and Vegetables
2. Determination of moisture content of grains.
3. Study of different types of dryers.
4. Study of domestic grain storage structures.
5. Visit to warehouses, packhouses and cold-storage.
6. Study of different packaging materials.

Suggested readings

1. Post Harvest Technology of Cereal, Pulses, Oil Seeds. A.Chakraverty Oxford & IBH Publication Co.
2. Unit Operation of Agro Processing Engineering. Dr.K.M. Sahay& K.K Singh Vikas Publications.
3. Post Harvest Technology of Fruits & Vegetables Thompson CBS Publishers and Distributors.
4. Post Harvest (Introduction Physiology Handling fruits & Vegetables) Wills R.B.H. Oxford & IBH Publication Co.

Teaching Learning Process

1. Class lectures
2. Seminars

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7. Objective type
    - Multiple choice questions
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8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from the temporary preparations, instruments and laboratory experiments as practical record books
2. Highlighting the properties of the organisms in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Introduction to post-harvest technology	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Post-harvest drying	Class room lectures, demonstrations and	Hands on exercises, PPT,

		Practical	assignments, tests
III	Post-harvest storage	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Management of post-harvest losses	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course – Biodiversity

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-601**		**BOTG-602(P)**	

Course objective

To study the characteristic features, classification and diversity of various microbes, lower plants and higher plants

Learning outcomes:

On completion of this course, the students will gain knowledge and able to:

1. Understand the fundamental concepts related to biodiversity and its conservation
2. Understand the general characteristics and diversity of microbial forms
3. Understand the general characteristics and diversity of algae, bryophytes and pteridophytes
4. Understand the general characteristics and diversity of gymnosperms and angiosperms

Paper Code: BOTG-601
Paper Title: Biodiversity (Theory)
Credit: 4

Unit I: Concept of Biodiversity **13 lectures**

What is biodiversity, Genetic diversity, Species diversity, Ecosystem diversity, Alfa beta gamma diversity, Hotspots of biodiversity, India as a mega biodiversity nation, Manipur as a region of biodiversity hotspot, Endangered and endemic species of India and Manipur, Conservation of biodiversity (in-situ and ex-situ); Organizations associated with biodiversity management-IUCN, UNEP, UNESCO, WWF, NBPGR.

Unit II: Microbial Diversity **15 lectures**

Tree of Life, 6 Kingdoms of Cavalier-Smith in detail, Evolution of multicellularity. Characteristic features and brief account on classification of viroids, viruses, bacteria and

fungi, diversity as illustrated by representative groups of viruses (bacteriophage, mycoviruses, plant viruses and animal viruses), bacteria (Eubacteria and Archaebacteria) and fungi (Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina).

Unit III: Diversity of Lower Plants 15 lectures

Characteristic features and brief account on classification of algae; diversity of algae as illustrated by the families: Chlorophyceae, Xanthophyceae, Phaeophyceae, Rhodophyceae, and Myxophyceae.

Characteristic features and brief account on classification of bryophytes; diversity of bryophytes as illustrated by the classes: Hepaticopsida, Anthocerotopsida and Bryopsida.

Characteristic features and brief account on classification of pteridophytes; diversity of pteridophytes as illustrated by the classes: Psilopsida, Lycopsida, Sphenopsida and Pteropsida.

Unit IV: Diversity of Higher Plants 17 lectures

Characteristic features and brief account on classification of gymnosperms; diversity of gymnosperms as illustrated by the families – Cycadaceae, Ginkgoacceae, Pinaceae, Ephedraceae and Gnetaceae

Characteristic features of angiosperms and dominance of angiosperms on earth; brief account on classification of angiosperms; diversity of flowering plants as illustrated by the families: Dicotyledons - Brassicaceae, Malvaceae, Rutaceae, Fabaceae, Cucurbitaceae, Apiaceae, Rubiaceae, Asteraceae, Apocynaceae, Solanaceae, Acanthaceae and Euphorbiaceae; Monocotyledons – Arecaceae, Liliaceae, Musaceae and Poaceae.

Paper code: BOTG-602(P)
Paper Title: Biodiversity (Practical)
Credit: 2

1. EMs/Models of viruses – T-Phage and TMV; Line drawing/Photograph of Lytic and Lysogenic Cycle.
2. Types of Bacteria from temporary/permanent slides/photographs; EM of bacterium, Binary Fission, Conjugation.
3. Gram staining of bacteria.
4. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas*, *Oedogonium, Vaucheria, Fucus* and *Polysiphonia* through temporary preparations and permanent slides.
5. Study of asexual and sexual stages from temporary mounts and permanent slides of *Rhizopus*/*Mucor, Penicillium/Aspergillus, Puccinia*/*Agaricus.*
6. Study of morphology and anatomy of vegetative and reproductive structures of *Marchantia*, *Anthoceros and Funaria* from temporary preparations and permanent slides.

7. Study of morphology and anatomy of vegetative and reproductive structures of *Selaginell*a, *Equisetum* and *Pteris* from temporary preparations and permanent slides.
8. Study of morphology and anatomy of vegetative and reproductive structures of *Cycas* and *Pinus.*
9. *Pisum* (Fabaceae), *Coriandrum* (Apiaceae), *Bidens/Acmella* (Asteraceae), *Calotropis* (Apocynaceae), *Phlogacanthus* (Acanthaceae). *Zea/Cynodon* (Poaceae), *Areca* (Arecaceae), *Musa* (Musaceae).
10. Field visit for studying plant and microbial diversity.

Suggested Readings

1. Kumar, H.D. (1999). Introductory Phycology.Affiliated East-West.Press Pvt. Ltd. Delhi.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology.Tata McGraw Hill, Delhi, India.
6. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms.New Age International (P) Ltd Publishers, New Delhi, India.
7. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
8. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
9. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
10. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
11. Sarbhoy, A.K. 2006. Text Book of Mycology, ICAR Publications, New Delhi.
12. Sharma T.A., Dubey, R.C. and Maheshwari, D.K. 1999. A Text Book of Microbiology. S Chand and Co, New Delhi
13. Krishnamurthy, K.V. (2004). *An Advanced Text Book of Biodiversity - Principles and Practices.*New Delhi, Delhi: Oxford and IBH Publications Co. Pvt. Ltd.
14. Samit Ray and Arun K. Ray (2012). Biodiversity and Biotechnology.New Central Book Agency (P) Ltd. London. Hyderabad, Delhi, Kolkata, Pune, Guwahati.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning

5. Question preparation
6. Subjective type
    - Long answer
    - Short answer
7. Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
8. Practical
9. Substantial laboratory-based practical component and experiments
10. Games
11. Technology-enabled learning
12. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from the temporary preparations laboratory experiments as practical record books
2. Highlighting the properties of the organisms in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Concept of biodiversity	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

II	Microbial diversity	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Diversity of lower plants	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Diversity of higher plants	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course – Plant Taxonomy and Ecology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-603**		**BOTG-604(P)**	

Course Objective

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

Learning outcomes:

On completion of this course, the students will gain knowledge and able to:

1. Comprehend the basic concepts of plant ecology and taxonomy and botanical nomenclature
2. Analysis of characteristics of different plant communities.
3. Examine the structure and functions of eco-system.
4. Evaluate the significance of herbarium
5. Analysis of implications of biometrics, numerical taxonomy and cladistics

Paper Code: BOTG-603
Paper Title: Plant Taxonomy and Ecology (Theory)
Credit: 4

Unit I: Taxonomic Hierarchy and Botanical Nomenclature **10 lectures**

Ranks, categories and taxonomic groups, Principles and rules of International Code of Nomenclature (ICN), binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit II: Classification, Biometrics, Numerical Taxonomy and Cladistics 10 lectures
Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (up to series), Takhtajan (up to superorder). Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms.

Unit III: Introduction, Factors, Communities and Ecosystem 20 lectures
Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variations, Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes.Characteristics; qualitative and quantitative; Ecotone and edge effect. Succession: processes and types, ecological amplitude. Structure, trophic organisation; energy flow; food chains and food web. Ecological pyramids. Gross and net productivity. Biogeochemical cycles of carbon and nitrogen.

Unit IV: Phytogeography, Introduction to Plant Taxonomy and Taxonomy 20 lectures
Biogeographical zones; Endemism, Description, Identification, Nomenclature, Classification. Importance of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: indented (yolked) and bracketed keys.

Paper Code: BOTG-604(P)
Paper Title: Plant Taxonomy and Ecology (Practical)
Credit: 2

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Brassicaceae – *Brassica*/ *Cardamine*/ *Iberis*; Asteraceae -*Sonchus*/*Launaea*, *Vernonia*/*Ageratum, Eclipta*/*Tridax*; Solanaceae -*Solanum nigrum*, *Physalis*; Lamiaceae -*Salvia*, *Ocimum*; Liliaceae - *Asphodelus* / *Lilium* / *Allium*.
2. Mounting of a properly dried and pressed specimen of any wild plants with herbarium label (to be submitted).
3. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
4. Determination of pH and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.
5. Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats.

6. (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.
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.

Suggested Readings

1. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4 edition. Hall, U.S.A.
2. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India.
3. Singh, J.S., Singh, S.P. and Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
4. Ambasht R. S. and Ambasht P. K. (1999) Environment and Pollution. C. B. S. Publishers & Distributers, New Delhi.
5. Dash, M. C. (2007). Fundamentals of Ecology. Tata Mc Graw Hill Publishing Company Limited.
6. Verma, P.S. and Agrawal, V. K. (2010). Environmental Biology. S. Chand and Company Ltd., New Delhi.
7. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
8. Singh, G. (2012). Plant Systematics: Theory and Practice. 3rd edition. Oxford & IBH Pvt. Ltd., NewDelhi.
9. Sambamurty A.V.S.S. (2005). Taxonomy of Angiosperms. I. K. International Pvt. Ltd., New Delhi.
10. Singh M. P. & Abbas S. G. Essentials of Plant Taxonomy and Ecology. Daya Publishing House, New Delhi.
11. Singh, V., Pande, P. C. & Jain, D. K. (2008). Taxonomy and Economic Botany. Rastogi Publications, Meerut.
12. Pandey, B. P. (2009). A Textbook of Botany Angiosperms. . S. Chand and Company Ltd., New Delhi.

Teaching Learning Process

13. Class lectures
14. Seminars
15. Group discussions and Workshops
16. Peer teaching and learning
17. Question preparation
18. Subjective type
    - Long answer
    - Short answer
19. Objective type

- Multiple choice questions
- One answer/two answer type questions
- Assertion and reasoning

20. Practical
21. Substantial laboratory-based practical component and experiments
22. Games
23. Technology-enabled learning
24. Internship in industry, and research establishments

Teaching Learning Plan:

16. Week 1 : Lecture
17. Week 2: Lecture
18. Week 3: Lecture
19. Week 4: Lecture
20. Week 5: Lecture/Practical
21. Week 6: Lecture/Practical
22. Week 7: Lecture/Practical
23. Week 8: Lecture/Practical
24. Week 9: Lecture/Practical
25. Week 10: Mid semester Exam
26. Week 11: Lecture/Practical
27. Week 12: Lecture/Practical/Field-based learning
28. Week 13: Lecture/Practical
29. Week 14: Lecture/Practical
30. Week 15: Lecture/Practical

Assessment Methods

3. Drawings and description from the temporary preparations as practical record books
4. Highlighting the properties of the organisms in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Taxonomic hierarchy and botanical nomenclature	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Classification, biometrics, numerical taxonomy and cladistics	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Introduction, factors, communities and ecosystem	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

IV	Phytogeography, introduction to plant taxonomy and taxonomy	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course - Phytochemistry

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-605(P)**		**BOTG-606(P)**	

Course objective

To provide knowledge on concepts of phytochemistry and their application in agriculture and disease management

Learning outcomes:

On completion of this course, the students will gain knowledge and able to:

1. Understand the fundamental concepts of phytochemistry
2. Develop the skills of cold and hot solvent extraction.
3. Examine the solvent fractionation.
4. Evaluate the process of screening each fraction for plant pathogens or human pathogens

Paper Code: BOTG- 605
Paper Title: Phytochemistry (Theory)
Credit: 4

Unit I: **18 lectures**

Collection of sample, identification, Extraction processes, Sample drying processes**,** Cold and hot solvent extraction (Soxhlet and otherwise) for analysis purpose

Unit II: **12 lectures**

Concentration of extract (Rotary evaporation/ air drying) and retrieving of solvent

Unit III: **12 lectures**

Solvent fractionation (using sperating funnel and solvent from polar to non polar like methanol/Chlorophorm/isopropanol/butanol/hexane/water.

Unit IV: **18 lectures**

Determination of each fraction for secondary metabolites.

1. Phenolic compounds Flavonoids/anthocyanin
2. Terpenes essential oils (Limonene/composite TLC)
3. Alkaloids (Aminoacids proteins (potato) or non-protein seed of Cucurbitaceae 2D paper chromatography)
4. Screening each fraction for plant pathogens or human pathogens
5. Further analysis for active ingredient

Paper Title: Phytochemistry (Practical)
Paper Code: BOTG- 606(P)
Credit: 2

The paper is a more practical based course so the teaching should be emphasized on explanation of the principles and demonstration. All possible experiments mentioned in the theory should be conducted in the laboratory.

Suggested Readings

1. Harborne. J.B. (1998).Phytochemical methods. A guide to modern techniques of Plant Anlysis. Chapman and Hall publication, London
2. Plumber, D. T. (2006). An introduction to practical biochemistry Tata-McGraw-Hill Publication, New Delhi
3. Shah, B.N. (2005). Text book of Pharmacognosy and phytochemistry. Cbs Publishers & Distributors-New Delhi
4. Egbuna, C., Chinenye, J. Stanley I. and Udedi, C. (2018). Phytochemistry: Fundamental, modern techniques and applications. Apple Academic Press. CRC press.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
   - Subjective type
   - Long answer
   - Short answer
6. Objective type
   - Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
7. Practical
8. Substantial laboratory-based practical component and experiments
9. Games
10. Technology-enabled learning
11. Internship in industry, and research establishments

Teaching Learning Plan:

16. Week 1 : Lecture
17. Week 2: Lecture
18. Week 3: Lecture
19. Week 4: Lecture
20. Week 5: Lecture/Practical
21. Week 6: Lecture/Practical
22. Week 7: Lecture/Practical
23. Week 8: Lecture/Practical
24. Week 9: Lecture/Practical
25. Week 10: Mid semester Exam
26. Week 11: Lecture/Practical
27. Week 12: Lecture/Practical/Field-based learning
28. Week 13: Lecture/Practical
29. Week 14: Lecture/Practical
30. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and description from temporary preparations and laboratory experiments as practical record books
2. Highlighting the experimental procedures and expected results in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV		Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Semester VII

Core Course – Molecular Systematics

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-701**		**BOTC-702(P)**	

Course Objective

This course will cover definition of molecular systematics, the underlying principles of the types of molecular markers, plant genomes, digital and classical taxonomic approaches, analysis of data and databases.

Learning outcomes

On completion of this course, the students will gain knowledge and able to:

1. Define and explain molecular systematics
2. Compare and contrast classical and molecular systematics
3. Compare and contrast the different types of molecular markers,
4. Understand the various computer-aided taxonomy and databases

Paper Code: BOTC-701
Paper Title: Molecular Systematics (Theory)
Credit: 4

Unit I: Plant Genome Organization **15 lectures**

Structure of nuclear, chloroplast and mitochondria genome, generating molecular data- gene mapping, gene sequencing techniques; molecular characters- and their role in plant systematic, RNA in Plant Systematic.

Unit II: Fundamentals of Molecular Systematics **14 lectures**

Concepts and scopes; collection and storage of cells and tissues. Methods of estimating genetic diversity –RFLP, RAPD, AFLP, SSR, Applications of molecular systematics - nuclear and organellar mitochondria and chloroplast genome, DNA barcodes.

Unit III: Digital & Cladistic Taxonomy **14 lectures**

Numerical Taxonomy and Phenetics;Types of molecular databases: DNA, RNA and proteins - GenBank, DDBJ, ENA, EMBL, PDB; analysis of molecular data – alignment of sequences, homoplasy, phylogeny construction and molecular evolution, gene trees and species trees.

Unit IV: Taxonomic Data Bases **17 lectures**

Background and concepts; Taxonomic Databases working Group, DNA Barcode of life (BOLD, CBOL); The Tree of life – Tree base – Database on Phylogenetic knowledge – Taxonomic information systems- Database at the Royal Botanical Garden – on line herbaria, eFloras – ETI database – Taxonomic softwares: Linnaeus, Darwin, Species 2000, ILDIS, other databases on Biodiversity

Paper Code: BOTC-702(P)
Paper Title: Molecular Systematics (Practical)
Credit: 2

1. Cladistic analysis of plants using morphological characters
2. Plant genome databases
    i. Ensembl Plants (https://plants.ensembl.org/index.html)
    ii. NCBI Genome (https://www.ncbi.nlm.nih.gov/datasets/genome/#!/overview/)
    iii. Plant Garden (https://plantgarden.jp/en/index)
    iv. Phytozome (https://phytozome-next.jgi.doe.gov/)
3. Bioversity Descriptors and application in numerical taxonomy (https://cgspace.cgiar.org/collections/835fa638-0167-4669-9532-ffc488facc94)
4. Cladogram Maker(https://creately.com/lp/cladogram-maker/)
5. BOLD – The Barcode of Life Data Systems (https://boldsystems.org/)
6. Taxonomic databases
    i. World Flora Online (https://about.worldfloraonline.org/consortium-members/species2000-catalogue-of-life)
    ii. International Plant Names Index (https://www.ipni.org/)
    iii. KEW data and digital resources(https://www.kew.org/science/collections-and-resources/data-and-digital)
    iv. eFloras (https://efloras.org)

Suggested Readings

1. M.G. Simpson(2006). Plant Systematics. Elsevier Academic Press, Burlington, MA.
2. G. Singh(2004). Plant Systematics, (2th edition.). Oxford& IBH Publishing Co, Pvt. Ltd., NewDelhi.
3. D.M. Hillis, C.Mortiz&B.K. Mable (1996). Molecular Systematics, Sinaver Associates,Sunderland, USA.
4. J.B. Harborne, &B.L. Turner (1984). Plant Chemosystematics, Academic Press, London.
5. K.V. Krishnamurthy (2003). An Advanced Text Book on Biodiversity. Oxford & IBH, New Delhi.

Teaching Learning Process

1. Class lectures

2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
8. Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
9. Practical
10. Field-based learning
11. Substantial laboratory-based practical component and experiments
12. Games
13. Technology-enabled learning
14. Internship in industry, and research establishments

Teaching Learning Plan:

Week 1 : Lecture

- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Herbarium preparation and specimen collection
3. Highlighting the salient features of the genera/ groups through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Plant genome	Class room lectures,	Hands on exercises,

	organization	demonstrations and Practical	PPT, assignments, tests
II	Fundamentals of molecular systematics	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Digital & cladistic taxonomy	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Taxonomic data bases	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Core Course – Advanced Plant Physiology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-703**		**BOTC-704(P)**	

Course Objective

To provide advance knowledge on important physiological processes, mechanism and functions of transportation, photosynthesis, respiration, energy metabolism, etc) in plants; to understand nitrogen fixation and roles of phytohormones.

Learning Outcomes

1. Gain knowledge water and its functions, transportation of water maintaining soil-plant-atmosphere continuum, transport of solutes via active and passive transportation
2. To understand the organization and functions of photosynthetic machinery, carbon fixation mechanisms, photoprotection and photorespiration
3. To learn the liberation of energy synthesized through photosynthesis
4. To understand biological nitrogen fixation as well as biosynthesis and mechanism of action of phytohormones.

Paper Code: BOTC-703
Paper Title: Advanced Plant Physiology (Theory)
Credit: 4

Unit I: Transportation of Water and Solutes **13 lectures**

Water and its properties, Water potential, diffusion, Osmosis, Kinetic theory, Water absorption, aquaporins, soil-plant-atmosphere continuum, Stomatal physiology and water movement from leaf to the atmosphere, Passive and active solute transport; H^+-ATPase

Unit II: Photosynthetic System – Organization and Functions **17 lectures**

Absorption and action spectra; Organization of photosynthetic apparatus: Structure of chloroplast, photosynthetic pigments and light harvesting complexes, Emerson's effect, Repair and regulation of photosynthetic machinery; Assimilation of carbon in CO_2, C3, C4 and CAM cycle, Photorespiration

Unit III: Energy Liberation and Utilization **15 lectures**

Glycolysis, Citric Acid Cycle, Fermentation, Pasteur's effect, Electron Transport System and Phosphorylation, Hexose Monophosphate Shunt, Glyoxylate Cycle, alternate oxidase

Unit IV: Nitrogen Fixation and Phytohormones **15 lectures**

An overview, Biological Nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction, ammonia assimilation, amino acid biosynthesis. Biosynthesis and mechanism of Action of Phytohormones, Auxin, Gibberellin, Cytokinin, Ethylene and ABA, Brassinosteroids, Strigolactones

Paper Code: BOTC-704(P)
Paper Title: Advanced Plant Physiology (Practical)
Credit: 2

1. To determine the percentage of water imbibed by gram seeds.
2. To demonstrate the process of osmosis with varying solution concentration
3. To compare the rate of transpiration between the upper and lower surfaces of a leaf.
4. To determine the Osmotic Pressure (O.P) and Diffusion pressure Deficit (D.P.D) of vacuolar sap of leaves by plasmolytic method (50% plasmolysis).
5. To determine the rate of transpiration of plant twig by weight, photometer, or Cobalt chloride method.
6. *In vivo* assay for nitrate reductase in leaves.
7. Determination of rate of photosynthesis at different wave lengths of light.
8. To measure the rate of photosynthesis in leaves by leaf area index.
9. Determination of aerobic respiration in germinating seedings
10. To study the absorption spectrum of leaf pigment extract in organic solvent

Suggested readings

1. B. Buchanan, G. Gruissem and R. Jones R (2000). Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA
2. P.J. Davies (2004). Plant Hormones: Biosynthesis, Signal Transduction, Action. 3rd Edition, Kluwer Academic Publisher, Dordrecht, The Netherlands.
3. B.R. Jordan (2006). The Molecular Biology and Biotechnology of Flowering, 2nd Edition, CAB International, Oxfordshire, UK

4. D.L. Nelson and M.M. Cox (2008). Lehninger Principles of Biochemistry (5th ed). New York
5. L. Taiz and E. Zeiger (2010). Plant Physiology 5th Edition, Sinauer Associates Inc., Sunderland
6. H.W. Heldt and B. Piechulla (2010). Plant Biochemistry. 4th edition, Academic Press
7. S.C. Bhatla and M.A. Lal (2018). Plant Physiology, Development and Metabolism, Springer Nature, Singapore
8. R. Sivakumar, P. Boominathan, C.N. Chandrasekhar (2015). Practical Plant Physiology, Narendra Publishing House
9. N.K. Gupta, M.K. Sangha, M. Bala and S. Gupta (2016). Practical in Plant Physiology and biochemistry. Scientific Publishers (India)
10. A. Verma and R. Sachan R (2025). Practical Manual on Plant Physiology, Bhavya Books

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
8. Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
9. Practical
10. Field-based learning
11. Substantial laboratory-based practical component and experiments
12. Games
13. Technology-enabled learning
14. Internship in industry, and research establishments

Teaching Learning Plan:

Week 1 : Lecture

- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical

- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Physiological experiments and records
3. Highlighting the salient features of physiological functions through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Transportation of water and solutes	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Photosynthetic system-organization and functions	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Energy liberation and utilization	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Nitrogen fixation and phytohormones	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Discipline Specific Elective Course – Tools and Techniques in Plant Research

Paper Code: BOTD-705
Paper Title: Tools and Techniques in Plant Research (Theory)
Credit: 4

Unit I: Research Methodology **15 lectures**

Review of literature, methods of citation (APA, Vancouver, Chicago, etc.), academic writings (Thesis/Research paper/ Reports), Experimental andsampling types and designs, hypothesis testing, Types of data, research ethics, , plagiarism and detection softwares, Patents and IPR

Unit II: Microscopy, Histology and Herbarium **15 lectures**

Microscopes-simple and compound, bright field and dark field microscopy, microscopic measurements, phase contrast, fluorescence, confocal and electron microscopy- SEM and TEM; Chromosome banding, FISH. Fixation of plant material, types of fixatives, dehydration

techniques, sectioning-types, staining-types, Herbarium specimen typification, voucher preparation and submission (MUMP, ASSAM, CAL, K)

Unit III: Cell Fractionation, Chromatography and Spectrophotometry 15 lectures

Centrifugation; Types: differential, density, sucrose density, analytical, ultracentrifugation; Chromatography: Principle, types- paper, thin layer, ion-exchange, affinity, HPLC, GC/LC, molecular sieve and column chromatography. Spectrophotometry: principle and applications, spectroscopic techniques (NMR, FTIR, AAS)

Unit IV: Characterization of Proteins and Nucleic Acids 15 lectures

Mass spectrometry (MS, MS-MS),; X-ray diffraction and crystallography; Characterization of proteins and nucleic acids; PCR; Electrophoresis: AGE, SDS PAGE, denaturing gradient gel electrophoresis, and Native gel

Paper Code: BOTD-706(P)
Paper Title: Tools and Techniques in Plant Research (Practical)
Credit: 2

1. Use of Bibliographic software (Mandley, EndNote, etc.)
2. Fixation of plant materials in different fixatives
3. Preparation of permanent slides
4. Micrometry
5. Preparation of media and sterilization
6. Separation of compounds by paper chromatography/TLC
7. Determination of nucleic acid, protein and chlorophyll concentration using spectrophotometer
8. Agarose Gel Electrophoresis
9. Study of staining techniques (negative, positive, fluorescence and FISH) through micrographs/photographs
10. Collection, field noting, processing and submission of herbarium specimens (vouchers)of vascular plants.
11. Preparation of wet specimens

Suggested Readings

1. DT. Plummer (1996). An introduction to practical biochemistry (3rd edition). Tata McGraw-Hill Publishing Co. ltd, New Delhi.
2. SE Ruzin (1999). Plant Micro technique and Microscopy, Oxford University Press, New York, USA
3. F. Ausubel , R. Brent , RE Kingston, DD. Moore , JG. Seidman , JA. Smith ,K. Struhl (1995). Short protocols in Molecular Biology(3rd edition). John Wiley and Sons.
4. SB Sawant , RS. Raju (2023). Handbook of Plant Science Research: Methods, Techniques, and Essential Tools, Narendra Publications
5. SM. Khasim , K.Thammasiri , SM. Rao and M. Rahamtulla (2025). Plant Techniques-Theory and Practice, Routledge (Taylor and Francis Group)
6. J. Sambrook, EF. Fritsch and T. Maniatis . Molecular Cloning: A laboratory Manual. Cold Spring Harbour Laboratory Press, New York

7. A. Brown , H. Smith (2014) Benson's Microbiological Applications, Laboratory Manual in General Microbiology, McGraw Hill education
8. K. Wilson, KH. Goulding KH (1986) A Biologist's Guide to Principles and Techniques of Practical Biochemistry, Edward Arnold Publishers Ltd, USA
9. RA. Dixon and RA. Gonzales RA (1995) Plant Cell Culture: A practical Approach
10. KH. Neumann, A. Kumar, J. Imani (2020) Plant Cell and Tissue Culture – a tool in Biotechnology, Springer

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
8. Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
9. Practical
10. Field-based learning
11. Substantial laboratory-based practical component and experiments
12. Games
13. Technology-enabled learning
14. Internship in industry, and research establishments

Teaching Learning Plan:

Week 1 : Lecture

- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Laboratory experiments and practical record books
2. Highlighting the salient features of various biological tools and techniques used in plant research through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Research methodology	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Microscopy, histology and herbarium	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Cell fractionation, chromatography and spectrophotometry	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Characterization of proteins and nucleic acids	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course – Plant Diversity and Conservation

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-701**		**BOTG-702(P)**	

Course Objective

To gain knowledge on plant diversity and concepts on different biodiversity conservation measures.

Learning Outcomes

On completion of this course, students will gain knowledge and will be able to:

1. Understand concepts of different types of biodiversity
2. Acquire knowledge on ecosystem services, biodiversity hotspots & threat categories of the existing plant resources

3. Gain knowledge on the causes of biodiversity loss & different methods for eco-restoration
4. Acquire knowledge on different global programme& technologies for conservation of biodiversity including scope of remote sensing & GIS and IPR.

Paper Code: BOTG-701
Paper Title: Plant Diversity and Conservation (Theory)
Credit: 4

Unit I: Biodiversity **15 hours**
Biodiversity concepts, Uses of biodiversity, Microbial biodiversity of Prokaryotes and Eukaryotes, Agrobiodiversity (agriculture and horticulture), Plant diversity of India with reference to North East India

Unit II: Categories of Biodiversity **15 hours**
Magnitude and levels of biodiversity, IUCN categories of threat, Red Data Book, Endemic species, Extinction of species, Terrestrial and marine hotspots of biodiversity, hotspots of biodiversity in India, Ecosystem services.

Unit III: Losses of Biodiversity **15 hours**
Deforestation, habitat fragmentation, biological consequence of fragmentation, Global warming and its consequence on biodiversity, Ecological restoration.

Unit IV: Conservation of Biodiversity **15 hours**
National and international programmes for biodiversity conservation, Principles and importance of conservation, Conservation strategies (in-situ, ex-situ), Conventions – CITES, CBD, Ramsar sites. Role of remote sensing and GIS in biodiversity conservation, Bio-prospecting (plant / microbes) and IPR, Bio-piracy & protection measures.

Paper Code: BOTG-702(P)
Paper Title: Plant Diversity and Conservation (Practical)
Credit: 2 **60 hours**

1. Assessment of density, frequency and abundance of plants in a community using various techniques viz. transect, quadrat etc.
2. Comparison between and among forest stands, plant communities.
3. Analysis of Importance Value Index (IVI) of plant species in grasslands
4. Determination of alpha and beta diversity.
5. Determination of biodiversity indices.
6. Study of plant species under Red Data Book with special reference to Manipur.

Suggested Readings

6. R.S. Ambasht, and N.K. Ambasht (2008). A text book of Plant Ecology (14th edition) , CBS Publishers & Distributors Pvt. Ltd.
7. E.J. Kormondy (2017). Concepts of Ecology (4th edition). Pearson India Education Services Pvt. Ltd.

8. E.P. Odum (2005). Fundamentals of Ecology(5th edition), Engage Learning India Pvt. Ltd., New Delhi.
9. P.D. Sharma (2015). Ecology and Environment (12th edition). Rastogi Publications, Meerut.
10. J.S. Singh, S.P. Singh, S.R. Gupta (2008). Ecology, Environmental Science and Conservation, Anamaya Publishers, New Delhi.
11. R. Majumdar and R. Kashyap (2019). Practical Manual of Ecology and Environmental Science, Prestige Publishers, New Delhi.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
    - Subjective type
    - Long answer
    - Short answer
6. Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
7. Practical
8. Substantial laboratory-based practical component and experiments
9. Games
10. Technology-enabled learning
11. Internship in industry, and research establishments

Teaching Learning Plan:

1. Week 1 : Lecture
2. Week 2: Lecture
3. Week 3: Lecture
4. Week 4: Lecture
5. Week 5: Lecture/Practical
6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical/Field-based learning
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical

15. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and records of field studies as practical record books
2. Highlighting the importance of causes and impact of global climate change in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Biodiversity	Classroom lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Categories of biodiversity	Classroom lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Losses of biodiversity	Classroom lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Conservation of biodiversity	Classroom lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course – Integrated Plant Disease Management

	L	T	P	Total
Credit	**4**	**0**	**4**	**6**
Paper Codes	**BOTG-703**		**BOTG-704(P)**	

Course Objective

This course will explain the fundamental knowledge of plant disease management. The course explains the aspects of plant disease control, host-pathogen interaction, disease resistance and plant quarantine tactics, and relevant international guidelines for preventing pathogen spread in agricultural and horticultural plants.

Learning Outcomes

On completion of this course, students will gain knowledge and will be able to:

1. Define and explain plant disease management.
2. Compare and contrast chemical and biological control measures.

3. Compare and contrast the different types of pesticides, fungicides, and insecticides.
4. Understand the various international conventions and rules related to plant quarantine.

Paper Code: BOTG-703
Paper Title: Integrated Plant Disease Management (Theory)
Credit: 4

Unit I: Fundamentals of Plant Disease Management 15 Lectures

Principles of plant disease management (avoidance, exclusion, eradication, protection, host resistance and therapy); Integrated Disease Management (IDM): concept, importance, tools of IDM (legislative, cultural, physical, chemical and botanicals, biological and host-resistance methods); Host-pathogen relationships; Concept of Disease Triangle (host, pathogen and environment); Ecological management of crop environment; Disease monitoring; General symptoms; Terminology of plant pathology.

Unit II: Plant Disease Management and Plant Quarantine 12 Lectures

General principles of plant quarantine; Exotic pathogens and pathogens introduced into India; Sanitary and phyto sanitary issues under WTO, TRIPS, and PRA; Genetic basis of disease resistance and pathogenicity: gene for gene hypothesis; Breeding of resistant varieties, Genetically modified plants (merits and demerits).

Unit III: Chemical and Biological Control 15 Lectures

Nature, properties, and mode of action of antifungal, antibacterial, and insecticidal chemicals; pathogen immobilization; Role of stickers, spreaders, and other adjuvants; Health vis-a-vis environmental hazards, residual effects, and safety measures; Foliage, seed and soil application of chemicals; Biological control; Biopesticides.

Unit IV: Disease Management of Agricultural and Horticultural Crops 18 Lectures

Agricultural Crops: Rust and smut diseases of wheat; Blight, brown spot, false smut and bacterial blight of rice; Red rot of sugarcane; Turcicum leaf blight and downy mildew of maize; Early and late blight of potato; Powdery mildew and rust of pea; Alternaria leaf spot and bacterial black rot of cabbage.

Horticultural Crops: Anthracnose, malformation and bacterial black spot of mango; Canker and gummosis of citrus; Downy mildew, powdery mildew and anthracnose of grapes; Scab, powdery mildew, fire blight and crown gall apple; Peach leaf curl.

Paper Code: BOTG-704(P)
Paper Title: Integrated Plant Disease Management (Practical)
Credit: 2

1. To study different types of disease symptoms produced due to infection by pathogens.

2. Preparation of temporary mounts (slides) and staining of plant pathogenic microbes.
3. Isolation of plant pathogens from soil, seed, and affected plant parts.
4. Preparation of culture media like Potato Dextrose Agar (PDA).
5. Proving pathogenicity through Koch's postulates.
6. Field visits for the diagnosis of field problems.
7. Collection and preservation of plant-diseased specimens for herbarium.
8. Note: Students should submit 20 pressed and well-mounted specimens.

Suggested Readings

1. R Agrios, G.N. (2024). Plant Pathology. Sixth Edition, Academic Press, USA. ISBN: 9780128224298
2. H.S. Chaube and V.S. Pundhir (2005). Crop Disease and Their Management. Prentice Hall of India Private Limited. ISBN : 9788120326743
3. M.K. Das Gupta (1994). Principles of Plant Pathology. 8170231922, Published by Allied Publishers. ISBN9788170231929 9788170231929
4. A.L. John and C.H. Dickinson (1998). Plant Pathology and Plant Pathogens. Wiley-Blackwell.
5. J.G. Manners (1993). Principles of Plant Pathology. Cambridge University Press, UK.
6. R.S. Singh 1984. Introduction to Principles of Plant Pathology, Oxford and IBH Publishing Co Pvt. Ltd., NewDelhi.
7. R.S. Mehrotra. Plant Pathology Tata McGRaw Hill. ISBN 9780070473997
8. P.D. Sharma. Plant Pathology. Rastogi Publications. ISBN 9789350781197
9. A. M. Tronsmo, D.B. Collinge, A. Djurle, L. Munk, J. Yuen and A.Tronsmo. Plant Pathology and Plant Diseases CABI. ISBN 9781789243178
10. A. Mahadevan and R. Sridhar :Methods in Physiological Plant Pathology, Sivakashi Publication, Madras
11. N.W. Schaod, :Plant Pathogenic Bacteria: Laboratory Guide for identification of plant pathogenic bacteria. Academic Press.
12. Manners, J.G.,:*Principles of Plant Pathology*, Cambridge University Press.
13. Sigee, D.C.,:*Bacterial Plant Pathology*, Cambridge University Press.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type

8. Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
9. Practical
10. Field-based learning
11. Substantial laboratory-based practical component and experiments
12. Games
13. Technology-enabled learning
14. Internship in industry, and research establishments

Teaching Learning Plan:

Week 1 : Lecture

- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Herbarium preparation and specimen collection diseased plant samples
3. Highlighting the salient features of different methods of plant disease control through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Fundamentals of plant disease management	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Plant disease management and plant quarantine	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Chemical and biological control	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

IV	Disease management of agricultural and horticultural crops	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Semester VIII

Core Course – Applied Microbiology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTC-801**		**BOTC-802(P)**	

Course Objective

To provide fundamental and advanced knowledge of microbiology including diversity, genetics, metabolism, molecular approach of identification, symbiotic association, plant microbe interaction, microbial techniques, microbial contamination and management, etc.

It will also impart the knowledge of microbiological applications in various fields of academic, research, agriculture, environment, waste management and industries (food, pharmaceutical, energy, etc.).

Learning Outcomes

After study of the course, students will be able:

1. To illustrate and describe diversity of microorganisms and their importance in different habitats (soil, water, milk and food materials).
2. To practice isolation and identification of microorganisms with the help of both morphological and molecular techniques.
3. To understand factors affecting distribution of microorganisms in soil, causal organisms and control measures of agriculturally important plant diseases.
4. To understand important physiological processes as well as genetic characteristics, their applications in fermentation and recombinant technology.
5. To isolate microbes in water and food products, applications of microbes in industrial fermentation of and waste management, production of antibiotics and regulatory guidelines on bio-safety and good pharmaceutical manufacturing practices.

Paper Code: BOTC-801
Paper Title: Applied Microbiology (Theory)
Credit: 4
Unit I: Microbial Diversity, Tools and Techniques **14 Lectures**

Identification, characterization and classification of microorganisms (bacteria, fungi and virus). Microbial taxonomy, Phenotypic characters and biochemical tests (e.g., API, BIOLOG) and chemotaxonomic markers. Principles and types of light and electron microscopy. Microbial growth, culture and staining techniques (acid fast, capsule, flagella and endospore staining). Molecular techniques to assess microbial diversity and phylogeny. Metagenomics and applications. Biosafety in Microbiology: common laboratory contaminants, Risk Assessment and Biological Safety Level (BSL).

Unit II: Agricultural Microbiology and Plant Pathology 15 Lectures

Natural habitats of microorganisms: - Microbial ecology of soils - factors affecting soil microflora. Rhizosphere, phyllosphere, mycorrhiza and actinorhiza. Symbiotic and non-symbiotic nitrogen fixation. Epidemiology of plant diseases – Pathology, aetiology and control of economically important crop diseases caused by bacteria (bacterial blight of paddy), fungi (downy mildew of grapes, red rot of sugarcane) and viruses (Tobacco mosaic virus). Molecular mechanisms of plant microbe interaction. Biopesticides and biofertilizers: mass production techniques and their applications.

Unit III: Microbial Physiology and Genetics 15 Lectures

Microbial metabolism-Catabolic and anabolic pathways in bacteria. Anaerobic respiration, methanogenesis. Prokaryotic genetic material (nucleoid), DNA replication, transcription and gene expression in prokaryotes. Operon Concept: Positive and negative regulation in *E.coli*, and *Lac* operons. Gene mapping in *E.coli*and Yeasts. Recombinant DNA technology-Restriction enzymes, synthetic DNA and cDNA, cloning hosts, vectors and strategies. Construction of genomic and c-DNA libraries.Screening and isolation of recombinants: Reporter genes. CRISPR technology and gene editing.

Unit IV: Environmental and Industrial Microbiology 16 Lectures

Microbiology of waterand water-borne pathogens, Microbiological examination of water and food products. Factors influencing microbial growth in food, principles of food preservation. Fermented foods, GM foods, food safety and quality control standards. Spoilage, contamination and examination of microorganisms in milk and milk products. Production of for non-distilled beverages (beer and wine) and distilled beverages, vinegars and vitamins. Antibiotics from microbes, bacterial and viral vaccines. Concepts of probiotics, prebiotics, symbiotics and postbiotics. Single Cell Protein (SCP). Microbial Enhanced Oil Recovery (MEOR). Microbes and sewage treatment, biological sludge treatment and biofuels. Good manufacturing practices in pharmaceutical industries (GPMP/GMP).

Paper Code: BOTC-802(P)
Paper Title: Applied Microbiology (Practical)
Credit: 2

1. Staining of bacteria and fungi (Gram staining, acid fast staining, negative staining for capsules and spore staining, cotton blue staining of fungi).
2. Preparation of culture media and isolation of bacteria and fungi by streak plate, pour plate and spread plate techniques.
3. Enumeration of microorganisms from soil, milk, bakery products and water.
4. Isolation of free-living nitrogen fixers from soil and *Rhizobium* from root nodules
5. Antimicrobial assay by Kirby-Bauer disk-diffusion assay
6. Isolation and identification of pathogens from infected plant tissues.
7. Antagonistic study of *Trichoderma* and pathogenic fungi by co-cultivation method.
8. Isolation of genomic DNA from bacteria and fungi by CTAB method.
9. Preparation of wine from locally available fruits and estimation of alcohol.
10. Production of citric acid using *Aspergillus niger*.
11. Screening of amylase, cellulase and protease producing fungi.
12. Cultivation of *Spirulina* (SCP) and edible mushrooms

Suggested Readings

1. R.C. Dubey , D.K. Maheshwari (2010). A Textbook of Microbiology(3rd edition). S. Chand & Co. New Delhi
2. M. T. Madigan, J. M. Martinko, K.S. Bender, D. H. Buckley and D.A. Stahl (2017) - Brock Biology of Microorganisms (14th edition). Pearson Education, Inc.
3. A. Jain, V. Venkatesh and J. Agarwal (2018). Microbiology Practical Manual (1st edition), Elsevier India.
4. K.R. Aneja. (2023). Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology (6th edition). New Age International Publisher, New Delhi
5. A.G. Moat, J.W. Foster and M.P. Spector (2009). Microbial Physiology (4th edition). Wiley.
6. S.R. Reddy, S.M. Reddy (2008). Microbial Physiology. Anmol Publications Pvt Ltd.
7. D.R. Cullimore (2010). Practical Atlas for Bacterial Identification(2nd edition). Publisher-Taylor &Francis.
8. R.L.Tate (2020). Soil Microbiology (3rd edition), Wiley Blackwell.
9. Ravichandra N.G. (2013). Fundamentals of Plant pathology. PHI Learning Pvt Ltd.
10. D.Freifelder, J.Cronan and S.R. Maloy (2009). Microbial Genetics (2nd edition). Narosa Publishing House.
11. K.Chaudhuri (2012). Recombinant DNA Technology. The Energy and Resources Institute, TERI
12. C.M.Roy (2014). Laboratory Manual for Molecular Genetic Tests. Jaypee Brothers Medical Publishers.
13. K.G. Mukerji (2013). Laboratory Manual of Food Microbiology. I. K. International Pvt. Ltd.
14. S. Mandal (2011). Laboratory Manual on Introductory Dairy Microbiology. ICAR-NDRI, Karnal.

15. Prasad G.S. and K. Srisailam (2019). Pharmaceutical Microbiology: A Laboratory Manual. Pharmamed Press.
16. L.E. Casida (2016). Industrial Microbiology. 2nd Edition. New Age International.
18 R.M. Atlas (1997). Principles of Microbiology (2nd edition). Mosby
19 J. Black. (2017). Microbiology: Principles and Explorations (10th edition),Wiley Publishers.
20 Pharmaceutical Microbiology Manual. (2020). Doc. No. ORA.007 / Revision 2. Food and Drug Administration (FDA). URL:https://www.fda.gov/media/88801/download.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
8. Multiple choice questions
   - One answer/two answer type questions
   - Assertion and reasoning
9. Practical
10. Field-based learning
11. Substantial laboratory-based practical component and experiments
12. Games
13. Technology-enabled learning
14. Internship in industry, and research establishments

Teaching Learning Plan:

Week 1 : Lecture

- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Collection of various microbiological samples
3. Highlighting the salient features of microbial diversity, biology, genetics and applications through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Microbial diversity, tools and techniques	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Agricultural microbiology and plant pathology	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Microbial physiology and genetics	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Environmental and industrial microbiology	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Core Course – Advanced Ecology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTD-705**		**BOTD-706(P)**	

Course Objective

To gain knowledge on recent advances in ecology and environmental sciences.

Learning Outcomes

On completion of this course, students will gain knowledge and will be able to:

8. Understand concepts & components of ecosystems, distribution of biodiversity, their threats & conservation measures.
9. Acquire detail knowledge on climate & soil variables as ecosystem components.
10. Gain knowledge on the causes, consequences & mitigation measures of pollution and issues related to Global Climate Change.
11. Acquire knowledge on components of Environment Impact Assessment and its significance in formulating & regulating Sustainable Development Programme.

Paper Code: BOTD-705
Paper Title: Advanced Ecology (Theory)
Credit: 4
Paper Code: BOTD-705
Paper Title: Advanced Ecology (Theory)
Credit: 4

Unit I: Concept of ecosystem & Biodiversity **15 lectures**

Structure and function of ecosystem, Plant community analysis: analytical and synthetic methods; Concept of ecotypes and their importance;Plant Adaptations; Primary and secondary production in ecosystems; Levels of biodiversity; Regional pattern of biodiversity, Biodiversity hotspots, Threats to biodiversity & its conservation measures.

Unit II: Ecological interactions& Ecological modelling **15 lectures**

Competition and mutualism; Plant-plant interactions: symbiosis, commensalism, Allelopathy and parasitism; Plant–animal interactions: herbivory, pollination-pollinators and Zoochory, Invasive Alien species; Ecosystem niche modelling; Principles & Applications of Remote Sensing & GIS in ecology; Concept of Landscape Ecology.

Unit III: Environmental pollution, Climate change& Ecological modelling **15 lectures**
Causes, consequences and mitigation of air, water, soil & noise pollution; Residence and persistence periods of pollutants; Causes, consequences and mitigation of Greenhouse effect, Possible impacts of global warming, Suitable tools to study global climate change; concepts of carbon sequestration, carbon pools & carbon credits.

Unit IV: Environmental Impact Assessment & Sustainable Development **15 lectures**
Origin & development, Environmental components of EIA & its process, Environmental Appraisal Procedures, Benefits & Effectiveness of EIA; Ecological footprints, sustainability indicators, Sustainability Index, Environmental Audit; National and International programme for sustainable development.

Paper Code: BOTD-706(P)
Paper Title: Advanced Ecology (Practical)
Credit: 2

1. Generation of Species-Area Curve for fixing quadrat size.
2. Determination of Importance Value Index of plant species by Quadrat Method.
3. Enumeration of Shanon-Weaver Species Diversity Index species by Quadrat Method.
4. Enumeration of Shorensen's similarity index.
5. Enumeration of Pileu's Evenness index.
6. Study of climatic variables viz. Light intensity, Air temperature, Relative humidity.

7. Study of soil physical parameters, viz. soil moisture, soil texture, soil pH, Bulk density, Water holding capacity.
8. Study of standing biomass & carbon pool in grassland ecosystem.
9. Application of Remote Sensing & GIS tools for ecological analysis & modelling.

Suggested Readings R.S. Ambasht & N.K. Ambasht (2008). A Text Book of Plant Ecology. CBS Publishers & Distributers, New Delhi.

1) D.B. Botkin & E.A. Keller (2004). Environment Science: Earth as a Living Planet, John Wiley & Sons Inc., New York.
2) E.J. Kormondy 2017. Concepts of Ecology(4th edition). Pearson India Education Services Pvt. Ltd..
3) Miller (Jr.) & G. Tyler (1994). Living in the Environment. Wadsworth Publishing Company, Belmont, California.
4) K.C. Misra (1991). Manual of Plant Ecology. Oxford & IBH. New Delhi.
5) E.P. Odum (1983). Fundamentals of Ecology. Sanders, Philadelphia.
6) H. Peter , P.H. Raven & L.R. Berg 2005. Environment (5th edition). John Wiley & Sons Inc., New York.
7) P.S. Ramakrishnan 2000. Ecology and Sustainable Development. National Book Trust, India.
8) P.D. Sharma 2015. Ecology and Environment (12th edition). Rastogi Publications, Meerut.
9) J.S. Singh, S.P. Singh, S.R. Gupta 2008. Ecology, Environmental Science and Conservation, Anamaya Publishers, New Delhi.
10) R.L. Smith 1996. Ecology and Field Biology, Harper Collins, New York.
11) R. Majumdar and R. Kashyap 2019. Practical Manual of Ecology and Environmental Science, Prestige Publishers, New Delhi.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
    - Subjective type
    - Long answer
    - Short answer
6. Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
7. Practical
8. Substantial laboratory-based practical component and experiments
9. Games
10. Technology-enabled learning
11. Internship in industry, and research establishments

Teaching Learning Plan:

16. Week 1 : Lecture
17. Week 2: Lecture
18. Week 3: Lecture
19. Week 4: Lecture
20. Week 5: Lecture/Practical
21. Week 6: Lecture/Practical
22. Week 7: Lecture/Practical
23. Week 8: Lecture/Practical
24. Week 9: Lecture/Practical
25. Week 10: Mid semester Exam
26. Week 11: Lecture/Practical
27. Week 12: Lecture/Practical/Field-based learning
28. Week 13: Lecture/Practical
29. Week 14: Lecture/Practical
30. Week 15: Lecture/Practical

Assessment Methods

1. Drawings and records of field studies as practical record books
2. Highlighting the importance of causes and impact of global climate change in digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Concept of ecosystem and biodiversity	Classroom lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Climatic & edaphic factors	Classroom lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Environmental pollution & climate change	Classroom lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Environmental impact assessment & sustainable development	Classroom lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Discipline Specific Elective Course – Research Project/Dissertation

	Dissertation & Presentation	Total

Credit	**6**	**6**
Paper Codes	**BOTD-805**	

Course/Project Objective

The research project aims to develop students' competencies in research methodology, scientific writing, critical thinking, and ethical practices. Students will identify research problems, design experiments, and systematically analyze and present their findings using modern tools and techniques in plant sciences.

Learning Outcomes

At the end of this research project, the students will be able to

1. Identify the research problem based on the literature review
2. Formulate the research design and initiate experimentation, fieldwork, or equivalent activities
3. Apply modern tools and techniques for data collection, analysis, interpretation, and develop competencies in scientific writing and presentation.
4. Cultivate a scientific temperament, enhance critical thinking and time management skills, and adopt a methodical approach to address the identified research problem.
5. Facilitate the transfer of research knowledge to society.

Course Description

Students will receive necessary guidance from faculty members in identifying research problems, conducting the study, and preparing a project report.

- The research topic must be finalized and approved by the Departmental Research Committee (DRC).
- The research project or dissertation will be conducted through field- or lab-based experiments.

Research Project Process

- Collection and review of relevant literature
- Presentation of the research proposal and finalization of the research topic
- Execution of field and/or laboratory-based experiments
- Compilation, analysis, and interpretation of research findings
- Publication or patenting of research outcomes (optional but encouraged).

Dissertation

- Students must submit a dissertation as a partial requirement for the award of the degree.
- The dissertation should be based on a selected research problem. The dissertation may present results from original empirical or documentary research, a reinterpretation of existing knowledge or data, or any other scholarly contribution as approved by the Departmental Faculty.
- Dissertation Structure
    - Topic/title
    - Introduction

- Review and literature
- Materials and methods
- Results and Discussions(or separate "Results" and "Discussion" sections if preferred)
- Conclusion

Assessment Methods

- Presentation and evaluation of the research project/dissertation before a committee that includes an external examiner.
- Research output may be supported by any one of the following:
  - Prototype or product development, or filing of a patent
  - Any other scholarly work as recommended by the Departmental Research Committee (DRC), the Board of Research Studies (BRS), or any board approved by the competent academic authority.
  - Publication in reputed journals, preferably those indexed in recognized databases such as Scopus, Web of Science, or similar indexing services.
  - Authorship of a book or a book chapter published by a reputed publisher

Generic Elective Course – Ethnobotany and ITK (Indian Traditional Knowledge)

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-801**		**BOTG-802(P)**	

Course Objective

The course objectives of this course are to define and understandthe concept of ethnobotany and Indian Traditional Knowledge (ITK), to discuss the scope of the subject area covered by this discipline, to discuss the historic roots of ethnobotany,to discuss the role, importance and contribution of Ethnobotany and ITK in our modern civilization andto make students aware about the ethnic importance of plants and their conservation of genetic resources.

Learning Outcomes

1. The learner will know the various tools and techniques used in plant research.
2. The learner will know the principle of microscopy and microscopes as well as preparation of sections and slides.
3. The learner will know microbiological and tissue culture techniques, cell fractionation, chromatography and spectrometric techniques.
4. The learner will be able to understand Characterization of proteins and nucleic acids.

Paper Code: BOTG-803
Paper Title: Ethnobotany and ITK (Indian Traditional Knowledge) (Theory)
Credit: 4

Unit I: Introduction of Ethnobotany **12 Lectures**

Ethnobotany as an Interdisciplinary Science, Medico-ethnobotanical sources, Digital Library on Traditional Knowledge, Role of ethnic groups in conservation of plant genetic resources.

Unit II: Methodology of Ethnobotanical Study **16 Lectures**
Types of ethnobotanical research methods: field work, documentation, questionnaire designs, Role of herbaria and literature, Qualitative and quantitative research methods and indices (FIC, FL and UV, etc.).

Unit III: Classification of Ethnobotanically Important Plants **17 Lectures**
Medicinal plants, timbers, dye yielding plants, wild edible plants, socio-culturally important plants; Significance of the following plants in ethnobotanical practices (along with their habitat and morphology) a) *Toona ciliata* b) *Bixa orellana* c) *Ocimum tenuiflorum*d) *Phlogacanthus pubinerviuse*) *Tectona grandis*, f) *Gmelina arborea*,
g) *Microtoenapachouliie*) *Centella asiatica, f) Goniothalamussesquipedalis, g) Isodonternifolius*

Unit IV: Indian Traditional Knowledge (ITK) **15 Lectures**
Historical background, Ayurveda systems, social needs and technological applications, scientific rationalism and technological efficacy, cultural mores, Traditional health practices, Folklore and sacred grooves of Manipur, Threats to Sacred Groves and its Sustainability, Issues concerning Bioprospecting and Bio-Piracy.

Paper Code: BOTG-802(P)
Paper Title: Ethnobotany and ITK (Indian Traditional Knowledge) (Practical)
Credit: 2

1. Questionnaire design for field study.
2. Collection and documentation of ethnobotanically important plants from wild habitats and from local markets of Manipur.
3. Preservation and voucher specimen deposition of ethno-botanically important plants of Manipur.
4. Survey, documentation and formulation methods for herbal medicines by local herbal healers.
5. Determination of FIC, FL and UV of ethnobotanical plants.

Related Readings

1) S.K. Jain.(1995). Manual of Ethnobotany, Scientific Publishers, Jodhpur.
2) S.K. Jain (ed.) (1981). Glimpses of Indian. Ethnobotany, Oxford and I B H, New Delhi.
3) Prakash Paranjpe. (2012). Indian Medicinal Plants:Forgotten Healers, Chaukhamba Sanskrit Pratisthan.
4) Ashok Kumar Awasthi. (2021). The Concepts of Ethnobotany, Ane Books Pvt. Ltd.
5) Kapil Kapoor and Avadhesh Kumar Singh. (2005). Indian Knowledge Systems, D.K. PrintworldPvt. Ltd.
6) M. Amirthalingam, Nanditha Krishna. (2014). Sacred Plants of India, India Penguin Publications.

Teaching Learning Process

1. Class lectures
2. Seminars

3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
    - Long answer
    - Short answer
7. Objective type
8. Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning
9. Practical
10. Field-based learning
11. Substantial laboratory-based practical component and experiments
12. Games
13. Technology-enabled learning
14. Internship in industry, and research establishments

Teaching Learning Plan:

Week 1 : Lecture

- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
- Week 5: Lecture/Practical
- Week 6: Lecture/Practical
- Week 7: Lecture/Practical
- Week 8: Lecture/Practical
- Week 9: Lecture/Practical
- Week 10: Mid semester Exam
- Week 11: Lecture/Practical
- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Herbarium preparation and collection of specimens relevant plant products
3. Highlighting the salient features of ethnobotany and Indian Traditional Knowledge through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Introduction to ethnobotany	Class room lectures, demonstrations and	Hands on exercises, PPT, assignments, tests

		Practical	
II	Methodology of ethnobotanical study	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Classification of ethnobotanically important plants	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Indian Traditional Knowledge (ITK)	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

Generic Elective Course– Plant Resources and Sustainable Management

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Codes	**BOTG-803**		**BOTG-804(P)**	

Course Objective

This course aims to cover the use of natural renewable materials derived from plants and animals such as products of food, feed, and fiber to produce medicines, livelihood, and management of resources.

Learning Outcomes

1. Fundamental understanding of the bioresources and their applications for the attainment of social objectives (energy, environment, product, sustainability).
2. Acquire knowledge concerning the properties of the bioresources and the conversion technologies.
3. Exhibiting knowledge of the systems used for bioresources and bioresource technology.

Paper Code: BOTG-803
Paper Title: Plant Resources and Sustainable Management (Theory)
Credit: 4

Unit-I: Bioresources **11 lectures**

Types of bio-resources and their utilization: Natural bio-resources: agricultural, forest, and aquatic biomass. Biomass availability, production, and food security, non-edible biomass characteristics.

Unit-II: Plant Resources **13 lectures**

Origin of agriculturally important crops; Centers of origin:de Candolle and Vavilov; Rice and Maize; Morphology and economically important plants (*Phlogacanthus pubinervius, Centella asiatica, Houttuynia cordata, Leucas aspera*,—*Persicaria chinensis, Lysimachia candida, Amaranthus viridis, Alpinia galanga*)

Unit-III: Bioresources and Livelihood **16 lectures**

Livelihood and its relation with bioresources management, threats to traditional livelihood, food insecurity; impact of globalization and urbanization on livelihood, sustainable development, energy crisis and need of green energy, Green buildings; Green walls (vertical gardens) (concept and examples). Green washing; eco labelling (Concept and examples).

Unit-IV: Bioresources Management Policies **18 lectures**

Indian Bioresources Information Network (IBIN)-Organization and role, Convention on Biological Diversity (CBD)-Aims and Objectives, Ramsar Convention (Scope and Objective), CITES, Nagoya Protocol, Environment Protection Act 1986-Scope and Objectives, Environment Impact Assessment (EIA)-Concept and Stages of EIA, Bioresource conservation and public participation, National Biodiversity Authority (NBA), Peoples Biodiversity register (PBR) and State Biodiversity Board (SBB) and Medicinal Plant Board (MPB).

Paper Code: BOTG-804(P)

Paper Title: Plant Resources and Sustainable Management (Practical)
Credit: 2

1. Submission ofplant based products (medicinal, dying, spice, jwelleries, etc.)
2. Determination of total phenol and poly-phenols from plant products.
3. Determinations of starch, carbohydrates.
4. Estimation of reducing sugar by dinitrosalicylic acid (DNS) method.
5. Collection and voucher specimen preparation of economically important plants (medicines, vegetables).

Suggested Readings

1. G. Tripathi (2002). Bioresource Technology, CBS Publications.
2. A. Pandey, Concise Encyclopaedia of Bioresource Technology, CRC Press.
3. M. Shuler, F. Kargi (2004). Bioprocess Engineering, Basic Concept, Prentice Hall of India Pvt. Ltd.
4. GE. Wickens (2004). Economic Botany: Principles and Practices, Springer, ISBN 978-0-7923- 6781-9.
5. Rashtra Vardhana (2009). Economic Botany. Sarup Book Publishers Pvt. Ltd, New Delhi -110002
6. Ramesh Umrani (2009). Basics of Economic Botany. Anmol Publications Pvt.Ltd, New Delhi – 110002.
7. P. Ganguli (2001). Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill. 13.
8. R. Saha. (2006). Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publishing House, New Delhi.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
   - Long answer
   - Short answer
7. Objective type
8. Multiple choice questions
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   - Assertion and reasoning
9. Practical
10. Field-based learning
11. Substantial laboratory-based practical component and experiments
12. Games
13. Technology-enabled learning
14. Internship in industry, and research establishments

Teaching Learning Plan:

Week 1 : Lecture

- Week 2: Lecture
- Week 3: Lecture
- Week 4: Lecture
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- Week 10: Mid semester Exam
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- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Herbarium preparation and specimen collection
3. Highlighting the salient features of bioresoueces and their management strategies through digital media such as power point presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Bioresources	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
II	Plant resources	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
III	Bioresources and livelihood	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests
IV	Bioresources management policies	Class room lectures, demonstrations and Practical	Hands on exercises, PPT, assignments, tests

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