ORIENTAL COLLEGE

Syllabus for
B.Sc. (Honours) Botany

Four-Year Undergraduate Programme
(Eight - Semester Course)

Learning Outcomes based Curriculum Framework (LOCF)
For B.Sc. with Botany
Undergraduate Programme 2022
In view of
National Education Policy (NEP) 2020,
And
University Grants Commission's Guidelines
(Course effective from Academic Year 2022-23)

COURSE CONTENTS
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Preamble

In view of the National Education Policy 2020 of Government of India and the University Grants Commission's Guidelines for Learning Outcomes-based Curriculum Framework (LOCF) under Choice Based Credit System (CBCS), the Oriental College, Imphal has decided to introduce the LOCF for four-year undergraduate programme from the session 2022-23. The LOCF syllabus under CBCS for the B.Sc. (Honours) is prepared in the model of syllabus prepared by the UGC.

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 students of the discipline to accuiant themselves with the various tools and techniques for exploring the world of plants upto the sub- cellular level visualize the curriculum more specifically in terms of the learning outcomes expected from unique students at the end of the instructional process . Keeping the employment entrepreneurship in mind, applied courses have also been introduced. These courses shall provide the botany students hands on experience and professional inputs. On the whole, the curriculum is a source of lot of information and is supported by rich resource materials. It is hoped that a student graduating in Botany with the new curriculum will be a complete Botanist at Honours level.

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 zoology, 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 require 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

Courses of Undergraduate Programmes:

The undergraduate course in Botany will be of four years duration having eight semesters with multiple entry-exit options within this period with appropriate certifications, namely,

(a) **Bachelor's Certificate in Botany** upon the successful completion of the First Year (Two Semesters);

(b) **Bachelor's Diploma in** Botany upon the successful completion of the Second Year (Four Semesters);

(c) **Bachelor's Degree in** Botany at the successful completion of the Third Year (Six Semesters);

(d) **Bachelor's Degree with Honours in** Botany at the successful completion of the Four Year (Eight Semesters).

The undergraduate programmes in Botany contain the following course components:

- **Core Course**: This is a course which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline/subject of study. Each of the Core Courses shall contain two components: Theory and Practical/Tutorial. Theory Paper having Practical shall carry 4 Credits, so that Practical carries 2 Credits.
- **Elective Course:** Generally, an elective course is a course which can be chosen from a pool of courses which may be very specific or specialized or advanced or supportive to the discipline/ subject of study, provides an extended scope or which enables exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill.

  An elective course may be three types:

  (a) Discipline Specific Elective (DSE) Course: Elective courses offered by the main discipline/subject of study are referred to as Discipline Specific Elective Courses. This course is to advance knowledge and skill in the core domain. Each of the DSE courses shall contain two components: Theory and Practical/Tutorial. Theory Paper having Practical shall carry 4 Credits, so that Practical carries 2 Credits.

(b) Dissertation/Project/Internship: An elective course designed to acquire special/advanced knowledge is termed a dissertation/project. This is considered a special course involving the application of knowledge in solving/ analyzing/ exploring a real-life situation/ difficult problem.

(c) Generic Elective Course (GEC): An elective course chosen generally from an unrelated discipline/subject, with an intention to seek a wide exposure, is called a Generic Elective. Each of the GEC Courses shall contain two components: Theory and Practical/Tutorial. Theory Paper having Practical shall carry 4 Credits, so that Practical carries 2 Credits.

- **Ability Enhancement Course:** The Ability Enhancement Course may be of two kinds: Ability Enhancement Compulsory Courses (AECC) and Skill Enhancement Courses (SEC). AECC courses are mandatory courses based upon the content that leads to Knowledge enhancement: (i) Environmental Science and (ii) English/MIL Communication.

  SEC courses are value-based and/or skill-based and are aimed at providing hands-on training, competencies, skills, etc. These may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge. Each of the AECC and SEC courses shall carry 4 Credits.
- **Value Addition Courses (VAC**): These are courses that will help develop all capacities of human beings – intellectual, aesthetic, social, physical, emotional, and moral in an integrated manner. It includes subjects like Yoga, Sports, Health Care, NCC, NSS, Ethics, Culture etc. VAC courses may be chosen from a pool of courses. Each VAC course shall carry 2 Credits.

Evaluation and Assessment Process:

The overall weightage of a course in the syllabi and scheme of Teaching and Examination shall be determined in terms of marks and/ or grades and/ or credits assigned to the course. The evaluation of students in a course shall have two components:

1. Continuous of Comprehensive Internal Assessment (CIA)
2. Semester End Examination (SEE)

Continuous & Comprehensive Internal Assessment:

For theory course, Continuous & Comprehensive Internal Assessment (CIA) comprises unit/ periodical tests, home assignments, group discussion, quiz, project works, seminars and attendance by the teacher(s) of the course. The components of CIA are given below:

Sl. NO.	CIA COMPONENT
1	Unit/ Periodical Test
2	Home Assignment
3	Seminar
4	Group Discussion

5	Quiz
6	Project Works
7	Class Attendance

Semester End Examination (SEE): For the end semester, students have to appear both Theory and Practical paper

Scheme for Choice Based Credit System in B. Sc. Botany Honours Semester

Course Structure

Semester I

Core Courses		
Course code	Title of the paper	Credit
BOT-HC-501 BOT-HC-501(P)	Introduction to Microbial World, Virus, Bacteria, Fungi and Phytopathology Introduction to Microbial World, Virus, Bacteria, Fungi and Phytopathology (Practical)	4 2
BOT-HC-502 BOTC-502(P)	Algae, Bryophytes, Pteridophytes and Gymnosperms Algae, Bryophytes, Pteridophytes and Gymnosperms (Practical)	4 2
Ability Enhancement Compulsory Courses (AECC)		
	English/MIL	4
Skill Enhancement Courses (SEC) to be opted one course		
BOT-SE-501 BOT-SE-501(P)	Biofertilizers Biofertilizers (Practical)	3 1
BOT-SE-501 BOT-SE-501(P)	Mushroom Cultivation Mushroom Cultivation(Practical)	3 1
BOT-SE-501 BOT-SE-501(P)	Fermentation Technology Fermentation Technology (Practical)	3 1

Value Addition Courses (VAC)		
	To be opted from central pool	2
	To be opted from central pool	2
Total Credit		**24**

Semester II

Core Courses		
Course code	Title of the paper	Credit
BOT-HC-503 BOT-HC-503(P)	Plant Systematics Plant Systematics (Practical)	4 2
BOT-HC-504 BOT-HC-503(P)	Biomolecules and Cell Biology Biomolecules and Cell Biology (Practical)	4 2
Ability Enhancement Compulsory Courses (AECC)		
	Environmental Science	4
Skill Enhancement Courses (SEC) to be opted one course		
BOT-SE-502 BOT-SE-502(P)	Botanical Garden and Landscaping Botanical Garden and Landscaping (Practical)	3 1
BOT-SE-502 BOT-SE-502(P)	Nursery and Gardening Nursery and Gardening (Practical)	3 1
BOT-SE-502 BOT-SE-502(P)	Floriculture Floriculture (Practical)	3 1
Value Addition Courses (VAC)		
	To be opted from central pool	2
	To be opted from central pool	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
BOT-HC-601 BOT-HC-601(P)	Plant Metabolism Plant Metabolism (Practical)	4 2
BOT-HC-602 BOT-HC-602(P)	Ecology and Phytogeography Ecology and Phytogeography (Practical)	4 2
BOT-HC-603 BOT-HC-603(P)	Genetics and Cytogenetics Genetics and Cytogenetics (Practical)	4 2
Generic Elective Course (GEC)		
BOT-HG-601	Theory (To be opted from other discipline)	6/4
BOT-HG-601(P)	Practical	2/0
Value Addition Courses (VAC)		
	To be opted from central pool	2
Total Credit		**26**

Semester IV

Core Courses		
Course code	Title of the paper	Credit
BOT-HC-604 BOT-HC-604(P)	Economic Botany and Plant Resource Utilization Economic Botany and Plant Resource Utilization (Practical)	4 2
BOT-HC-605 BOT-HC-605(P)	Molecular Biology Molecular Biology (Practical)	4 2
BOT-HC-606 BOT-HC-606(P)	Plant Morphology and Anatomy Plant Morphology and Anatomy (Practical)	4 2
Generic Elective Course (GEC)		
BOT-HG-602	Theory (To be opted from other discipline)	6/4
BOT-HG-602(P)	Practical	2/0
Value Addition Courses (VAC)		
	To be opted from central pool	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
BOT-HC-701	Reproductive Biology of Angiosperms	4
BOT-HC-701(P)	Reproductive Biology of Angiosperms (Practical)	2
BOT-HC-702	Plant Physiology	4
BOT-HC-702(P)	Plant Physiology (Practical)	2
Discipline Specific Elective Course (DSE) to be opted one course		
BOT-HE-701	Stress Physiology	4
BOT-HE-701(P)	Stress Physiology (Practical)	2
BOT-HE-701	Natural resource management	4
BOT-HE-701(P)	Natural resource management (Practical)	2
Generic Elective Course (GEC)		
BOT-HG-701	Theory (To be opted from other discipline)	6/4
BOT-HG-701(P)	Practical	2/0
Value Addition Courses (VAC)		
	To be opted from central pool	2
Total Credit		**26**

Semester VI

Core Courses		
Course code	Title of the paper	Credit
BOT-HC-703	Biostatistics and Bioinformatics	4
BOT-HC-703(P)	Biostatistics and Bioinformatics (Practical)	2
BOT-HC-704	Plant Biotechnology	4
BOT-HC-704(P)	Plant Biotechnology (Practical)	2
Discipline Specific Elective Course (DSE) to be opted one course		
BOT-HE-702	Biodiversity Conservation	4
BOT-HE-702(P)	Biodiversity Conservation (Practical)	2
BOT-HE-702	Post-Harvest Technology	4
BOT-HE-702(P)	Post-Harvest Technology (Practical)	2
Generic Elective Course (GEC)		
BOT-HG-702	Theory (To be opted from other discipline)	6/4
BOT-HG-702(P)	Practical	2/0
Value Addition Courses (VAC)		
	To be opted from central pool	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
BOT-HC-801 BOT-HC-801(P)	Pharmacognosy and Phytochemistry Pharmacognosy and Phytochemistry (Practical)	4 2
BOT-HC-802 BOT-HC-802(P)	Ethnobotany Ethnobotany (Practical)Industrial and Environmental	4 2
Discipline Specific Elective Course (DSE) to be opted one course		
BOT-HE-801 BOT-HE-801(P)	Analytical techniques in Plant science Analytical techniques in Plant science (Practical)	4 2
Generic Elective Course (GEC) to be opted two courses from other discipline		
BOT-HG-801	Theory	6/4
	Practical	2/0
Total Credit		**24**

Semester VIII

Core Courses		
Course code	Title of the paper	Credit
BOT-HC-803 BOT-HC-803(P)	Microbiology Industrial and Environmental Microbiology (Practical)	4 2
BOT-HC-804 BOT-HC-804(P)	Research Methodology Research Methodology (Practical)	4 2
Discipline Specific Elective Course (DSE) to be opted one course		
BOT-HE-802	Project Work/Dissertation	6
Generic Elective Course (GEC) to be opted one course from other discipline		
BOT-HG-802	Theory	6/4
BOT-HG-802(P)	Practical	2/0
Total Credit		**24**

Exit option after fourth year: Bachelor's Degree in Botany Honours (Level 8) on completion of 140 credits

1. HONOURS CORE COURSES(Compulsory Courses)

Core Course 1	Introduction to Microbial World**,** Viruses, Bacteria, Fungi and Plant Pathology
Core Course 2	Algae, Bryophyta, Pteridophyta and Gymnosperm
Core Course 3	Plant Systematics
Core Course 4	Biomolecules and Cell Biology
Core Course 5	Plant Metabolism
Core Course 6	Ecology and Phytogeography
Core Course 7	Genetics and Cytogenetics
Core Course 8	Economic Botany and Plant Resource Utilization
Core Course 9	Molecular Biology
Core Course 10	Plant Morphology and Anatomy
Core Course 11	Reproductive Biology of Angiosperms
Core Course 12	Plant Physiology
Core Course 13	Biostatistics and Bioinformatics
Core Course 14	Plant Biotechnology
Core Course 15	Pharmacognosy and Phytochemistry
Core Course 16	Ethnobotany
Core Course 17	Industrial and environmental microbiology

2. DISCIPLINE SPECIFIC ELECTIVE COURSES

(To be opted one course in each semester)

Semester V	DSE 1	Stress Physiology
	DSE 2	Natural resource management
Semester VI	DSE 3	Microbiology
	DSE 4	Biodiversity conservation
Semester VII	DSE 5	Analytical techniques in plant science
Semester VIII	DSE 6	Project work/ Dissertation

3. Ability Enhancement Compulsory Courses (AECC)

A. Semester I

1. English/MIL

B. Semester II

1. Environmental Science

4. Generic Elective Courses (GEC)

(To be offered to candidates of other disciplines)

Semester III	**GEC 1**	Biodiversity
	GEC 2	Algal Biotechnology
Semester IV	**GEC 3**	Food science
	GEC 4	Plant Ecology and Taxonomy
Semester V	**GEC 5**	Plant Physiology and Metabolism
	GEC 6	Environmental monitoring and management
Semester VI	**GEC 7**	Economic Botany
	GEC 8	Global Warming and Climate change
Semester VII	**GEC 9**	Plant anatomy and embryology
Semester VIII	**GEC 10**	Current trends in plant science

5. Skill Enhancement Courses (SEC)

(to be opted one course each in Semester I and Semester II)

Semester I	SEC 1	Biofertilizers
	SEC 2	Mushroom Cultivation
	SEC 3	Fermentation Technology
Semester II	SEC 4	Botanical Garden and Landscaping
	SEC 5	Nursery and Gardening
	SEC 6	Floriculture

6. **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.

Semester-I

Core course -1

(Introduction to Microbial World, Virus, Bacteria, Fungi and Phytopathology)

Paper-Code: BOT-HC-501
Paper Title: Introduction to Microbial World, Virus, Bacteria, Fungi and Phytopathology
Credits: 6 (Theory - 4, Practical - 2)

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 and will be able to:

1. Know 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.

THEORY

Unit-1 3 Lectures, 5 marks

Introduction to microbial world; History of microbiology; Scope and relevance of microbes in industry and environment; Microbial nutrition, growth and metabolism; major groups of the microbial world.

Unit-2 10 Lectures, 15 marks

Viruses ;Discovery, physiochemical and biological characteristics; classification (Baltimore), general structure with special reference to viroids and prions; replication (general account), DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV). Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases.

Unit-3 10 Lectures, 15 marks

Bacteria ;Discovery, general characteristics; Types-archaebacteria, eubacteria, actinomycetes, mycoplasma, rickettsia, chlamydiae and sphaeroplasts; Cell structure; Nutritional types; Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction). Economic importance of bacteria with reference to their role in agriculture and industry (Alcohol and Antibiotic production).

Unit-4 12 Lectures ,25 marks

Fungi ;General characteristics; Status of Fungi in living system; Thallus organization, modification of hyphae; Cell and Cell wall composition; Nutrition, homothallism and heterothallism. Classification of Fungi (Ainsworth, 1973, Webster, 1977) up to sub-division with diagnostic characters and examples. General characteristics of Chytridiomycota – *Synchytrium, Allomyces*; Oomycota - *Phytopthora, Albugo*; Zygomycota – *Rhizopus, Mucor*; Ascomycota - *Saccharomyces, Aspergillus*; Basidiomycota -*Puccinia, Agaricus*; Deuteromycota (mitosporic fungi) – *Fusarium, Alternaria*.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-5 10 Lectures, 15 marks

Plant Pathology; 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, white rust of Crucifer; Bacterial diseases– citrus canker and bacterial blight of rice; Viral diseases – tobacco mosaic virus and vein clearing.

Practical

Paper Code: BOT-HC-501(P)
Paper Title: Introduction to Microbial World, Virus, Bacteria, Fungi and Phytopathology (Practical)

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 (early 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.

Core course -2(Algae, Bryophytes, Pteridophytes and Gymnosperms)

Paper Code: BOT-HC-502
Paper Title: Algae, Bryophytes, Pteridophytes and Gymnosperms
Credits: 6 (Theory - 4, Practical - 2)

Course Objectives

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

THEORY

Unit-1 **2 Lectures, 20 marks**

Algae

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-2 **11 Lectures ,18 marks**

Bryophytes

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-3 **11 Lectures, 17 marks**

Pteridophytes (15 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-4 **11 Lectures, 20 marks**

Gymnosperms (15 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.

Practical

Paper Code: BOT-HC-502 (P)
Paper Title: Algae, Bryophytes, Pteridophytes and Gymnosperm (Practical)

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. Parihar, N.S. 1972. An Introduction to Embryophyta. Vol.II: Pteridophyta. Allahabad, UP: Central Book Deport.
6. Parihar, N.S. 1991. An Introduction to Embryophyta. Vol. I: Bryophyta. Allahabad, UP: Central Book Deport.
7. Vashistha P.C., Sinha A.K., Kumar A. 2010. Pteridophyta. S. Chand. Delhi, India.

Skill Enhancement Courses (To be opted one course)

Skill Enhancement Course 1– Biofertilizers

Paper Code: BOT-SE-501

Paper Title: Biofertilizers

Credit: 4(Theory-3, Practical-1)

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

THEORY

Unit-1 **8 Lectures ,15 marks**

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-2 **8 Lectures ,15 marks**

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-3 **7 Lectures ,15 marks**

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-4 **7 Lectures ,15 marks**

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

Practical

Paper Code: BOT-SE-501 (P)
Paper Title: Biofertilizers (Practical)

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. SubhaRao, N.S. 2000. Soil Microbiology.New Delhi, Delhi: Oxford & IBH Publishers.
5. Vayas,S.C, Vayas, S., Modi, H.A. 1998. Bio-fertilizers and organic Farming. Nadiad, Gujarat: AktaPrakashan

Skill Enhancement Course 2 – Mushroom Cultivation

Paper Codes: BOT-SE-501
Paper Title: Mushroom Cultivation
Credit:4 (Theory-3, Practical-1)

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.

THEORY

Unit-1 **8 Lectures, 15 marks**

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

Unit-2 **8 Lectures, 15 marks**

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-3 **7 Lectures, 15 marks**

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-4 **7 Lectures, 15 marks**

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.

Practical

Paper Code: BOT-SE-501(P)
Paper Title: Mushroom Cultivation (Practical)

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.

Skill Enhancement Course 3 - Fermentation Technology

Paper Codes: BOT-SE-501
Paper Title: Fermentation Technology
Credit: 4(Theory-3,Practical-1)

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

THEORY

Unit-1 **8 Lectures, 15 marks**
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-2 **7 Lectures, 15 marks**
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-3 **8 Lectures, 15 mark**
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-4 **7 Lectures, 15 marks**
Production of alcohol; Organic acid − Citric acid; Antibiotic − Penicillin, Amino acid − Glutamic acid; Vitamin − B1; Single Cell Protein (SCP)

Practical

Paper Code: BOT-SE-501(P)

Paper Title: Fermentation Technology (Practical)

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.

Semester II

Core course-3(Plant Systematics)

Paper Code: BOT-HC-503
Paper Title: Plant Systematics
Credit: 6 (Theory-4, Practical-2)

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

Theory

Unit-1 **13 Lectures ,22 marks**

Plant systematics

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-2 **10 Lectures ,17 marks**

Botanical Nomenclature and System of Classification

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-3 **7 Lectures ,11 marks**

Biometrics, Numerical Taxonomy and Cladistics

Characters; Variations; OTUs, character weighting and coding; Cluster analysis;

Phenograms, cladograms (definitions and differences).

Unit-4 **15 Lectures ,25 marks**

Taxonomic hierarchy and Phylogenetic Systematics

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).

Practical

Paper code: BOT-HC-503(P)
Paper Title: Plant Systematics (Practical)

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

   Ranunculaceae- *Ranunculus, Delphinium*

   Brassicaceae- *Brassica, Alyssum/ Iberis*

   Fabaceace- *Calliandra/Prosopis/ Acacia, Cajanus/Sesbania, Cassia*

   Myrtaceae- *Eucalyptus, Callistemon* Umbelliferae-*Coriandrum/ Anethum*/ FoeniculumAsteraceae- *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/Cascabalathevitea/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.

Core course-4 (Biomolecules and Cell Biology)

Paper Code: BOT-HC-504 (Theory)
Paper Title: Biomolecules and Cell Biology
Credit: 6(Theory-4,Practical-2)

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

THEORY

Unit-1 **10 Lectures ,17 marks**

Bioenergetics and Enzymes

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-2 **11 Lectures ,18 marks**

Biomolecules

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-3 **12 Lectures ,20 marks**

Cell Biology-1

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-4 **12 Lectures ,20 marks**

Cell Biology – II

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.

Practical

Paper Code: BOT-HC – 504(P)
Paper Title: Biomolecules and Cell Biology (Practical)

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion/ 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. 2015. The cell: A Molecular Approach. 7th Edition. Sinauer Associates.

Skill Enhancement Course(To be opted one course)

Skill Enhancement Course 4– Botanical Garden and Landscaping

Paper code: BOT-SE-502
Paper Title: Botanical Garden and Landscaping
Credit: 4(Theory-3,Practical-1)

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

THEORY

Unit-1 **8 Lectures ,15 marks**

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-2 **7 Lectures ,15 marks**

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-3 **8 Lectures ,15 marks**

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-4 **7 Lectures ,15 marks**

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)

Practical

Paper code: BOT-SE-502(P)
Paper Title: Botanical Garden and Landscaping (Practical)

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).

Skill Enhancement Course 5 - Nursery and Gardening

Paper code: BOT-SE-502
Paper Title: Nursery and Gardening
Credit: 4(Theory-3, Practical-1)

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

Theory

Unit-1 **7 Lectures ,14 marks**

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

.

Unit-2 **7 Lectures ,14 marks**

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-3 **7 Lectures ,15 marks**

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-4 **9 Lectures ,17 marks**

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.

Practical

Paper code: BOT-SE-502(P)
Paper Title: Nursery and Gardening (Practical)

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.

Skill Enhancement Course 6– Floriculture

Paper code: BOT-SE-502
Paper Title: Floriculture
Credit: 4(Theory-3, Practical-1)

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.

Theory

Unit-1 **7 Lectures ,15 marks**

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-2 **7 Lectures ,15 marks**

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-3 **8 Lectures ,15 marks**

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-4 **8 Lectures ,15 marks**

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.

Practical

Paper code: BOT-SE-502(P)
Paper Title: Floriculture (Practical)

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. A.K.Singh.2006. Flower crops, cultivation andmanagement. New India publishing agency,Pitampura, New Delhi.
3. T.K. Bose, L.P. Yadav, P. Patil, P. Das and V.A. ParthaSarthy. 2003. Commercial Flowers. ParthaSankarBasu, Nayaudyog, 206, BidhanSarani, Kolkata.
4. S.K. Bhattacharjee and L.C. De. 2003. Advanced Commercial Floriculture. AavishkarPublishers,Distributors, Jaipur.
5. DewasishChoudhary and Amal Mehta. 2010. Flower crops cultivation and management.
6. Arora, J.S. 2006. Introductory Ornamental Horticulture.Kalyani Publishers, Ludhiana.
7. Bhattacharjee, S.K. Advanced Commercial Floriculture. Aavishkar Publishers Distributors, Jaipur.
8. Abhinov Kumar. 2000. Production Technology of Ornamental Crops, Medicinal Plants and Landscaping. Kalyani Publishers, New Delhi.

Semester III

Core Course 5- Plant Metabolism

Paper Code: BOT-HC-601
Paper Title: Plant Metabolism
Credit: 6(Theory-4, Practical-2)

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 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

Theory

Unit-1 **8 Lectures, 14 marks**

Concept of Metabolism and Photosynthetic pigments

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-2 **16 Lectures, 26 marks**

Carbon Assimilation, Metabolism and Oxidation

Photochemical reactions, PSI, PSII, photosynthetic electron transport, photophosphorylation, Q cycle, CO_2 Reduction/Carbon Assimilation: C3, C4 and CAM pathways; photorespiration; Factors affecting CO2 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-3 **8 Lectures, 13 marks**

ATP-Synthesis

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-4 **13 Lectures, 22 marks**

Lipid and Nitrogen Metabolism, Mechanism of Signal Transduction

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.

Practical

Course Code:BOT-HC- 601 (P)
Paper Title: Plant Metabolism (Practical)

1. Solvent partitioning of photosynthetic pigments.
2. Experimental demonstration of Hill's reaction.
3. To study the effect of light intensity on the rate of photosynthesis.
4. Effect of carbon dioxide on the rate of photosynthesis.
5. To compare the rate of respiration in different parts of a plant.
6. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
7. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
8. Demonstration of fluorescence by isolated chlorophyll pigments.
9. Demonstration of absorption spectrum of photosynthetic pigments.
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. Jain V.K.2016. Fundamentals of Plant Physiology 18th edition. New Delhi, India: S. Chand & Company Pvt. Ltd.
5. Nelson, D.L., Cox, M.M. 2017. Lehninger Principle of Biochemistry, 7th edition. New York, NY: W.H. Freeman, Macmillan learning.
6. Salisbury F.B., Ross C.W. 2006. Plant Physiology 4th edition. Delhi, India: CBS Publishers and Distributors.

Core Course 6 – Ecology and Phytogeography

Paper Code: BOT-HC-602
Paper Title: Ecology and Phytogeography
Credit: 6 (Theory-4, Practical-2)

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 phytogeographical regions.

Learning Outcomes

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

1. Understand the complex interrelationship between organisms and environment
2. acquire knowledges 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

Theory

Unit-1 **9 Lectures, 15 marks**

Introduction

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-2 **12 Lectures, 20 marks**

Population ecology and plant adaptations

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-3 **16 Lectures, 26 marks**

Ecosystem and Plant communities

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-4 **8 Lectures, 14 marks**

Phytogeography

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.

Practical

Paper Code: BOTC-602(P)
Paper Title: Ecology and Phytogeography (Practical)

1. 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 quadrate 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.

References

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.

Core Course 7- Genetics and Cytogenetics

Paper code: BOT-HC-603
Paper title: Genetics and Cytogenetics
Credits: 6(Theory-4, Practical-2)

Course Objective

1. To highlight the principles of inheritance and types of expressions resulting from the interaction of genes.
2. To discuss on how mutation occurs at the genetic level and agents that cause mutation.
3. To give stress on the importance of theories of genetics in relation with genetic variation and speciation.
4. Provide knowledge on Mendelian concepts in genetics; structure, functions and properties of chromosome; chromosomal aberration.
5. Provide practical knowledge on chromosomal mapping and gene interaction studies.

Learning outcomes

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

1. Possess 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. Analyse the effect of mutations on gene functions and dosage.
5. Examine the structure, function and replication of DNA.

Theory

Unit-1 **12 Lectures, 20 marks**

Mendelian genetics and its extension

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Numericals; Polygenic inheritance.

Unit-2 **5 Lectures, 8 marks**

Extrachromosomal Inheritance

Chloroplast inheritance: Variegation in Four o'clock plant; Mitochondrial inheritance in yeast; Maternal effects-shell coiling in snail; Kappa particles in *Paramecium.*

Unit-3 **8 Lectures, 14 marks**

Linkage, crossing over and chromosome mapping

Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.

Unit-4 **5 Lectures, 8 marks**

Variation in chromosome number and structure

Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy 24

Unit-5 **10 Lectures, 17 marks**

Fine structure of gene and Gene mutations

Classical vs molecular concepts of gene; Cistron, Recon, Muton, rII locus . Types of mutations; Molecular basis of Mutations; 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-6 **5 Lectures, 8 marks**

Population and Evolutionary Genetics

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation

Practical

Paper code: BOT-HC-603(P)
Paper title: Genetics and Cytogenetics (Practical)

Meiosis through temporary squash preparation.

2. Mendel's laws through seed ratios.
3. Chromosome mapping using point test cross data.
4. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
5. Permanent Slides showing Translocation Ring, Photograph showing Laggards and Inversion Bridge.

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India.8th edition.

2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India.5th edition.

3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics.Benjamin Cummings, U.S.A. 9th edition.

4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis.W. H. Freeman and Co., U.S.A. 10th edition. 5. Genetics- P.K.Gupta, Rastogi Publications, Meerut.

5. Genetics- P.K.Gupta, Rastogi Publications, Meerut.

Unit-5 **10 Lectures, 17 marks**

Fine structure of gene and Gene mutations

Classical vs molecular concepts of gene; Cistron, Recon, Muton, rII locus . Types of mutations; Molecular basis of Mutations; 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-6 **5 Lectures, 8 marks**

Population and Evolutionary Genetics

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation

Practical

Paper code: BOT-HC-603(P)
Paper title: Genetics and Cytogenetics (Practical)

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3. Chromosome mapping using point test cross data.
4. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
5. Permanent Slides showing Translocation Ring, Photograph showing Laggards and Inversion Bridge.

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India.8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India.5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics.Benjamin Cummings, U.S.A. 9th edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis.W. H. Freeman and Co., U.S.A. 10th edition. 5. Genetics- P.K.Gupta, Rastogi Publications, Meerut.
5. Genetics- P.K.Gupta, Rastogi Publications, Meerut.

Generic Elective Course (GEC)

Generic Elective Course 1- Biodiversity

Paper code: BOT-HG-601
Paper Title: Biodiversity
Credit: 6 (Theory-4,Practical-2)

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

1. Introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi, to various plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms).

2. Information on the Ecological and Economic Importance of Microbes, Fungi and various plant groups to enable students understand and appreciate relevance of Microbes and Plants to environment and human well-being.

3. Insight into the line of Plant Evolution on Earth and the consequent Biodiversity is instrumental in creating Awareness on the threats to biodiversity and sensitize young minds towards the Biodiversity Conservation for sustainable development.

Learning Outcomes:

1. Combination of Theoretical and Practical components will provide comprehensive information and insight into the fascinating world of Microbes and Plants.

2. Hands on Training will help students learn use of microscope, mounting, section-cutting and staining techniques for the study of plant materials.

3. Making Drawings in Practical Records will enhance understanding morphological and structural details and related functional aspects in diverse plant groups.

4. Use of Illustrations, Photographs, Charts, Permanent Slides, Museum and Herbarium Specimens along with ICT Methods will provide an interesting insight into the beautiful world of microbes and plants
.

5. Scope of Biodiversity includes Medicinal field, Industry, Agriculture, Research and Study, Job Opportunities and Environmental Conservation. This paper is both informative and interesting and will enable students to learn about Biodiversity not only as a plant or nature lover, but also for higher academic pursuits, particularly in the field of Biological Sciences, Environment and Biodiversity Conservation.

Theory

Unit-1 **9 Lectures, 15 marks**

Microbes : Viruses and Bacteria – Discovery, general structure, replication (general account), DNA virus (T-phage);Lytic and lysogenic cycle, RNA virus (TMV); Economic importance; **Bacteria** – Discovery, General characteristics and cell structure; Reproduction – vegetative, asexual and recombination (conjugation,transformation and transduction); Economic importance.

Unit-2 **9 Lectures, 15 marks**

Algae: General characteristics; Ecology and distribution; Range of thallus organization and reproduction;Classification of algae; Morphology and life-cycles of the following: Nostoc,Chlamydomonas,Oedogonium, Vaucheria, Fucus, Polysiphonia. Economic importance of algae.

Unit-3 **9 Lectures, 15 marks**

Fungi: Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition, nutrition, reproduction and classification; True Fungi- General characteristics, ecology and significance, life cycle of Rhizopus (Zygomycota) Penicillium, Alternaria (Ascomycota), Puccinia,Agaricus (Basidiomycota); Symbiotic Associations-Lichens: General account, reproduction andsignificance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance

Unit-4 **9 Lectures, 15 marks**

Introduction to Archegoniate: Unifying features of archegoniates, Transition to land habit, Alternation of generations, Bryophytes: General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction of Marchantia and Funaria.(Developmental details not to be included). Ecology and economic importance of bryophytes with special mention of Sphagnum.

Unit-5 **9 Lectures, 15 marks**

Pteridophytes and Gymnosperms: General characteristics, classification, Early land plants (Cooksonia and Rhynia).Classification (up to family), morphology, anatomy and reproduction of Selaginella, Equisetum and Pteris,(Developmental details not to be included), Heterospory and seed habit, stellar evolution. Ecological andeconomical importance of Pteridophytes, Gymnosperms: General characteristics; Classification (up tofamily), morphology, anatomy and reproduction of Cycas and Pinus (Developmental details not to beincluded), Ecological and economical importance

Practical

Paper code: BOT-HG-601

Paper Title: Biodiversity

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 bacterium; Binary Fission; Conjugation; Structure of root nodule.
3. Gram staining
4. Study of vegetative and reproductive structures of Nostoc, Chlamydomonas (electron micrographs), Oedogonium, Vaucheria, Fucus* and Polysiphonia through temporary preparations and permanent slides. (* Fucus - Specimen and permanent slides)
5. *Rhizopus* and Penicillium: Asexual stage from temporary mounts and sexual structures through permanent slides.
6. *Alternaria*: Specimens/photographs and tease mounts.

7. Puccinia: Herbarium specimens of Black Stem Rust of Wheat
8. Agaricus: Specimens of button stage and full grown mushroom; Sectioning of gills of Agaricus.
9. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
10. Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs)
11. Marchantia- morphology of thallus, reproductive structures
12. Selaginella- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus, w.m.microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
13. Equisetum- morphology, t.s. internode, l.s. strobilus, t.s. strobilus, w.m. sporangiophore,w.m. spores (wet and dry)(temporary slides); t.s rhizome (permanent slide).
14. Pteris- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores(temporary slides), t.s.rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).
15. Cycas- morphology (coralloid roots, bulbil, leaf), t.s. coralloid root, t.s. rachis, v.s. leaflet,v.s. microsporophyll, w.m. spores (temporary slides), l.s. ovule, t.s. root (permanent slide).
16. Pinus- morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m.dwarf shoot, t.s.needle, t.s. stem, , l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), l.s.female cone, t.l.s. &r.l.s. stem (permanent slide).

Suggested Readings

1) Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2 Nd edition.
2) Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin
Cummings, U.S.A. 10th edition.
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. 4thedition.
5) Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
6) Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
7) Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, NewDelhi, India.
8) Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot

Generic Elective Course 2- Algal Biotechnology

Paper Code: BOT-HG-601
Paper Title: Algal Biotechnology
Credit: 6(Theory-4, Practical-2)

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. 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.

Theory

Unit-1 **10 Lectures ,17 marks**

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-2 **12 Lectures ,20 marks**

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 algae. Drying.

Unit-3 **10 Lectures ,18 marks**

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-4 **13 Lectures ,20 marks**

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.

Practical

Paper Code: BOT-HG-601(P)

Paper Title: Algal Biotechnology (Practical)

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.

Semester IV

Core Course 8 - Economic Botany and Plant Resource Utilization

Paper Code: BOT-HC-604
Paper Title: Economic Botany and Plant Resource Utilization
Credit: 6(Theory-4, Practical-2)

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

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

Theory

Unit-1 **9 Lectures ,15 marks**
Origin of Cultivated Plants: Concept of Centres of Origin, their importance with reference to Vavilov'swork. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution ofnew crops/varieties, importance of germplasm diversity, **Timber plants :**General accountwith specialreference to teak and pine

Unit-2 **9 Lectures ,15 marks**
Cereals : Wheat and Rice (origin, morphology, processing & uses); Brief account of millets.
Legumes: Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes, Importance to man and ecosystem
.

Unit-3 **9 Lectures ,15 marks**
Sources of sugars and starches : Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses. Listing of important spices, their family and part used. Reference to fennel, saffron, clove and black pepper Economic importance with special Spices, Beverages: Tea, Coffee (morphology, processing & uses),
Fibers: Classification based on the origin of fibers; Cotton, Coir and Jute (morphology, extraction and uses).

Unit-4 **9 Lectures ,15 marks**

Sources of oils and fats : General description, classification, extraction, their uses and health implications groundnut, coconut, linseed, soybean, mustard and coconut (Botanical name, family & uses). Essential Oils:General account, extraction methods, comparison with fatty oils & their uses.

Unit-5 **9 Lectures ,15 marks**

Natural Rubber : Para-rubber: tapping, processing and uses. **Drug-yielding plants:** Therapeutic and habitformingdrugs with special reference to Cinchona, Digitalis, Papaver and Cannabis; Tobacco (Morphology,processing, uses and health hazards).

Practical

Paper Code: BOT-HC-604

Paper Title: Economic Botany and Plant Resource Utilization

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, microchemical tests).
4. Spices: Black pepper, Fennel and Clove (habit and sections).
5. Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. Sources of oils and fats: Coconut- T.S. nut, Mustard–plant specimen, seeds; tests for fats in crushed seeds.
7. Essential oil-yielding plants: Habit sketch of Rosa, Vetiveria, Santalum and Eucalyptus
8. (Specimens/photographs).
9. Rubber: specimen, photograph/model of tapping, samples of rubber products.
10. Drug-yielding plants: Specimens of Digitalis, Papaver and Cannabis.
11. Tobacco: specimen and products of Tobacco.
12. Woods: Tectona, Pinus: Specimen, Section of young stem.
13. Fiber-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

Suggested Readings

1) Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
2) Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
3) Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers.

Core Course 9 – Molecular Biology

Paper Code: BOT-HC-605
Paper Title: Molecular Biology (Theory)
Credit: 6 (Theory-4, Practical-2)

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

Theory

Unit-1 **9 Lectures ,15 marks**

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

Unit-2 **9 Lectures ,15 marks**

The structure of RNA and DNA/Genetic material

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-3 **9 Lectures ,15 marks**

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-4 **9 Lectures ,15 marks**

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.

Practical

Paper Code: BOT-HC-605 (P)
Paper Title: Molecular Biology (Practical)

Course Content

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

Core Course 10 – Plant Morphology and Anatomy

Paper Code: BOT-HC - 606
Paper Title: Plant Morphology and Anatomy (Theory)
Credit: 6 (Theory-4, Practical-2)

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

Theory

Unit-1 **9 Lectures ,15 marks**

Morphology of vegetative organs

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-2 **9 Lectures ,15 marks**

Morphology of Reproductive organs.

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-3 **9 Lectures ,15 marks**

Internal organization and primary plant body

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-4 **9 Lectures ,15 marks**

Secondary growth

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.

Unit-5 **9 Lectures ,15 marks**

Protective and Adaptive system: 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.

Practical

Paper Code: BOT-HC-606(P)
Paper Title: Plant Morphology and Anatomy (Practical)

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

Suggested readings

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. Mitra, J.N. D. Mitra, D., S.K. Chowdhuri, S.K. 2017. Studies in Botany Vol. 1 and 2, Moulik Library, Kolkata.
5. Pandey, B.P. 2001. Plant Anatomy, S. Chand Publishing, New Delhi
6. Vasistha, P.C. 2000. Plant Anatomy, Pradeep Publications, Jalandhar

Generic Elective Course (To be opted one course)

Generic Elective Course 3 - Food Science

Paper Code: BOT-HG-602
Paper Title: Food Science
Credit: 6(Theory 4, Practical-2)

Course Objective

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

Theory

Unit-1 **9 Lectures ,15 marks**

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

Unit-2 **9 Lectures, 15 marks**

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-3 **9 Lectures ,15 marks**

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

Unit-4 **9 Lectures ,15 marks**

Food Biotechnology: Biotechnology in food industry, production of biocolours, flavours, vitamins, biopreservatives, antibiotics and industrial alcohol. Genetically modified foods.

Unit-5 **9 Lectures ,15 marks**.

Food Packaging: Aseptic and Packaging of specific foods, fruits, vegetables, dairy products, cereals snacks etc; Food laws and quality control: Food safety and standard act and other Indian and International standards.

Practical

Paper Title: Food Science (Practical)
Paper Code: BOT-HG-602(P)

Course Content

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.

Generic Elective Course 4 – Plant Ecology and Taxonomy

Paper code: BOT-HG-602
Paper Title: Plant Ecology and Taxonomy
Credit: 6(Theory-4, Practical-2)

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

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

Theory

Unit-1 **9 Lectures ,15 marks.**

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

Unit-2 **9 Lectures ,15 marks**.

Ecosystem: Structure; energy flow tropic organization; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous, **Phytogeography:** Principle biogeographical zones; Endemism

Unit-3 **9 Lectures ,15 marks**.

Plant communities: Characters; Ecotone and edge effect; Succession; Processes and types, Introduction to plant taxonomy: Identification, Classification, Nomenclature; **Identification:** Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora,Keys: single access and multi-access

Unit-4 **9 Lectures ,15 marks**.

Taxonomic evidences from palynology, cytology, phytochemistry and molecular data; **Taxonomic hierarchy**: Ranks, categories and taxonomic groups; **Botanical nomenclature:** Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit-5 **9 Lectures ,15 marks**.

Classification: Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (up to series), Engler and Prantl (upto series); Biometrics, numerical taxonomy and cladistics Characters; variations; OTUs, character weighting and coding; cluster analysis;phenograms, cladogram(definitions and differences).

Practical

Paper code: BOT-HG-602(P)
Paper Title: Plant Ecology and Taxonomy (Practical)

Course Content

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.

Semester V

Core Course 11 - Reproductive Biology of Angiosperms

Paper Code: BOT-HC–701
Paper Title: Reproductive Biology of Angiosperms
Credit: 6(Theory-4, Practical-2)

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

Theory

Unit-1 **9 Lectures ,15 marks**

Introduction: 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.
Reproductive development: Induction of flowering; flower as a modified determinate shoot. Flower
development: genetic and molecular aspects.

Unit-2 **9 Lectures ,15 marks**

Anther and pollen biology: Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; abnormal features: Pseudomonads, polyads, massulae, pollinia

Unit-3 **9 Lectures ,15 marks**

Ovule: Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of Polygonum type); Organization and ultrastructure of mature embryo sac.

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

Unit-4 **9 Lectures ,15 marks**

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

.

Unit-5 **9 Lectures ,15 marks**

Embryo, Endosperm and Seed : Structure and types; General pattern of development of dicot and
embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of
embryo; Unusual features; Embryo development in Paeonia. Seed structure, importance and dispersal
mechanisms

Polyembryony and apomixes: Introduction; Classification; Causes and applications.

Practical

Paper Code: BOT-HC - 701(P)
Paper Title: Reproductive Biology of Angiosperms (Practical)

Course Content

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.

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.

Core Course 12 – Plant Physiology

Paper Code: BOT-HC – 702
Core Course: Plant Physiology
Credit – 6(Theory-4,Practical-2)

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

Theory

Unit-1 **9 Lectures ,15 marks**

Plant water relationship

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.

Unit-2 **9 Lectures ,15 marks**

Mineral nutrition and uptake

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 and facilitated diffusion, active absorption, uniport, co-transport (symport, antiport). Phloem as the site of sugar translocation, source-sink relationship, Pressure-Flow Model, phloem loading and unloading.

Unit-3 **9 Lectures ,15 marks**

Plant growth regulators

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-4 **9 Lectures ,15 marks**

Physiology of flowering and Photomorphogenesis

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).

Unit-5 **9 Lectures ,15 marks**

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.

Practical

Paper Code: BOT-HC – 702 (P)
Core Course: Plant Physiology (Practical)

Course Content

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.

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.

Discipline Specific Elective Course (To be opted one course)

Discipline Specific Elective Course 1 – Stress Physiology

Paper Code: BOT-HE-701
Paper Title: Stress Physiology
Credit: 6 (Theory-4,Practical-2)

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. Analyze the role of production and scavenging mechanisms

Theory

Unit-1 **9 Lectures ,15 marks**

Concept of Plant stress and strain

Stress and Strain terminology; Abiotic and Biotic Stress; Stress and stress factors, Resistance Mechanisms; Tolerance, Acclimation and avoidance.

Unit-2 **9 Lectures ,15 marks**

Abiotic Stress Factors

Water stress; Salinity stress, High light stress; UV and Ionizing radiation injury:Temperature stress; mechanism of tolerance, Hypersensitive reaction;

Unit-3 **9 Lectures ,15 marks**

Biotic stress factors: 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 alleopathy.

Unit-4 **9 Lectures ,15 marks**

Stress Sensing Mechanisms in Plants

Signalling: Hormonal, Calcium modulation, Phospholipid signaling.

Unit-5 **9 Lectures ,15 marks**

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

Practical

Paper Code: BOT-HE-701 (P)
Paper Title: Stress Physiology (Practical)

Course content

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

Discipline Specific Elective Course 2- Natural Resource Management

Paper Code: BOT-HE-701
Paper tittle: Natural Resource Management
Credits: 6(Theory-4,Practical-2)

Course Objective

1. Provide comprehensive knowledge regarding different types of natural resources and their ecological, economical and socio-cultural values.
2. Highlight the backgrounds of land, water and forest resources.
3. Discuss on resource degradation, importance of their judicious use and management for sustainability.
4. Discuss on ‘biodiversity’ - its importance, management and Bioprospecting

Learning outcomes:

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

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

Theory

Unit-1 **9 Lectures ,15 marks**

Natural resources;Definition and types,Sustainable utilization Concept, approaches (economic, ecological and socio-cultural).

Unit-2 **9 Lectures ,15 marks**

Land, Water and Forest;Land Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management. Water, Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies. Forests,Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion; Management.

Unit-3 **9 Lectures ,15 marks**

Biological Resources

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

Unit-4 **9 Lectures ,15 marks**

Energy Renewable and non-renewable sources of energy.

Unit-5 **9 Lectures ,15 marks**

Contemporary practices in resource management (8 lectures)

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

Practical

Paper Code: BOT-HE-701(P)
Paper tittle: Natural Resource Management (Practical)

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
2. Collection of data on forest cover of specific area.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Uses of GPS and GIS (Mapping of an area).

Suggested Readings:

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi

Generic Elective Course (To be opted one course)

Generic Elective Course 5- Plant Physiology and Metabolism

Paper Code: BOT-HG-701
Paper Title: Plant Physiology and Metabolism
Credits: 6(Theory-4, Practical-2)

Course Objective:

1. Provide knowledge on plant-water relations and various factors affecting transpiration.
2. Highlight on the role of micro- and macro-elements in plants.
3. Discuss on photosynthesis and carbon fixation pathways.
4. Provide knowledge on enzyme properties, actions and inhibitions.
5. Highlight on biological nitrogen fixation.
6. Discuss on plant hormones, and plant responses to light and temperature.
7. Demonstrate the effect of pH and concentrations in catalase activity.

Learning outcomes:

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

1. Comprehend the basic concepts of plant-water relations understanding transpiration and its significance.

2. Elaborate on the role of essential elements and mechanism of ion transport across cell membrane.
3. Understand the concept of photosynthesis, Electron transport, mechanism of ATP synthesis and Photorespiration.
4. Imbibe the concepts of Glycolysis, anaerobic respiration, TCA cycle and Oxidative phosphorylation.
5. Examine the structure and properties of enzymes.
6. Analyze the implications of biometrics, numerical taxonomy and cladistics.

Theory

Unit-1 **9 Lectures ,15 marks**

Plant-water relations and mineral nutrition

Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation. Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps

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Unit-2 **9 Lectures ,15 marks**

Photosynthesis

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.

Unit-3 **9 Lectures ,15 marks**

Respiration

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway.

Unit4 **9 Lectures ,15 marks**

Enzy-mes and Plant growth regulators cture and properties; Mechanism of enzyme catalysis and enzyme inhibition. Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.

Unit-5 **9 Lectures ,15 marks**

Nitrogen metabolism and Plant response to light and temperature ;Nitrate and ammonia assimilation , Biological nitrogen fixation.Photoperiodism and vernalization

Practical

Paper Code: BOT-HG-701(P)
Paper Title: Plant Physiology and Metabolism (Practical) Course content

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of light on transpiration by excised twig.
3. Calculation of stomatal index and stomatal frequency.
4. Demonstrate the activity of catalase and study the effect of pH and enzyme concentration.
5. To study the effect of bicarbonate concentration on O2 evolution in photosynthesis.

Demonstration experiments

1. Bolting.
2. Effect of auxins on rooting.
3. Suction due to transpiration.
4. R.Q.
5. Respiration in roots

Suggested Readings

1. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House

Generic Elective Course 6 – Environmental Monitoring and Management

Paper Code: BOT-HG-701
Paper Title: Environmental Monitoring and Management
Credit: 6(Theory-4, Practical-2)

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

Theory

Unit-1 **12 Lectures ,20 marks**

Environment pollution, assessment and monitoring

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-2 **12 Lectures ,20 marks**

Drinking water standards parameters.

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 - primary,secondary and tertiary treatment methods.

Unit-3 **12 Lectures ,20 marks**

Waste water treatment technologies

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-4 **9 Lectures ,15 marks**

Solid waste management

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.

Practical

Paper Code: BOT-HG-701(P)

Paper Title: Environmental monitoring and management (Practical)

Course content

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. TataMcGraw Hill Publication. Co. Ltd.
3. Soli J. Arceivala. Wastewater treatment for pollution control. 2nd edition, TataMcGrawHill 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).

Semester VI

Core Course 13- Biostatistics and Bioinformatics

Paper Code: BOT-HC-703
Paper Title: Biostatistics and Bioinformatics
Credit: 6(Theory-4, Practical-2)

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 the above course, the students certainly gain knowledge and be 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.

Theory

Unit-1 **9 Lectures ,15 marks**

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,

Unit-2 **9 Lectures ,15 marks**

Measures of central tendency - mean, median, mode, Measures of dispersion - range, standard deviation, mean deviation, standard error, skewness and kurtosis, quartile deviation –merits and demerits; Co- efficient of variations

Unit-3 **9 Lectures ,15 marks**

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-4 **9 Lectures ,15 marks**

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-5 **9 Lectures ,15 marks**

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.

Practical

Core Course: BOT-HC-703 (P)

Paper title: Biostatistics and bioinformatics (Practical)

Course content

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. Lohar, P.S. 2015.Bioinformatics, MJP Publishers, Chennai
6. Murthy, C.S.V. 2008. Bioinformatics : Himalaya Publishing House Pvt. Ltd. Mumbai
7. Pansey, V.G., Sukhatme, P.V. 1995. Statistical Methods for Agricultural Workers, ICAR, New Delhi
8. Ramsden, J., 2009, Computational Biology - Bioinformatics: An introduction 2nd edition, Springer,1-271
9. Rastogi, S.C., Mendiratta, N., Rastogi, P. 2013. Bioinformatics-Methods and Applications, PHI Learning Private Limited, Delhi
10. Sharma, V., Munjal, A. and Shanker, A. 2008. A Text Book of Bioinformatics , Rastogi Publications , Meerut

Core Course 14 – Plant Biotechnology

Paper Code: BOT-HC-704
Paper Title: Plant Biotechnology
Credit: 6(Theory-4, Practical-2)

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. Have the ability of explanation of 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

Explain how biotechnology is used to for plant improvement and discuss the biosafety concern and ethical issue of that use.

Theory

Unit-1 **9 Lectures ,15 marks**

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-2 **9 Lectures ,15 marks**

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-3 **9 Lectures ,15 marks**

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.

Unit-4 **9 Lectures ,15 marks**

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-5 **9 Lectures ,15 marks**

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)

Practical

Paper Code: BOT-HC-704 (P)

Paper Title: Plant Biotechnology (Practical)

Course content

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, micropropagation. somatic embryogenesis & artificial seeds through photographs.
3. Isolation of protoplasts.
4. Construction of restriction map of circular and linear DNA from the data provided.
5. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
6. Study of steps of genetic engineering for production of *Bt* cotton, Golden rice, FlavrSavr tomato through photographs.
7. Isolation of plasmid DNA.
8. Restriction digestion and gel electrophoresis of plasmid DNA (demonstration/ photograph).
9. Calculate the percentage similarity between different cultivars of a species using RAPD profile. Construct a dendrogram and interpret results.

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.

Discipline Specific Elective Course (To be opted one course)

Discipline Specific Elective Course 4 – Biodiversity Conservation

Paper code: BOT-HE-702

Paper Title: Biodiversity Conservation (Theory)

Credit: 6(Theory-4, Practical-2)

Course Objective

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

Learning outcomes:

At the end of the course the students will be 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.

Theory

Unit-1 **9 Lectures ,15 marks**

Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at the ecosystem 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 **9 Lectures ,15 marks**

Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss,

Unit-3 **9 Lectures ,15 marks**

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-4 **9 Lectures ,15 marks**

Conservation of Biodiversity: 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-5 **9 Lectures ,15 marks**

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

Practical

Paper code: BOT-HE-702 (P)
Paper Title: Biodiversity Conservation (Practical)

Course Content

1. Mapping species diversity
2. mapping of crop diversity
3. Visits of plant conservatories
4. study of wood features
5. Herbarium study of Avenue trees, Ornamental plants, Fruits and nuts: Important fruit crops and Wood
6. Procedure of *exsitu* conservation methods
7. Procedure of *in situ* conservation methods

References

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

Discipline Specific Elective Course 5: Horticultural practices and post-harvest technology

Paper code: BOT-HE-702
Paper Title: Horticultural practices and post- harvest technology (Theory)
Credit: 6(Theory-4, Practical-2)

Course Objective:

1. This course deals with overall post harvest management of fruits and vegetables from farm to fork.
2. The students are expected to gain knowledge on various management technologies on preharvest and post harvest of fruits and vegetables.
3. Students are also expected to gain knowledge on conventional and modern packaging method.

Learning Outcome:
Students will acquire knowledge on post harvest management tools and novel packaging techniques

Theory

Unit-1 **9 lectures ,15 marks**

Introduction: Scope and importance, Branches of horticulture; Role in rural economy and employment generation; Importance in food and nutritional security; Urban horticulture and ecotourism. **Landscaping and garden design:** Planning and layout (parks and avenues); gardening traditions – Ancient Indian, European, Mughal and Japanese Gardens; Urban forestry; policies and practices.

Unit-2 **9 lectures ,15 marks**

Ornamental plants: Types, classification (annuals, perennials, climbers and trees); Identification and salient features of some ornamental plants [rose, marigold, gladiolus, carnations, orchids, poppies, gerberas,tuberose, sages, cacti and succulents (opuntia, agave and spurges)] Ornamental flowering trees (Indian laburnum, gulmohar, Jacaranda, Lagerstroemia, fishtail and areca palms, semul, coraltree).**Fruit and vegetable crops:** Production, origin and distribution; Description of plants and their economic products; Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties (citrus, banana, mango, chillies and cucurbits)

.

Unit-3 **9 lectures ,15 marks**

Floriculture: Cut flowers, bonsai, commerce (market demand and supply); Importance of flower shows and exhibitions. **Horticultural crops - conservation and management:** Documentation and conservation of germplasm; Role of micropropagation and tissue culture techniques; Varieties and cultivars of various horticultural crops; IPR issues; National, international and professional societies and sources of information on horticulture.

Unit-4 **9 lectures ,15 marks**

Horticultural techniques: Application of manure, fertilizers, nutrients and PGRs; Weed control;

Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation), Scope and limitations. **Post-harvest technology:** Importance of post-harvest technology in horticultural crops; Evaluation of quality traits; Harvesting and handling of fruits, vegetables and cut flowers; Principles, methods of preservation and processing; Methods of minimizing loses during storage and transportation; Food irradiation - advantages and disadvantages; food safety.

Unit-5 **9 lectures ,15 marks**

Disease control and management: Field and post-harvest diseases; Identification of deficiency symptoms; remedial measures and nutritional management practices; Crop sanitation; IPM strategies (genetic, biological and chemical methods for pest control); Quarantine practices; Identification of common diseases and pests of ornamentals, fruits and vegetable crops

Practical

Paper code: BOT-HE-702(P)
Paper Title: Horticultural practices and post- harvest technology (Practical)

Course content
Field trip: Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations.

Suggested Readings

1) Singh, D. & Manivannan, S. (2009). Genetic Resources of Horticultural Crops. Ridhi International, Delhi,India.
2) Swaminathan, M.S. and Kochhar, S.L. (2007). Groves of Beauty and Plenty: An Atlas of Major Flowering Trees in India. Macmillan Publishers, India.
3) NIIR Board (2005). Cultivation of Fruits, Vegetables and Floriculture. National Institute of Industrial Research Board, Delhi.

Generic Elective Course (To be opted one course)

Generic Elective Course 7– Economic Botany

Paper Code: BOT-HG-702
Paper Title: Economic Botany
Credit: 6(Theory-4,Practical-2)

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

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

Theory

Unit-1 **9 Lectures ,15 marks**

Origin of Cultivated Plants: Concept of Centres of Origin, their importance with reference to Vavilov'swork. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution ofnew crops/varieties, importance of germplasm diversity, **Timber plants :**General accountwith specialreference to teak and pine

Unit-2 **9 Lectures ,15 marks**

Cereals : Wheat and Rice (origin, morphology, processing & uses); Brief account of millets.
Legumes: Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes, Importance to man and ecosystem

Unit-3 **9 Lectures ,15 marks**

Sources of sugars and starches: Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses. Listing of important spices, their family and part used. Reference to fennel, saffron, clove and black pepper Economic importance with special Spices, Beverages: Tea, Coffee (morphology, processing & uses), **Fibers:** Classification based on the origin of fibers; Cotton, Coir and Jute (morphology, extraction and uses).

Unit-4 **9 Lectures ,15 marks**

Sources of oils and fats: General description, classification, extraction, their uses and health implications groundnut, coconut, linseed, soybean, mustard and coconut (Botanical name, family & uses). Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.

Unit-5 **9 Lectures ,15 marks**

Natural Rubber: Para-rubber: tapping, processing and uses. **Drug-yielding plants:** Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis; Tobacco (Morphology, processing, uses and health hazards).

Practical

Paper Code: BOT-HG-702(P)
Paper Title: Economic Botany(Practical)

Course content

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, microchemical tests).
4. Spices: Black pepper, Fennel and Clove (habit and sections).
5. Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. Sources of oils and fats: Coconut- T.S. nut, Mustard–plant specimen, seeds; tests for fats in crushed seeds.
7. Essential oil-yielding plants: Habit sketch of Rosa, Vetiveria, Santalum and Eucalyptus
8. (Specimens/photographs).
9. Rubber: specimen, photograph/model of tapping, samples of rubber products.
10. Drug-yielding plants: Specimens of Digitalis, Papaver and Cannabis.
11. Tobacco: specimen and products of Tobacco.
12. Woods: Tectona, Pinus: Specimen, Section of young stem.
13. Fiber-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

Suggested Readings

1) Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
2) Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, Netherlands.
3) Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers

Generic elective course 8- Global warming and climate change

Paper Code: BOT-HG-702
Paper Title: Global warming and climate change
Credit: 6(Theory-4 Practical-2)

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. Analyse 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

Theory

Unit-1 **9 lectures 15 marks**

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-2 **12 lectures 20 marks**

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

Unit-3 **12 lectures 20 marks**

Factors responsible for global warming & Climate change; Change of Temperature in the environment; role of fossil fuels in global warming & 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-4 **12 lectures 20 marks**

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

Practical

Paper Code: BOT-HG-702(P)
Paper Title: Global warming and climate change (Practical)

Course Content

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.

Semester VII

Core Course 15 – Pharmacognosy and Phytochemistry

Paper Code: BOT-HC – 801

Paper tittle:Pharmacognosy and Phytochemistry

Credit – 6(Theory-4,Practical-2)

Course Objectives:

Upon completion of this course, the students should be able:

1. Understand the types of drugs and drug evaluation methods.
2. Know the common adulterants of plant products.
3. Acquire the knowledge of primary and secondary metabolites.

Learning outcomes:

1. To develop an understanding of the importance of plant metabolites and its further research.
2. Developing entrepreneurship skills to promote pharmacological products.

Theory

Unit-1 **9 lectures 15 marks**

Pharmacognosy

Definition, Importance, Classification of drugs - Chemical and Pharmacological, Drug evaluation methods

Unit –2 **9 lectures 15 marks**

Organoleptic and microscopic studies: Organoleptic and microscopic studies with reference to nature of active principles and common adulterants of *Alstonia scholaris* (bark), *Adhatoda vasica*(leaf), *Strychnos nuxvomica* (seed), R*auwolfia serpentina*(root) and *Zinziber officinalis* C*atharanthus roseus.*

Unit-3 **9 lectures 15 marks**

Secondary Metabolites

i. Definition of primary and secondary metabolites and their differences, major types -terpenes, phenolics, alkaloids, terpenoids, steroids.

ii. A brief idea about extraction of alkaloids.Origin of secondary metabolites – detailed account of acetate pathway, mevalonate pathway, shikimate pathway.

Unit-4 **9 lectures 15 marks**

Phytochemistry

Biosynthesis and sources of drugs:

(i) Phenols and phenolic glycosides : structural types, biosynthesis, importance of simple phenolic compounds, tannins, anthraquinones, coumarins and furanocoumarins,flavones and related flavonoid glycosides, anthocyanins, betacyanins, stilbenes,lignins and lignans).

(ii) Steroids, sterols, saponins, withanolides, ecdysones, cucurbitacins:Biosynthesis, commercial importance.

(iii) Alkaloids: Different groups, biosynthesis, bioactivity.

(v) Volatile oils, aromatherapy.

Unit-5 **9 lectures 15 marks**

Enzymes, proteins and amino acids as drugs

i. Vaccines, toxins and toxoids, antitoxins, immune globulins, antiserums,

ii. Vitamins, Antibiotics – chemical nature, mode of action.

iii. Pharmacological action of plant drugs – tumor inhibitors, PAF antagonists,antioxidants, phytoestrogens and others.

iv. Role of different enzyme inhibitors.

Practical

Paper Code: BOT-HC – 801(P)

Paper tittle:Pharmacognosy and Phytochemistry(Practical)

Course content

1. Physical and chemical tests for evaluation of unorganized drugs- Asaphoetida. Honey,Castor oil. Acacia
2. Identification of bark drugs – cinchona, cinnamom
3. Identification of fruit drugs – Cardamom, Coriander
4. Identification of root and rhizome drugs- Ginger, Garlic, Turmeric
5. Identification of whole plant – Aloes,Vinca, Punarnava
6. Herbarium of medicinal plants (minimum of 20 platns)
7. Collection of locally available crude drugs from local venders (minimum of 20)

Suggested readings

1. Wallis, T. E. 1946. Text book of Pharmacognosy, J & A Churchill Ltd. 2. Roseline, A. 2011. Pharmacognosy. MJP Publishers, Chennai.
2. Gurdeep Chatwal, 1980. Organic chemistry of natural productis.Vol.I.Himalaya Publishing house.
3. Kalsi, P. S. and Jagtap, S., 2012. Pharmaceutical medicinal and natural product chemistry N.K. Mehra . Narosa Publishing House Pvt. Ltd. New Delhi.
4. Agarwal, O. P. 2002. Organic chemistry–Chemistry of organic natural products. Vol. II. Goel publishing house , Meerut.
5. Harborne, J. B. 1998. Phytochemical methods –a guide to modern techniques of plant analysis 3 rd edition, Chapman and Hall
6. Datta & Mukerji, 1952. Pharmacognosy of Indian roots of Rhizome drugs. Bulletin No.1 Ministry of Health, Govt. of India.

Core Course 16 – Ethnobotany

Paper Code: BOT-HC-802

Paper Title: Ethnobotany

Credit: 6(Theory-4,Practical-2)

Course Objective:

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

Course Learning Outcomes:

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

Theory

Unit-1 **9 lectures 15 marks**

Introduction to Ethnobotany

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

Unit-2 **9 lectures 15 marks**

Methodology of Ethnobotanical studies

1. Field work
2. Herbarium
3. Ancient Literature
4. Archaeological findings
5. Temples and sacred places.

Unit-3 **9 lectures 15 marks**

Role of ethnobotany in modern Medicine

Medico-ethnobotanical sources in India;Significance of the following plants in ethnobotanical practices (along with their habitat and morphology) a) Azadiractha indica b)Ocimum sanctum c) Vitex negundo. d) Gloriosa superba e) Tribulus terrestris f) Pongamia pinnata g)Cassia auriculata h) Indigofera tinctoria.

Unit-4 **9 lectures 15 marks**

Role of ethnobotany in modern medicine with special example of *Rauvolfia sepentina,Trichopus zeylanicus, Artemisia,Withania.* Role of ethnic groups in conservation of plant genetic resources.Endangered taxa and forest management (participatory forest management).

Unit-5 **9 lectures 15 marks**

Ethnobotany and legal aspects

Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy

Practical:

Paper Code: BOT-HG-802(P)

Paper Title: Ethnobotany (Practical)

Course content

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

2. Preparation of crude extract of ethenobotanically important plants with appropriate references (any method to be used)
3. Project work-documentation, literature survey, and collection of information on ethnobotanically useful plants from traditional healers)

Suggestive Readings:

1.Gupta , R., Rajpal , T., (2012) Concise R.,(2011) , Plant Taxonomy past Present and Future TERI Press
2.Gupta , R., Rajpal , T., (2012) Concise Mc Graw Hill Publication
3.Jain, S.K. (1995). *Manual of Ethnobotany.* Rajasthan: Scientific Publishers.

Discipline Specific Elective Course 5 -Analytical Techniques in Plant Sciences

Paper code:BOT-HE-801
Paper tittle: Analytical Techniques in Plant Sciences
Credits: 6 (Theory - 4, Practical - 2)

Course Objective

1. Provide knowledge on microscopy and imaging in plant science.
2. Highlight principles and application of centrifuge, spectroscopy and chromatography in biology.
3. Enabling students imbibe practical knowledge on microscopy, chromatography, centrifugation and spectroscopy.

Learning outcomes:

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

1. Explain the principles of Light microscopy, Compound microscopy, Fluorescence microscopy and Confocal microscopy.
2. Develop conceptual understanding of cell fractionation.

Classify different types of chromatography techniques.

Theory

Unit-1 **9 lectures, 15 marks**

Imaging and related techniques

Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit-2 **9 lectures, 15 marks**

Cell fractionation

Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CsCl2 gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit-3 **9 lectures, 15 marks**

Radioisotopes

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

Unit-4 **9 lectures, 15 marks**

Spectrophotometry

Principle and its application in biological research

Unit-5 **9 lectures, 15 marks**

Chromatography (8 lectures), Characterization of proteins and nucleic acids

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

Practical

BOT-HE-801(P)
Paper tittle: Analytical Techniques in Plant Sciences (Practical)

Course content

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Demonstration of ELISA.
3. To separate sugars by thin layer chromatography.
4. Isolation of chloroplasts by differential centrifugation.
5. To separate chloroplast pigments by column chromatography.
6. To estimate protein concentration through Lowry's methods.
7. To separate proteins using PAGE.
8. To separation DNA (marker) using AGE.
9. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).

Suggested Readings

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

Generic elective course 9: Plant Anatomy and Embryology

Paper Code: BOT-HG-801
Paper Title: Plant Anatomy and Embryology
Credit: 6(Theory 4, Practical-2)

Course Objective:

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

Learning Outcomes:

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

Theory

Unit-1 **9 lectures,15 marks**

Meristematic and permanent tissues: Root and shoot apical meristems; Simple and complex tissues,**Organs:** Structure of dicot and monocot root stem and leaf

.

Unit-2 **9 lectures,15 marks**

Secondary Growth: Vascular cambium – structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood) **Adaptive and protective systems:** Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

Unit-3 **9 lectures,15 marks**

Structural organization of flower: Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac.

Unit-4 **9 lectures,15 marks**

Pollination and fertilization: Pollination mechanisms and adaptations; Double fertilization; Seedstructure appendages and dispersal mechanisms.

Unit-5 **9 lectures,15 marks**

Embryo and endosperm: Endosperm types, structure and functions; Dicot and monocot embryo;Embryo- endosperm relationship **Apomixis and polyembryony:** Definition, types and Practical applications

Practical

Paper Code: BOT-HG-801(P)
Paper Title: Plant Anatomy and Embryology(Practical)

Course content

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem
   (Permanent slides, photographs)
3. Stem: Monocot: Zea mays; Dicot: Helianthus; Secondary: Helianthus (only Permanent slides).
4. Root: Monocot: Zea mays; Dicot: Helianthus; Secondary: Helianthus (only Permanent slides).
5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Adaptive anatomy: Xerophyte (Nerium leaf); Hydrophyte (Hydrilla stem).
7. Structure of anther (young and mature), tapetum (amoeboid and secretory) (Permanent slides).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: Polygonum (monosporic) type of Embryo sac Development (Permanent
   slides/photographs).
10. Ultrastructure of mature egg apparatus cells through electron micrographs.
11. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (Photographs and specimens).
12. Dissection of embryo/endosperm from developing seeds.
13. Calculation of percentage of germinated pollen in a given medium.

Suggested Readings

1) Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt.Ltd. New Delhi. 5 Th edition.
2) Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

Semester VIII

Core Course 17- Industrial and Environmental Microbiology

Paper Code:BOT-HC-803
Paper tittle: Industrial and Environmental Microbiology
Credits: 6 (Theory - 4, Practical - 2)

Course Objective

1. Highlight the roles of microbes in industries and environment.
2. Provide basic knowledge of different kinds of bioreactors and fermentation processes.

3. Impart knowledge of production processes of some microbial products in industries through site visits.
4. Discuss on the applications of enzymes in industries.
5. Discuss in detail on the diversity and distribution of microbes in air, water and soil.
6. Highlight on water microbiology and water analysis methods.
7. Discuss the usefulness of microbes in agriculture and bioremediation of contaminated soils.
8. Provide practical experiences on basic microbiological techniques and handlings.

Learning outcomes

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

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

THEORY

Unit-1 **9 Lectures,15 marks**

Scope of microbes in industry and environment. Bioreactors/Fermenters and fermentation processes. Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Unit-2 **9 Lectures,15 marks**

Microbial production of industrial products

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

Unit-3 **9 Lectures,15 marks**

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

Unit-4 **9 Lectures,15 marks**

Microbes and quality of environment (6 lectures) Distribution of microbes in air; Isolation of microorganisms from soil, air and water. Microbial flora of water. (8 lectures) Water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD,

COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples.

Unit-5 **9 Lectures,15 marks**

Microbes in agriculture and remediation of contaminated soils.

Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root modulating bacteria, arbuscular mycorrhizal colonization in plant roots.

Practical

Paper Code: BOT-HC-803(P)
Paper title: Industrial and Environmental Microbiology (Practical)

Course content

1. Principles and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.
3. Pure culture techniques.

Suggested Readings

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.

Core course18- Research Methodology

Paper Code: BOT-HC-804
Paper tittle: Research Methodology
Credits: 6 (Theory - 4, Practical - 2)

Course Objectives:

The aim of the course is to familiarize students with basics of research and the research process; provide an introduction to research methods and report writing; give insight into various kinds research design and sampling.

Learning outcomes:

1. Understand the concept of research and different types of research in the context of biology.
2. Have basic knowledge on qualitative research techniques and also acquainted with practical knowledge of research work. Develop laboratory experiment related skills.
3. Develop competence on data collection, data analysis, hypothesis testing procedures and process of scientific documentation. Evaluate the different methods of scientific writing and reporting.

Theory

Unit-1 **17 marks 10 lectures**

Foundations of Research:Meaning, objectives, motivation: types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs empirical). Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.

Unit 2 **15 marks 9 lectures**

Research Design: Need for research design: features of good design, important concepts related to good design- Observation and Facts, Prediction and Explanation, Development of Models. Developing a research plan: Problem identification, Formulating hypotheses, Experimentation, Determining experimental and sample designs.

Unit-3: **12 marks 7 lectures**

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

Unit-4: **13 marks 8 lectures**

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

Unit-5: **18 marks 11 lectures**

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

Practical

Paper Code: BOT-HC-804(P)
Paper tittle: Research Methodology (Practical)

Course content

1. Sketching a research proposal.
2. Designing an experimental work (field / Lab.)
3. Performing a study in related field (aquatic / aerial / land) for taxonomic study.
4. Report preparation of field experiment or lab experiment.
5. Presentation of report in class seminar on related topic through power-point presentation.
6. Analysis of references and citation for at least 10 documents (books, journals, reports, thesis etc.)

Suggested readings

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.

2. M. L. Singh (1998). Understanding Research Methodology.

3. F. N. Kerlinger (2000). Foundations of Behavioural Research. Surjeet Publication, New-Delhi.

4. Walliman, N. (2011) Research Methods: The Basics. Taylor and Francis, London, New York ISBN No- 9780415489942

5. Wadhera, B. L (2002) Law Relating to Patents, Trademarks, Copyright Designs and Geographical Indications, Universal Law Publishing ISBN No- 9789350350300

6. Kothari, C. R (2009) Research Methodology, New Age International, New Delhi ISBN No-9788122415223

7. Ruzin, S. E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

Discipline Specific Elective Course 6- Project Work / Dissertation

BOT-HE-802
Paper tittle: Project Work (or) Dissertation
Credits: 6

Course Objective:

1. To learn about field work techniques
2. To understand pilot survey relevance
3. To teach about specific Survey/laboratory techniques chosen by the student.
4. To train for basic principles in Environmental Biotechnology/ Herbal Technology/ plant Chemistry/Industrial Production etc.
5. To conduct primary data collection for a specific topic in one specific field.
6. To teach various analysis techniques.
7. To prepare report on the basis of data and analysis undertaken

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Dissertation/Project Work:

Students of B.Sc. (Hons.) Botany should undergo a /Dissertation/project work/ in plant training work for a period of three months during the fourth year (eight semester). The programme should be arranged by the Department. On completion, each student should prepare a project / training report

Generic Elective Course 8– Current trends in plant sciences

Paper Code: BOT-HG-802
Paper Title: Current trends in plant sciences
Credit: 6(Theory-4, Practical-2)

Course Objectives:

1. The paper aims to enhance the knowledge of students on Parmacopoeia and secondary metabolites.
2. To make understand the types of forests in India and sustainable agricultural practices.
3. To impart students the knowledge of Horticulture, Gardening and Tissue-Culture,

Learning Outcomes:

1. Students will learn the basic idea of Parmacopoeia and secondary metabolites along with the various adulterants.
2. Students will learn about Agro-forestry, organic farming and economic plants of India.
3. Students will be able to apply the knowledge of Tissue culture.

Unit 1 **9 lectures,15 marks**

Pharmacognosy and phytochemistry

Introduction to **Pharmacognosy and phytochemistry**,Secondary Metabolites: Sources, properties, uses and adulterants, regional and seasonal variations Adulterants: *Saraca asoca, Polyalthia longifolia Terminalia arjuna, Terminalia tomentosa Bacopa monnieri, Centella asiatica Abrus, Glycyrrhiza Phyllanthus amarus (Bhuiamla)*

Unit 2 **9 lectures,15 marks**

Forestry and Economic Botany

Forestry: Outline of types of forest in India Forestry: Agro-forestry, Urban forestry, organic farming, Silviculture Economic Botany: Types of fibers: Jute and cotton, Current trends in Fiber industries Spices and condiments: Saffron and cardamom Commercial market of spices

Unit 3 **9 lectures,15 marks**

Industry based on plant products

Aromatherapy- Introduction, Uses with few examples. Jojoba, lemon, jasmin Botanical and nutraceuticals -*Spirulina, Vanillin, Garcinia indica/ Garcinia cambogia, Chlorella,* and *Kale.* Enzymes industry: Cellulases, Papain, Bromelain Biofuels

Unit 4 **9 lectures,15 marks**

Horticulture and Gardening Introduction to Horticulture:

Branches of Horticulture

Gardening:

Locations in the garden- edges, hedges, lawn, flower beds, avenue, water garden (with names of two plants for each category).

Focal point.

Types of garden

1. Formal and informal gardens
2. National Park: Sanjay Gandhi National Park.

3. Botanical Garden: Veer Mata JijabaiUdyan (Victoria Garden).

Unit 5 **9 lectures,15 marks**

Biotechnology

Introduction to plant tissue culture

Laboratory organization and techniques in plant tissue culture Totipotency, Organogenesis Organ culture – root cultures, meristem cultures, anther and pollen culture, embryo culture.

R-DNA technology-

1. Gene cloning
2. Enzymes involved in Gene cloning
3. Vectors used for Gene cloning.

Practical

Paper Code: BOT-HG-802(P)

Paper Title: Current trends in plant sciences (Practical)

Course content

1. Study of *Phyllanthus amarus Saraca asoka Bacopa monieri*
2. Study of biodiversity

(Visit to National Park/ Botanical Garden)
Sources of: Fibres & Paper
Spices & condiments

1. Estimation of crude fibre in cereals & their products
2. Preparation & evaluation of probiotic foods
3. Evaluation of nutraceutical value of mushroom/ wheat germ

Horticulture:
1 Study of five examples of plants for each of the garden locations as prescribed for theory
2 Preparation of garden plans – formal and informal gardens
3 Bottle and dish garden preparation