Learning Outcomes Based Curriculum Framework (LOCF)

for

Post graduate Programme (M.Sc.) in Botany

Department Of Botany

Cotton University,

Guwahati-781001,

Assam

PREAMBLE

The father of our nation, Mahatma Gandhi had once quoted "True education must correspond to the surrounding circumstances, or it is not a healthy growth". In accordance with this view, Cotton University has striven to develop various courses for the students which will not only enable them to be aware of their surroundings but contribute significantly towards the future of the society. The various courses are being developed with Learning Outcome-based Curriculum Framework (LOCF) approach for all the Undergraduate and postgraduate programmes of the Cotton university. The LOCF approach enables the university to build a student-centric syllabus and engage themselves into courses of their choices. The syllabus also focuses on employability opportunities. Each program under this framework has described in detail with primary focus on three sectors viz. teaching-learning criteria, learning outcome and skill development.

The programs offered by the department of Botany, Cotton University, namely, B.Sc. Botany and M.Sc. Botany envision to inculcate a holistic approach towards the plant world. The salient features of these programmes can be enlisted as-

1. They will offer essential knowledge on various groups of plants, ranging from lower plants to highly evolved ones and the various relationships that exist through the various core papers offered in different semesters of the course.
2. They will enhance the skills for studying the plants in detail by virtue of various laboratory work they will learn in the practical classes.
3. They will enable the students to gain knowledge on the local flora and ethno- botanical facts by the help of different elective papers in different semesters.
4. They will make the students aware of the economic contribution of the plants to the nation through various papers on economic botany they will study.
5. They will encourage the students for critical thinking and research-oriented behaviour through the dissertation work.
6. They will boost the confidence of the students and groom them for public speaking with the help of seminars that they will present.

With the aid of these salient features, the LOCF so developed by the department of botany, Cotton university hopes to encourage the students to take courses in botany and make a career in this field. The LOCF will give the students a detailed information regarding the course and will help them to take decisions to achieve their goals.

Part I

1.1.INTRODUCTION

The northeast part of India is rich in floral diversity which play a significant role in day-to- day life of all communities here. As such, the department of Botany, Cotton university, which is situated in Assam, a part of NE India, endeavored to introduce programs on botany. These programs will throw light on plant life, endemic plants, and usage of plants by various NE communities.

The B.Sc. Botany and M.Sc. botany programs have been designed to empower the students to gather essential knowledge on plants and develop technical skills to study them in detail. The syllabi, composed of a combination of core and elective papers will expose the students to current developments in plant world. They will learn the various aspects of plant life like their metabolism, ecological interactions, and evolutions in a holistic approach. Further, these courses have endeavoured to introduce the ethnic plants used by many tribes of NE India through courses on ethnobotany and economic botany.

The entire program has been designed in accordance with Bloom's taxonomy. Thereby, the course levels have been arranged in a manner where courses of first year (1st and 2nd semester of UG and PG) are based on levels 1, 2 and 3 of the Bloom's taxonomy. The students at these levels will get introduced to various basic concepts of Botany. He or she can **recognize** the various facts and factors of the plant world, **understand** the concept of different processes and principles involved in plant life and **apply** this knowledge and concepts into regular lives. The higher semesters of the PG (3rd and 4th) and UG (3rd-6th) programs have courses which enable the students **analyse** the different topics he or she studied and **evaluate or judge** the content they studied. Further, with the wholesome knowledge that they acquire through the various semesters, he or she will be able to **synthesise** new concepts and apply them in research studies.

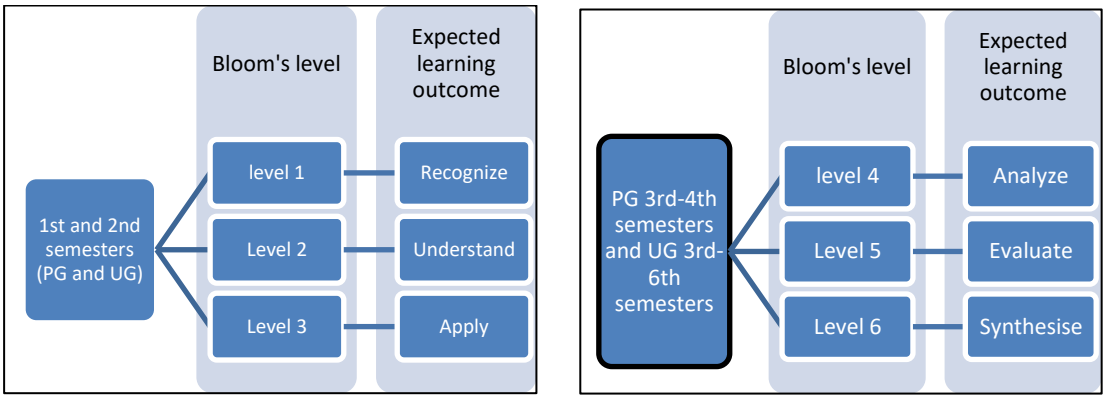

Fig. Chart showing relation between Bloom's taxonomy and program learning outcomes

1.2. Learning Outcomes-Based Approach to Curriculum planning and development

The B.Sc (H) and M.Sc. Botany Programmes impart knowledge on various fields of plant biology through teaching, interactions and practical classes. The current syllabi focus on enabling the learners to prepare them for future employment in various fields including academics as well as competitive exams. The graduates will gain wide knowledge on the following aspects:

1. Diversity of plants and microbes, their habitat, morphology, and reproduction.
2. Genetics and molecular biology of plants.
3. Fungi and plant pathology.
4. Economic value of plants and their use in Biotechnology.
5. Ecology of plants and structure and functions of ecosystems.

The combination of theoretical and practical components will provide comprehensive information and insight into the following fields:

1. **Knowledge** on microbial and plant diversity.
2. **Understand** the cell metabolism, chemical composition, physiochemical and functional organization of organelles and contemporary approaches in modern cell and molecular biology.
3. **Comprehend** the relationship between the properties of macromolecules, their cellular activities, and biological responses.
4. **Knowledge** on the occurrence, abundance, and distribution of microorganism in the environment and **describe** their role in the environment and **learn** different methods for their detection.
5. **Understand** the basic principles of organism, environment interactions and biogeochemical cycles **summarise** the application of the same in solving environmental problems like wastewater treatment and bioremediation.
6. **Learn** the basic concepts, principles, and processes in plant biotechnology. **Describe and analyse** the concepts, principles, and **apply** the acquired knowledge in biotechnological, pharmaceutical, medical, ecological, and agricultural fields.
7. **Illustrate** various morphological and structural details and related functional aspects in diverse plant groups and use illustrations, photographs, charts, permanent Slides, museum specimen and herbaria for **explaining** and **demonstrating** various processes.

8. **Develop skills** by hands on training on use of microscope, mounting, section-cutting and staining techniques for the study of plant materials.
9. **Synthesise** ideas for various projects based on the concepts acquired through learning the different courses of the program.
10. **Relate** to various job opportunities in the medicine, plant-based industries, agriculture, research, and innovation.

1.3. Key outcomes underpinning curriculum planning and development

The learning outcomes-based curriculum framework is a framework based on the expected learning outcomes and academic standards that are expected to be attained by graduates of a programme of study. The key outcomes that underpin curriculum planning and development include Graduate Attributes, Programme Outcomes, Programme Specific Outcomes, and Course Outcomes.

1.3.1. Graduate Attributes

The disciplinary expertise or technical knowledge that has formed the core of the university courses. They are qualities that also prepare graduates as agents for social good in future. Some of the characteristic attributes that a graduate should demonstrate are as follows:

1. **Disciplinary knowledge**: Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines.
2. **Research-related skills**: A sense of inquiry and capability for asking relevant/appropriate questions, problematising, synthesising and articulating.
3. **Analytical reasoning**: Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others.
4. **Critical thinking**: Capability to apply analytic thought to a body of knowledge.
5. **Problem solving**: Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems.
6. **Communication Skills**: Ability to express thoughts and ideas effectively in writing and orally.

7. **Information/digital literacy**: Capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources; and use appropriate software for analysis of data.
8. **Self-directed learning**: Ability to work independently, identify appropriate resources required for a project, and manage a project through to completion.
9. **Cooperation/Teamwork**: Ability to work effectively and respectfully with diverse teams.
10. **Scientific reasoning**: Ability to analyse, interpret and draw conclusions from quantitative/qualitative data; and critically evaluate ideas, evidence, and experiences from an open-minded and reasoned perspective.
11. **Reflective thinking**: Critical sensibility to lived experiences, with self-awareness and reflexivity of both self and society.
12. **Multicultural competence**: Possess knowledge of the values and beliefs of multiple cultures and a global perspective.
13. **Moral and ethical awareness/reasoning**: Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work.
14. **Leadership readiness/qualities**: Capability for mapping out the tasks of a team or an organization, and setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision, and using management skills to guide people to the right destination, in a smooth and efficient way.
15. **Lifelong learning**: Ability to acquire knowledge and skills, including 'learning how to learn', that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic,

social and cultural objectives, and adapting to changing trades and demands of workplace through knowledge/skill development/reskilling.

1.3.2. Programme Outcomes (POs) for Postgraduate programme

POs are statements that describe what the students graduating from any of the educational programmes should able to do. They are the indicators of what knowledge, skills and attitudes a graduate should have at the time of graduation.

1. **In-depth knowledge**: Acquire a systematic, extensive, and coherent knowledge and understanding of their academic discipline as a whole and its applications, and links to related disciplinary areas/subjects of study; demonstrate a critical understanding of the latest developments in the subject, and an ability to use established techniques of analysis and enquiry within the subject domain.
2. **Understanding Theories**: Apply, assess, and debate the major schools of thought and theories, principles and concepts, and emerging issues in the academic discipline.
3. **Analytical and critical thinking**: Demonstrate independent learning, analytical and critical thinking of a wide range of ideas and complex problems and issues.
4. **Critical assessment**: Use knowledge, understanding and skills for the critical assessment of a wide range of ideas and complex problems and issues relating to the chosen field of study.
5. **Research and Innovation**: Demonstrate comprehensive knowledge about current research and innovation, and acquire techniques and skills required for identifying problems and issues to produce a well-researched written work that engages with various sources employing a range of disciplinary techniques and scientific methods applicable.
6. **Interdisciplinary Perspective**: Commitment to intellectual openness and developing understanding beyond subject domains; answering questions, solving problems, and

addressing contemporary social issues by synthesizing knowledge from multiple disciplines.

7. **Communication Competence**: Demonstrate effective oral and written communicative skills to covey disciplinary knowledge and to communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs, and techniques of the subject(s) of study.
8. **Career development**: Demonstrate subject-related knowledge and skills that are relevant to academic, professional, soft skills and employability required for higher education and placements.
9. **Teamwork**: Work in teams with enhanced interpersonal skills and leadership qualities.
10. **Commitment to the society and to the Nation**: Recognise the importance of social, environmental, human and other critical issues faced by humanity at the local, national and international level; appreciate the pluralistic national culture and the importance of national integration.

1.3.3. Qualification Descriptors

On completion of the course, the descriptors of a graduate or post graduate student may be listed as such-

1. He /she will have a **comprehensive and systematic knowledge on the subject** and can **apply this knowledge** on different aspects of research and teaching.
2. He/ she can **develop skills** to undertake professional teaching in universities, colleges and other institutes, government and public services, farm consultants, plant research institutes etc.

3. He/ she can **demonstrate procedural knowledge** that creates different types of professionals related to the disciplinary/subject area of study, including research and development, teaching and government and public service.
4. He/ she should be able to **use knowledge understanding and skills for critical assessment** of wide range of ideas and problems in the field of Botany.
5. He /she should be able to **apply one's disciplinary knowledge** and **transferable skills** to new/unfamiliar contexts and to identify and analyse problems and issues and seek solutions to real-life problems.

1.3.4. Programme Specific Outcomes (PSOs) in M.Sc Botany

Programme specific outcomes include subject-specific skills and generic skills, including transferable global skills and competencies. The students of a specific programme of study should be able to demonstrate the knowledge and skill acquired during the program and show application of this knowledge for the award of the degree. The programme specific outcomes also focus on knowledge and skills that prepare students for further study, employment, and citizenship. They help ensure comparability of learning levels and academic standards across universities and provide a broad picture of the level of competence of graduates of a given programme of study. The PSOs of M.Sc in Botany are -

PSO 1: Describe disciplinary knowledge through understanding of different areas of Botany like Microbiology, Mycology, Non-Vascular Cryptogams, Gymnosperms, Angiosperms, Plant -Morphology, Anatomy, Taxonomy, Cell and Molecular Biology, Embryology, Evolution, Pathology, Physiology, Biochemistry , Ecology, Ethnobotany, Economic Botany, Pharmocognosy , Biofertilizers, Bioinformatics, Biotechnology, and Biostatistics.

PSO 2: Communicate their subject related knowledge, findings, observations or views through presentations in seminars and through scientific writing.

PSO 3: Demonstrate digital proficiency in preparing project reports, seminar presentation, performing bioinformatics or bio statistical activities using different software's and online platform to increased their competency via e-learning process using Massive Open Online Course(MOOC) and other platform for lifelong learning.

PSO 4: Apply disciplinary knowledge and appreciate sustainable development, green economy, and conservation of nature.

PSO 5: Perform and develop experiments related to Botany and learn to use scientific equipment's that will enhance their research skills.

PSO 6: Design a discipline related minor research work as dissertation, execute it and prepare the report.

PSO 7: Analyse critical thinking over discipline related concepts learnt during the course and scientific analysis of the knowledge gained.

PSO 8: Work in team in the group assignments, departmental events or field works that would enhance their ability to collaborate.

PSO 9: Adopt moral and ethical values in accurate data representation, maintaining bio safety in laboratory work and in all relevant activities.

1.4.Course Level Learning Outcome Matrix or Curriculum Mapping

Curriculum mapping is the process which helps to determine where, when, and how learning outcomes are taught and assessed within a degree program. The curriculum map clearly demonstrates in which courses learning outcomes are taught and assessed in the curriculum. It provides an effective strategy for articulating, aligning and integrating learning outcomes across a sequence of courses. The following table shows the possible linkage between the course learning outcomes and programme learning outcomes.

1.4.1. Course outcomes (Cos) and Programme Outcomes (POs) matrix

Programme outcomes (POs)	701C	702C	703C	704C	Lab1	801C	802C	803C	804C	Lab2	901C	902C	903C	905OPE	904SP	1001C	1002SP	1003OPE	1004DPW
In-depth knowledge	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Understanding theories	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Analytical and critical thinking	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Critical assessment						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓
Research and innovation																			✓
Interdisciplinary					✓					✓			✓						✓

Programme outcomes (POs)	701C	702C	703C	704C	Lab1	801C	802C	803C	804C	Lab2	901C	902C	903C	905OPE	904SP	1001C	1002SP	1003OPE	1004DPW
perspective																			
Communication competence	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Career development	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Teamwork					✓					✓									✓
Commitment to the society and to the Nation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

1.4.2. Course outcomes (Cos) and Programme Specific Outcomes (PSOs) matrix

Programme Specific outcomes (PSOs)	701C	702C	703C	704C	Lab1	801C	802C	803C	804C	Lab2	901C	902C	903C	905OPE	904SP	1001C	1002SP	1003OPE	1004DPW
Describe	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Communicate	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Demonstrate	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
Apply		✓																	
Perform and develop	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Design																			✓
Analyse	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Work in team	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adopt moral and ethical values					✓					✓									✓

1.5. Teaching-learning process

The LOCF based syllabi of undergraduate and postgraduate programs of botany have been conceived with an aim to encourage students to gather subject-specific knowledge with an understanding of their applications in various fields. The syllabi will not only aid in acquiring professional skills for various botany-based fields but develop a rational thinking and problem-solving attitude in the students. For the successful execution of the syllabi of UG and PG programs, support of various types of teaching-learning processes will be adopted. Some of the relevant processes or tools of pedagogy are enlisted below-

A) Theory:

1. Class lectures with the use of interactive teaching-learning tools. The theory topics will be covered in lectures with the help of both conventional (chalk board and Charts) and modern (ICT) methods, including PPT slides, animations etc.
2. Tutorials.
3. Seminars.
4. Assignment
5. Tests /assessment based on problem solving
6. Group discussion
7. Question papers with very short, short, and long questions.
8. Peer teaching and learning among the core groups.

B) **Practical**:

1. Laboratory-based practical components and experiments.
2. Field-based learning.

C) **Project/ dissertation**:

1. Research problem discussion.

2. Technology-enabled learning.
3. Internship or summer training as and when possible.
4. Encouragement for interdisciplinary approach

Along with the support of these processes, some innovative teaching strategies will also be used by individual teachers to in still problem-solving skills, logical reasoning, and analysis, social responsibilities towards the society and environment. Students mentoring system will be implemented for student progression. All the above focuses on the pedagogy of the subject will be helpful to develop an amalgamation of teacher-centric methods, learner-centric methods, content-focused methods, and participative methods.

1.6. Scheme Of Evaluation (Assessment)

The M.Sc. Botany program will consist of four semesters with the minimum credits required for the complete program being 86. Each course in a program will be of one of the following categories:

1. Core Course (Core): A course that should compulsorily be studied by a candidate as a core requirement is termed as a Core Course. Each core course is of 4 credits.
2. Lab Course (LAB): A Lab (Laboratory) course is a compulsory course in the first two semesters where the major part of the study involves laboratory work. Each Lab course is of 4 credits.
3. Elective Course: A course that can be chosen from a pool of courses and which may extend the discipline/subject of study or which provides exposure to some other discipline/subject or which enhances the student's proficiency or skill is termed an Elective course.

- ✓ Special Paper (SPL): Specialized courses within the department which will lead to specialized knowledge and expertise. Each SPL course is of 5 credits.
- ✓ Open Elective (OPE): An elective course offered under the main discipline/subject of study is an Open Elective and may be offered to students of other disciplines. A student from a given discipline will be eligible to take one open elective in the third semester and one in the fourth semester. Each OPE course is of 5 credits.

- ✓ Skill Enhancement Course (SEC): These courses may be chosen from a pool of courses designed to provide skill-based knowledge and should ideally contain both theory and lab/hands-on/training/fieldwork. The primary purpose is to provide students with life skills in hands-on mode to increase their employability. Each SEC course is of 2 credits.

4. Practical/Tutorials: A practical or tutorial component (or both) is to be provided with every core and special paper/open elective paper.
5. Dissertation/Project Work (DPW): A course designed for the student to acquire special/advanced knowledge which a candidate studies on his own with advisory support by a teacher/faculty member is a dissertation/project work. Each DPW course is of 6 credits.The credits for a course will be of the structure L+T+P, where L, T and P stand for lecture, tutorial and practical respectively.

i. Each 4-credit course with practical is of the pattern 3+0+1=4 and for a 4 credit course without practical the pattern is 3+1+0=4.

ii. For the 5 credit courses with practical the credit division will be either 3+0+2=5 or 3+1+1=5 and will be decided by the department offering that course. For a course without practical, the structure will be 4+1+0=5.

iii. The credit division for the Lab course of 4 credits will be 0+0+4=4. For certain disciplines he 4 credits may be divided between fieldwork and laboratory.

Evaluation of the student will be carried out through a grading system. For each course a letter grade will be awarded which is converted to a grade point according to the following scheme.

Letter Grade	Grade Point	
O	10	Outstanding
A+	9	Excellent
A	8	Very Good
B+	7	Good
B	6	Above Average
C+	5	Average
C	4	Pass
F	0	Fail
Abs	0	Absent

1. The evaluation over a semester will be based on mainly two examinations. The first one at the middle of each semester will be the mid-semester examination (briefly midsem) and another at the end of the semester called the end-semester examination

(briefly endsem). The midsem will be of 30 marks and the endsem of 70 marks. For courses with a practical component of 1 credit a practical examination of 30 marks will be held at the end of the semester.

2. The midsem examination will be of 90 minutes duration and the endsem will be of 3 hours duration.
3. A departmental committee should be formed in each department to moderate the question papers of the midsem written examination.
4. In order to continuously assess a student's progress, further evaluation through class tests/home assignments/field work/seminars etc. may be employed. These are to be considered part of the midsem. The total marks of any form of evaluation other than the midsem examination cannot exceed 15 marks to ensure that the dominant weightage is given to the midsem examination. The midsem marks will be evaluated using the following formula:

$$\frac{\text{Total marks obtained in (midsem exam + classtest/assignment/fieldwork/seminar)}}{\text{Full marks of (midsem exam[30] + classtest/assignment/fieldwork/seminar[15])}} \times 30$$

5. The midsem examination of 30 marks cannot be substituted by any other form of evaluation.
6. As mentioned earlier the endsem written examination will be of 70 marks for courses with or without a practical component. For courses with a practical component, a 30-mark examination will be held and the marks for the endsem examination will be calculated as follows:

$$\frac{\text{marks obtained in (theory paper + practical paper)}}{\text{full marks of (theory paper[70] + practical paper[30])}} \times 70$$

7. The total of midsem and endsem will clearly be a score out of a total of 30 + 70 = 100 marks respectively for each course and this mark is the raw score to be converted to a letter grade.
8. To be eligible for a minimum passing grade, a student must obtain a minimum of 9 marks out of 30 in the midsem, a minimum of 21 marks out of 70 in the endsem and a minimum of 12 out of 30 in the practical examination.
9. It will be mandatory to appear in both the midsem and the endsem examinations as well as the practical examination (for a course with a practical component).
10. For LAB courses, i.e. 4 credit laboratory courses as well as all practical components of 2 or more credits, there will two examiners, one of whom will be an external examiner from a recognized university. The LAB courses of 4 credits will be evaluated by a midsem practical examination of 30 marks and an endsem examination of 70 marks.
11. The dissertation/project work DPW course will be evaluated on the basis of thesis/project report submitted to the department and an oral presentation followed by a viva-voce examination conducted by a panel of at least two members. One examiner will an external examiner and another examiner will be the student's supervisor/guide for the DPW course.
12. The credit break-up in L-T-P format for each paper will be explicitly shown in the gradesheet.

Part II

2.1.Choice Based Credit System (CBCS)

The CBCS comprises of core, elective and skill-based courses. The students get the freedom to choose courses of their choice but there should always be a combination of core courses, elective courses, and skill enhancement courses for each program. The courses can be evaluated following the CGPA (Cumulative Grade Point Average) grading system as UGC guidelines. This will benefit the students to move across institutions within India and across countries. This grading system will enable potential employers in assessing the performance of the candidates.

Outline of Choice Based Credit System

1. **Core Course** compulsorily to be studied by a candidate as a core requirement is termed as a core course.
2. **Elective Course** which can be chosen from a pool of courses, and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope, or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.
    i. **Discipline Specific Elective (DSE) Courses** which are elective courses which are offered by the maindiscipline/subject of study. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
    ii. **Dissertation/Project work** is designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.

iii. **Generic Elective (GE) Course** is generally from an unrelated discipline/subject, with an intention to seek exposure.

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

i) **Ability Enhancement Compulsory Course (AECC):**

a) Environmental Science,

b) English Communication/MIL Communication.

ii) **Ability Enhancement Elective Course (AEEC):**

These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

2.2.Course Structure and Credit Distribution for M.Sc In Botany, CU

A student in the M.Sc. program will take the following minimum number of courses in different categories of courses. The distribution of credits and courses in each of the four semesters for the M.Sc. program will be according to the following scheme:

Semester	Core Course (12) Total Credit 12*4= 48	LAB (2) Total Credit 4*2= 8	Skill Enhancement Course (SEC) (2) Total Credit 2*2= 4	SP Total Credit 5*2= 10	OPE Total Credit 5*2= 10	DPW Total Credit 6*1= 6	Total Credits
I	**BOT-701C** Non-vascular Cryptogams **BOT-702C** Vascular plants **BOT-703C** Angiosperm Taxonomy and ethnobotany **BOT-704C** Plant Ecology, Biodiversity and Conservation Biology	**BOT-LAB-1** LAB-1	**SEC-1**				**22**
II	**BOT-801C** Analytical Techniques and molecular biology **BOT-802C** Plant physiology and biochemistry **BOT-803C** Microbiology and plant pathology **BOT-804C** Cytogenetics and plant breeding	**BOT-LAB-2** LAB-2	**SEC-2**				**22**
III	**BOT-901C** Plant Anatomy **BOT-902C** Pharmacognosy and economic botany **BOT-903C** Plant biotechnology and biostatistics			**BOT-904 SP** Special paper- I	**BOT-905OPE** Biofertilizer and bioremediation		**22**
IV	**B0T-1001C** Reproductive and developmental biology			**BOT-1002 SP** Special paper-II	**BOT-1003OPE** Energy and Environment	**BOT-1004DPW** Dissertation	**20**
Credits	**48**	**08**	**04**	**10**	**10**	**6**	**86**

COURSE STRUCTURE AND CREDIT DISTRIBUTION FOR M.Sc. IN BOTANY, CU

SEMESTER-I			
Sub Code	Subject Title	L+T+P	Credits
BOT-701C	Non Vascular Cryptogams	4+0+0	4
BOT-702C	Vascular Plants	4+0+0	4
BOT-703C	Angiosperm Taxonomy& Ethnobotany	4+0+0	4
BOT-704C	Plant Ecology, Biodiversity and Conservation Biology	4+0+0	4
BOT-LAB-1	LAB	0+0+4	4
SEC-1	To be offered at University level		2
SEMESTER– II			
BOT-801C	Analytical Techniques and Molecular Biology	4+0+0	4
BOT-802C	Plant Physiology and Biochemistry	4+0+0	4
BOT-803C	Microbiology and Plant Pathology	4+0+0	4
BOT-804C	Cytogenetics & Plant Breeding	4+0+0	4
BOT-LAB-2	LAB	0+0+4	4
SEC-2	To be offered at University level		2
SEMESTER– III			
BOT-901C	Plant Anatomy	3+0+1	4
BOT-902C	Pharmacognosy and Economic Botany	3+0+1	4

BOT-903C	Plant Biotechnology and Biostatistics	3+0+1	4
BOT-905OPE	Biofertilizer and Bioremediation	4+1+0	5
BOT-904 SP Special paper-I	Student will opt for a special paper from the pool of papers offered by the department.	3+0+2	5
SEMESTER– IV			
BOT-1001C	Reproductive and Developmental Biology	3+0+1	4
BOT-1002 SP Special paper- II	Continuation of special paper opted in 3rdSem	3+0+2	5
BOT-1003 OPE	Energy and Environment	4+1+0	5
BOT-1004 DPW	Dissertation is a course designed for the student to acquire special/advanced knowledge which a candidate studies on his own with advisory support by a teacher/faculty member *(Department must allot students' advisory support by a teacher/ faculty member in the area of special paper opted by the student. The allotment process must be complete before the start of Semester-III to provide sufficient time to student completing dissertation)*. Each DPW course is of 6 credits. The dissertation, DPW course will be evaluated on the basis of report submitted to the department and an oral presentation followed by a viva- voce examination conducted by a panel of at least two members. One examiner will be an external examiner and another examiner will be the student's supervisor/guide for the DPW course. Distributation of marks: End sem assessment: 70 Midterm assessment: 30 Total: 100	0+0+6	6

(All practical should be supported with field studies, field reports, herbariums and collections or photographs and practical records whichever is applicable).

POOL OF SPECIAL PAPERS

Paper Code	Title of the paper options offered	Credits L+T+P
PG-III Semester **BOT-904 SP** **(1 to 6)**	1. Angiosperm Taxonomy–I 2. Advanced Plant Physiology and Biochemistry–I 3. Cell Biology, Genetics and Molecular Biology–I 4. Mycology and Plant Pathology–I 5. Microbiology–I 6. Plant Ecology–I	3+0+2
PG-IV Semester **BOT-1002 SP** **(1 to 6)**	1. Angiosperm Taxonomy–II 2. Advanced Plant Physiology and Biochemistry–II 3. Cell Biology, Genetics and Molecular 4. Biology–II 5. Mycology and Plant Pathology–II 6. Microbiology–II 7. Plant Ecology–II	3+0+2

PG- Semester-I

Paper Code: BOT-701C

Paper Title: NON-VASCULAR CRYPTOGAMS

(Credits: Theory-4, Practical-0, Type of paper: THEORY, No. of Lectures: 48)

Course outcomes:

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

CO1- Gain Knowledge on the distribution, characteristic features, classification, phylogeny, and economic importance of non-vascular cryptogams

CO2- Understand the structural organization of algae, fungi, lichens and bryophytes.

CO3-Relate to the economic importance with special emphasis on ecological significance of lower cryptogams.

CO4- Demonstrate collaborative learning and communication skills through practical sessions, teamwork, group discussions and home assignments.

a) Algae: **Lectures -15**

Unit 1:

- Classification of algae- comparative survey of important system: Fritsch- Smith-Round.
- Ultrastructure of algal cells: cell wall, flagella, chloroplast, pyrenoid, eyespot and their importance in classification. Structure and function of heterocysts, pigments in algae and Economic importance of algae.

Unit 2:

- General account of thallus structure, reproduction, relationships, and evolutionary trends in the following groups - Cyanophyta, Chlorophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta

b) Fungi & Lichen: **Lectures - 18**

Unit-3:

- Present status of fungi, classification, cell structure, Thallus organization, Reproduction, degeneration of sex, Heterothallism, Parasexuality, Nutrition, phylogeny, and Economic importance of fungi.

Unit-4:

Comparative account of thallus structure, reproduction, and life cycle pattern of- Myxomycotina: Plasmodiophorales, Mastigomycotina: Perenosporales, Zygomycotina:Mucorales, Ascomycotina: Endomycetales, Erysiphales, Eurotiales,and Pezizales, Basidiomycotina: Uredinales, Ustilaginales and Agaricales, Deuteromycotina: Melanconiales and Moniliales. **Lichen:** Thallus structure, Classification, reproduction and Economic importance

c) **Bryophytes:** **Lectures - 15**

Unit-5:

- Classification of bryophytes, origin, evolution, and fossil history of bryophytes, primitive versus advanced characters, evolution of sporophyte, spore germination, protonemal differentiation, bud formation, parthenogenesis, apogamy, apospory and regeneration. Comparative morphology and developmental anatomy of hepaticae, Anthocerotae and Musci.

Unit-6:

- Ecology- Habitats, water relations (Ectohydric, endohydric and myxohydric bryophytes); Bryophytes as pollution indicators; Economic importance of bryophytes.Bryo-geographical regions of India with reference to North- Eastern India.

Suggested readings:

a) Algae

- Bilgrami K.S. and Saha L.C. 2007. A Textbook of Algae. CBS Publishers & Distribution
- Bold and Wynee. 1985. Introduction to algae – Structure and reproduction. Prentice – Hall, India,
- Kumar, H. D. 1990. Introductory phycology, Affiliated East West Pvt Ltd., Bangalore, India.
- Round, F. E. 1973. Biology of algae. Edward Arnold Publishers, London
- Sambamurty, A.V.S.S. 2005. A Textbook of Algae. I.K. International Pvt.Ltd., New Delhi.
- Sharma.O.P. 2011. Algae. Tata McGraw Hill Education Pvt. Ltd., New Delhi.

b) Fungi

- Ainsnorth G.C 1973. The Fungi Vol IV A, IV B Academic Press.
- AlexopoulusC.J, Mims C.W. and Blackwel M.I 1996. Introductory Mycology. John Wiley and Sons Inc.
- Burnett J.H. 1968. Fundamentals of Mycology. Edwards Arnold Publication. Hawker L.E. 1967. An Introduction to Fungi Cambridge Press.
- Mehrotra R. S and Aneja R. S. 1998.An introduction to Mycology. New Age Intermediate.
- Sharma, O.P. (1989): Textbook of Fungi
- Webster J. 1985. Introduction to Fungi. Cambridge University Press.

c) Bryophytes

- A.H. E Smith. Bryophyte Ecology
- Hait, Bhattacharya, Ghosh. A textbook of Botany. Vol 1
- Shaw AJ and B Goffinet (2000) Bryophyte Biology. Cambridge University Press.
- Vashishta,B.R. Bryophyta-Part III

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Paper code: BOT -702C

Paper title: VASCULAR PLANTS

(Credits: Theory-4, Practical-0, Type of paper: THEORY, No. of Lectures: 48)

Course outcomes:

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

CO1: Understand the distribution, characteristic features, classification, phylogeny (Extinct and extant), and economic importance of pteridophytes and gymnosperms.

CO2: Develop skills to identify pteridophytes and gymnosperms based on morphological and anatomical observations.

CO3: Conceptualize the structural peculiarities and ideas on origin of angiosperms.

CO4: Interpret the knowledge received and apply it to the daily life.

a) Pteridophytes

Unit-1: **Lectures-10**

- Theories of origin and interrelationship of pteridophytes; Classification , Diversity of life cycle pattern, apospory and apogamy, heterospory and seed habit, Evolution of Sorus; Evolutionary trends & Economic importance of pteridophytes.
- Ecology & distribution of ferns of N. E India with special reference to Assam. Morphology, anatomy and reproduction of Psilophyta (*Psilotum, Tmesipteris*), Lycophyta (*Phylloglossum, Isoetes*), Sphenophyta (*Equisetum*) and Pterophyta (*Ophioglossum, Dryopteris, Polypodium, Marsilea and Salvinia*).

Unit-2: **Lectures - 6**

- Fossils Pteridophytes: Morphology, anatomy and reproductive characteristics and affinities of major fossil groups- Psilophytales, Lepidodendrales, Zosterophyllales, Sphenophyllales, Calamitales, Cladoxylales and Coenopteridales.

b) Gymnosperms

Unit-3: **Lectures-08**

- Geological time-scale and correlated predominant gymnosperm flora; Salient structural features and affinities of fossil gymnosperms - Pro-gymnosperms, Pteridospermales, Bennettitales, Pentoxylales, Cordaitales.

Unit-4: **Lectures-08**

- Diversity and distribution, Morphology, anatomy and reproduction of Cycadales (Cycas, *Zamia*); Coniferales (*Pinus, Araucaria, Cupressus)*, Ginkgoales (*Ginkgo*); Taxales (*Taxus*); Ephedrales (*Ephedra*); Gnetales (*Gnetum*).

c) Angiosperm:

Unit-5: **Lectures-08**

- Range of vegetative and reproductive structure and their modification in angiosperms; A critical study of the current ideas on the origin of angiosperms.

Unit-6: **Lectures-08**

- Origin and evolution of inflorescence and flower, co-evolution of flower vis-à- vis pollinators, special type of inflorescence, origin and evolution of stamens, origin and evolution of carpels, different types; types of ovaries, evolution of placentation types, inferior ovary- foliar and axial concepts.

Suggested readings:

a) Pteridophytes:

- Agashe S.N.(1995). *Paleobotany*. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
  Arnold A.C. (2005*). An Introduction to Paleobotany*. Agrobios (India). Jodhpur.
- Eames E.J. (1983). *Morphology of Vascular Plants*. Standard University Press.
- Gangulee and Kar(2006*). College Botany*. New Central Book Agency.
- Rashid A.(1999). *An Introduction to Pteridophyta*. VikasPubishing House Pvt. Ltd. New Delhi.

b) Gymnosperms

- Bhatnagar, S.P. and Moitra A. 1996. Gymnosperms. New Age International Private Limited, New Delhi;
- Biswas, C. and Johri, B.M. 1997. The Gymnosperms, Narosa Publishing House, New Delhi;
- Coulter, J.M. and Chamberlain, C.J. Morphology of Gymnosperms, Central Book Depot, Allahabad;
- Maheshwari, P. and Vasil, V. Gnetum CSIR (Monographs);
- Sharma, O.P. 1996. Gymnosperms, PragatiPrakashan, Meerut;
- Vashishta, P.C. 1999. Gymnosperms, S.Chand& Company Ltd. New Delhi;

c) Angiosperm:

- David, P.H. and Heywood, P.H(1963). *Principles of Angiosperms taxonomy*. Oliver and Boys, London.
- Eames A. J(1981) Morphology of angiosperms, McGraw Hill Publisher, New York.
- Hutchinson, J(1964). *Genera of flowering plants*.Cambridge University Press, London.
- Jain, S.K. and Rao, R.R(1977). *A Hand Book of Field and Herbarium Methods*. Today and Tomorrow Publications, New Delhi.
- Mabberley, D.J(2017). *The Plant Book*. Cambridge University Press, London.
- Mitra , J.N (1964) Taxonomy of angiosperm, Oxford and IBH publishers, New Delhi
- Takhtajan, A(1969) *Origin and dispersal of Flowering Plants*. Oliver and Boyd Edenberg

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Paper code: BOT-703C

Paper title: ANGIOSPERM TAXONOMY AND ETHNOBOTANY

(Credits: Theory-4, Practical-0, Type of paper: THEORY, No. of Lectures:48)

Course outcomes:

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

CO1- Gain knowledge on historical development in plant taxonomy and conceptualize the categories and approaches of plant classification.

CO2- Identify, analyse and interpret the sources of taxonomic characters in different disciplines.

CO3- Interpret the rules of ICN in botanical nomenclature and understand the role of herbaria, botanical gardens and BSI in taxonomic studies.

CO4- Conceptualize basics of ethnobotany and recognise the role of ethnic communities in plants utilization.

Unit-1: **Lectures-08**

- Historical development of plant taxonomy, systems of classification- artificial, natural and phylogenetic; phenetic and phylogenetic systems, cladistics in taxonomy; taxonomic hierarchy concept of taxa, species, genus and family, infraspecific categories, use of computer in taxonomy; changing trends in plant taxonomy.

Unit-2: **Lectures-08**

- Plant nomenclature- history of nomenclature, detailed study of salient features and major provisions of ICN including effective and valid publication, rule of priority and its limitations, typification, rejection of names and names of hybrid, biocode.

Unit-3: **Lectures-08**

- Plant collection, exploration, importance of botanic garden and herbaria in taxonomic studies, important botanic garden and herbaria in the world and India, Indian flora- its past and present position with particular reference to N.E. India; Botanical Survey of India-organisation and activities.

Unit-4 **Lectures-08**

- hylogeny, floral evolution and economic importance of selected families (mostly Indian distribution) of the following orders- Magnoliales, Ranunculales, Lamiales, Asterales, Orchidales, Zingiberales and Poales.

Unit-5: **Lectures-08**

- Ethnobotany- Nature, scope, History, Objectives and as an intra & inter-disciplinary science; Cross cultural study; disciplines and sub-disciplines of ethnobotany; The relevance of ethnobotany in the present context: Life style, Material Culture and Indigenous Technology. Methods and techniques in ethnobotany

Unit-6: **Lectures-08**

- Ethnic groups and Ethnobotany: Medico-ethnobotanical resources in India with special reference to NE states. Socio-economy and other aspects of Ethnobotany with reference to:
    - Food,
    - Intoxicants and Beverages,
    - Ropes and Binding Materials
    - Resins and Oils
    - Cosmetics
    - Ornamentals
    - Fodder
    - Medicinal and Aromatic properties.

Suggested Readings:

Angiosperm Taxonomy:

- Hutchinson, J. 1964. *Genera of flowering plants*. Cambridge University Press, London.
- Jain, S.K. and Rao, R.R. *1977. A Hand Book of Field and Herbarium Methods*. Today and Tomorrow Publications, New Delhi.
- Naik, V.N. 1984. *Taxonomy of Angiosperms*. Tata McGraw Hill, New Delhi.
- Singh, G. 2012. Plant Systematics: Theory and Practice. Completely revised and enlarged. 3rd edition. Oxford & IBH, New Delhi.
- Sivarajan, V.V. and Robinson, N.K.P. 1991. *Introduction to the principles of plant taxonomy*. Oxford IBH, New Delhi.

Ethnobotany:

- Cotton C.M. 1997. Ethnobotany – *Principles and applications*. John Wiley and sons – Chichester.
- Faulks, P.J. 1958. *An introduction to Ethnobotany*, Moredale Pub. Ltd., London.
- Jain S.K., (ed.) 1981. *Glimpses of Indian Ethnobotany*, Oxford and I B.H., New Delhi.
- Jain S.K., 1995 *Manual of Ethnobotany*, Scientific Publishers, Jodhpur.
- Martin, G.J. 1996, *Ethnobotany, A methods manual*, Chapman & Hall, London.
- Schultes, R.E. 1995. *Ethnobotany*, Chapman and Hall.

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Paper code: BOT-704C

Paper title: PLANT ECOLOGY, BIODIVERSITY AND CONSERVATION BIOLOGY

(Credits: Theory-4, Practical-0, Type of paper:THEORY, No. of Lectures: 48)

Course outcomes:

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

CO1: Understand various scopes and principles of plant ecology, and different ecological factors and **gain in-depth knowledge** of population characteristics, dynamics, growth curves, regulation and life history strategies.

CO2- Develop skills for performing experiments to measure the primary productivity in aquatic and terrestrial ecosystems and **correlate** ecological dynamics and regulation of vital processes on earth as biogeochemical cycles.

CO3- Analyse different sources of environmental problems in N.E. India and ways of ecological restoration.

CO4-Apply the basic principles of conservation biology to solve local and national conservation and management issues.

Unit-1: Introduction: **Lectures-08**

- Scope and concept of plant ecology; relation of plant ecology with other disciplines; principles of ecology; light, water and fire as ecological factors; origin and development of soil; soil horizons and profile.

Unit-2: Population Ecology: **Lectures-08**

- Concept; population characteristics: density, natality, mortality, dispersion, population size, age structure, biotic potential, life tables; population dynamics: population increase, population growth curves; population regulation; Life history strategies:r and K selection, population genetics (Bottleneck and Founder Effect).

Unit-3: Community Ecology: **Lectures-08**

- Nature and concept of biotic community, characteristics of communities (analytical and synthetic); community structure and attributes; classification of communities; ecotone and edge effect; concept of ecological niche. Ecological succession: types; mechanisms; changes involved in succession; examples of succession.

Unit-4: Ecosystem Ecology: **Lectures-06**

- Structure and function of ecosystems; energy flow and mineral cycling (C,N, P& S); primary production; methods of measurement of primary productivity; development and evolution of ecosystems.

Unit-5: Phyto-geography and applied ecology: **Lectures-08**

- Definition, principles and objectives of phytogeography; descriptive and dynamic phytogeography; continuous and discontinuous plant distribution; routes and barriers to plant migration; Centers of origin (Primary and secondary centers); Endemism – types and endemism in Indian flora. Environmental pollution (green house gases, ozone hole, sea level rise); ecological restoration; environmental problems of N.E. India.

Unit-6: Biodiversity and Conservation Biology **Lectures-10**

- Biodiversity – types, levels, threats, value and uses ; distribution and gradients of biodiversity, agro-biodiversity outlines, megadiverse nations; biodiversity hotspots with special emphasis on Indian hotspots, conservation strategies, IUCN Red list of threatened species; extinction of species, IUCN protected area management categories, Biodiversity and Ecosystem services (BES), status of biodiversity conservation in India; role of organisations in the conservation of biodiversity – IUCN, WCED, UNEP, NBPGR, CBD.

Suggested Readings:

- Bharucha, F.R.(1983) - *A textbook of plant geography of India*, Oxford University Press, 179 pages

- Cain, S.A . (1944) : *Foundations of Plant Geography*, Harper & Brothers, N.Y.
- Chapman, J. L. and Reiss, M. J. (1992). *Ecology – Principles and Applications*, Cambridge University Press, Cambridge, UK
- Good, R. (1997) : *The Geography of flowering Plants (2nd Edn.,*), Longmans, Green & Co., Inc., London & Allied Science Publishers, New Delhi -495pp.,
- Krishnamurthy, K.V. *A textbook of Biodiversity*, Science Publishers Inc.,Enfield, New Hampshire, USA.
- Mishra, K. C. *Manual of Plant Ecology* - Oxford & IBH
- Sharma, P. D. (2009). *Ecology and Environment*, Rastogi Publications, Meerut, India
- Shukla, R.S. & Chandel P.S.(1991): *Plant Ecology & Soil Science*, S.Chand & Co., New Delhi.
- Townsend, C.R., Begon, M. and Harper, J.L. 2003. *Essentials of Ecology* (2nd Edn.) Blackwell Publishing, Oxford.

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Paper code: BOT- LAB -1

Paper Title: Lab 1

(Credits: Theory-0, Practical-4, Type of paper: Pratical, No. of Lectures: 48**)**

A. NON-VASCULAR CRYPTOGAMS & VASCULAR PLANTS (Credit-2)

B. ANGIOSPERM TAXONOMY & ETHNOBOTANY AND PLANT ECOLOGY, BIODIVERSITY & CONSERVATION BIOLOGY (Credit-2)

Course outcomes:

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

CO1- Develop practical skills for taxonomic determination of locally available non vascular & vascular cryptogams.

CO2-Create practical skills for comparative study of gymnosperm based on morphology and anatomy.

CO3-Prepare questionaries, data collection, interpretation, and report preparation through ethnobotanical field survey.

CO3- Identify taxa up to the rank of species of common plants following Bentham & Hooker's system of classification.

CO4- Recognize the ecological characteristics of plant communities by using quadrate methods.

A. NON-VASCULAR CRYPTOGAMS &, VASCULAR PLANTS (Practicals)

- **Algae:** Study and identification of available specimen (at least two) in each of the following classes: Cyanophyta, Chlorophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta.
- **Fungi:** Thallus organization, Spore producing organs, Tissue differentiation and accessory structures of following –Myxomycotina, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina
- **Bryophytes:** Study and identification of available specimen (at least two) in each of the following classes: Hepaticopsida, Anthocerotopsida, and Bryopsida
- **Pteridophytes:** Study of major groups of fossil pteridophytes, study of available living members of pteridophytes, study of soral characters of ferns available in N.E. region, study of epidermal morphology of some important ferns.
- **Gymnosperm:** Comparative study of the vegetative, reproductive parts and anatomy of the following: *Zamia*, *Araucaria*, *Cupressus*, *Ginkgo*, *Taxus*, *Ephedra* and *Gnetum.*
- **Angiosperms Morphology**: Study of epidermal morphology: hair, trichomes, venation, stomata, morphology of different types of inflorescences, morphological study of primitive and advanced flowers, morphology of different types of ovary and placentation types.

B. ANGIOSPERM TAXONOMY & ETHNOBOTANY AND PLANT ECOLOGY, BIODIVERSITY & CONSERVATION BIOLOGY: (Practicals)

Angiosperm Taxonomy

- Taxonomic study of angiospermic plants with analytical drawings, botanical description, and identification up to the rank of species.
- Collection and preparation of herbarium specimens to be submitted along with field notebook so as to get acquainted with herbarium techniques. At least 20 herbarium specimens of common plants to be prepared and submitted.

- Handling of floras, manuals, and herbarium for identification of plants.
- Field studies.

Ethnobotany:

- Field trips within and nearby areas, compilation of field notes and identification, field notes, visual and digital records, and preparation of herbarium, specially of the following categories (1 each) – oils, medicines for asthma, skin diseases, diarrhoea, family planning.

Plant Ecology, Biodiversity and Conservation Biology:

- Determination of abundance, density, and frequency of plant community by quadrat method.
- Determination of the minimum size of the quadrats necessary to study herbaceous communities by 'species area curve' method.
- Determination of the minimum number of quadrats necessary to study herbaceous communities.
- Determination of community coefficient of two sites by quadrat method.
- Determination of the basal area of a plant species in the study area.
- Determination of phytomass.
- Study of phytoplanktons.
- Study of seed dispersal of plant species.
- To prepare a map and study the Centers of origin of cultivated plants (Primary and secondary centers).
- Study of endemic vascular plants in Indian flora (at least ten)

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PG- Semester-II

Paper code: BOT-801C

Paper title: ANALYTICAL TECHNIQUES AND MOLECULAR BIOLOGY

(Credits: Theory-4, Practical-0, Type of paper: THEORY, No. of lectures:48)

Course outcomes:

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

CO1-Understand the principles and applications of basic chromatographic, spectroscopic, and microscopic techniques.

CO2-Acquire knowledge on media preparation and *invitro* culture of plants and microbes and **conceptualize** basics of cytochemical and histochemical techniques in plant.

CO3- Recognize the fundamentals of DNA structure, function, replications, damage, repair in plants, isolation, amplification, cloning, sequencing and DNA/gene transfer techniques in plant.

CO4-Develop conceptual understanding of genetic code, sequential flow of genetic information, regulation of gene expression in prokaryotes and eukaryotes, protein folding and post translational modification of protein in plants.

Unit-1: Cytochemical and histochemical techniques **Lectures - 06**

- Fixatives, dyes, and stains: Principles, types, procedures, and application; mounting media, fixations, embedding, staining methods. Histochemical detection of phytochemicals (secondary metabolites), biomolecules (nucleic acids, lipids, starch, enzymes) and microbes in plant tissues.

Unit-2: Basic culture techniques **Lectures -06**

- Basic plant and microbe culture media –Types, preparation, and methods of sterilization; Somatic embryogenesis.

Unit-3: Microscopy and spectroscopy techniques **Lectures - 08**

- Principle, methods and application in plant science of Phase-Contrast, Fluorescence, Electron, Confocal Microscopy; Spectroscopic Techniques - Principle,

instrumentation and application of Visible, UV, IR Spectrophotometry, fluorimetry & ESR Spectroscopy, atomic absorption and mass spectrometry.

Unit-4: Separation Techniques **Lectures - 08**

- Principle & applications in plant sciences; One- and two-dimensional Chromatography, Column chromatography, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit -5: Nucleic Acid **Lecture-10**

- Structure, function and replication of DNA and RNA, DNA damage & repair, DNA topoisomerase and DNA polymerase. DNA isolation, amplification (PCR and Real time PCR) and Cloning techniques, sequencing techniques including NGS; DNA transfer techniques in plant**.**

Unit-6: Gene expression **Lecture-10**

- Genetic code, decoding system translational mechinary, post translational modification of Protein, Non covalent interaction and folding of polypeptide chain, regulation of gene expression in prokaryote ('Lac'& 'Trp' operon) and eukaryotes.

Suggested Readings

- Plummer, D.T.(1996). An Introductionto Practical Biochemistry. TataMcGraw-Hill PublishingCo. Ltd. NewDelhi. 3rdedition.
- Ruzin, S.E. (1999).PlantMicro-technique and Microscopy, Oxford University Press, New York. U.S.A.
- Sheehan D (2009). Physical biochemistry: Principles and applications (2nd Edition) , A John Wiley & Sons, Ltd, Publication.
- Wilson, K. &Walkar, J. (Eds) (2010) Practical Biochemistry: Principles & Techniques (7th Edition, Cambridge University Press.
- David Freielder(2015) *Molecular Biology*- Narosa Publishing House.
- Jocelyn E. Krebs,Elliott S.Goldstein& Stephen T *(2013)Lewin's Genes*-. Kilpatrick, Jones and Bartlett Publishers.

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Paper code: BOT-802C

Paper title: PLANT PHYSIOLOGY AND BIOCHEMISTRY

(Credits: Theory-4, Practical-0, Type of paper: THEORY, No. of Lectures:48)

Course outcome:

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

CO1-Understand the concept of aquaporins and their role related to water absorption and understand the concept of water potential. Acquire knowledge about stomatal conductance, transpiration, and mineral nutrition in plants.

CO2-Gather knowledge about carbon fixing pathways, oxidative pathways, respiration, ATP synthesis and solute transport in plants.

CO3-Conceptualize photoperiodisdormancy,tion, dormancy , biosynthesis and role of various plant growth regulators.

CO4-Understand the fundamentals of enzymology, molecular aspects of nitrogen metabolism and biosynthesis of lipids in plants.

a) PLANT PHYSIOLOGY:

Unit-1: Water Relation and mineral nutrition in plants **Lectures-08**

- Water potential in plant, transpiration, stomatal regulation and signalling and physiology of water stress and its adaptation in plant. Mineral Nutrition: Criteria of essentiality, detection of mineral elements by chemical analysis; uptake, role and deficiency of essential mineralelements in plants.

Unit-2: Photosynthesis and Solute Transport **Lectures-06**

- Photosynthetic pigments, Photosystems, Photochemical reactions and light harvesting complexes, carbon fixation pathways in plants. Solute transport in plants, Uniport, Symport, Antiport channels, ATP driven active transport Source and sink relationship (Phloem loading and unloading): Pressure flow model; Polymer trapping model.

Unit-3: Respiration **Lectures-06**

- Different types of respiration. Glycolysis, TCA cycle, Pentose Phosphate Pathways, Cyanide resistance pathway, Gluconeogenesis, ATP synthesis. Mitochondrial

electron transport system coupled with oxidative phosphorylation, High energy compounds: Synthesis and utilization, Inhibitors of electron transport system.

Unit-4: Photobiology and plant growth regulators **Lectures-12**

- Structure, function and mechanisms of action of phytochromes, plant morphogenesis-Physiology of flowering, florigen concept, circadian rhythms, photoperiodism and its regulation, vernalization, fruit ripening. Dormancy (bud and seed), seed germination-metabolic changes during seed germination, and senescence. Physiological effect, biosynthesis and mechanism of action of plant growth regulators: Auxins, Gibberellins, (GA), Cytokinins, Ethylene, Abscicsic Acid, Brassinosteroids, Jasmonic acid and Salysylic acid. Role of PGR's in agriculture, floriculture, horticulture and biotic and abiotic stress adaptation in plants.

b) PLANT BIOCHEMISTRY:

Unit-5: Enzymology **Lectures-06**

- General classification, mechanism of enzyme action, Cofactor and Coenzymes, Isozymes and factors affecting enzyme activity, enzyme inhibition, regulation of Enzyme action, allosteric enzymes, Enzyme kinetics, Industrial application of enzymes.

Unit-6: Metabolism in plant **Lectures-10**

- Structure, function, classification, synthesis and break down of carbohydrates, (starch and sucrose). Mechanism of N_2 fixation and assimilation. Structure, classification, synthesis, properties and oxidation of amino acids and proteins. Structure, function, classification, synthesis, oxidation and regulation of lipids in plants. Lipids as signal molecules, cofactors and pigments
- **Visit to research institute/laboratories of national repute and submission of report.**

Suggested Readings: -

- Buchanan B.B, Gruissem W. and Jones R. L (2000). *Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland,USA.*
- Dennis D. T., Turpin, D. H. LefebvreD. D. and LayzellD. B.(eds)(1997*).Plant Metabolism* (Second Edition) Longman, Essex, England

- Willium G Hopkins, Norman P Hunar (2009) Introduction To Plant Physiology, Wiley.
- Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
- David L Nelson and Michael M. Cox (2017) (seventh edition), Leninger Principles of Biochemistry, W. H. Freeman and Company.

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Paper code: BOT-803C

Paper title: MICROBIOLOGY AND PLANT PATHOLOGY

(Credits: Theory-4, Practical-0, type of paper: THEORY, No. of Lectures: 48)

Course outcomes:

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

CO1-Describe the methods used in microbial taxonomy and categorise the different types of microorganisms.

CO2-Explain the principles of microbial metabolism, nutrition and growth and the various pathological events during the progression of an infectious disease.

CO3-Illustrate the interactions among the microbes along with their importance.

CO4-Apply the principle of epidemiological sciences in studying the underlying mechanisms of spread of disease and controls required thereof to combat the spread of pathogens.

Unit-1: Microbial Taxonomy and Diversity **Lectures-08**

- Molecular approaches to microbial taxonomy. Bergy's manual and its importance, general properties of bacterial groups, Archea and their broad classification; Viruses and their classification; Nature of virus, replication in virus.

Unit-2: Microbial Growth and nutrition **Lectures-06**

- Definition of growth; growth curve; Mathematical expression of exponential growth phase; Measurement of growth and growth yields; Synchronous growth; Continuous culture; strategies of cell division, stress response.

- Microbial nutrition and metabolism: autotrophy, photoautotrophy and bacterial photosynthesis Chemoautotrophy and heterotrophic metabolism

Unit-3 Microbial Interactions **Lectures-08**

- Microbes and plant interactions – Rhizosphere, Phyllosphere and Mycorrhizae; Plant growth promoting microorganisms (PGPM): Plant growth promoting rhizobacteria (PGPR): Direct and Indirect mechanisms of plant growth promotion. Cell signalling in microbial interactions.

Unit-4: Pathogen and Plant Defence **Lecture-10**

- History of plant pathology, classification of plant diseases, Symptoms, Mode of infection and role of enzymes and toxins in plant disease. Défense mechanisms of plants against infection, Epidemiology, role of phytoalexins and other phenolic compounds.

Unit-5: Molecular plant pathology and disease control **Lecture-08**

- **Molecular aspects of host pathogen interactions:** PR proteins, systemic resistance mechanism; application of molecular biology to plant disease control ; transgenic approach for crop protection.
- **Management of Plant Diseases:** Cultural, chemical, biological, bio pesticides, breeding for resistant varieties, plant quarantine and integrated pest management.

Unit-6: Study of plant diseases **Lecture-08**

- Symptomology, causal organism, etiology and management of diseases in:Rice, Wheat, Sugarcane, potato, Pea, Coconut, Tea, Citrus, Banana, Papaya, Tobacco.

Suggested Readings:

- Agrios, G. N. 1978: Plant Pathology
- Aneja, K. R. 1993: Experiments in Microbiology, plant pathology and Tissue culture
- Cooke, A. A. 1981. Diseases of Tropical and Subtropical field, Fiber and oil plants
- Dubey, R. C & D.K. Maheswari: A Text Book of Microbiology.
- Mahadevan, A. and R. Shridhar, 1982. Methods in physiological plant pathology
- Mishra, R. R. 1996. Soil Microbiology. CBS Publ.
- Nyvall, R. F. 1979 : Field Crop Diseases Handbook

- Paul Khurana, S. M. 1998: Pathological Problems of Economic crop plants and their management
- Pelczar, M.J. (2001) *Microbiology, 5th edition,* Tata McGraw-Hill Co, New Delhi. Planke, J. E. Vander. 1963 : Plant Diseases Epidemics and control
- Presscott, L. Harley, J. and Klein, D. (2005) *Microbiology, 6th edition,* Tata McGraw-Hill Co. New Delhi.
- Rangaswamy G. and Mahadevan A. 1999. Diseases of crop plants in India (Fourth Edition) Prentice Hall of India Pvt. Ltd. New Delhi.

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Paper code: BOT-804C

Paper title: CYTOGENETICS AND PLANT BREEDING

(Credits: Theory-4, Practical-0, Type of paper: THEORY, No. of Lectures: 48)

Course outcomes:

On completion of this course, the students/learners would be able to-

CO1-Demonstrate an understanding of chromosomes, their types, representation, and analysis.

CO2- Acquire concepts of crossing over and linkages and their underlying principles and **create** awareness and appreciation about the ideotypes of crop plants and the development of ideal varieties.

CO3-Develop understanding of the different patterns of inheritance.

CO4-Comprehend the effects of numerical and structural mutations and their importance in the evolutionary processes of different plants and **conceptualise** the domestication, introduction and selection of crops and the different approaches adopted in overcoming the different stress conditions.

Unit -1: Eukaryotic Chromosome **Lecture-10**

- Molecular organization of eukaryotic chromosomes, euchromatin and heterochromatin and its significance, synaptonemal complex, Karyotype and Idiogram, chromosome banding, special types of chromosomes, Genome editing and genome plasticity.

Unit-2: Gene and Inheritance pattern **Lecture-06**

- Nuclear, cytoplasm, quantitative and sex-linked inheritance, gene interactions, Multiple alleles.

Unit-3: Linkage and crossing over **Lecture-10**

- Linkage: Introduction and definition and types of Linkage, Coupling and Repulsion hypothesis, Theories of linkage. Linkage group- Drosophila and maize, Factors affecting linkage.
- Crossing over: definition and types of crossing over, Cytological basis of crossing over, Mechanism of crossing over, Molecular mechanism of crossing over (Holiday model), Construction of genetic maps.

Unit-4: Chromosomal aberrations **Lecture-06**

- Chromosomal aberrations, Numerical- Euploidy Polyploidy and aneuploid, Structural- Deletions, Duplication, Translocation, and Inversions. Evolutionary significance of chromosomal aberrations.

Unit-5: Plant breeding **Lecture-08**

- **Plant domestication, Introduction, and selection** (self- & cross-pollinated plants), hybridization, heterosis& inbreeding depression, male sterility, breeding for stress (biotic & abiotic) and mutation breeding (Special emphasis on Polyploid)

Unit-6: Plant type concept **Lecture-08**

- Plant type concept in plant improvement, breeding methods and improved varieties of Rice, Wheat, Maize, legumes and pulses.

Suggested Readings:

- Chaudhury, R. C (1989) ,Introduction to Plant Breeding, Oxford and IBH publishing PVT LTD.
- Elrod S. & Stansfield W. (2004) Genetics, Tata McGraw Hill.
- Frailer, D. (2007) Molecular Biology-, Narosa Publishing House.
- Gupta,P. K (2009), Biotechnology and Genomics, Rastogi Publications.
- Jocelyn E. Krebs,E., S.Goldstein & Kilpatrick, S. T., Jones(2013) Lewin's Genes-Xi Bartlett Publishers.
- Singh, B. D. (2007) Plant Breding , Kalyani Publishers

- Strickberger M. W (2008), Genetics, PHI learning Pvt. Ltd.
- Tamarin R. H. (2006), Prnciples of Genetics- Tata McGraw Hill

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Paper code: BOT- LAB-2

Paper Title: Lab 2

(Credits: Theory-0, Practical-4, type of paper: Practical, No. of Lectures: 48)

A: ANALYTICAL TECHNIQUES & MOLECULAR BIOLOGY AND PLANT PHYSIOLOGY AND BIOCHEMISTRY (Credit-2)

B: MICROBIOLOGY & PLANT PATHOLOGY AND CYTOGENETICS & PLANT BREEDING (Credit-2)

Course outcomes:

On completion of this course, the students would be able to-

CO1-Develop concept on basic laboratory biosafety measures and aseptic techniques.

CO2-Inculcate skills in culture media preparation, invitro culture of plants and microbes, isolate DNA, and protein, quantify protein, sugar and amino acids, measure amylase activity, study kinetics of enzymes and analyse soil physicochemical properties.

CO3-Create experimental proficiency in isolation and pure culture of microbes from different samples.

CO4-Develop skills in cytogenetic techniques to study mitosis, meiosis, karyotyping and chromosomal aberration in plants and work out genetical problems on gene interactions, linkage, crossing over and construction of genetic map based on three-point cross.

A: ANALYTICAL TECHNIQUES & MOLECULAR BIOLOGY AND PLANT PHYSIOLOGY AND BIOCHEMISTRY

i) ANALYTICAL TECHNIQUES & MOLECULAR BIOLOGY

- Study of basic laboratory biosafety measures
- Preparation of buffers (phosphate/ citrate buffer/TAE/ TBE)
- Preparation & sterilization of plant culture media.
- Callus culture from plant materials
- To separate sugars by thin layer chromatography
- To estimate total sugar using spectrophotometer

- To estimate amino acid concentration in plant.
- Isolation of plant genomic DNA
- To separate protein using SDS PAGE
- To analyse soil physicochemical properties.

ii) PLANT PHYSIOLOGY AND BIOCHEMISTRY:

- Determination of water potential in different plant tissue.
- Determination of chlorophyll a &chlorophyll b and total chlorophyll from different types of plant tissue by solvent method.
- Determination of chlorophyll a/b ratio from different types of plant tissue (i.e. C3 C4plant)
- Determination of reducing sugar in plant species
- Estimation of total soluble protein by Bradford's and Lowry's methods.
- Estimation of total sugar from plant by anthrone methods.
- Spot identification of proline, sulpher-containing amino acids and amino acids with aromatic rings.
- Extraction and estimation of amylase activity from plant samples.
- Determination of isoelectric point of protein.
- Study of enzyme kinetics for effect of time/enzyme & substrate concentration/pH.
- Paper chromatographic technique to separate sugars, amino acids, chloroplast pigments.

Visit to research institute/laboratories of national repute and submission of report

B. MICROBIOLOGY & PLANT PATHOLOGY AND CYTOGENETICS & PLANT BREEDING.

i) MICROBIOLOGY AND PLANT PATHOLOGY:

- Principles & working of tools, equipment and other requirements in the Microbiology,Mycology& Plant Pathology laboratory.
- Introduction to basic techniques and Lab. safety; methods of sterilization, media preparationand culturing.
- Isolation and pure culture of microbes from soil, air and seed
- Identification and characterization of isolated pure cultures and determination of microbialpopulation by haemocytometer

- Study of plant pathogenic fungi from diseased specimens (symptoms, causal organism andtheir morphological & reproductive characters)
- Demonstration of Koch's Postulate.
- Study of Gram positive and Gram-negative bacteria.

ii) CYTOGENETICS AND PLANT BREEDING:

- Important techniques of cytogenetics and plant breeding
- Study of mitosis in locally available plant species.
- Study of meiosis in locally available plant species
- Study of karyotype and to find out the evolutionary status of the species.
- Study of natural chromosomal aberration in plant species.
- Variation of chromosome number in plant species (natural and induced).
- Demonstration of emasculation
- To work out some genetical problems on gene interactions, linkage, crossing over and construction of genetic map based on three-point cross.

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PG- Semester-III

Paper code: BOT-901C

Paper title: PLANT ANATOMY

(Credits: Theory-3, Practical-1, Type of paper: THEORY+ PRACTICAL, Lectures:48)

Course outcomes:

On completion of this course, the students/learners would be able to-

CO1-Develop conceptual understanding of plant anatomy-the ultra-structure of cell wall, origin and activity of cambium, wood anatomy, nodal and floral anatomy in detail.

CO2-Understand the function of protective and secretory structures.

CO3-Critically analyse the applied aspects of plant anatomy in various fields.

CO4-Develop skills in observation and examination of anatomical features through sectioning, staining and permanent slide preparations.

Unit-1: Cell wall **Lecture-08**

- Function, types and ultrastructure of cell wall, modification and chemical changes of the cell wall, transfer cells, growth of cell wall by intussusception and apposition.

Unit-2: Cambium **Lecture-08**

- Origin and activity of vascular cambium; factors influencing the activity of vascular cambium; accessory and cork cambium, wound healing; Periderm: development and structure, rhytidome, polyderm and lenticels.

Unit-3: Wood anatomy **Lecture-08**

- Axially and radially oriented elements; Types of rays and axial parenchyma, annual rings, Softwood & Hardwood, Sapwood and Heartwood, Ring porous and Diffuse porous wood; Reaction wood, tylosis and tylosoid.

Unit-4: Nodal and Floral Anatomy **Lecture-08**

- Types of nodes, leaf trace and leaf gaps, root-stem transition, Floral apex and vascular anatomy of floral Parts.

Unit-5. Applied aspects of plant anatomy **Lecture-08**

- To identify fragmentary plant materials, wood and archaeological plant remains, Taxonomic applications, Forensic applications and Paleobotany.

Unit-6: Protective and Secretory Structures **Lecture-08**

- Cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and non-glandular, two examples of each), hydathodes, salt glands, nectaries; ducts and cavities, lithocysts and laticifers.

Practicals:

- Study of anatomical details through permanent slides/temporary stain mounts/macerations/museum specimens/photographs of the following: trichomes (non-glandular and glandular), hydathodes, salt glands, nectaries, ducts, and cavities, lithocysts, laticifers and lenticels.
- Study of nodal anatomy in the following specimens - *Nerium oleander, Chenopodium album, Azadirachta indica* and *Coriandrum, sativum.*
- Study of wood anatomy through permanent slides/museum specimens/photographs of the following: ring porous; diffuse porous; heart- and sapwood, tylosis and tylosoid.
- Study of anomalous secondary growth in stems and root of the following specimens: *Boerhaavia, Bignonia*, *Tinospora*, *Calotropis*, *Beta vulgaris*, *Ipomea batatus*.

Suggested Readings:

- Easau, K. 1983. Plant Anatomy – Wiley Eastern Limited.
- Fahn, A. 1977. Plant Anatomy, Pergamon Press.
- Cutter, E. G. & Edward, E. 1978. Plant Anatomy: Experiment and Interprettations Part I and II.
- Mauseth, J. D. 1988. Plant Anatomy – The Nenjamin Cumming Publishing Co.
- Forester, A. S. 1948. Practical Plant Anatomy. D. Van Nostrand Company Inc.
- Roy, Pijush. 2010, Plant Anatomy, New Central Book Agency (P) Ltd.

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BOT-902C PHARMACOGNOSY AND ECONOMIC BOTANY

(Credits: Theory-3, Practical-1) THEORY Lectures:48

Course outcomes:

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

CO1-Develop understanding on identification of crude drugs and processed medicine, their quality control methods, monitoring and regulation, standard techniques for collection and processing, packaging and maintenance of herbs and herbal products.

CO2-Evaluate adulteration, substitution or contamination of crude drugs using microscopic, macroscopic and analytical methods.

CO3-Describe understanding on pharmacognosy of certain medicinal plants and develop practical skills on phytochemical screening (both qualitative and quantitative) of plants with special reference to Alkaloids, Flavonoids, Cardiac Glycosides, Steroids, Tannins, Volatile oils, and Resins.

CO4-Understand core concepts of Economic Botany and realise the commercial and industrial aspects of certain economically important plants.

a) PHARMACOGNOSY

Unit -1: Introduction **Lectures-08**

- Phamacognosy as a tool for identification of crude drugs and processed medicine. Introduction to the techniques for quality control, monitoring, and regulation. Identification and standardization of herbs and herbal products. Standard Techniques for collection and processing, packaging and maintenance of herbs and herbal produces. Classification of crude drugs. Drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs. Contamination of herbal drugs with special reference to Aflatoxins, Heavy Metals and Pesticides.

Unit-2: Quality control of herbal drug **Lectures-08**

- Evaluation and Adulteration of Crude Drugs. Quality Control Methods for Herbal Drugs: Macroscopic and Microscopic Examination. Chromatography. Water Content. Spectroscopy. Ash Value, Volatile Oil Determination. DNA Analysis (DNA fingerprinting, DNA microarray and DNA barcoding).

Unit-3: Secondary Metabolites and Phamacognosy **Lectures-08**

- Biosynthesis of Secondary Metabolites with special reference to phenolics. Phamacognosy of the following plants: -
    - *Taxus*
    - *Podophyllum*
    - *Panax,*
    - *Andrographis*
    - *Swertia*
    - *Curcuma and*
    - *Camellia sinensis*

Unit-4: Analytical pharmacognosy **Lecture-08**

Phytochemical screening of plants. Phytoconstituents important to therapy: Alkaloids, Flavonoids, Cardiac, Glycosides, Steroids, Tannins, Volatile oils and Resins. Toxicity of commonly used medicinal plants: Side effects, cautions and contraindications.

b) ECONOMIC BOTANY:

Unit-5 **Lecture-08**

- Centres of origin of cultivated plants, their importance with reference to Vavilov's work. Plants in commerce & industry- Tea, Sugarcane, Cotton, Rubber, Jute, Bamboo

Unit-6 **Lecture-08**

Origin, Botany and uses of the following:

- **Cereals-** Rice and wheat with special references to cultivation and processing.
- **Legumes-**Gram and Soyabean
- **Spices-**Ginger and Pepper.
- **Dyes-** Achiote (Bixa) and Henna.
- **Masticatories-**Arecanut, Beetle Leaf and Tobacco**.**
- **Beverages-**Tea and Coffee with special references to cultivation and processing

Practical:

a) Pharmacognosy and Economic Botany Pharmacognosy:

- Qualitative and quantitative analysis of at least one in each class of the following phytochemicals:
    - Alkaloids
    - Flavonoids,
    - Phenolics,
    - Tannins and
    - Volatile oil.
- Separation of phytochemicals by TLC.
- Determination of antioxidant activity from plants.

b) Economic botany:

- Collection and submission of economically important plant/plant products.

Suggested readings :

a) Pharmacognosy

- Bruneton, J. (1999). Pharmacognosy: Phytochemistry of Medicinal Plants. Lavoisier Publishing.
- Dewick,P.M. (2002). Medicinal natural products: a biosynthetic approach. Wiely.
- Charlwood and Banthorpe (1991). Methods in Plant Biochemistry. Academic Press.
- Trease and Evans, (2002). Pharmacognosy. W. B. Saunders Company.

- Mukherjee P. K. (2002). Quality control of Herbal Drugs–An Approach to Evaluation of Botanicals, Business Horizons, New Delhi, 1 Edition.
- Kokate, C.K., A.P. Purohit & S.P. Gokhale, 2000. Pharmacognosy, Nirali Prakasan.
- Kar A, Pharmacognosy and Pharmacobiotechnology, 2nd Edition, New Age international publisher

b) Economic Botany:

- Pandey B P. 2015. Economic Botany. S.Chand
- Kochhar S.L. 2016. Economic Botany in the Tropics. A comprehensive study.
- Sambamurty A.V.S.S. and N.S. Subrahmanyam. Economic Botany of Crop Plants. Asiatech Publishers Inc., Delhi
- Miglani S, 2016. A Textbook of Economic Botany. ABS Books.
- Verma V, 2009. Textbook of Economic Botany. ANE Books.

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Paper code: BOT-903C

PLANT BIOTECHNOLOGY AND BIOSTATISTICS

(Credits: Theory-3, Practical-1, Type of paper: THEORY, No. of Lectures: 48)

Course outcomes:

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

CO1-Develop understanding on the core concepts and fundamentals of plant biotechnology, genetic engineering, bioinformatics and biostatistics.

CO2-Inculcate practical skill on preparation of plant culture media, invitro culture of plant, isolation and estimation of plant DNA and its separation by agarose gel electrophoresis.

CO3- Understand core concepts of sequence alignment, sequence homology and gene annotation and construction of phylogenetic tree.

CO4-Solve statistical problems on standard deviation, standard error, variance and coefficient of variation and to formulate research hypothesis and apply statistical principles to test it.

a) Biotechnology

Unit-1- Plant tissue culture and in vitro morphogenesis **Lectures-10**

- Plant tissue culture techniques, embryo culture and its applications, embryogenesis and organogenesis, micropropagation, haploids and their applications, somaclonal variations and applications, Endosperm culture and production of triploids.

- Introduction to protoplast isolation, somatic hybridization. Protoplast and tissue culture for genetic manipulation of plants, crop improvement and development of transgenic plants. Single cell protein (SCP), economic implications of SCP.

Unit-2- Genetic manipulations and practical utility **Lectures-10**

- Basic concept of recombinant DNA technology, principles of gene cloning. Restriction modification systems, use of restriction enzymes in biotechnology, cloning vectors, methods of gene transfer, DNA libraries, Introduction to PCR, RFLP.
- Development of recombinant vaccines, monoclonal antibody their applications. Introduction to trangenics, gene therapy, Production of secondary metabolites/products: Insulin, growth hormones and interferons.

Unit-3- Introduction to bioinformatics and data generation **Lectures-10**

- Bioinformatics and its relation with molecular biology, related tools, databases(protein, nucleic acid and structural databases) and data retrieving system
- Data generation: Generation of large scale molecular biology data. (Through Genome sequencing, Protein sequencing, Gel electrophoresis, NMR Spectroscopy, X-Ray Diffraction, and microarray).

Unit-4 Bioinformatics and application **Lectures-08**

- Applications of Bioinformatics.
- Genome Annotation, Genome Assembly, Structural and Functional Genomics.
- Concept of metabolome and metabolomics, drug discovery and designing
- Chemoinformatics and cheminformatics tools for drug discovery.

Biostatistics

Unit-5 **Lectures-05**

- Sampling of data, frequency distribution, Measures of central tendency (mean, mode, median), Variance, Standard deviation and Standard error and coefficient of variation.

Unit-6 **Lectures-05**

- Correlation and regression, Probability, Test of significance (t-test, chi-square test), ANOVA.

Principles of design in biological experiments, Randomized design. Randomized block design, split plot design, Latin square design**.**

Practicals

a) Biotechnology and Biostatistics

- Preparation of culture media and micropropagation
- Isolation and estimation of DNA in plants
- Separation of DNA by Agarose gel electrophoresis.
- Sequence alignment, Sequence homology and Gene annotation.
- Construction of phylogenetic tree
- To work out statistical problems on standard deviation, standard error, variance and coefficient of variation on biological data.
- Problems on Probability, Correlation and regression and on test of significance

Suggested Readings:

- Singh BD. 2007. Biotechnology: Expanding Horizon. Kalyani.
- Harisha, S. (2007) Fundamentals of Bioinformatics. I.K. International PublishingHouse.
- Jogdand, S.N. Gene Biotechnology ––Himalay PublishingHouse
- Prasad S, Elements of Biostatics – RastogiPublications
- Xiong, J. (2006) Essential Bioinformatics. Cambridge UniversityPress.
- P. W. Arora, P.K. Malhan (1st eds, 2018), Biostatistics, Himalayas pub. House, Mumbai.
- Surnder P. S. S. Rao and J. Richard (5th eds, 2012), An introduction to Biostatistics, Prentice Hall of India.
- Norman T. J. Bailey, (2012), Statistical Method in biology. Cambridge University Press
- Gupta P.K, 2010, Plant Biotechhnology, Rastogi Publications
- Slater (2008) Plant Biotechnology: The Genetic Manipulation of Plants, Oxford; Second edition.

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Paper code: BOT-905OPE

Paper title: BIOFERTILIZER AND BIOREMEDIATION

(Credits: Theory-3, Tutorial-1, Practical-0, type of paper: THEORY, No. of Lectures:48)

Course outcomes-

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

CO1-Conceptualize biofertilizers, their types and application of it for sustainable crop production.

CO2-Elaborate the use of microbes as biofertilizer and its production technology.

CO3-Understand the application of microbes and plants in bioremediation.

CO4-Enhance collaborative learning and communication skills through teamwork, seminar, and home assignments.

Unit-1 **Lectures-04**

- **Biofertilizers:** Definition, types and applications in agriculture

Unit-2 **Lectures-06**

- **Characteristics of biofertilizers:** *Rhizobium, Azotobactor, Azospirillum,* phosphate-solubilizing microorganisms (PSMs), cyanobacteria, *Azolla*, mycorrhizae

Unit-3 **Lectures-12**

- **Biological nitrogen fixation**: Nitrogenase, substrates for nitrogenase, mechanism of action of nitrogenase, strategies to exclude oxygen and need to control hydrogen evolution, regulation of nitrogen fixation, *Rhizobium*-legume symbiosis.

Unit-4 **Lectures-08**

- **Production technology**: Strain selection, sterilization, growth and fermentation, mass production of various biofertilizers

Unit-5 **Lectures-06**

- **Application technology**: Standard and quality control, application for field and tree crops, nursery plants and seedlings, agronomical significance.

Unit-6 **Lectures-12**

- **Bioremediation:** Introduction, Fundamental principles, In-situ bioremediation of soil and ground water, Ex-situ bioremediation of soil, Waste water bioremediation, Phytoremediation, Innovative treatment technologies, Bioremediation in practice.

Suggested readings:

- Smith RJ, Lea PJ, Chaplin JR (1999) Nitrogen Fixation. In : Plant Biochemistry & Molecular Biology, 2nd edition, eds: Lea PJ, Leegood RC, John Wiley & Sons, New York, pp. 137-162.
- Rai AN (1990) A Handbook of Symbiotic Cyanobacteria, CRC Press, Boca Raton, USA.
- Stacey G, Burris RH, Evans HJ (1992) Biological Nitrogen Fixation, Chapman & Hall, New York.
- Sprent JI, Sprent P (1990) Nitrogen Fixing Organisms: Pure and Applied Aspects. Chapman & Hall, London.
- Kannaiyan S, Kumar K, Govindrajan K (2007) Biofertlizers Technology, Saujanya Books, New Delhi.
- Bruce E. R., Perry L. McCarty (2001), Environmental Biotechnology: Principles and Applications. McGraw-Hill,
- Rajendran P., Guansekaran P (2011) Microbial Bioremediation, Mjp Publishers.

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Paper code: BOT-904C

Paper title: Special paper I

(Credits: Theory-3, Tutorial-0, Practical-2, type of paper: THEORY+PRACTICAL, No. of Lectures:48)

Names and codes of the special papers:

Sl.No	Paper Code	Name of the paper
1	BOT904C SP-1	Angiosperm Taxonomy–I
2	BOT904C SP-2	Advanced Plant Physiology and Biochemistry–I
3	BOT904C SP-3	Cell Biology, Genetics and Molecular Biology–I
4	BOT904C SP-4	Mycology and Plant Pathology–I
5	BOT904C SP-5	Microbiology–I
6	BOT904C SP-6	Plant Ecology–I

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Paper code: BOT904C SP1

Paper title: Angiosperm Taxonomy

Course outcomes:

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

CO1- Develop knowledge on historical development of Plant Taxonomy and develop understanding of different concepts, categories, and approaches of plant classification.

CO2- Conceptualize the nature, categories and sources of taxonomic character and recognise the significance of taxonomic studies.

CO3- Interpret the phylogeny and floral evolution of the mentioned orders and elaborate their economic importance.

CO4-Demonstrate problems of taxonomy teaching and research in India.

CO5-Develop skills in identification of taxa up to the rank of species of Angiosperm following Bentham & Hooker's system of classification and other relevant taxonomic literature.

Unit-1 **Lectures-08**

- Aim, objectives, and principles of taxonomy; Historical development of classificatory systems; Artificial, natural and phylogenetic systems of classification.

Unit-2 **Lectures-08**

- Concept of phenetic, phyletic, cladistic and APG; Alpha and Omega taxonomy; Taxonomic structure – taxonomic hierarchy, concept of species, genus, family and infra- specific categories.

Unit-3 **Lectures-08**

- ICN- application of ICN in naming a new taxon, Type concept and its significance, typification, rule of priority, effective and valid publication, retention, choice and rejection of names, nomina conservenda, different codes of nomenclature; Name changes in taxonomy.

Unit-4 **Lectures-08**

- Flora and forest types of Northeast India; endemic and exotic elements in North East flora; rare and endangered plants of India with special reference to NE India and their conservation; Evolutionary trends in Angiosperms, cradle of flowering plants.

Unit-5 **Lectures-08**

- Phylogeny and floral evolution of following angiospermic orders: Magnoliales, Ranunculales, Malvales, Fabales, Lamiales, Asterales, Orchidales, Poales, Zingiberales (following Takhtajan).

Unit-6 **Lectures-08**

- Major problems of Taxonomy teaching and research in India and some remedies, Role of plant taxonomy in difference branches of plant research including medicinal

plants research, forensic science and CITES operation, Population concept in taxonomy.

PRACTICALS:

- Floristic study of certain area in and around Guwahati, making collection of their own and from these analytical drawings should be made. Describe the specimen using botanical terms and keying out the prominent characters for identification up to the rank of species for the preparation of a flora.
- Handling of floras, manuals, icons, and Index Kewensis.

Suggested readings:

- Cronquist, A. 1988. Evolution and Classification of Flowering Plants. New York Botanic Gardens, Bronx, New York.
- Good, R. 1974. The geography of flowering plants. Longman, London.
- Greuter. W. et al. International Code of Botanical Nomenclature. St. Louis Code. Koeltz Scientific Books, Konigstein.
- Hutchinson, J. 1964. Genera of flowering plants.Cambridge University Press, London.
- Hutchinson, J. 1974. The families of flowering plants: Oxford University Press.
- Simpson, M.G. 2006. Plant Systematics– introduction, definition, importance and simpson. Elsevier Academic Press.
- Sivarajan, V.V. and Robinson, N.K.P. 1991. Introduction to the principles of plant taxonomy. Oxforb IBH.

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Paper code: BOT-904C SP-2

Paper title: ADVANCED PLANT PHYSIOLOGY AND BIOCHEMISTRY-I

Course Outcomes:

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

CO1-Conceptualize plant water relations, transport, mineral nutrition, molecular aspects of metabolism in plant.

CO2-Understand the signal transduction process in plant, concept of stress physiology, radiation effect on plant.

CO3-Develop the concepts on analytical approaches in plant physiology and its application to study gene expression at RNA and protein level.

CO4-Perform experiments to study water status, growth, stress injury index, stress tolerance index, pigments, carbohydrate and proteins content in plant.

CO5-Enhance collaborative learning and communication skills through practical session, teamwork, seminar and home assignments.

Unit-1 **Lectures-08**

- **Water relations, Transport, and nutrition in plants:** Water potential and plant cell, Hydraulic conductivity, stomatal conductance. Light and microbes induced signalling in guard cell, regulation of water supply, Aquaporins: Dynamic roles and regulations. Winter Water Relations and Freezing Tolerance. Phloem transport in plants, Glucose, and sucrose transporter in plant. Mineral uptake and transport, boron, phosphate, sulphate, and iron transporter in plant. Structure and function of HKT, CaX, NHX & ZIP transporter in plant

Unit-2 **Lectures-06**

- **Molecular aspects of plant metabolism**: Physiological and molecular aspects of photosynthesis. Enhancing plant photosynthesis, C_4 rice. Molecular aspect of biological nitrogen fixation (BNF) in plants: Organization, function and regulation of *nif* and *nod* genes, genes for nitrate assimilation in plant, transcriptional and post transcriptional regulation of nitrate assimilation in plant, NO metabolism in plant. Molecular aspects of seed germination and dormancy

Unit-3 **Lectures-08**

- **Signal transduction and physiology of plant:** Receptors and G-proteins, phospholipid signaling, calcium-calmodulin cascade, diversity in protein kinases and phosphatases. Two component sensing/signalling system in plants. Role of cyclic nucleotides, miRNAs, circular RNAs and long-noncoding RNAs in plant growth, morphogenesis and flowering. Hormonal cross talk in plant development

Unit-4 **Lectures-08**

- **Analytical approaches and molecular plant physiology:** Analysis of gene expression at RNA and protein level in plants during different physiological phenomena, Plant phenomics, Global expression profiling by NGS and comparative proteomics analysis. Genome editing in plant, Protein sequencing methods, detection of post translation modification of proteins. Detection of molecules using northern blot, western blot, immunoprecipitation, and immunofluorescence microscopy.

Unit-5 **Lectures-12**

- **Stress physiology in plants:** Types of stress, biotic and abiotic stress, (HSP, LEA). Environmental stresses, salinity, water stress, heat, chilling, anaerobiosis, pathogenesis, heavy metals, radiations and their impact on plant growth and

metabolism, stress management. Oxidative stress, reactive oxygen and nitrogen species. Stress management in plants. Role of i*n-vitro* culture in plant propagation and production of stress tolerant plants.

- **Antioxidative defence system in plants–**Reactive oxygen species and their generation, enzymic and non-enzymic components of antioxidative defense mechanism.
- **Chemical defence:** Biochemical mechanisms of plants' chemical war against other plants and animals. Plant responses to herbivory; constitutive defence mechanisms; induced phytochemical responses; biochemical mechanisms of allelopathy.

Unit-6 **Lectures–06**

- **Plant toxin and tree physiology:** Mycotoxins, lathyrogens, nitriles, protease inhibitors, protein toxins in plants. Leaf canopies, radiation environment, effect of irradiance in plants, Light- Response Curve of Sun and Shade Leaves, Physiological and Biochemical, Differences Between Sun and Shade Leaves. Responses to variable Irradiance in plant

PRACTICALS:

- Determination of relative growth rate (RGR) in plant
- Determination of water loss rate (WLR) in plant
- Determination of water and osmotic potential in different plant tissue.
- Determination of chlorophyll a, b and total chlorophyll by Arnon'smethod.
- Determination of chlorophyll a/b ratio in C3,C4 and CAM plants.
- To determine stress tolerance index in plant
- To determine membrane injury index in plant
- To determine carotenoid contents in plant
- To determine mineral translocation efficiency and ratio in plant
- Determination of reducing/total sugar by DNS method.
- Estimation of total carbohydrates by Anthrone method.
- Estimation of fats/oil in different oily seeds.
- Estimation of proteins by Lowry's method.
- Separation of soluble proteins by Gel Electophoresis.

Suggested Readings:

- Buchanan B.B, Gruissem W and Jones R.L (2007). Biochemistry and Molecular Biology of Plants. 1st Edition IK International.

- Salisbury F.B. and RossC.W (1992). Plant physiology (Fourth Edition) Wadsworth Publishing Company, California, USA.
  Taiz L. Zeiger E, Moller IM and Murphy A. (2014). Plant Physiology and Development (Sixth Edition). Sinauer Associates, Inc. Publishes, Massachusetts, USA.
- Norman P. A. Huner, William G. Hopkins (2013) Introduction to Plant Physiology-4th Edition, Wiley India Pvt. Ltd
- Sinha R K (2014). Modern Plant Physiology, Narosa Publishing House, India
- David L Nelson and Michael M. Cox (2017) (seventh Edition), Leninger Principles of Biochemistry, W. H. Freeman and Company.

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Paper code: BOT-904C SP-3

Paper title: CELL BIOLOGY, GENETICS AND MOLECULAR BIOLOGY–I

Course outcomes:

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

CO1-Gain knowledge of inheritance pattern, genetic and somatic recombination.

CO2-Understand genome organization and evolution, DNA biosynthesis and packaging, damage & repair.

CO3-Develop concept of gene pool, changes in gene frequency in population and population structure.

CO4-Work out problems on gene interactions, sex linked inheritance, multiple alleles, linkage, crossing over and genetic mapping.

CO5-Develop skills to study cell division and chromosomal aberration, DNA isolation and estimation in plants.

Unit-1 **Lectures-08**

- **Gene and Inheritance pattern:** Gene &eukaryotic Chromosome, Gene interactions, Extra nuclear, Quantitative and Sex-linked inheritance, Multiple alleles, Linkage; Genetic mapping.

Unit-2 **Lectures-08**

- **Recombination:** Recombination in Bacteria, fungi and Virus; homologous and site-specific recombination; somatic recombination,

Unit-3 **Lecture-08**

- **Genome organization:** Organization of nuclear and organelle genome; transposable elements (yeast, maize and *Drosophilla*), DNA packaging; genome evolution.

Unit-4 **Lecture-08**

- **DNA replication:** Replication of eukaryotic linear DNA Singled-stranded circular, double- stranded circular and double-stranded linear DNA (viral); Role of enzymes and protein factors in DNA replication.

Unit-5 **Lectures-08**

- **Mutation and DNA repair:** Gene Mutation, Mutation at Biochemical and molecular level; DNA damage & repair**.**

Unit-6: **Lectures-08**

- **Genetic material in population:** Gene frequencies and equilibrium, changes in gene frequencies, Genetic structure of population, speciation, and control of human evolution. (Biological evolution & limitation, deleterious gene, and eugenics).

PRACTICALS:

- Study of Mitosis in locally available plants.
- Study of Meiosis in locally available plants.
- Study of chromosomal aberration in plant species.
- Study of variation of chromosome number in plant species.
- Isolation of plant genomic DNA and its estimation by spectrophotometric method
- To find out the evolutionary status of plants by karyotype analysis
- Working out genetically problems on Gene interactions, Sex linked inheritance, Multiple alleles, Linkage, crossing over and Genetic mapping.

Suggested Readings:

- Ahluwalia.K.B. (2009) Genetics-, New Age International. .
- Elrod S. &Stansfield W. (2004) Genetics, Tata McGraw Hill.
- Geoffrey,M.C.& Robert E.H.(2009),The Cell –A molecular Approach, ASM Press,Wasington D.C & SINAUER Associated.INC Sunderland,Massachusetts.
- Gupta,P. K (2009) Genetics, Rastogi Publications.

- Sharma, A.K. & Sharma, A. (1980), Chromosome Technique &Practice. Bullerwort, London.
- Strickberger M. W (2008) Genetics, PHI learning Pvt. Ltd.
- Watson, J.D, Baker,T.A, Bell, S.P., Gann,A, Levine, M,Losick,R (2007) , Cold Spring Harbor Laboratory Press.

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Paper Code: BOT-904C SP-4

Paper title: MYCOLOGY AND PLANT PATHOLOGY (SPECIAL PAPER-1)

Course outcomes:

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

CO1-Understand the recent trend in the study of Mycology and Plant Pathology.

CO2-Develop an understanding of fungi and appreciate their adaptive strategies.

CO3-Understand the application of mycology in food, pharmaceutical, agriculture and environment.

CO4-Develop skills in identification of fungi through the application of specialised laboratory techniques.

CO5-Enhance collaborative learning and communication skills through practical session, teamwork, seminar, and home assignments.

Unit-1 **Lectures–08**

- **Classification and general characters:** Recent trends in Classification of Fungi and phylogeny. Ultra structure of fungal cell. Reproduction, parasexuality, degeneration of sex, Sex hormones, heterothallism, and Spore dispersal mechanism in fungi.

Unit-2 **Lectures–08**

- **Fungal physiology and ecology:** Factors influencing the fungal growth. Mode of nutrition, Important ecological fungal groups, role of fungi in biogeochemical cycle.

Unit-3 **Lectures–08**

- **Substrate relationship in fungi: i) Fungi in Soil:** Soil as an environment for plant pathogens, techniques of isolation of soil fungi, rhizosphere and rhizoplane, root exudates, root and soil borne diseases and their control. ii) **Aerobiology and Plant**

diseases: Air micro flora, air sampling techniques, air-borne plant diseases and their control, aero-allergens

Unit-4 **Lectures-08**

- **Introduction to plant pathology:** History: Milestones in phytopathology with reference to India. Symptoms of plant diseases caused by fungi, bacteria, and viruses. Epidemiology and disease forecasting, Major epidemics, and their social impacts. Physiological changes due to disease in plants

Unit-5 **Lectures-08**

- **Fungi as welfare to human beings:** Fungi in food processing: soybean products, cheese, fermented milk, other fermented foods. Fungal metabolites – General account of production and application: Primary metabolites (vitamins, proteins), Secondary metabolites (antibiotics, pigments, alkaloids). Fungi as food. Concept of biodeterioration and biodegradation. Biodeterioration of non-cellulosic and cellulosic materials**.**

Unit-6 **Lectures-08**

- **Mycorrhiza and wood rotting fungi:** Kinds of mycorrhizae. Ectotrophic and endotrophic mycorrhizae, their morphology and anatomy. AM- mycorrhiza. Mycorrhiza in plant growth promotion, mycorrhiza in plant disease control. Disintegration of tissue by wood rotting fungi.

PRACTICALS:

- Principles & working of tools, equipment and other requirements in the Mycology & Plant Pathology laboratory.
- Isolation and identification of different groups of fungi occurring on different substrates.
- Effect of different physical and chemical factors on the growth of fungi.
- Estimation of enzymes: Cellulases, Pectinases, and Amylases
- Study of mycorrhiza.
- Study of morphological characters and reproductive structures of fungal species available inAssam.
- Anatomical study of wood infected by fungi
- Students are expected to submit preserved specimens (either wet or dry) belonging to Fungi /
- Photograph of fungal specimen and slides during the Practical Examination.

Suggested readings:

- Ainsworth, G. G. and A.S. Sussman (1973): The Fungi Vols. I, II, III, IV- A and IV B
- Alexopoulos, C.J. and C. W. Mims (1996): Introductory Mycology
- Bessey, E. A. (1967): Morphology and Taxonomy of Fungi
- Brook, T.D. Smith, D.W and Madigan, M.T. 1984. Biology of Microorganisms, 4th ed.Eaglewood Cliffts. N.J. Prentice-Hall. New Delhi.
- Burnett J.H. 1968. Fundamentals of Mycology. Edwards Arnold Publication.Press
- Ketchum, PA. 1988. Microbiology, concepts and applications. John Wiley and Sons. New York.
- Mehrotra R.S and Aneja R.S 1998.An introduction to Mycology. New Age Intermediate
  Rangaswamy G. and Mahadevan A. 1999. Diseases of crop plants in India (FourthEdition) Prentice Hall of India Pvt. Ltd. New Delhi.
- Stainer, Roger, Y. Ingrahan, John, L. Wheelis, Mark, L and Painter, Page, R. 1990.Microbial World 5th edition. Prentice-Hall India, Pvt. Ltd. New Delhi.
- Webster J. 1985. Introduction to Fungi. Cambridge University Press.

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Paper code: BOT-904C SP-5

Paper title: MICROBIOLOGY SPECIAL PAPER- I

Course outcomes:

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

CO1-Gain knowledge on different microorganisms present in soil, air and water and different techniques in microbiological studies,

CO2-Conceptualize immunology, microbial metabolism and cell signalling of prokaryotes.

CO3-Realise the role of microbes in environment and design strategies for bioremediation and waste management.

CO4-Develop skills on microbial techniques, understanding of microbiota and their applications.

CO5-Enhance collaborative learning and communication skills through practical session, teamwork, seminar, and home assignments.

Unit-1 **Lectures 08**

- **Methods in microbiology:** Isolation and cultivation of microbes from environment-serial dilution and pour-plate method, spread-plate method, streak-plate method,

cultural characteristics of different microbes in different media. Biochemical tests for bacterial identification- Carbohydrate fermentation, Triple sugar, Iron-Agar test, IMVIC test, Hydrogen-sulphide test.

Unit-2 **Lectures-08**

- **Soil Microbiology:** Soil properties (physical, chemical and biological), Soil microorganisms, methods of enumeration and activity of microbes in environment/soil; Microbes and plant interactions – rhizosphere, and mycorrhizae, degradation of carbonaceous materials in soil – cellulose, hemicellulose and lignin decomposition, factors governing the decomposition and biochemistry of decomposition, Soil humus formation. Biogeochemical cycles-carbon, nitrogen and sulphur cycles.

Unit-3 **Lectures 10**

- **Environmental microbiology:** Distribution and implications of microbes in air and water. Waste as resource: organic compost, Vermicomposting sewage treatment, biodegradation of industrial waste, bioremediation, water pollution management; Application of rDNA technology in waste treatment; degradation of xenobiotic substances (Hydrocarbons, Heavy metals Pesticides) bioremediation.

Unit-4 **Lectures 08**

- **Microbial Metabolism:** An overview of metabolism; Aerobic and anaerobic respiration, fermentation, Principles of bioenergetics: redox reactions and electron carriers; Generation of ATP, An overview of metabolism; catabolic pathways, glycolysis; TCA, pentose-phosphate pathway; bacterial photosynthesis; chemosynthesis; metabolism of fatty acids and amino acids.

Unit-5 **Lectures 08**

- **Introduction to Immunology:** Cells of immune systems, types of immunity, properties of antigens and antibodies. Types of antibody diversity, monoclonal antibodies. Different classes of immunoglobulins, MHC, immune disorders, vaccine and chemotherapy.

Unit-6 **Lectures 06**

- **Cell signalling:** Signalling molecules and their receptors. Function of cell surface receptors. Pathways of intracellular receptors, cyclic AMP, cyclic GMP and MAP

kinases, regulation of signalling pathways, bacterial and plant two-component systems, light signalling in plants, bacterial chemotaxis and quorum sensing.

PRACTICALS:

- Basic microbiological techniques: preparation of media, sterilization, slant preparation and pure culture by streak and pour plate method.
- Qualitative and quantitative analysis of soil microbiota
- characterization of selected pure culture
- Study of mycorrhizae
- Study of air microflora by exposure plate technique.
- Staining of bacterial cells.
- Study of bacterial growth curve by spectrophotometric method.
- Screening of microbes for production of enzymes.
- Screening of microbes for production of organic acids.

Suggested readings:

- Banerjee, A. K. & N. Banerjee: Fundamentals of Microbiology and Immunology
- Dubey, R. C & D.K. Maheswari: A Textbook of Microbiology.
- Mishra, R. R. 1996. Soil Microbiology. CBS Publ.
- Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
- Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan Roitt M. 2017 Roitt's Essential Immunology, 13th Edition Wiley-Blackwell.
- Prescott, L. Harley, J. and Klein, D. (2005) Microbiology, 6th edition, Tata McGraw-Hill Co. New Delhi.
- Subbarao N.S. Soil Microbiology English-OXFORD & IBH Publishing co. Pvt Ltd.

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Paper code: BOT-904C SP-6

Paper title: PLANT ECOLOGY SPECIAL PAPER -I

Course outcomes:

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

CO1-Demonstrate the knowledge of spatial and temporal scales in effective sampling design and resource requirements.

CO2-Understand the concept of Genecology from an ecological perspective, soil formation, soil profile, SOM and soil ecosystem services.

CO3-Conceptualize metapopulation theory that permit the survival of populations with negative rates of growth.

CO4-Identify soil types; Determine the Importance Value Index (IVI) of the plant species in the community.

CO5-Develop skills in determination of hardness of polluted and unpolluted water samples.

Unit-1 **Lectures 08**

- **Introduction:** Importance and scope of ecology, levels of organization, spatial and temporal scales, interaction of ecological factors in the environment, Tolerance range and limiting factors, adaptations, genecology

Unit-2 **Lectures 08**

- **Soil Science:** Soil composition and structure, factors influencing soil formation, properties of soil (physical, chemical and biological), soil organic matter, soil types of India, contribution of soil to ecosystem services.

Unit-3 **Lectures 08**

- **Population structure and dynamics:** Concept, characteristics of a population; population regulation - by abiotic factors - nutrients, moisture, food availability, space, weather and climate; by biotic factors - competition , predation, density, parasites and diseases, natural disasters; Evolutionary strategies (strategies as shown by survivorship curves and r and K-strategies); modular organisms, population interactions; concept of metapopulation - demes and dispersal; interdemic extinctions.

Unit-4 **Lectures 08**

- **Community organization and development:** Nature of communities; community structure and attributes; edges and ecotones; vegetation characteristics (analytical and synthetic characters); methods of sampling vegetation and data analysis; concept of habitat and niche; niche width and overlap; fundamental and realized niche.

Unit-5 **Lectures 08**

- **Ecological Succession:** Concept and changes in ecosystem properties during succession, basic theories; concept of climax, examples of secondary and heterotrophic succession, methods of studying succession.

Unit-6 **Lectures 08**

- **Ecosystem organization:** Structure and functions; primary production (global pattern and controlling factors); ecological energetics - trophic levels, energy flow pathways and ecological efficiencies; decomposition (mechanism, substrate quality and climatic factors); global biogeochemical cycles of C, N and P and water cycle.

PRACTICALS:

- Study of the following microclimatic variables in different habitats: soil and air temperature, wind speed, relative humidity, rainfall and light intensity.
- To study the physical characteristics (temperature, colour and texture) of soil.
- To determine the water holding capacity of soil collected from different locations.
- To study the species composition of an area for analyzing biological spectrum and comparison with Raunkiaer's normal biological spectrum.
- Determination of Importance Value Index (IVI) of the plant species in the community by quadrat method.
- Estimation of primary productivity of an aquatic ecosystem.
- Determination of hardness of polluted and unpolluted water samples.

Suggested Readings:

- Chapman, J. L. and Reiss, M. J. (1992). Ecology – Principles and Applications, Cambridge University Press, Cambridge, UK
- Freeman, B. (ed.), 1995. - Environmental Ecology- The ecological effects of pollution, disturbance, and other stresses. Academic press.
- Krishnamurthy K.V. A textbook of Biodiversity, Science Publishers Inc., Enfield, New Hampshire, USA.
- Michael, P. 1990. - Ecological methods for field and laboratory investigations. Tata McGraw Hill,
- Odum, E. P. and Barrett, G. W. (2005). Fundamentals of Ecology, 5th Edition, Cengage Learning, New Delhi, India
- Pullin, A.S. (2002) Conservation Biology, , Cambridge University Press, Cambridge.
- Singh, J.S. Singh S.P. and Gupta S.R. (2014). Ecology, Environmental Science and Conservation. S. Chand and Company Pvt. Ltd., New Delhi.

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SEMESTER– IV

Paper code: BOT- 1001C

Paper title: REPRODUCTIVE AND DEVELOPMENTAL BIOLOGY

(Credits: Theory-3, Practical-1, type of paper: THEORY+Practical , No. of Lectures:48)

Course outcomes:

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

CO1-Conceptualise pollination, pre-fertilisation, fertilization and post fertilization in plants.

CO2-Appreciate the applications of experimental embryology, palynology and application of invitro culture techniques.

CO3-Demonstrate proficiency in the experimental techniques and methods of embryology and palynology.

CO4-Enhance collaborative learning and communication skills through practical session, teamwork, seminar and home assignments.

Unit -1 **Lecture-12**

- **Pre Fertilization events: a) Male Gametophyte:** Structure of anthers; microsporagenesis; Microgametogenesis. Tapetum-types and role of tapetum; b) **Female Gametophyte:** Ovule Structure, megasporogenesis development of different types & special types of embryo sacs, ultra structure & nutrition of female gametophyte.

Unit -2 **Lecture-08**

- **Pollination and Fertilization**: Pollen-pistil interaction, Pollen germination, growth, entry and discharge, self- incompatibility, different methods to overcome self-incompatability, Fertilization and barriers to fertilization.

Unit -3 **Lecture-10**

- **Post-fertilization events:** Endosperm development; Types of Endosperm; haustorial variations; ruminate & composite endosperm, Functions of endosperm. Embryo-Structure; development of monocot and dicot embryo; significance of embryonal suspensor, polyembryony.

Unit -4 **Lecture-08**

- **Experimental Embryology-Scope & application:** Outlines of Experimental Embryology – Cell and Tissue culture, Anther culture, ovary culture, ovule culture and embryo culture. Somatic hybridization -Protoplast isolation, fusion and culture, hybrid selection and regeneration. Applications of plant tissue culture - Clonal propagation, artificial seed, somaclonal variation.

Unit -5 **Lecture-05**

- **Palynology:** Pollen architecture, morphology, types, Pollen aperture types, NPC classification, Pollen production and sterility. Chemical nature of the sporopollenin, pollen wall development, ubisch body, exineless pollens.

Unit -6 **Lecture-05**

- **Applied Palynology:** Aeropalynology – pollen allergy, palynological calendars, Forensic palynology and Melissopalynology

PRACTICALS:

a) Embryology of Angiosperms:

- Study of microsporogenesis and gametogenesis in sections of anthers.
- Embryo sac development through examination of permanent stained serial sections.
- Study of nuclear and cellular endosperm through dissections and staining.
- Isolation of different stages of embryo development from suitable seeds.

b) Palynology:

- Pollen morphology of common angiosperm taxa using permanent slides/temporary slides.
- To study the pollen viability in plant.
- Study of pollen morphology by acetolysis method from the plant materials available in the locality.

Suggested References:

a) Embryology:

- Bhojwani,S. S. and Bhatnagar, S. P., 2009. The Embryology of Angiosperms, Vikas Publishing House Pvt. Ltd., New Delhi.
- Ganguly, A. K. and Kumar, N.C., 2008. Developmental and Experimental Embryology of Angiosperms. Emkay Publications, Delhi.

- Maheswari P, 1971. An Introduction to the Embryology of Angiosperms. Tata McGraw Hill Publishing Co., Ltd., New Delhi.
- Pandey, B. P., 1995. Embryology of Angiosperms. S Chand & Co. New Delhi.
- Singh,V.,Pande, P. C. and Jain, D. K., 1997. Embryology of Angiosperms, Rastogi Publications, Meerut.

b) Palynology:

- Erdtman, G.:Pollen Morphology and Plant Taxonomy.
- Faegri, K. & J. Iverson:Text Book of Pollen Analysis.
- Nair, P.K.K:Pollen Morphology of Angiosperms.
- Shivana, K.R. & N.S. Rangaswami: Pollen Biology

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Paper code: BOT-1003 OPE

Paper title: ENERGY AND ENVIRONMENT

(Credits: Theory-4, Tutorial-1, Practical-0, type of paper: THEORY, No. of Lectures:48

Course outcomes:

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

CO1-Conceptualise energy flow in ecosystem, global warming and climate change.

CO2-Realise the use of green and clean energy resources, ways of reducing the Carbon footprint.

CO3-Gain knowledge on the important non- renewable natural resources of Assam i.e. petroleum, natural gas and coal and how it causes socio-economic development in NE India.

CO4-Understand the importance of sustainable agriculture in India as a means of environmental conservation.

CO5-Elaborate the application of GIS in EIA and a know-how on the Environmental policies of India.

Unit-1 **Lecture-06**

- **Introduction:** Energy flow in ecosystem, Law of thermodynamics, Entropy.

Unit-2 **Lecture-08**

- **Global warming and Climate change:** Carbon cycle, greenhouse gases and global warming; Climate change – causes and consequences; Carbon footprint; Management of greenhouse gases.

Unit-3 **Lecture-08**

- **Natural resources:** Concept of Natural Resources; Natural Resources of Assam — Petroleum, natural gas and coal; Natural Resources and Socio-Economic Development in Northeast India. Natural Resource Management (NRM) — an idea; NRM approaches — Community-based natural resource management (CBNRM) and Ecosystem management; Sustainable use of natural resources.

Unit-4 **Lecture-08**

- **Agricultural systems and environment:** Sustainable agriculture— definition and key concepts, goals, current status of sustainable agriculture in India; Environmental impact of agriculture; Agricultural systems for environmental conservation.

Unit-5 **Lecture-08**

- **Energy and environment:** Green energy: Concept, Types — Solar Energy, Wind energy, Hydroelectric Energy, Biogas, Biomass and Geothermal energy; Benefits of green energy; Importance of green energy. Clean energy: Concept, importance, and benefits; Renewable Energy: Concept, benefits and disadvantages.

Unit-6 **Lecture-08**

- **Environment management:** Environmental policy of India; EIA, SIA, Application of GIS in EIA, Solid waste management, water resource management (Rain water harvesting), Concept of Environmental sustainability and Sustainable development.

Suggested readings:

- Dwivedi, O.P. India's Environmental Policies, Programmes and Stewardship
- Chopra K. R. Development and Environmental Policy in India: The Last few decades.

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BOT-1002 SP: SPECIAL PAPER-II

(Credits: Theory-3, Tutorial-0, Practical-2, Type of paper: THEORY+Practical, No. of Lectures: 48)

Names and codes of the special papers:

Sl.No	Paper Code	Name of the paper
1	BOT1002 SP-1	Angiosperm Taxonomy–II
2	BOT1002 SP-2	Advanced Plant Physiology and Biochemistry–II
3	BOT1002 SP-3	Cell Biology, Genetics and Molecular Biology–II
4	BOT1002 SP-4	Mycology and Plant Pathology–II
5	BOT1002 SP-5	Microbiology–II
6	BOT1002 SP-6	Plant Ecology–II

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Paper code: BOT-1002 SP-1

Paper title: ANGIOSPERM TAXONOMY –II

Course outcomes:

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

CO1-Conceptualize the ideas on the origin and evolutionary trends of angiosperms.

CO2- Develop understanding of different concepts, categories, and approaches of plant classification.

CO3-Evaluate the significance of taxonomic studies in different branches of science.

CO4-Explain different forms of taxonomic literature and conceptualize different aspects of biosystematics and molecular taxonomy.

CO5-Develop skills in construction of botanical keys for identification of taxa during a floristic study and plant exploration through conducting field survey and identification of Angiosperm following Bentham & Hooker's system of classification and other relevant taxonomic literature.

Unit-1 **Lectures-08**

- A critical study of the ideas on the origin and evolutionary trends of angiosperms with special reference to their ancestral stock, concept of primitive angiosperms; Patterns of geographical distribution, endemism, alien species, cradle of flowering plants.

Unit-2 **Lectures-08**

- Concept of Characters – Qualitative and quantitative characters, Good and bad character, analytical and synthetic characters, conservative characters, co-relation of characters, isolation and speciation of characters; Sources of Taxonomic Characters - Morphology, Anatomy, Palynology, Ecology, Embryology, Cytology and genetics.

Unit-3 **Lectures-06**

- Changing trends in taxonomy- Chemotaxonomy, Numerical taxonomy, Computers and taxonomy- Documentation and data processing. Molecular plant taxonomy scope, tools and techniques.

Unit-4 **Lectures-08**

- Biosystematics: Scope and Significance, Principles, Practical applications, Procedure and methods in the study of biosystematics, Relationship between experimental and classical taxonomy.

Unit-5 **Lectures-08**

- Plant identification – Botanical keys-their construction and use; Herbaria- kinds, role in taxonomic research; major herbaria in the world and in India; Botanic Garden and its role in biodiversity conservation, teaching, research, plant introduction and domestication; major botanic gardens of world and India.

Unit-6 **Lectures-10**

- Taxonomic literature- Classical and recent literature, general reference, Icons; Important state, regional and all India floras, Journals of taxonomy, Literature on economic plants of India; Presentation of data- Manual and flora, Monograph and revision, Preparation of flora, rich and poor floras.

PRACTICALS:

- Study of morphological peculiarities in locally available angiospermic taxa.
- Comparative morphology, anatomy, cytology, palynology or any other aspect assigned on certain angiospermic taxa.

Suggested readings

- Naik, V.N. 1984. Taxonomy of Angiosperms. Tata McGraw Hill, New Delhi.
- Mabberley, D.J. 2017. The Plant Book. Cambridge University Press, London.
- Takhtajan, A. 1969. Origin and dispersal of Flowering Plants. Oliver & Boyd, Edinburg.
- Hutchinson, J. 1884-1972. Evolution and Phylogeny of flowering plants; Academic Press, London & New York.
- Stace, Clive A. 1991. Plant Taxonomy and Biosystematics. Cambridge University Press
- Sharadwata Pan Indira P. Sarethy. 2016. Biosystematics and Taxonomy. Intelliz Press LLC
- Stafleu, F. & Richard Cowan. 1967. Taxonomic Literature: A selective guide to botanical publications and collections with dates, commentaries and types (Vol. I-VII)
- Hooker, J.D. (1872-1897), The Flora of British India, 7 vols. Reeve & Co. Ltd., London.
- Kanjilal, U.N. et al. (1934-1940), Flora of Assam. 5 vols. Government press, Shillong.

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Paper code: BOT-1002 SP-2

Paper title: ADVANCED PLANT PHYSIOLOGY AND BIOCHEMISTRY-II

Course Outcomes:

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

CO1-Conceptualize principles of thermodynamics, redox potentials, activation energy and group transfer reactions in plant cell.

CO2-Understand the concept of enzymes, enzyme engineering and industrial applications.

CO3-Infer the metabolism of carbohydratres, proteins and nitrogen.

CO4-Recognise the protein structure, kinetics and post translational modification in plants.

CO5-Aquire in-depth knowledge of the biosynthesis of fatty acid, nucleotides and secondary metabolites in plants.

Unit-1: Lectures-6

- **Energy Dynamics**: Structure of atoms, molecules and chemical bonds, Principles of thermodynamics, free energy, Redox potentials, Dissociation and associations constants, Activation energy, Structure of active site, Transition state complex, electrophilic and nucleophilic catalysis, Binding energy, Group transfer reactions.

Unit-2 Lectures-8

- **Enzymology:** Allosteric enzymes and its mechanism, Isozymes, Factors affecting enzyme activity, Enzyme Kinetics, Michaelis –Menton equation, Different Plots and their importance in kinetic studies, Enzyme engineering, enzyme immobilization & Method of analysis of enzyme activity and subcellular localization of enzymes.

Unit-3 Lectures-06

- **Carbohydrates:** Synthesis and breakdown of carbohydrates-starch, cellulose, sucrose, glycogen, pectin and their regulation

Unit-4 Lectures-08

- **Amino acids and proteins metabolism:** Structure, synthesis and properties of amino acids, biosynthesis and regulation of amino acid in plant with special reference to tryptophan, serine, lysine and proline. Protein structure (Primary, secondary, tertiary and quaternary), Ramchandran plot. Protein denaturation and

folding, Post-translational modification, protein oxidation in plants. Protein –protein interaction, protein nucleic acid interaction.

Unit-5 **Lectures-10**

- **Nitrogen metabolism:** Nitrogen transport in plant. Structure and function of Nitrogenase, Nitrate reductase and Glutamate Synthase. General classification of major pathways, Phenolics (Lignins, tannins) Flavonoids, terpenoids, steroids, Alkaloids, pigments (Carotenoids, Anthocyanins)

Unit-6 **Lectures-10**

- **Nucleic acid and lipid metabolism:** Purines, Pyrimidines, their biosynthesis and metabolism in plant. DNA micro array and its application in plant physiology, Micro RNA and its role in regulation of physiological process in plant. General classification of Phospho, Spingo, Glyco-Lipid. Biosynthesis of fatty acid, triacylglycerol and oxidation of fatty acid in plants, LOX, Lipid peroxidation in plants, energetics of beta oxidation of fatty acid in plant.

PRACTICALS:

- Paper chromatographic (single and two dimensional) technique to separate sugars, amino acids, chloroplast pigments.
- Thin layer chromatographic technique to separate chloroplast sugars.
- Spectrophotometry: Determination of absorption spectra of chlorophyll a and b with spectrophotometer.
- Determination of Km value, effect of time/temperature/enzyme& substrate on centration/ pH on
    - Peroxidase
    - Amylase
    - Catalase
- To determine ascorbate content in plant
- In-vivo assay for nitrate reductase in leaf tissues.
- Extraction of proteins from plant tissue and their quantitative(Bradford's)and qualitative(SDS, PAGE gel) analysis.
- Comparative assessment of methods for protein quantification.
- Isolation, separation and quantification of plant DNA
- Isolation, separation and quantification of plant RNA

Suggested Readings:

- Buchanan B.B, Gruissem W. and Jones R.L (2007). *Biochemistry and Molecular Biology of Plants*. 1st Edition IK International.
- David L Nelson and Michael M. Cox(2017) (seventh Edition), Leninger Principles of Biochemistry, W. H. Freeman and Company.
- Norman P. A. Huner, William G. Hopkins (2013) Introduction to Plant Physiology-4th Edition, Wiley India Pvt Ltd
- Salisbury F.B. and Ross C.W (1992). *Plant physiology* (Fourth Edition)Wadsworth Publishing Company, California,USA.
- Sinha R K (2014). Modern Plant Physiology, Narosa Publishing House, India.
- Taiz L. Zeiger E, Moller IM and Murphy A.(2014*). Plant Physiology and Development* (Sixth Edition). Sinauer Associates,Inc. Publishes, Massachusetts, USA**.**

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Paper code: BOT-1002 SP-3

Paper title: CELL BIOLOGY, GENETICS AND MOLECULAR BIOLOGY – II

Course outcomes:

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

CO1-Develop concept of the cell structure, membrane dynamics, plant cell signaling, transcription and post transcription modification, protein trafficking and regulation of gene expression.

CO2-Conceptualize, plant genomics, in-silico gene discovery, transcript profiling and molecular phylogeny.

CO3-Isolate & quantify DNA from plant part, perform restriction digestion of DNA and construction of restriction map.

CO4-Develop skills to separate seed protein by SDS PAGE, prepare competent cell, to perform sequence alignment, Sequence homology and gene annotation and construction of phylogenetic tree.

CO5-Enhance collaborative learning and communication skills through practical session, teamwork, seminar and home assignments.

Unit-1 **Lecture-08**

- **Cell structure and function:** Cell and cell organelles- nucleus, mitochondria, chloroplast, Golgi complex, lysosome. Membrane dynamics.

Unit-2 **Lecture-08**

- **Cell signalling and trafficking:** Cell signalling, signal protein and role of plasma membrane in signalling; Signal transduction pathways, cellular trafficking.

Unit-3 **Lecture-08**

- **Transcription and post transcriptional mechanisms:** Prokaryotic and Eukaryotic Ribosome, Association and dissociation of Ribosomal subunits, Eukaryotic transcription, RNA splicing, folding and processing; mRNA Stability and localization, Translation and post translational modification.& Protein degradation.

Unit-4 **Lecture-08**

- **Gene regulation and Expression:** The Operon (Lac, Trp, Ara), Mutation in *Lac* Operon; Eukaryotic transcriptional and Translational Regulation, Regulatory RNAs.

Unit-5 **Lectures-08**

- **Plant Genomics:** Molecular Map, Its development, preparation and uses, DNASequencing and uses, Whole genome sequences in plants (*Arabidopsis*, *Oryza, Zea mays*).

Unit-6 **Lectures-08**

- **Functional genomics:** Comparative genomics, Insilico discovery of genes, Management of data for functional genomics, gene expression and transcript profiling, phylogenetic analysis.

PRACTICALS:

- Studies of induced chromosomal abnormalities in plant species
- Isolation & quantification of DNA.
- Restriction digestion of DNA.
- Construction of restriction map from data provided.
- Separation of soluble seed protein by SDS PAGE.
- Preparation of Competent Cell.
- Sequence alignment, Sequence homology and Gene annotation.
- Construction of phylogenetic tree

Suggested Readings:

- Freidfelder, D. (2007) Molecular Biology-, Narosa Publishing House.
- Geoffrey,M.C.& Robert E.H.(2009), The Cell –A molecular Approach, ASM Press, Wasington D.C & SINAUER Associated.INC Sunderland, Massachusetts.
- Gupta,P. K (2009), Biotechnology and Genomics, Rastogi Publications..
- Jocelyn E. Krebs, E., S. Goldstein& Kilpatrick, S. T., Jones (2013) Lewin's Genes-Xi Bartlett Publishers.

- Robertis, De, E.B. P. and Robertis De Jr E.M.F.(2010) Cell and molecular biology. WoltersKluver, Lippincott Willium and Wilkins.
- Watson, J.D, Baker, T.A, Bell, S.P., Gann, A, Levine, M, Losick, R (2007) , Molecular biology of gene, Cold Spring Harbor Laboratory Press.

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Paper code: BOT-1002 SP-4

Paper title: MYCOLOGY AND PLANT PATHOLOGY –II.

Course outcomes:

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

CO1-Know substrate relationship in fungi, the genetics of plant diseases, resistance, and host-parasite interaction.

CO2-Understand the strategies for integrated plant disease management.

CO3-Perform isolation and identify microflora from seed, phylloplane, phyllosphere, diseased plant material, and aquatic environment.

CO4-Identify common plant diseases and perform biochemical analysis.

CO5-Enhance collaborative learning and communication skills through practical session, teamwork, seminar, and home assignments.

Unit-1 **Lectures-08**

- **Genetics of plant disease and resistance:** Disease Resistance – Genetics of virulence and resistance, gene-for-gene concept, Techniques in plant breeding for disease resistance, Genetics of Host – parasite interaction –heterokaryosis,

Unit-2 **Lectures-10**

- **Pathogens and diseases:** Mode of infection, host parasite interaction, role of enzymes and toxins in plant diseases. Dissemination of plant pathogens, disease cycle. Effect of environment on plant disease development. Defence mechanisms of plant diseases against infection. Physiological changes due to disease in plants. Koch's postulates.

Unit-3 **Lectures-10**

- **Fungi in aquatic environment:** Techniques of isolation of fungi from water.
- **Fungi in Seed:** seed infection and establishment, seed health testing and methods for detecting seed microorganisms, quarantine, and seed certification.

- **Fungi on leaf surfaces*:*** Phyllosphere, phylloplane and leaf leachates. (General account)

Unit-4 **Lectures-06**

- **Post-harvest disease:** post-harvest fungal diseases of fruits and vegetables and their management. Biochemical changes in fruits and vegetables due to post harvest fungal infections.

Unit-5 **Lectures-06**

- **Plant disease management:** Genetic engineering and crop protection. Cultural, chemical, biological plant disease management, bio pesticides, integrated disease management (IDM)

Unit-6 **Lectures-08**

- **Plant diseases**: Study of symptoms, etiology and control of fungal, bacterial and viral diseases of crop plants with special reference to N.E. India: Rice, wheat, areca nut, banana, potato, sugarcane, jute, and tea.

PRACTICALS:

- Isolation of external and internal seed borne mycoflora by blotter and Agar Plate method.
- Isolation and identification of aquatic, phyllosphere and phylloplane fungi.
- Isolation & identification of plant pathogenic fungi from diseased materials.
- Estimation of sugars, proteins and amino acids from diseased materials and culture filtrates.
- Production and estimation of citric acid from *Aspergillus niger.*
- Demonstration of Koch's Postulate.
- Study of plant diseases in field. Submission of collection /herbarium/ Photograph of fungal specimen and diseased materials and permanent slides.
- Practical notebooks.

Suggested Readings:

- Ainsworth G.C 1973. The Fungi Vol IV A, IV B Academic Press.
- Alexopoulos, C.J. and C. W. Mims (1996): Introductory Mycology
- Allas, R.M. Microbiology: Fundamentals and Applications, Macmillan Publishing co. New York.
- Bessey 1950.Morphology and Taxonomy of fungi. The Blakistan Co.

- Brook, T.D. Smith, D.W and Madigan, M.T. 1984. Biology of Microorganisms, 4th ed. Eaglewood Cliffts.N.J. Prentice-Hall. New Delhi.
- Dayal RU (2009): Zoosporic fungi of India. Inter-India Publication.
- Kamat M.N 1959. Handbook of Mycology, Prakash Publication.
- Ketchum, PA. 1988. Microbiology, concepts, and applications. John Wiley and Sons. New York.
- Mehrotra R. S and Aneja R.S 1998.An introduction to Mycology. New Age Intermediate.
- Rangaswamy G. and Mahadevan A. 1999. Diseases of crop plants in India (Fourth Edition) Prentice Hall of India Pvt. Ltd. New Delhi.
- Schlegel, H.G.1986. General Microbiology. Cambridge University Press. London.
- Sharma, O.P. (1989): Textbook of Fungi.
- Stainer, Roger, Y. Ingrahan, John, L. Wheelis, Mark, L and Painter, Page, R. 1990.Microbial World 5th edition. Prentice-Hall India, Pvt. Ltd. New Delhi.
- Webster J. 1985. Introduction to Fungi. Cambridge University Press.

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Paper code: BOT-1002 SP-5

Paper title: MICROBIOLOGY – II

Course outcomes:

After completing this course, the students will be able to

CO1-Understand DNA organization and replication in bacteria and eukaryotes.

CO2-Elaborate genetic recombination, gene expressions, mutation and DNA damage and repair.

CO3-Comprehend the concept of microbial DNA technology and its application.

CO4-Conceptualize fermentation process and its utility in food microbiology.

CO5-Perform experiments to isolate and enumerate microbes, optimize the process of organic acid and enzyme production, bacterial DNA isolation and amplification and **design** strategies using microbes to help in bioremediation and crop improvement.

Unit -1 **Lectures-08**

- **Microbial Genetics:** Genome organization and DNA replication in prokaryotes, Plasmids: nature, classification, properties and replication, Denaturation and melting curves, Bacterial genetic system: transformation, conjugation, transduction, Horizontal gene transfer and Transposable elements.

Unit -2 **Lectures-08**

- **Gene expressions, mutation and repair of prokaryotic genes:** Transcription and Translation in Prokaryotes, regulation of gene expression- inducible and repressible operons, lytic cascade and lysogenic repression in Phage λ. Detection and analysis of mutations (Replica plating, Antibiotic enrichment, Ames test etc). DNA damage and repair.

Unit-3 **Lectures-08**

- **Microbial DNA technology:** Selection and strain improvement strategies,microbes as the tools of genetic engineering, creating a genomic library, Production of Insulin, Production of vaccines, Production of Interferon, Production of Enzymes, Bt-Cotton, Super-bug.

Unit-4: Lectures-08

- **Introduction to Industrial Microbiology**: Types of fermentation process, microbial biomass, microbial enzymes, microbial metabolites and transformation process. Types of fermentation- Solid state fermentation and submerged fermentation, batch and continuous fermentation.

Unit-5 **Lectures-08**

- **Microbial Production:** Antibiotic: penicillin, Amino acid: lysine, enzym: amylase, organic acid: citric acid, biofuel, biopolymer – PHB, PLA. Alcoholic beverage: beer and wine, SCP, enzyme production& immobilisation, MEOR.

Unit- 6 **Lectures-08**

- **Food Microbiology:** Microbial fermentation; Microbial food spoilage and food poisoning (cereals and sugar products, fruits and vegetables). Different types of fermented foods and the microbes involved. Food preservation- aseptic healing, high temperature, boiling, steam under pressure, pasteurization; low temperature-freezing.

PRACTICALS:

- Use of different types of media for microbial culture of fungi and bacteria.
- Study of motility of bacteria.
- Study of zone of inhibition.
- Study of microbial cells by haemocytometer.
- Optimisation of process parameters in production of organic acids
- Assay and optimisation of process parameters in fermentative enzyme production.
- DNA extraction and separation by electrophoresis.
- Microbial DNA amplification by PCR.

Suggested Readings:

- Alberts B. Johnson A, Lewis J, Raff M., Roberts K,.Walte P (2007), Molecular Biology of the Cell 5th edition, Garland Science, New York and London,
- Banerjee, A. K. & N. Banerjee: Fundamentals of Microbiology and Immunology
- Dubey, R. C & D.K. Maheswari: A Text Book of Microbiology.
- Frazier C,Food Microbiology by William. Tata Mgraw Hill.
- Jocelyn E. Krebs, E., S.Goldstein& Kilpatrick, S. T., Jones(2017) Lewin's Genes-XII Bartlett Publishers.
- Presscott, L. Harley, J. and Klein, D. (2005) Microbiology, 6th edition, Tata McGraw-Hill Co. New Delhi.

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BOT-1002 SP-6 PLANT ECOLOGY –II

Course outcomes:

After completing this course, the students should be able to

CO1-Understand different natural resources and human impact on these resources, different environmental pollutions and their management.

CO2-Conceptualise ecosystems stability and ecological management.

CO3-Comprehend the concepts, principles and strategies of biological conservation and ecological restoration.

CO4-Recognise the ideas of EIA, ecological economics, RS, GIS and GPS.

CO5-Know the various environmental issues and problems of NE India, particularly Shifting cultivation and Ramsar sites.

Unit-1 **Lectures-08**

- **Environmental pollution and Management:** Air, water and soil pollution - Sources and kind; impact on plants and ecosystem; control measures; ecotoxicology.

Unit-2 **Lectures-08**

- **Ecosystem stability and ecological management**: Concept (resistance and resilience); ecological perturbations (Both natural and anthropogenic) and their

impacts on plants and ecosystems; ecology of plant invasion; basic concept of RS, GIS and GPS.

Unit-3 **Lectures-08**

- **Natural resources and human impact:** Resources - Types (land, water, and energy), degradation and conservation.

Unit -4 **Lectures-08**

- **Conservation biology:** Principles of conservation, Problems of conservation, causes of extinction; hot spots, key stone species, flag ship species; umbrella species; conservation strategies - in-situ (wildlife sanctuaries, national parks and biosphere reserves) and ex-situ conservation (gene bank, Botanical gardens.)

Unit-5 **Lectures-08**

- **Environment and society**: Ecological restoration - concept, principles and strategies, restoring degraded ecosystems in India, EIA, Sustainable development and sustainability indicators; ecological economics.

Unit-6 **Lectures-08**

- **Environmental Issues and Problems of North East India:** Forest ecology and forest types of India; issues and problems associated with shifting cultivation; environmental impact of coal mining, quarrying of sand from hills and rivers; Extraction of petroleum and natural gas; issues relating to conservation of Ramsar sites of north-east India: Loktak lake, Deeparbeel and Rudrasagar lake; Traditional System of Forest Management; State Forest Policies and Autonomous District Council Forest Policies.

PRACTICALS:

- To study the chemical characteristics of soil by rapid field test.
- NPK analysis of soil.
- Study of different stages of succession in plant communities.
- To record the abiotic components i.e. pH, temperature, turbidity and light intensity of water in a pond ecosystem.
- Determination of D.O. of polluted and unpolluted water samples.
- To study the reproductive capacity of different plant species.
- Study of allelopathic effects.
- Morpho-anatomical variation of plant species as affected by environmental changes.

Suggested Readings:

- Ananthakrishnan, T.N.(1978) : *Bioresources Ecology(3rd Edn.,)* Oxford &IBH Publishing Co, (P)Ltd., New Delhi, Bombay, Calcutta-226pp.,
- Freeman, B. (ed.), 1995. - *Environmental Ecology- The ecological effects of pollution, disturbance, and other stresses*. Academic press.
- Glasson, J., Therivel, R. & Chadwick, A. 1995. - *Introduction to environment impact assessment*, UCL Press Ltd., London.
- K.V.Krishnamurthy, *A textbook of Biodiversity*, Science Publishers Inc., Enfield, New Hampshire, USA.
- Misra, R. 1968. - Ecology Work Book. Oxford & IBH, New Delhi.
- Moldan, B & Billharz, S. 1997. - *Sustainable indicators*. John Wiley Sons, New York.
- Mukherjee, B. 1996. - *Environmental biology*. Tata McGraw Hill Publ., New Delhi
- Newman, E.I. (2000): *Applied Ecology*, Blackwell Scientific Publisher, U.K-328pp.,
- Pullin, A.S., *Conservation Biology*, (2002), Cambridge University Press, Cambridge.
- Smith, R.L. (1996), *Ecology and Field Biology*, Harper Collins, New York.

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Paper code: BOT 1004 DPW

Paper title: Dissertation

(Credits: Theory-0, Tutorial-0, Practical-6, type of paper: Practical, No. of lectures/ hours: 72 hrs)

Course outcome:

On completion of the dissertation work, the students will be able to:

CO1-Identify research problems based on literature survey.

CO2-Gain knowledge on basic research methodology and ethics.

CO3-Develop a scientific temperament, critical thinking, time management and inculcate a methodical approach to solve the identified research problem.

CO4-Grow skills in data analysis, interpretation, scientific writing and presentation.

*Topics for the dissertation will be as per the choice of the students and their respective faculty supervisors.

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