Learning Outcomes Based Curriculum Framework (LOCF) for Undergraduate Programme (B.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.

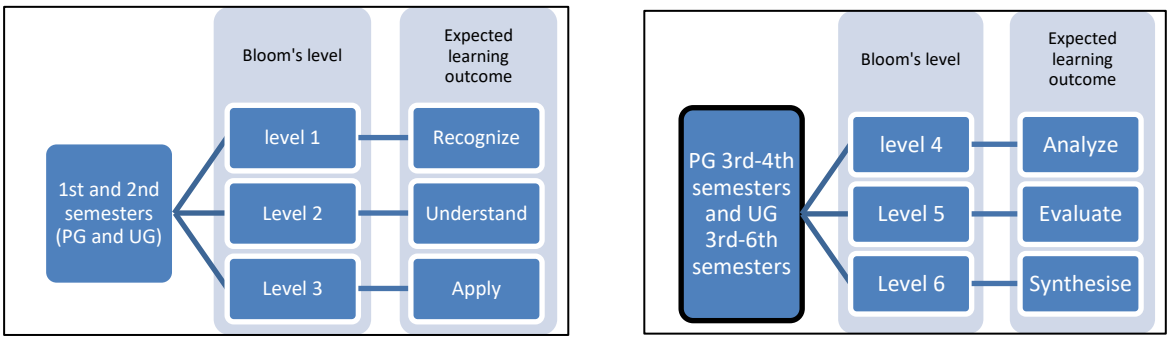

Fig. Chart showing relation between Bloom's taxonomy and program learning outcomes.

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 be 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 the comparability of learning levels and academic standards across universities and provide a broad picture of the level of competence of graduates of a given program of study. The students after completion of three years undergraduate programme and being conferred B.Sc Botany (Hons) degree are expected to have acquired the following outcomes:

PSO 1: Demonstrate disciplinary knowledge of different areas of Botany starting from simplest life forms like bacteria to most advanced angiosperms along with their origin, morphology, anatomy, taxonomy, cell biology, molecular biology, physiology,

biochemistry, ecology, diseases, along with their analytical techniques, bioinformatics and various other branches.

PSO 2: Analyse different aspects of disciplinary knowledge and show critical thinking on the subject.

PSO 3: **Exhibit experimental proficiency** in Botany and **develop skills** in using scientific equipments related to plant science.

PSO 4: Create teams through group activities, field trips and departmental events.

PSO 5: Display digital proficiency in preparing project report and use of basic biostatical and bioinformatic tools.

PSO 6: Communicate confidently their **subject-related knowledge**, findings, observations, or views through presentations in seminars and through writing**.**

PSO 7: Learn to undertake **discipline-related research** through project work and dissertation.

PSO 8: Show moral and **ethical behaviour** in accurate data presentation, maintaining biosafety in the laboratory, avoiding plagiarism and adopting moral practices in all activities.

PSO 9: Apply knowledge gathered during the course to address different issues of society and environment by encouraging sustainable development and scientific temperament.

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

Programme outcomes (POs)	101 C	102 C	201 C	202 C	301 C	302 C	303 C	401 C	402 C	403 C	501 C	502 C	601 C	602 C
In-depth knowledge	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Understanding theories	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Analytical and critical thinking	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Critical assessment					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Research and innovation														
Interdisciplinary perspective					✓					✓			✓	
Communication competence	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓
Career development	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Teamwork					✓									
Commitment to the society and to the Nation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

1.4.2. Elective Course outcomes (Cos) and Programme Outcomes (POs) matrix

Programme outcomes (POs)	103 GE	203 GE	304 GE	404 GE	503 DSE	504 DSE	603 DSE	604 DSE
In-depth knowledge	✓	✓	✓	✓	✓	✓	✓	
Understanding theories	✓	✓	✓	✓	✓	✓	✓	
Analytical and critical thinking					✓	✓	✓	
Critical assessment					✓	✓	✓	
Research and innovation								✓
Interdisciplinary perspective					✓			✓
Communication competence	✓	✓	✓	✓		✓	✓	✓
Career development	✓	✓	✓	✓	✓	✓	✓	✓
Teamwork					✓			✓
Commitment to the society and to the Nation	✓	✓	✓	✓	✓	✓	✓	✓

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

Programme Specific outcomes (PSOs)	101 C	102 C	201 C	202 C	301 C	302 C	303 C	401 C	402 C	403 C	501 C	502 C	601 C	602 C
Demonstrate	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Analyse								✓	✓	✓	✓	✓	✓	✓
Exhibit	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Create														
Display	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Communicate														
Learn	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Show	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Apply					✓			✓	✓	✓	✓	✓	✓	✓

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

Programme Specific outcomes (PSOs)	103 GE	203 GE	304 GE	305 SEC	404 GE	503 DSE	504 DSE	603 DSE	604 DSE
Demonstrate	✓	✓	✓	✓	✓				
Analyse						✓	✓	✓	✓
Exhibit	✓	✓	✓	✓	✓	✓	✓	✓	✓
Create						✓	✓	✓	✓
Display	✓	✓	✓	✓	✓	✓	✓	✓	✓
Communicate								✓	✓
Learn	✓	✓	✓	✓	✓	✓	✓	✓	✓
Show	✓	✓	✓	✓	✓	✓	✓	✓	✓
Apply						✓	✓	✓	✓

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.

----------XXXXXXXXXXXXXXXXXX----------

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 B. 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 B.Sc. program will be according to the following scheme:

COURSE STRUCTURE WITH CREDIT DISTRIBUTION FOR B.Sc. in BOTANY, CU

SEMESTER - I			
Sub Code	**Subject Title**	**L+T+P**	**Credits**
BOT 101C	Nonvascular Cryptogams	4+0+2	6
BOT 102C	Instrumentation and Laboratory Techniques	4+0+2	6
BOT 103GE	Microbes and Lower Cryptogams	4+0+2	6
AECC-1	English communication (*(To be offered by the concerned subject Department of CU)*	2+0+0	2
SEMESTER – II			
BOT 201C	Vascular Cryptogams and Gymnosperm	4+0+2	6
BOT 202C	Advanced Morphology & Plant Anatomy	4+0+2	6
BOT 203GE	Pteridophytes, Gymnosperm and Angiosperms	4+0+2	6
AECC-2	Environmental Science *(To be offered by the concerned subject Department of CU)*	2+0+0	2
SEMESTER – III			
BOT-301C	Angiosperm Taxonomy	4+0+2	6
BOT-302C	Cell and Molecular Biology	4+0+2	6
BOT-303C	Reproductive Biology & Evolution	4+0+2	6
BOT-304GE	Cytogenetics & Plant anatomy	4+0+2	6
BOT-305SEC	Biofertilizers	2+0+0	2
SEMESTER – IV			

BOT-401C	Plant Ecology & Phytogeography	4+0+2	6
BOT-402C	Plant Pathology	4+0+2	6
BOT-403C	Economic Botany, Ethnobotany and Pharmacognosy	4+0+2	6
BOT-404GE	Plant Physiology and Plant Ecology	4+0+2	6
SEC -2	(SEC-2 Courses to be offered by other Discipline)		2
SEMESTER – V			
BOT-501C	Plant Physiology	4+0+2	6
BOT-502C	Microbiology	4+0+2	6
DSE-1	• DSE-1 to be opted from MOOCs under swayam courses / from the pool of courses offered by the department as listed below. • DSE-2 to be opted from the pool of courses offered by the department as listed below	0+0+6/ 4+0+2	6
DSE-2		4+0+2	6
SEMESTER – VI			
BOT-601C	Cytogenetics & Plant Breeding	4+0+2	6
BOT-602C	Plant Biochemistry	4+0+2	6
DSE-3	DSE-3 to be opted from the pool of courses offered by the department as listed below.	4+0+2	6
DSE-4	Project Work/Dissertation	0+0+6	6

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

POOL OF DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES

Semester	DSE	Paper Code	Title of the paper	Credits
Semester-V	**DSE-1**	BOT-503DSE (To be opted from MOOCs under swayam courses in any of the specified area	BIOETHICS, IPR & BIOSAFETY/TRENDS IN PLANT SCIENCES /ENVIRONMENT IMPACT ASSESSMENT & ECOSYSTEM	5+1+0

		mentioned in the title of the paper)	SERVICES	
	DSE-2	BOT-504DSE	1. PLANT STRESS BIOLOGY 2. BIODIVERSITY AND CONSERVATION BIOLOGY 3. PLANT IDENTIFICATION: TOOLS & TECHNIQUES	4+0+2 4+0+2 4+0+2
Semester-VI	**DSE-3**	BOT-603DSE	1. BIOTECHNOLOGY, BIOINFORMATICS & BIOSTATISTICS 2. ADVANCED PLANT PATHOLOGY & MICROBIOLOGY	4+0+2 4+0+2
	DSE-4	BOT-604DSE	PROJECT WORK(Compulsory)	0+0+6

****

Semester-I

Paper code: BOT-101C

Paper title: NON-VASCULAR CRYPTOGAMS

(Credits: Theory-4, Practical-2, Type of paper: Theory+Practical, No. of Lectures: 60)

Course outcomes –

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

CO1-Understand the distribution, characteristic features and life cycles of non-vascular cryptogams.

CO2-Know the economic importance of algae, fungi, lichens and bryophytes.

CO3-Inculcate scientific skills to study the specimens of non-vascular cryptogams in laboratory.

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

CO5-Develop practical skills to identify, classify and distinguish nonvascular cryptogams.

Unit-1- **Lectures-10**

- **Algae General features-:** General characteristics, ecology and distribution, range of thallus organization, reproduction, classification, origin and evolution of sex and economic importance of algae.

Unit -2 **Lectures-10**

- **Algae Life Cycle**: Life cycles of Cyanophyceae- Microcystis, *Anabaena*; Chlorophyceae- *Chlorella*, *Volvox*, *Oedogonium*, *Chara*, Bacillariophyceae- (General account–Diatoms) Phaeophyceae- *Ectocarpus*, Rhodophyceae- *Batrachospermum*, *Polysiphonia*.

Unit 3 **Lectures-10**

- **Fungi Introduction**: General characteristics; Status of fungi in living system, Thallus organization; Cell structure; Nutrition; homothallism and heterothallism. History of classification, Classification of fungi (Ainsworth, 1973) up to sub-division with diagnostic characters and examples, Economic importance.

Unit 4 **Lectures-10**

- **Fungi Life Cycle:** General characteristics of the subdivisions and life cycle of:

Phytophthora, *Albugo, Saccharomyces, Aspergillus*, *Penicillium, Peziza, Agaricus,Puccinia, Alternaria, Colletotrichum.*

Unit -5 **Lectures-5**

- **Lichen**: Occurrence; General characteristics and range of thallus organization; Reproduction and economic importance of lichens.

Unit-6 **Lectures-15**

- **Bryophytes:** Characteristic features, amphibian nature, classification, alternation of generation, origin and evolution of sporophyte, economic importance of bryophytes.
- Structure, reproduction and life history of *Riccia, Marchantia, Anthoceros, Sphagnum, Polytrichum* and Funaria.

Practical: **Credits: 2**

1. **Algae:** Study of vegetative and reproductive structure through temporary preparations and permanent slides of the following algal types-*Microsystis, Anabaena, Chlorella, Volvox, Oedogonium, Chara ,Diatoms, Ectocarpus , Batrachospermum, Polysiphonia.*
2. **Fungi:** Study of vegetative and reproductive structure through temporary preparations of the following fungal types-*Albugo, Rhizopus*, *Aspergillus*, *Penicillium, Peziza, Puccinia*, *Agaricus, Alternaria.*
3. **Lichens:** Study of growth forms of lichens (Crustose, Foliose and Fruticose).
4. **Bryophytes:** Study of the gametophyte and sporophytes of *Riccia, Marchantia, Anthoceros, Sphagnum and Funaria*.

Practicals should be supported by practical record/slides and specimens.

Suggested Readings:

a) Algae:

- Bold, H.C.and Wayne, MJ. Introduction to Algae (2nd edition). Prentice Hall, New Jersey Delhi.
- Fritsch, F. E.(1961), Structure and reproduction in algae, Vol- I, & II Cambridge University.
- Kumar, H.D.(1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
- Sambamurty, A. A Text Book of Algae. I.K. International Pvt. Ltd., New Delhi.
- Sharma.O.P. (2011). Text book of Algae. Tata Mc Graw Hill Education Pvt. Ltd., New
- Vashishta B.R., Sinha A. K., V. P. Singh .Botany for Degree student- Algae. S. Chand and Company

b) Fungi:

- Mehrotra R.S. and Aneja K.R.(1990). An Introduction to Mycology, Wiley, Eastern Limited, New Delhi.Press, London.
- Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
- Sharma, O.P. (2011). Fungi and allied microbes. Tata McGraw Hill Pvt Ltd., New Delhi.
- Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
- Vashishta B.R., Revised by Sinha A. K., (2003), Botany for Degree student- Part II-Fungi . S. Chand and Company.

c) Lichen:

- Nash, T. H. 1996. Lichen Biology. Cambridge University Press, London
- Gupta, P and Sinha G P. (2018), The Lichen Flora of Assam, Scientific Book Publications.

d) Bryophytes:

- Chopra, R. N and Kumar, P. K. (1988). Biology of Bryophytes. New Age International Publishers, New Delhi.
- Goffinet B and Jonathan Shaw, A. (2009). Bryophyte Biology. Cambridge University Press, New York.
- N. S. Parihar, (2013). An Introduction to Embryophyta. Vol. I Bryophyta, Surjeet Publication, New Delhi.
- Rashid, A. (1998). An Introduction to Bryophyta. Vikas Publishing House, Pvt. Ltd., New Delhi.
- Watson, E. V. (2015). The structure and life of Bryophytes. Scientific Publication, Jodhpur, India

****

Paper code: BOT-102C

Paper title: INSTRUMENTATION AND LABORATORY TECHNIQUES

(Credits: Theory-4, Practical-2, type of paper: Theory+Practical, No. of Lectures: 60)

Course outcomes:

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

CO1-Develop theoretical understanding of basic microscopy, chromatography, histochemical, cytogenetic and imaging techniques.

CO2-Use the laboratory equipment's like Spectrophotometer, pH meter, micrometer, microscope and camera lucida.

CO3-Analyse data using descriptive statistics and to prepare graphs and tables on MS excel.

CO4-Gain knowledge on inferential statistics using Chi-square test and scientific writing, presentation and academic misconduct and ethics.

CO5-Enhance collaborative learning and communication skills through practical sessions, teamwork, group discussions and home assignments.

Unit-1 **Lectures-10**

- **Microscopy and Imaging techniques:** Camera lucida types and principle; principles and application of microscopy (light microscopy; fluorescence microscopy; confocal microscopy). Electron microscopy (principles and applications of transmission and scanning electron microscopy).

Unit-2 **Lectures-10**

- **Basic laboratory instruments:** Principles and applications of hot air oven, incubators, autoclave, and laminar air flow chamber, Different types of centrifuge, pH meter, Microtome techniques. Spectrophotometry: Principle and its application in biological research.

Unit-3 **Lectures-08**

- **Chromatography**: Principles & applications; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Affinity chromatography

Unit-4 **Lectures-10**

- **Basic Laboratory Techniques**: Basic plant and microbe culture media and methods of sterilization, concept of solutions, indicators, pH and buffers. Preparation of normal, molal, molar, ppm and percent solutions. Field and herbarium techniques, preservation of museum and herbarium specimens, preservation techniques for special types of plant (bryophytes, aquatic plants, succulents and xerophytes, palm, canes and bamboos).

Unit-5 **Lectures-08**

- **Plant microtechniques:** Staining procedures, classification and chemistry of stains. Cytogenetic techniques- (Pre-treatment, maceration, smear & squash); dissection, peeling and whole mount , serial sectioning – double / multiple staining. Histochemical Techniques – Localisation of specific compounds.

Unit -6 **Lectures-14**

- **Data analysis and presentation techniques:** a) Statistics: data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation critical difference, Chi-square test for goodness of fit. b) Scientific writing and its representation: Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references, power-point presentation, poster presentation. Scientific writing and ethics (Introduction to copyright, academic misconduct/plagiarism).

Practical: **Credits: 2**

1. Spore measurement by micrometry,
2. Camera lucida diagram of stomata and spore.
3. Basic asceptic techniques,
4. Preparation of solutions (normal, molal, molar, ppm and percent solutions) of known concentrations using pure samples and stock solutions.
5. Preparation of reagents, fixatives, stains and Indicators,
6. Preparation of permanent slides (double staining).
7. Measurement of pH using pH metre (water and soil).
8. Preparation of buffers (phosphate/ acetate buffer).
9. Preparations of tables and graphs using MS Excel
10. Calculation of mean, mode, median, SD, SE from the supplied data.

Practicals should be supported by practical record.

Suggested Readings

- Harborne JB(1998). Phytochemical Methods A Guide to Modern Techniques of Plant Analysis : JB. Springer.
- Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.

- Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A.
- Wilson, K. & Walkar, J (Eds) (2000) Practical Biochemistry: Principles & Techniques, Cambridge University Press.

****

Paper code: BOT-103GE

Paper title: MICROBES AND LOWER CRYPTOGAMS

(Credits: Theory-4, Practical-2, Type of paper: THEORY+PRACTICAL, No. of Lectures: 60)

Course outcomes:

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

CO1-Explain the fundamental concepts and general characteristics features related to virus, bacteria, algae, fungi, lichen, and mycorrhiza.

CO2-Examine the morphology and life cycles of certain genera of algae, fungi and bryophytes.

CO3-Evaluate the significance of fungi and their different types.

CO4-Analyse the significance of viruses and mycorrhizae and economic importance of bacteria, algae, fungi, lichen and bryophytes.

CO5-Develop practical skills to identify, classify and distinguish microbes and non-vascular cryptogams.

Unit-1: Lectures-06

- **Virus**: Structure, Replication – lytic and lysogenic cycles, importance of viruses.

Unit-2 Lectures-05

- **Bacteria**: Classification, ultrastructure of a bacterial cell, reproduction asexual and sexual (transformation, conjugation and conduction) and economic importance.

Unit-3 Lectures-15

- **Algae**: General account, thallus organization, classification (F.E. Fritch, 1935), reproduction, Life cycle patterns of Anabaena*, Volvox, Chara, , Ectocarpus, Batrachospermum* and economic importance of algae

Unit-4: Lectures-15

- **Fungi:** General characteristics, Classification (Ainsworth), vegetative structures, nutrition,

reproduction, Life cycles of *Rhizopus, Penicillium,Peziza, Puccinia, Alternaria*. Economic importance of fungi

Unit -5: Lectures-04

- **Lichen and Mycorrhizae:** General account, economic importance, Ectomycorrhizae and endo mycorrhizae and their significance.

.Unit-6 Lectures-15

- **Bryophyta**: Characteristic features, classification (Proskeur, 1965), reproduction, alternation of generation, origin and evolution of bryophytes, Life cycles of *Marchantia, Anthoceros*, and *Funaria.* Economic importance.

Practicals: (2 Credit)

1. **Bacteria**: Observation of gram positive and gram negative bacteria by Gram staining.
2. **Algae**: Study of vegetative and reproductive structures of the following algal types: *Microcystis*, *Anabaena, Volvox, Chara, Ectocarpus, Batrachospermum*.
3. **Fungi**: Study of vegetative and reproductive structures of the following taxa: *Rhizopus, Penicillium, Peziza, Puccinia* and *Alternaria*
4. **Lichen**: Thallus morphology of Crustose, Foliose and Fruticose types.
5. **Bryophytes**: Study of the gametophytic and sporophytic structures of the following genera and their identification: *Marchantia, Anthoceros, and Funaria*.

Practicals should be supported by practical record & Slides/ specimens / herbariums (at least 10).

Suggested Readings:

Microbes:

- Pelczar, M.J. (2001) ***Microbiology, 5th edition,*** Tata Mc Graw-Hill Co, New Delhi.
- Dubey, R.C & D.K. Maheswari: A Text Book of Microbiology.
- Presscott, L. Harley, J. and Klein, D. (2005) Microbiology, 6th edition,Tata McGraw-Hill Co.New Delhi.

Algae:

- Pandey, B.P (2010) : Botany for Degree students
- Sharma. O.P(2017) : Algae
- Vasishtha, B.R. - (1974) Botany for Degree Students – Vol-I Algae.

Fungi:

- Mitra.J.N., Mitra. D., Chowdhuri, S.K.;Studies in Botany(Vol. one)(2018)Moulik Library 18-B

- Sharma, O.P., (1999) Text book of fungi. Tata McGraw Hill publishing Company Ltd. New Delhi.

Lichens

- Misra, A. & R.P. Agarwal : Lichens – A Preliminary Text.

Bryophyta:

- Parihar, N.S : An Introduction to Embryophyta.
- Puri, P.: Bryophytes.
- Vasishtha, B.R. - (1974) Botany for Degree Students: Vol. III – Bryophyta

----------XXXXXXXXXXXXXXXXXX----------

Semester-II

Paper code: BOT-201C

Paper title: VASCULAR CRYPTOGAMS & GYMNOSPERM

(Credits: Theory-4, Practical-2, type of paper: Theory+Practical, No. of Lectures: 60)

Course outcomes:

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

CO1-Characterise pteridophytes and gymnosperms and understand their life cycle.

CO2-Explain the economic importance and evolutionary trends of vascular cryptogams & gymnosperm.

CO3-Develop skills to identify pteridophytes and gymnosperms based on morphological and anatomical features.

CO4-Demonstrate an understanding of fossilisation and the fossilised members

CO5-Exhibit proficiency in the experimental techniques and methods to study pteridophytes and gymnosperms.

a) Pteridophytes: Lectures-24

Unit-1: Characteristics features and life cycle of Pteridophytes; Apogamy and Apospory,

Unit-2: Classification with special reference to Wardlaw (1955), ecological significance, stelar structure, origin and evolution of pteridophytes, heterospory and origin of seed habit.

Unit-3 Comparative account of morphology, anatomy and reproduction of *Psilotum, Lycopodium, Selaginella, Equisetum, Marsilea and Pteris.*

b) Gymnosperms: Lectures-36

Unit-4: Classification of gymnosperms with special reference to Sporne's classification (1965) upto class with characters and examples; significance of gymnosperms; resemblances and differences between gymnosperms, pteridophytes and angiosperms.

Unit-5: Comparative account of morphology, anatomy and reproduction of *Cycas*, *Pinus*, *Ginkgo* and *Gnetum*.

Unit-6: Fossils: Definition, types, nomenclature of fossils and conditions for fossilization; geological time scale and major events of plant life through geological ages. General account of

Psilophytales (*Rhynia*), Lepidodendrales (*Lepidodendron*) Sphenophyllales (*Sphenophylum*) and Bennetittales (*Williamsonia*).

PRACTICALS: **Credits-2**

a) Pteridophyte

1. Study of vegetative and reproductive structures of the following taxa through temporary mounts, permanent slides or fresh material whichever is available.

b) Gymnosperm:

2. Study of vegetative and reproductive structures of the following taxa- *Cycas*, *Pinus*, *Ginkgo* and *Gnetum* (through temporary mounts, permanent slides or fresh material whichever available).
3. Study of Fossil forms using permanent slides /photographs –*Rhynia*, *Lepidodendron*, *Sphenophylum* and *Williamsonia*.

Suggested readings:

a) Pteridophyta:

- Dutta A.C. 2016. Botany for Degree Students. Oxford University Press.
- Pandey, B. P. 2006. College Botany, Vol. II: Pteridophyta, Gymnosperms and Paleobotany.S. Chand & Company Ltd, New Delhi.
- Rashid A., (1999). An Introduction to Pteridophyta, Vikas Publishing House Ltd.
- Vasishtha, P.C. (2006) Botany for Degree Students: Vol.IV- Pteridophyta

b) Gymnosperm:

- Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
- Chamberlain, C.J.: Gymnosperms: Structure and evolution,(CBS publishers anddistributors)
- Karkar,R.K. and Karkar,R.: The Gymnosperms
- Sporne, K.R.(1961): The Morphology of Gymnosperms,(Hutchinson University Library, London)
- Stewart, W.N. & Rothwell, G.W.: Paleobotany and evolution of plants,(CambridgeUniversityPress)
- Vashishta, P.C.(1990): Gymnosperm,(S.C.Chand)

****

Paper code: BOT-202C

Paper title: ADVANCED MORPHOLOGY & PLANT ANATOMY

(Credits: Theory-4, Practical-2, type of paper: Theory+Practical, No. of Lectures: 60)

Course outcomes:

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

CO1-Develop conceptual understanding of plant anatomy, organization of shoot and root apex and angiosperm evolution.

CO2-Analyse the anatomical composition of different parts of plants and their relationships

CO3-Identify special types of inflorescences, fruits, secondary growth and anomalous secondary growth in plant

CO4-Grow skills of section cutting and preparation of permanent slides

CO5-Enhance collaborative learning and communication skills through practical sessions, teamwork, group discussions and home assignments.

a) Advanced morphology: Lectures-25

Unit-1:

- Origin and evolution of angiosperms, inflorescence and angiospermic flowers , concept of flower as modified determinate shoot , special types of fruits – Spurious fruits (*Dillenia*) ; Aggregate fruits (*Annona* , *Michelia*, *Catharanthus*, *Polyalthia*); Multiple fruits (*Ananas, Artocarpus*). Homology and analogy of plant parts. Origin and evolution of angiosperms

Unit-2:

- Theories and the development of leaf, stamen and carpel (Phyllode theory, Telome theory, Carpel polymorphism, Inferior ovary), role of morphology in plant classification.

b) Plant Anatomy: Lectures-35

Unit-3:

- Structure and function of cell wall and plasma-membrane, extra cell wall materials - lignin, cutin, suberin, callose, wax.

Unit-4: Tissues and tissue system:

- Theories of structural organisation of root apex and shoot apex, Different types of tissue and tissue systems and their functions, mechanical tissue.

Unit-5: Leaf, stem and root anatomy:

- Leaf anatomy, anatomy of primary monocot and dicot stems/roots, anomalous structure in the primary body of stem.

Unit-6: Secondary growth:

- Secondary and anomalous secondary growth in monocot and dicot stems with special reference to (*Bignonia , Amaranthus, Tecoma* and *Dracaena*.)

Practicals : **Credits-2**

a) Advanced morphology :

1. Study of special types of inflorescences – Cyathium, Hypanthodium, Verticillaster.
2. Study of special types of fruits – *Dillenia*; *Annona* , *Michelia*, *Catharanthus*, *Polyalthia*, *Ananas, Artocarpus* .

b) **Anatomy :**

3. Study of anatomical details of the following through permanent slides/temporary stain mounts/ macerations/specimens with the help of suitable examples-stomatal types, trichomes, xylem and phloem elements.
4. Study of primary structures of monocot and dicot root and stem.
5. Study of anomalous structure in the primary body of stem - *Bougainvillea*, *Nyctanthes* .and *Oryza*.
6. Study of anomalous secondary growth in *Bignonia*, *Amaranthus*, *Tecoma* and *Dracaena*.

Practicals should be supported by practical record/slides and specimens

Suggested readings:

a) Advanced morphology:

- Mitra J.N. (1988), An introduction to systematic Botany and Ecology, The world press private Ltd., Calcutta
- Eames, A J. (1983), Morphology of Vascular plants, Standard University press.

b) Plant anatomy:

- Abraham, F. (1982). Plant Anatomy 3 editions, Pergaon Press, Oxford.
- Roy P (2010) Plant Anatomy, New Central Book Agency.
- Pandey B.P.(2001). Plant Anatomy. S. Chand and Company Ltd., New Delhi.
- Cutter, E. G. (1971). Plant Anatomy – Part I & II, Cell and Tissues. Edward Arnold, London.
- Easu, K. (1996). Anatomy of Seed Plants. First wiley Reprint, New Delhi.
- Fahn, A. (1985). Plant anatomy, Pergaon Press, Headington Hill Hall, Oxford.

****

Paper code: BOT 203 GE

Paper title: PTERIDOPHYTES, GYMNOSPERMS AND ANGIOSPEMS

(Credits: Theory-4, Practical-2, type of paper: Theory+Practical, No. of Lectures: 60)

Course outcomes:

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

CO1-Demonstrate conceptual understanding of characteristics, classification, anatomy, reproduction, economic importance, origin and evolution of vascular plants.

CO2-Develop practical skills to identify pteridophytes and gymnosperms based on morphology and anatomy.

CO3-Determine conceptual understanding of the aims and objectives of plant taxonomy, ICN classification and role of herbaria.

CO4-Grow skills to collect plant specimens, herbarium preparations and identify angiosperms.

CO5-Enhance collaborative learning and communication skills through practical sessions, teamwork, group discussions and home assignments.

Unit-1: Lectures-10

- General characteristics, Classification by Sporne(1975), Economic importance, Apogamy and Apospory, Origin and evolution of pteridophytes, Heterospory and origin of seed habit.

Unit-2: Lectures 10

- Life cycle patterns, Life history and Comparative account of morphology, anatomy and reproduction of *Psilotum, Lycopodium, Selaginella* and *Pteris*.

Unit-3: Lectures 08

- General charcatreistics, Classification by Sporne (1975), distribution and economic importance of Gymnosperm

Unit-4: Lectures 10

- Life history and Comparative account of morphology, anatomy and reproduction of *Cycas*, *Pinus*, *Ginkgo* and *Gnetum*

Unit-5: Lectures 08

- Aims and objectives of Plant Taxonomy, Role of herbaria, binomial nomenclature, ICN, General account of systems of classification with special reference to Bentham and Hooker's system.

Unit-6: **Lectures-14**

- General characters, distinguishing characters and economic importance of the following families- Magnoliaceae, Brassicaceae, Fabaceae, Solanaceae, Lamiaceae, Verbenaceae, Asteraceae, Poaceae, Orchidaceae.

Practicals : **Credits-2**

1. Pteridophytes, Study of the sporophytic structures of the following genera by prepration of temporary and permanent slides: *Lycopodium, Selaginella, Pteris, Marsilea* and *Drynaria*
2. Gymnosperms: Study of habit, vegetative and reproductive structures of the following taxa through specimens, temporary mounts and permanent slides or fresh material whichever is available: *Cycas*, *Pinus, Ephedra* and *Gnetum.*
3. Angiosperm: Description and identification (up to genus) of angiospermic specimens of locally available plants belonging to the families included in the theory syllabus.

*Practicals should be supported by practical record & Slides/ specimens / herbariums (at least 10).

*Field study.

Suggested Readings:

a) Pteridophytes :

- Rashid, A.(1999). Introduction to Pteridophyta.
- Singh, S.K.(2008). Pteridophyta.
- Vasishtha, P.C. (2006) Botany for Degree Students: Vol. IV- Pteridophyta

b) Gymnosperms :

- Bhatnagar, S.P. & A. Moitra : Gymnosperms.
- Chamberlain, C.J(2009). Gymnosperm, Structure and Evolution.
- Johri B. & Biswas .(1984) Gymnosperms.
- Vasishta, P.C(2010) : Botany for Degree Students :Gymnosperm.

c) Angiosperm:

- George, H.M. Lawrence (2012), Taxonomy of Vascular Plants.
- Mitra.J.N., Mitra. D., Chowdhuri, S.K (2018). Studies in Botany (Vol. one) Moulik Library 18-B
- Singh G (2011), Plant Systematics - Theory and Practice.
- Vasistha, P.C., Taxonomy of Angiosperms.

----------XXXXXXXXXXXXX----------

Semester-III

Paper code: BOT-301C

Paper title: ANGIOSPERM TAXONOMY

(Credits: Theory-4, Practical-2, Type of paper: THEORY+PRACTICAL, No. of Lectures:60

Course outcomes:

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

CO1-Develop understanding on concepts and chief categories of Plant classification and recognize the role of herbaria and importance of botanical garden.

CO2-Analyse the role and activities of Botanical Survey of India.

CO3-Evaluate the role of herbaria in taxonomic studies and interpret the rules of ICN in mentioned aspects of botanical nomenclature.

CO4-Develop knowledge on affinity, phylogeny and economic importance of mentioned dicot and monocot families of Angiosperms.

CO5-Generalize the features of locally available angiosperms and identify their diagnostic features.

CO6- Grow Skills in herbarium techniques and identify the locally available angiosperms following Bentham & Hooker's system of classification.

Unit-1: **Lecture- 10**

- Aim and objectives of plant taxonomy, history and concept of different classificatory system with particular reference to Bentham and Hooker and Takhtajans system of classification, brief idea on phenetic, phyletic, cladistics and APG.

Unit-2: **Lecture- 08**

- Principles and rules of binomial nomenclature, ICN rules and recommendations, type concept and its applications, rules of priority and its limitations, valid and effective publication; concept of species, genus and family.

Unit-3: **Lecture-08**

- Botanical survey of India, Organization, publication and activities, herbaria collection, Preservation, documentation, filing system; Botanical gardens-types its role in biodiversity conservation, teaching and research.

Unit-4: **Lecture-09**

- Changing trends in taxonomy- role of anatomy, palynology, cytology, phytochemistry, numerical taxonomy, and molecular taxonomy, computers in plant taxonomy, classification; biosystematics

Unit-5: **Lecture: 10**

- Affinity, phylogeny, economic importance, comparative studies of the following families- Magnoliaceae, Fabaceae, Caesalpiniaceae, Mimosaceae, Rubiaceae, Solanaceae, Cucurbitaceae, Lamiaceae,

Unit-6: **Lecture: 15**

- Affinity, phylogeny, economic importance, comparative studies of the following families- Acanthaceae, Asteraceae, Amaranthaceae, Arecaceae, Poaceae, Musaceae, Zingiberaceae, Orchidaceae.

Practicals: **Credit: 2**

1. Description and identification (upto genus) of specimens from members of locally available dicotyledonous and monocotyledonous families included in the theory syllabus.
2. Preparation of herbarium of common angiospermic plants (at least ten) and must be submitted in the examination.
3. Field study to get an idea about the flora and to prepare field report to be submitted in the examination.

Suggested Readings:

- George, H.M. Lawrence(2012), Taxonomy of Vascular Plants.
- Mitra.J.N., Mitra. D., Chowdhuri, S.K (2018). Studies in Botany(Vol. one) Moulik Library 18-B
- Singh Gurucharan (2010) Plant Systematics - Theory & Practice.
- Vasistha, P.C., Taxonomy of Angiosperms.

****

Paper code: BOT-302C

Paper title: CELL AND MOLECULAR BIOLOGY

(Credits: Theory-4, Practical-2, Type of paper: THEORY+ Practical, No. of Lectures:60)

Course outcomes:

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

CO1-Develop conceptual understanding of the cell structure, cell growth, development and proliferation.

CO2-Demonstrate conceptual understanding of structure and function of bimolecular, genetic materials, and their replication.

CO3-Explain gene expression regulation and sequential flow of genetic information.

CO4- Grow experimental proficiency in isolation and quantification of plant DNA and proteins, separation of proteins by SDS PAGE,

CO5-Develop skills in study of mitosis and meiosis in plants.

CO6-Enhance collaborative learning and communication skills through practical sessions, teamwork, group discussions and home assignments.

Unit-1 **Lecture-10**

- **Introduction to cell biology**: Introduction to cell, cellular organelles (structure & function) –Nucleus, Chloroplast, Mitochondria, Endoplasmic Reticulum, Golgi Apparatus, Peroxisomes, Cilia and & Flagella.

Unit-2 **Lecture-05**

- **Membrane structure and function:** Membrane structure, physiology, membrane pump and membrane trafficking.

Unit-3 **Lecture-05**

- **Cell Signalling**: Secondary messenger, signalling mechanism, signal transductions, signal protein.

Unit-4: **Lecture-10**

- **Chromosome & Cell cycle**: Structure and organization of chromosome, special types of chromosome and their significance, cell cycle (special emphasis on cell reproduction), cell proliferation

Unit-5 **Lecture -15**

- **Structure and function of nucleic acid and protein:** Structure and function of DNA, RNA and protein, DNA replication, transcription and translation, genetic code & its properties, regulation of gene expression in prokaryotes (Lac Operon concept).

Unit-6 **Lecture-15**

- **Mutation:** Definition and concept of mutation, mutagens, mechanism of action of physical & chemical mutagens, deletion, insertion, translocation, substitution mutation, chemical mutagenesis (tautomerization, alkylation, deamination, base analogues).

Practical: **Credit: 2**

1. Study of Plant cell structure with the help of epidermal peel mount.
2. Cytochemical staining of DNA- Feulgen and cell wall in the epidermal peel of plant material - periodic Schiff's technique (PAS)
3. DNA quantification from plant sample/ standard DNA.
4. Study of different stages of mitosis of locally available plant specimen
5. Study of different stages of meiosis of locally available plant specimen
6. Preparation of standard curve for protein.
7. Separation of protein by SDS-PAGE (Only Demonstration)

Suggested Readings:

- Gupta P.K. Cell and Molecular Biology (2017) Fifth edition - Rastogi Publications.
- Singh S P & B.S. Tomar (2015) Cell Biology –,Rastogi Publications
- David Freielder (2007)*, Molecular Biology*-, Narosa Publishing House.
- David Freielder (2009) *Microbial genetics*- Narosa Publishing House.
- Power CB (2010). Cell Biology – Himalay Publishing House

****

Paper code: BOT-303C

Paper title: **REPRODUCTIVE BIOLOGY & EVOLUTION**

(Credits: Theory-4, Practical-2, Type of paper: THEORY+PRACTICAL, No. of Lectures: 60)

Course outcomes:

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

CO1-Conceptualize reproductive development in plant, Pollination and Fertilization process, apomixis and polyembryony in plant.

CO2-Draw knowledge on theories of evolution, variation, speciation and polymorphism in plant.

CO3-Develop experimental proficiency in study of anthers, pollen grain through slide preparation, dissection of embryo from developing seeds.

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

Unit-1 **Lecture-16**

- **Introduction:** Structure of anther and pollen- microsporogenesis and development of male gametophyte, pollen morphology and NPC system. Structure and types of ovules, megasporogenesis and development of female gametophyte, Types of embryo sacs, organization and ultrastructure of mature embryo sac.

Unit-2 **Lecture-08**

- **Pollination and Fertilization**: Pollination - Types, mechanisms and adaptations, double fertilization.

Unit-3 **Lecture-08**

- **Post fertilisation events:** Endosperm - Types, structure and functions. Development of dicot and monocot embryo.

Unit-4 **Lecture-08**

- **Apomixis and Polyembryony**: Definition, types and practical applications.

Unit-5 **Lecture-12**

- **Evolution**: Evidence, theories and mechanism of evolution, origin of new species. Population, gene frequencies; gene pool; genetic drift; The Hardy- Weinberg Law, changes in gene frequencies in populations. Micro and macroevolution

Unit- 6 **Lecture-08**

- **Variation, speciation and polymorphism:** Variations: Causes and consequences of variations and polymorphism. Isolation mechanism and speciation,

Practical: **Credit-2**

1. Structure of anther (young and mature), tapetum (amoeboid and secretory) (permanent slides/photographs/specimen).
2. Study of pollen grains by acetolysis.
3. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
4. Female gametophyte: *Polygonum* (monosporic) type of embryo sac development (permanent slides/photographs/specimens).

5. Ultrastructure of mature egg apparatus cells.
6. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (permanent slides /photographs /specimens).
7. Dissection of embryo from developing seeds.

Practicals should be supported by practical record, field report, slides/specimens/ herbarium whichever is applicable.

Suggested Readings:

a) Embryology of Angiosperm:

- Singh, V.,Pande, P. C. and Jain, D. K., (1997). Embryology of Angiosperms, Rastogi Publications, Meerut.
- Ganguly, A. K. and Kumar, N.C., (2008). Developmental and Experimental Embryology of Angiosperms. Emkay Publications, Delhi.
- Bhojwani, S. S. and Bhatnagar, S. P., (2009). The Embryology of Angiosperms, Vikas Publishing House Pvt. Ltd., New 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.

b) **Evolution:**

- Stewart W.N. and Rothwell G.W. (2005). Paleobotany and the Evolution of Plants. 2nd Edn. Cambridge University Press.
- Verma P.S and Agarwal V.K. (2006) Cell Biology, Genetics, Molecular Biology, Evolution, Ecology. S.Chand and Company, New Delhi.

****

Paper code: BOT-304GE

Paper title: CYTOGENETICS & PLANT ANATOMY

(Credits: Theory-4, Practical-2, Type of paper: Theory + Practical, No. of Lectures:60)

Course outcomes:

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

CO1-Develop conceptual understanding of the cell structure and function, gene interaction, inheritance pattern and mutation.

CO2- Explain gene expression and sequential flow of genetic information.

CO3- Develop conceptual understanding of plant anatomy.

CO4-Grow skills in identification of secondary growth and anomalous secondary growth in stem and preparation of permanent slide.

CO5-Solve problems on gene interaction.

CO6-Study of mitosis and meiosis in plant using cytogenetic techniques.

a) Cytogenetics: Lectures-35

Unit-1: Eukaryotic cell: **Structure and Function**

- Structure and function of cell wall, plasma membrane, structure and function of nucleus, mitochondria and chloroplast, chromosome structure and types.

Unit-2: Inheritance Pattern:

- Mendelian inheritance, cytoplasmic inheritance, allelic and non-allelic interactions, linkage & crossing over and their significance.

Unit-3: Cell division, **replication and gene expression**

- Mitosis and Meiosis and their significance, structure and function of DNA and RNA & replications of DNA, regulation of gene expression in prokaryotic (Lac operon)

Unit-4: Mutation:

- Spontaneous and induced mutation, numerical and structural changes of chromosome, role of polyploidy in evolution of new species

b) Anatomy Lectures-25

Unit-5: Tissue and Tissue system

- Tissue organization of root and shoot apices, types of tissues, classification, tissue system

Unit-6 Anatomy and Secondary growth

- Primary and secondary structure of root and stem, anatomy of monocot and dicot leaf, anamolous secondary growth in stem.

PRACTICAL: (Credits: 2)

a) Cytogenetics

1. Study of various stages of mitosis in plant materials.
2. Study of meiosis in plant materials.

3. Study of gene interaction
4. Study of few polyploid (plants or photographs) plant species.

b) Anatomy

5. T. S of root, stem and leaf.
6. Studies of anomalous secondary growth by permanent preparation (differentially stained slides) of the following specimens : *Amaranthus, Boerhaavia, Mirabilis, Dracaena*

Practicals should be supported by practical record and slides.

Suggested Reading :

a) Cytogenetics :

- Sharma, A. K. and A. Sharma (1999). Plant Chromosomes: Analysis, Manipulation and Engineering. Harward Academic Publishers, Australia.
- Shukla, R. S. and P. S. Chandel (2007). Cytogenetics, Evolution, Biostatistics and Plant Breeding. S.Chand & Company Ltd., New Delhi.
- Singh, H. R. (2005). Environmental Biology. S. Chand & Company Ltd., New Delhi.
- Snustad, D. P. and M. J. Simmons (2000). Principles of Genetics. John Wiley & Sons, Inc., U S A.
- Verma, P. S. and V. K. Agrawal (2004). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand & Company Ltd., New Delhi

b) Plant anatomy:

- Roy P (2010) Plant Anatomy, New Central Book Agency.
- Pandey B.P.(2001). Plant Anatomy. S. Chand and Company Ltd., New Delhi.
- Easu, K. (1996). Anatomy of Seed Plants. First wiley Reprint, New Delhi.
- Fahn, A. (1985). Plant anatomy, Pergaon Press, Headington Hill Hall, Oxford.

****

Paper code: BOT-305

Paper title: SEC BIOFERTILIZERS

(Credits: Theory-2, Practical-0, Type of paper: Theory, No. of Lectures: 30)

Course outcomes:

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

CO1-Elaborate the types of biofertilizers and green manures.

CO2-Demonstrate the process of production of biofertilizer

CO3-Design an integrated management scheme for best uses of biofertilizers and waste management.

CO4-Develop conceptual understanding of organic farming and vermicompost and encourage their application in day-to-day life.

CO5-Enhance collaborative learning and communication skills through teamwork, group discussions and home assignments.

Unit-1 **Lectures-10**

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

Unit–2 **Lectures: 14**

- Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.
- Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Unit 3 **Lectures: 06**

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

Suggested Readings

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

Publication, New Delhi.

- Sathe, T.V. 2004 Vermiculture and Organic Farming. Daya publishers.
- Subha Rao, N.S. 2000, Soil Microbiology, Oxford & IBH Publishers, New Delhi.
- Vayas,S.C, Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and organic Farming Akta Prakashan, Nadiad
- Bhoopander Giri, Ram Prasad, Qiang-Sheng Wu, Ajit Varma,2019. Biofertilizers for Sustainable Agriculture and Environment, 1st Edition, Volume 55, Springer Nature Switzerland AG
- Hakeem, K.R., Dar, G.H., Mehmood, M.A., Bhat, R.A. (Eds.), 2020, Microbiota and Biofertilizers Springer Nature Switzerland AG

----------XXXXXXXXXXXXX----------

Semester-IV

Paper code: BOT-401C

Paper title: PLANT ECOLOGY AND PHYTOGEOGRAPHY

(Credits: Theory-4, Practical-2, Type of paper: THEORY+PRACTICAL, Lectures:60)

Course outcomes –

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

CO1-Understand the key concept of ecology with different climatic and edaphic factors along with population characteristics, dynamics and various interactions.

CO2-Develop empathy for various life forms and appreciate the various ecological linkages within the web of life.

CO3-Increase analytical ability to link cause and impact of air and water pollution on plants.

CO4-Recognize different phytogeographical regions of India and their vegetations.

CO5-Develop proficiency in using various meteorological instruments (Lux meter, Rain gauge, Secchi disc, Soil thermometer, Min-Max thermometer) and quantitative analysis of herbaceous vegetation by quadrat method.

Unit 1. Plants and Environment: **Lectures-10**

- Basic concepts of ecology, Ecological factors –Climatic factors (light, water or moisture), edaphic factor (soil formation and soil profile)
- Plant adaptations (hydric & xeric adaptations), Principles of limiting factors.

Unit 2. Population ecology: **Lectures-10**

- Concept, density, natality and mortality, age distribution of population, environmental resistance & carrying capacity, ecads, ecotypes and ecoclines, concept of population interactions.

Unit 3. Ecosystem Ecology: **Lectures-10**

- Structure and function - food chain, food web, ecological pyramids, energy flow
- Biogeochemical cycle (Nitrogen & Phosphorus cycle).

Unit 4. Community Ecology: **Lectures-10**

- Community characteristics and structure (analytical and synthetic characters),ecotone and edge effect;

- Ecological succession; types and processes, seral stages (with reference to Hydrosere and xerosere), Habitat and Niche.

Unit: 5 Environmental Pollution: **Lectures-10**

- Pollution and pollutants - Definition and types; Air and water pollution: sources and kinds, impact on plants, greenhouse effect, Ozone layer depletion and acid rain.

Unit: 6 Phytogeography: **Lectures-10**

- General Principles and objectives; Phytogeographical regions of India (Chatterjee 1960); vegetation characteristics of Eastern Himalayas, Endemism –concept & types.

Practical: Plant ecology and phytogeography **Credit-2**

- Study of basic meteorological instruments (Lux meter, Rain gauge, Secchi disc, Soil thermometer, Min-Max thermometer).
- Quantitative analysis of herbaceous vegetation for abundance, density and frequency by quadrat method.
- Study of ecological adaptation (morphological & anatomical) of hydrophytes (*Eichhornia, Jussiaea* and *Hydrilla*) and xerophytes (*Nerium*, *Aloe* and Cladode of *Asparagus*).
- To prepare map of India with respect to-major climatic zones and phyto-geographical regions of India and to comment on it.

Suggested Readings:

a) Plant Ecology:

- Chapman, J. L. and Reiss, M. J. (1992). Ecology – Principles and Applications, Cambridge University Press, Cambridge, UK
- Odum, E. P. and Barrett, G. W. (2005). Fundamentals of Ecology, 5th Edition, Cengage Learning, New Delhi, India
- 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.
- Bhatia, K. N., and Sharma, K. K.(1998),(5thEdition), A Treatise on Plant Ecology, Pradeep Publications, Jalaandhar.

b) Plant Geography:

- Good, R. (1997) : The Geography of flowering Plants (2nd Edn.,), Longmans, Green & Co., Inc., London & Allied Science Publishers, New Delhi -495pp.,
- Cain, S.A. (1944): Foundations of Plant Geography, Harper & Brothers, N.Y.

****

Paper code: BOT-402C

Paper title: PLANT PATHOLOGY

(Credits: Theory-4, Practical-2, Type of paper: Theory+Practical, No. of Lectures: 60)

Course outcomes:

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

CO1: Understand the basic concept of plant pathology and comprehend the disease cycle and various host and pathogen interactions.

CO2: Identify the common plant diseases and pathogens, isolate the pathogen and suggest control measures.

CO3-Demonstrate skills in laboratory and field related to plant pathology.

CO4-Identify the common plant diseases according to geographical location.

CO5-Enhance collaborative learning and communication skills through practical sessions, teamwork, group discussions and home assignments.

Unit: 1 Fundamentals of plant pathology **Lectures-10**

- Introduction, Concept of plant disease, history of plant pathology, common symptoms of plant diseases.

Unit: 2 Disease development **Lectures-10**

- Concept of disease cycle, Inoculation, Pre penetration, Penetration and post penetration. Host parasite interaction, Dissemination. Epidemics, defence mechanisms,

Unit: 3 Methods of Studying Plant Diseases **Lectures-10**

- Microscopic study, Macroscopic study, Koch's postulates. Culture technique, Media, Types and Preparation. Pure culture methods- streak plate, Pour plate, spread plate, Serial dilution.

Unit: 4. Principles of Plant Disease Control **Lectures-10**

- Eradication, cultural control practices, biological control, chemical control. Use of EMS, Plant Quarantine, IPM.

Unit: 5 Plant Diseases **Lectures-10**

- Study of Diseases- Club root of Crucifers, Powdery mildew of Pea, Late blight of potato, White rust of Brassicaceae, Rust of wheat, Leaf spot of cabbage, Blast of Paddy, Citrus

Canker, Tobacco Mosaic Disease with reference to causal organism, symptoms and signs, disease cycle and control measures.

Unit: 6. Resistance- **Lectures-10**

- Systemic acquired and induced systemic, Disease resistance, R-genes, gene for gene concept, immunity (PTI & ETI), hypersensitive response and cell death.

Practical: **Credit-2**

1. Preparation of fungal media (PDA).
2. Sterilization process.
3. Isolation of pathogen from diseased material.
4. Study of plant pathogenic fungi from diseased specimens (symptoms, causal organism and their morphological & reproductive characters) of Club root of Crucifers, Powdery mildew of Pea, Late blight of potato, White rust of Brasicaceae, Rust of wheat, Leaf spot of cabbage, Blast of Paddy, Citrus Canker, Tobacco Mosaic Disease.

Suggested Readings

- Dickinson, M.2008,-*Molecular Plant Pathology* ,Bios Scientific Publishers, London
- Gupta, G.P.,2004, *Text book of plant diseases*, Discovery Publ.House ,New, Delhi
- Mehrotra, R.S. 1991, *Plant Pathology*, Tata McGraw Hill Co.Delhi
- Singh, R.S.2004, *Plant Diseases*, Oxford & IBH Publishing Co. Pvt. Ltd., Delhi.
- Trigiano, Windham and Windham, 2003, *Plant pathology , Concepts and laboratory exercises* CRC Press London.

****

Paper code: BOT-403C

Paper title: ECONOMIC BOTANY, ETHNOBOTANY AND PHARMACOGNOSY

(Credits: Theory-4, Practical-2, Type of paper: THEORY+ Practical, No. of Lectures: 60)

Course outcomes:

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

CO1-Develop understanding of origin, distribution, and economic importance of certain plants.

CO2-Conceptualize ethnobotany as an interdisciplinary science and categorise various indigenous ethnic groups of Assam and realize their role in biodiversity and conservation.

CO3-Develop understanding on the pharmacognostic features of plants and recognize the basic medicinal plant.

CO4-Inculcate practical knowledge on phytochemical screening (both qualitative and quantitative) of plants.

CO5-Evaluate the drug adulteration and contamination through the microscopic, macroscopic and analytical methods.

a) Economic Botany: Lectures-15

Unit 1:

- Concept of Vavilov's centres of origin; primary and secondary centers of diversity, plant introductions, classification of plant resources on the basis of their uses.

Unit 2:

- A brief account, origin, distribution, botanical description, morphology, economically important products and uses of the following: Cereals -Rice; Beverages -Tea; Medicinal plants - *Taxus wallichiana, Cinchona, Rauwolfia*; Fibres - cotton and jute; Forest products - teak, bamboos and rattans (of NE India), gums and resins.

b) Ethnobotany: Lectures-15

Unit 3:

- Introduction, scope and objectives; Ethnobotany as an interdisciplinary science. Sacred groves and their role in conservation of biodiversity.

Unit 4:

- Different ethnic groups of Assam, Plants used by different ethnic groups of Assam as: a) Food, b) Intoxicants and beverages and c) Medicine.

c) Pharmacognosy:

Unit-5: Lectures-15

- Aims and objective of pharmacognosy, pharmacopoeas: History of Indian pharmacopoeas.
- Pharmacognosy of some medicinal plants Eg: *Ginger, Turmeric, Chirata, Rauwolfia, Adhatoda, Andrographis, Cinchona, Opium Poppy.*

Unit-6: Lectures-15

- Classification of crude drug, adulteration, substitution and contamination of Herbal drug.
- Introduction to the techniques for quality control, monitoring and regulation.

- Quality control methods: microscopic and macroscopic, chromatography, spectroscopy.
- Phytoconstituent Important to therapy -Alkaloids, Flavonoids, Tanins and steroids.

Practical : **Credit-2**

a) Economic Botany –

- Study of economically important plants.
- Rice, Tea, *Oscimum* and Neem, Jute, Cotton

b) Pharmacognosy

- Qualitative determination of phytochemicals from plants
- Determination of curcumin in Turmeric.
- Organographis studies of *Zingiber*, *Curcuma*, *Rauwolfia, Adhatoda, Andrographis, Cinchona*
- Determination of alkaloids by TLC.
- Determination of tannins in tea leaves

c) Ethnobotany

- Study of wild medicinal and edible plants used by ethnic communities of Assam.

Practicals should be supported by practical record /slides and specimens.

Suggested Readings:

a) Economic Botany.

- Hill, A. - (1972) Economic Botany.
- P.L. Kochar -(1981) Economic Botany.
- S.D. Sabnis and M. Daniel – (1990) A Phytochemical Approach to economic Botany.

b) Ethnobotany:

- Colton C.M. 1997. Ethnobotany – Principles and applications. John Wiley and sons-Chichester.
- Jain, S.K., 1989. Methods and approaches in ethnobotany. Society of ethnobotanists,
- Jain, S.K. , 1990. Contributions of Indian ethnobotny. Scientific publishers, Jodhpur.
- Jain, S.K(1995). Manual of Ethnobotany, Scientific Publishers, Jodhpur.
- Subramanyam, N.S. & Samba Murty, A.V.S. , Economic Botany. Wiley Eastern Ltd.

c) Pharmacognosy:

- Ali, Mohammad (2010) Text Book of Pharmacognosy (2nd Edition). CBS Publishers & Distributor Pvt .Ltd, New Delhi, India

- Raje V N (2010) Pharmacognosy, CBS Publishers & Distributor Pvt .Ltd, New Delhi, India.
- Shah, B and Seth A K(2014) A Text Book of Pharmacognosy & Phytochemistry (2nd Edition). Elsevier, India Private Limited.
- Singh, G K and A Bhandari A (2011) Text Book of Pharmacognosy, CBS Publishers & Distributor Pvt .Ltd, New Delhi, India.

****

Paper code: BOT-405GE

Paper title: PLANT PHYSIOLOGY & PLANT ECOLOGY

(Credits: Theory-4, Practical-2, types of paper: Theory+ Practical, No. of Lectures: 60)

Course Outcomes :

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

CO1-Develop conceptual understanding of plant water relation, mineral nutrition, plant metabolism and plant growth regulators.

CO2-Understand the physiological processes like, seed germination, photosynthesis, respiration and nitrogen metabolism.

CO3-Develop conceptual understanding of basic of ecology, ecosystem, community, biosphere, ecological succession, bio-geochemical cycles, energy flow and ecological factors.

CO4-Perform quantitative analysis of herbaceous vegetation by quadrate method and understanding ecological adaptations in Hydrophytes and Xerophytes.

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

a) Plant Physiology

Unit- 1: Plant water relations and Mineral nutrition: **Lectures-10**

- Diffusion, osmosis, plasmolysis, imbibition, ascent of sap, transpiration.
- Role of minerals in plants (deficiency symptoms, disease and function),
- Translocation of organic solutes.

Unit- 2: Plant metabolism: **Lectures-10**

- Photosynthesis - Photosynthetic pigments, photosynthetic light reactions, photo-phosphorylation, carbon assimilation pathways: C_3, C_4, and CAM (brief account);
- Respiration - Glycolysis, anaerobic respiration, TCA cycle, electron transport system;

- Nitrogen metabolism – Nitrate reduction and biological nitrogen fixation in *Rhizobium*.

Unit-3: Growth and development: **Lectures-08**

- Seed dormancy .
- Seed germinations
- Fruit ripening
- Physiology of flowering.
- Phytochrome

Unit-4: Plant growth regulators: **Lectures-10**

- Struction and role of Auxin, Gibberellin, Cytokinin, ABA and Ethylene
- Abiotic stress and role of hormone
- PGR's and their practical applications;

b) Plant Ecology

Unit 5 Plants and Environment: **Lectures-10**

- Basic concept of ecology, ecological organization- species, population, community, ecosystem and biosphere.
- Ecological factors: climatic factors- light and water. Ecological adaptations of Hydrophytes and Xerophytes.

Unit- 6. Community and Ecosystem Ecology: **Lectures-10**

- Community – Concept and characteristics (abundance, density and frequency),
- Ecological Succession- Causes, mechanism, primary and secondary succession, seral stages (with special reference to Hydrosere).
- Ecosystem - structure and functions, food chain, food web, energy flow, Bio- geo chemical cycles (with special reference to nitrogen cycle) and concept of ecological pyramids.

PRACTICALS:- **(Credits: -2)**

a) Plant Physiology:

- Determine the osmotic potential of cell sap by plasmolytic method.
- Determine the diffusion pressure deficit of plant cells by weight method.
- Determine the effect of time period on the rate of imbibition in different types of seeds (Starchy, proteinaceous and oily).
- Measure the effect of different environmental conditions on the rate of transpiration by Ganong's potometer.

- Determine the effect of CO_2 concentration on the rate of photosynthesis.
- Determine the RQ of different germinating seeds.

b) Ecology:

- Quantitative analysis of density and frequency of herbaceous vegetation by quadrate method
- Study of ecological adaptations
    - Hydrophytes - *Hydrilla, Eichhornia* and *Nymphaea*
    - Xerophytes: *Nerium, Aloe* and *Asparagus.*

Practicals should be supported by practical record.

Suggested Readings:

a) Plant physiology:

- Verma, S.K. and Verma M(2007) A textbook of Plant Physiology and Biochemistry, S Chand, India
- Malik, C.P.(2014) Plant Physiology, Kalyani Publisher, India.
- Hopkins WG (2014) Introduction to Plant Physiology, Wiley India.

b) Plant Ecology:

- Ambasht, R.S. (1974) - A text book of plant ecology (3rd Edn.) Students' Friends. & Co., Varanasi, India.
- Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4thedition.
- Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut,India.

----------XXXXXXXXXXXXXXX----------

Semester-V

Paper code: BOT-501C

Paper title: PLANT PHYSIOLOGY

(Credits: Theory-4, Practical-2, Type of paper: Theory+Practical, No. of Lectures: 60)

Course Outcomes:

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

CO1-Develop conceptual understanding of plant water relation, mineral nutrition, plant metabolism, plant growth regulators, translocation and photoperiodism in plant

CO2-Perform experiments to corelate physiological processes with plant functioning.

CO3-Develop experimental proficiency in isolation, separation and quantification of plant pigments, analysis of plant ash and estimation of amylase activity in seed.

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

Unit 1: Plant water relationship & Mineral nutrition **Lectures-11**

- Water Potential, water absorption by roots, pathway of water movement , aquaporins, Ascent of sap. Transpiration, mechanism and factors affecting transpiration, antitranspirant.
- Mineral nutrients- types, methods of study and importance, chelating agents, criteria for essentiality, mineral deficiency symptoms. Solute transport across cell the membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.

Unit 2: Plant photosynthesis **Lectures-10**

- Historical background, general concepts and factors affecting photosynthesis, photosynthetic pigments and LHCs and photosystems, photo-oxidation of water, mechanism of electron transport- photophosphorylation, C_3, C_4 and CAM pathways, photorespiration.

Unit 3: Respiration: **Lectures-08**

- General aspects, glycolysis, TCA cycle, electron transport and ATP synthesis and alternate oxidase system. Pentose phosphate pathway and its significance.

Unit 4: Translocation in the phloem: **Lectures-08**

- Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.

Unit 5: Plant growth regulators : Lectures-15

- Discovery, chemical nature (basic structure), bioassay and physiological roles of hormone (Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene. Brassinosteroids and Jasmonic acid) and their applications in agriculture and horticulture.

Unit 6: Plant responses to light and temperature Lectures-08

- Photoperiodism (SDP, LDP, Day neutral plants);
- Phytochrome: Discovery, chemical nature, mode of action, role of phytochrome in photomorphogenesis, low energy responses: (LER) and high irradiance responses (HIR).
- Vernalization.

Practical : Credit-2

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
4. Isolation and detection of photosynthetic pigments (Paper & TLC methods).
5. Effect of carbon dioxide on the rate of photosynthesis.
6. To compare the rate of respiration in plants.
7. To study the amylase activity in germinating seed.
8. Determination of photosynthetic pigments from leaf using spectrophotometer
9. Qualitative determination of elements in plant ash
10. Quantitative determination of at least two element from plant ash(Ca/P/Zn/Fe/Mg/B)

Suggested Readings

- Buchanan, B.B. Gruissem, W. and Jones, R.L. 2004. Biochemistry and Molecular Biology of plants. I.K. International PVT., New Delhi.
- Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U. S.A. 4th edition.
- Moore, T.C. 1989. Biochemistry and physiology of Plant Hormones. 2nd edition. Springer – Verlag, New York, USA.
- Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A (2015). Plant Physiology and Development.

****

Paper code: BOT-502C

Paper title: MICROBIOLOGY

(Credits: Theory-4, Practical-2, Type of paper: Theory+Practical, No. of Lectures: 60)

Course outcomes:

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

CO1-Recall the landmark historical events in the field of microbiology.

CO2-Summarize the characteristics of different types of microorganisms, and the methods used to classify them.

CO3-Describe structure, reproduction and importance of bacteria and virus along with the principles of microbial metabolism and growth

CO4-Explain the basic principles of immunology.

CO5-Demonstrate experimental proficiency in use of laboratory equipments and apply microbiological techniques to culture and isolate microorganisms from various sources.

Unit 1 : Fundamentals of microbiology **Lectures-11**

- **Historical Perspective**: Discovery of microbial world; Landmark discoveries relevant to the field of microbiology; Controversy over spontaneous generation
- **Methods in Microbiology**: Pure culture techniques; Theory and practice of sterilization; Principles of microbial nutrition; Enrichment culture techniques for isolation of microorganisms

Unit -2 Microbial Taxonomy and Diversity: **Lectures-10**

- Microbial taxonomy and its modern trends, Bergey's Classification of Bacteria ,distinguishing features of Actinomycetes, Archaebacteria and Mycoplasma, Rickettsiae & Chlamydeae, Microbiology of soil, water and air.

Unit- 3 Microbial growth and metabolism: **Lectures-15**

- Introduction to Metabolism, Catabolism: Catabolic Pathways (Glycolysis; Pentose-phosphate pathway; Entner-Doudoroff Glyoxylate pathway; The citric acid cycle) ATP generation pathways (Fermentation; Aerobic and anaerobic respiration;) Definition of growth; Growth curve; Mathematical expression of exponential growth phase; Measurement of growth and growth yields; Synchronous growth; Continuous culture

Unit -4 : Bacteriology **Lectures-08**

- Ultra structure of bacterial cell ,Reproduction- vegetative, asexual, sexual (conjugation, transformation and transduction) ,Bacterial genome and plasmid ,Economic importance of Bacteria

Unit -5 Virology **Lectures-10**

- Discovery of Virus, Classification of viruses. Replication, lytic (T4 phage) and Lysogenic cycle (Lambda phage); RNA virus (TMV), Retro virus (HIV); Virioids and Prions

Unit -6: Immunology: **Lectures-6**

- Concept of immunology, types of immunity, antigen and antibody-structure and classes.

Practical:

1. Techniques on cleaning and Sterilization of equipments.
2. Preparation of media (Potato-dextrose- Agar and Rose Bengal Agar Media)
3. Pure culture technique: slant, Streak-plate methods; Pour-plate method.
4. Inoculation of microbes from air, soil and water by serial dilution.
5. Determination of microbial population by haemocytometer.
6. Study of Gram positive and Gram negative bacteria.
7. Isolation of plasmid-DNA (E.coli) by using a standard method of any authentic kit: Gel-electrophoresis (Agarose-gel), quantification of DNA and purity.

Suggested readings:

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

****

Paper Code: BOT-503DSE

Paper title: DSE-1

(Credit: 5+1+0)

(To be opted from MOOCs under swayam courses in any of the specified area mentioned in the title of the paper or the student can opt from the pool of theory papers given)

- BIOETHICS, IPR & BIOSAFETY
- TRENDS IN PLANT SCIENCES
- ENVIRONMENT IMPACT ASSESSMENT
- ECOSYSTEM SERVICES

Course outcomes:

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

CO1-Gain knowledge on different upcoming fields of botany.

CO2-Comprehend the significance of upcoming concerns related to bioethics, IPR practices etc.

CO3-Realise the importance of environmental issues for sustainable development.

****

Theory papers for DSE:

Paper code: BOT-503DSE-1

Paper title: BIOETHICS, IPR AND BIOSAFETY

(Credits: Theory-5, Tutorial-1, Type of paper: THEORY Lectures:70

Course outcomes-

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

CO1-Accumulate concept on Intellectual Property Rights legislations and regulations.

CO2-Develop understanding on bio-piracy and traditional knowledge

CO3-Appreciate the importance biosafety and their guidelines

CO4-Understand the implications of bio-hazards and bio- terrorism

CO5-Inculcate good laboratory and manufacturing practices

CO6-Demonstrate understanding on Bio-ethics and their relevance to the current scenario

Unit-1: Intellectual Property Rights (IPR) **Lectures-10**

- Introduction to IPR, types of IPR (patent, copyrights, geographical indications, trademarks, trade secret), treaties in ipr, patent laws, legislations covering ipr's in india, ipr protection,

Unit-2: IPR and Biotechnology **Lectures-08**

- Patent filing in biotechnology, provisional and complete specification, patentable and non-patentable items.

Unit-3: Protection of resources **Lectures-08**

- Biopiracy, protection of traditional knowledge, protection of plant varieties and farmers right .

Unit-4: Biosafety concept **Lectures-10**

- History and concept of biosafety, guidelines, regulations ,need and application of biosafety in laboratories and industries; norms of biosafety,

Unit -5: Risk management **Lectures-10**

- Risk assessment and containment levels; biohazard, bio-medical and hazardous wastes, handling and disposal; transportation of biological materials; bio-terrorism.

Unit-6: Biosafety protocol and guidelines **Lectures-10**

- Biosafety protocol (Cartagena biosafety protocol) regulations to protect nature, growers and consumers interest and nation interest; GMO products, release and related issues.

Unit -7: Biosafety practices and quality control **Lectures-04**

- Good laboratory practices (GLP) and Good manufacturing practices (GMP) – quality control Bioproducts.

Unit- 8: Bioethics **Lectures-10**

- Introduction and need of bioethics, its relation with other branches, Ethics related to agriculture, Bioethical ethical issues in India through case studies.

Suggested readings:

- Arthur Raphael Miller, MichealH.Davis(2000) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers.
- Jonathan, Y.R(2005). Anthology of Biosafety (Vols. 1-4), American Biological Safety Association
- N.K. Acharya (2001): Textbook on intellectual property rights, Asia Law House.

- Sateesh, M.K. (2008). Bioethics and Biosafety, IK International publishers.
- Singh I. and Kaur, B. (2006). Patent law and Entrepreneurship, Kalyani Publishers.

****

Paper code: BOT-503 DSE-2

Paper titles: TRENDS IN PLANT SCIENCES

(Credits: Theory-5, Tutorial-1, Type of paper: THEORY, No. of Lectures: 70)

Course outcomes:

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

CO1-Develop fundamental understanding of emerging fields of botany like plant phenomics, genomics, proteomics and metabolomics.

CO2-Inculcate understanding on techniques of growing plants like hydrophonics , aerophonics and aquaponics.

CO3-Conceptualize fundamentals of nanotechnology and phytosynthesis of nanoparticles and its application in agriculture.

Unit-1: Plant Phenomics **Lectures-13**

- Plant phenomics: Definition and concept; History of plant phenotyping; Traits for phenotyping, Screening for plant features, Concept of High-Throughput plant phenotyping platforms.

Unit-2: Plant Genomics **Lectures-10**

- Concept of genes and genomes; Plant genome projects (Arabidopsis, Rice and Maize), gene sequencing, Plant genomic databases, importance of genomics in agriculture

Unit-3: Plant Proteomics **Lectures-15**

- Proteomics: Basic concepts: Aims, strategies, application and challenges in proteomics. Proteomics technologies: 2D-electrophoresis, MALDI-TOF mass spectrometry, Protein-protein interactions: experimental and computational methods, Protein structure and function analysis, Proteomic databases.

Unit-4: Plant metabolomics **Lectures-10**

- Metabolomics: Introduction to metabolomics: metabolite, metabolome and metabolic pathways, techniques in metabolomics. NMR, LC-MS and GC-MS in metabolomics, metabolic databases, metabolic data analysis.

Unit-5: Trends in plant propagations **Lectures -10**

- Micropropagation: Principle and applications, Hydrophonics - definition , concept , advantages and disadvantages; aerophonics, aquaphonics .Principle and application; types of aquaphonics design.

Unit-6: Phyto-nanotechnology **Lectures- 12**

- Basic concept of nanotechnology: Definition and Scope, Biomimetic and bioinspired nanomaterials, phytosynthesis of nanoparticles, physiological effect of nanoparticles on plants; uptake, translocation and phytoxicity; Application of nanoparticles in agriculture.

Suggested Readings

- Jitendra Kumar , Aditya Pratap and Shiv Kumar(Eds)(2015), Phenomics in Crop Plants: Trends, Options and Limitations, DOI 10.1007/978-81-322-2226-2_1,
- Shivendu_Ranjan , Nandita_Dasgupta Eric_Lichtfouse (Editors)(2016) Nanoscience and Food in Agriculture Vol-I, © Springer International Publishing Switzerland.
- Tripathi DK, P Ahmad, S Sharma, D Chauhan, N K Dubey(2017) Nanomaterials in Plants, Algae, and Microorganisms(Vol-1&2), Elsevier, India
- Richard Twyman(2004), Principles of Proteomics. CBS Publishers & Distributors-New Delhi
- Sastia Prama Putri and Eiichiro Fukusak, Mass Spectrometry-Based Metabolomics: A Practical Guide .
- William J Griffiths (Editor), Stephen Neidle , Metabolomics, Metabonomics and Metabolite Profiling.

****

Paper code: BOT-503 DSE-3

Paper title: ENVIRONMENT IMPACT ASSESSMENT & ECOSYSTEM SERVICES

(Credits: Theory-5, Tutorial-1, Type of paper: THEORY, No. of Lectures:70)

Course outcomes:

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

CO1-Develop critical understanding of environmental impact.

CO2-Grow understanding of important steps of EIA processes.

CO3-Understand ecosystem functions and services.

CO4-Comprehend the concept of MEA, PES and Payment for Carbon sequestration.

a) Environment Impact Assessment (EIA): Lectures-35

Unit 1- EIA – concept, origin and development; purpose and aim; core values and principle.

Unit 2 EIA process; environmental components of EIA.

Unit 3- Main participants in EIA process; evaluation methodology; diversification of EIA.

Unit 4- EIA in India; EIA notification 2006 (amended in 2009).

b) Ecosystem Services: Lectures-35

Unit 1- Ecosystem functions and ecosystem services; value of ecosystem services and natural capital at a global level.

Unit 2- The Millennium Ecosystem Assessment (MEA) categories; valuation of ecosystem services.

Unit 3- Payment for ecosystem services (PES).

Unit 4- PES based on upstream forest conservation; wetland banking; payment for Carbon sequestration by forest.

Suggested readings:

- Ecology, Environmental Science and Conservation.J.S. Singh, S.P. Singh and S.R. Gupta (2014). S.Chand and Company Pvt. Ltd., New Delhi.
- A Text Book of Botany (Ecology and Environmental Biology; Economic Botany and Pharmacognosy) . Vol. IV. K. Bhattacharya, A.K. Ghosh and G. Hait (2017). New Central Book Agency (P) Ltd.
- Payment for Environmental Services in Agricultural Landscapes: Economic Policies and Poverty Reduction in Developing Countries. L. Lipper, T. Sakuyama, R. Stringer, D. Zilberman (Eds) (2009). Springer.
- Environmental Impact Assessment: A guide to Best Professional Practices. C.H Eccleston (2011). CRC Press.
- Environmental Impact Assessment. A.K. Shrivastava (2003). APH Publishing.

****

Paper code: BOT-504DSE

Paper title: DSE-2

(Credit: 4+0+2)

(Only one To be opted from the following pool of papers)

1. PLANT STRESS BIOLOGY
2. BIODIVERSITY AND CONSERVATION BIOLOGY
3. PLANT IDENTIFICATION: TOOLS & TECHNIQUES

Detail of the papers:

Paper code: BOT-504DSE-1

Paper title: PLANT STRESS BIOLOGY

(Credits: Theory-4, Practical-2, types of paper: THEORY, No. of Lectures: 60)

Course outcomes:

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

CO1-Develop fundamental understanding of plant stress physiology.

CO2-Elaborate physiological impact of abiotic and biotic stress in plants and develop strategies for managing abiotic stress for increasing sustainable crop production.

CO3-Develop experimental proficiency in study of physiological and biochemical traits in plant in response to stress.

Unit-1 Fundamentals of stress physiology: Lectures-06

- Basic concept of stress: Definition, Types; Stress avoidance, acclimatization and adaptation in plant.

Unit-2 Stress signalling in plant: Lectures-12

- Stress sensing and perception, signaling components; Calcium, MAPP Kinases, IP, Abiotic stress signaling in plant.Hormone mediated abiotic stress signaling and responses in plants

Unit-3-Stress responses in plants : Lectures-10

- Physiological impact of abiotic stress in plant; drought stress, flood stress, metal stress , temperature stress, salt stress, biotic stress in plant: allellopathic stress, pathogen induced stress.

Unit-4-Defence systems in plant: **Lectures-12**

- ROS and antioxidant: definition, types, sources, impact and methods of ROS detection in plant.
- Osmotic adjustment: Role of proline, glycine betain, sorbitol, mannitol.

Unit-5 Stress-responsive proteins in plants **Lectures-10**

- Stress responsive proteins and their functions in plants; Aquaporins, Dehydrins, HSP, Phytochelatins and metallothionins LEA, transcription factors and abiotic stress regulation in plants

Unit-6 Abiotic stress management in plant : **Lectures-10**

- Role of mineral nutrition; Micro RNA ; Transgenic approach for stress resistant crop. Bt cotton, Bt Brinjal, Golden Rice.

PRACTICAL: **(Credit-2)**

1. To measure relative water content in leaves of plant
2. To determine RGR in plant
3. To study morphological changes in plant under water stress.
4. To determine stress tolerance index in plant
5. To isolate and estimate protein by Bradford in stressed plant
6. To estimate proline content in stressed leaves
7. To study lipid peroxidation in plant during abiotic stress
8. To estimate Ascorbate content in plant
9. To estimate Antioxidant activity in plant
10. To estimate catalase activity in plant
11. To estimate peroxidase activity in plant
12. Determination of H_2O_2 content in plants
13. **Demonstrations**

- Histochemical detection of ROS in plant
- Electrophoresis of Protein using SDS PAGE
- Study of plant phenotype under stress
- Amplification of stress responsive gene using PCR.

Practicals should be supported by practical record.

Suggested readings:

- Buchanan, Gruissem, and Jones. 2000. Biochemistry and Molecular Biology of Plants. Wiley-Blackwell-ASPB, Rockville, MD.
- G R Rout & A B Das (Eds)(2013)Molecular Stress Physiology of Plants, Springer, India
- Levitt.J. 1980.Response of Plants to Environmental Stresses.Vols. I, II.Academic John Wiley & Sons.
- Sergey Shabala (2017) Plant Stress Physiology, CABI international
- Taiz and Zeiger 2010. Plant Physiology. 5th Edition. Sinauer Associates, Inc. Sunderland, MA

****

Paper code: BOT-504 DSE-2

Paper title: Biodiversity and Conservation Biology

(Credits: Theory-4, Practical-2, type of paper: THEORY+ PRACTICAL, No of Lectures: 60)

Course outcomes:

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

CO1-Understand the concept and scope of biodiversity.

CO2- Learn the origin of crop plants and concept of agrobiodiversity.

CO3-Identify the causes and implications of loss of biodiversity.

CO4- Utilize various strategies for the conservation of biodiversity.

a) Biodiversity: Lectures-24

Unit-1: Defining biodiversity

- Definition, concept, scope and importance of biodiversity, levels and value of biodiversity..

Unit-2: Agrobiodiversity

- Vavilov's centre of origin of crop plants. Wild relatives of cultivated plants,

Unit-3: Biodiversity in India

- India as a megabiodiversity nation, biodiversity in India with special reference to Northeastern region, hotspots in India

b) Conservation Biology: Lectures-36

Unit-4: Conceptual foundations

- Definition and concept of conservation biology. Significance and Conservation of biodiversity.

Unit-5: Threats to biodiversity

- Habitat degradation and loss, Habitat fragmentation, species invasions and overharvesting /overexploitation.

Unit-6: Principles of conservation

- Conservation strategies- IUCN threat categories, Red Data Book-RET plants of India, *in-situ* conservation (Biosphere reserves and National Parks) and ex-situ conservation (Botanical gardens, seed bank and germplasm bank) ;

Practical: **Credits-2**

1. To study the plant diversity within the University campus.
2. To identify plant conservation measures taken up in and around Guwahati.
3. Study of endemic plants in Indian flora with special reference to N.E India (at least 10) and to prepare a map.
4. To prepare a map of Biodiversity Hotspots of India with special reference to North eastern region.
5. Study of the state flower and state tree of Assam - specimen/chart/photographs.
6. Study of wild relatives of cultivated plants through fresh specimens/photographs/herbariums/museum specimens: *Camellia sinensis* var. *assamica*, *Citrus assamensis*, *Trichosanthes tomentosa.*

Practicals should be supported by practical record.

Suggested readings:

- J.S. Singh, S.P. Singh and S.R. Gupta (2014). Ecology, Environmental Science and Conservation. S.Chand and Company Pvt. Ltd., New Delhi.
- K. Bhattacharya, A.K. Ghosh and G. Hait (2017). A Text Book of Botany (Ecology and Environmental Biology; Economic Botany and Pharmacognosy) . Vol. IV. New Central Book Agency (P) Ltd.
- Biodiversity and Conservation. M.J. Jeffries (1997). Routledge, Taylor and Francis Group.
- Tropical Rain Forest Ecology, Diversity & Conservation. J. Ghazoul and D. Sheil (2010). Oxford Biology.

- F.V. Dyke (2003). Conservation Biology: Foundation, Concepts, Applications. Springer.

****

Paper code: BOT-504 DSE-2

Paper title: Plant Identification: Tools and Techniques

(Credits: Theory-4, Practical-2, Type of paper: Theory+ PRACTICAL, No. of Lectures-60)

Course outcomes:

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

CO1- Develop understanding of different concepts, categories and approaches of plant classification.

CO2-Identify the sources of taxonomic characters in different disciplines.

CO3-Interpret the rules of ICN in relevant aspects of botanical nomenclature.

CO4-Explain different forms of taxonomic literature.

CO5-Learn the methods and techniques of identification of different group of plants.

CO6- Grow skills in adopting specific techniques suitable for identification of locally available plants of different groups.

Unit-1: Principles of plant Identification **Lecture- 10**

- Aim and objectives, Concept and approach of different classificatory systems, phenetic, phyletic, cladistics and APG in plant classification and identification.

Unit-2: Nomenclature **Lecture- 10**

- ICN- salient features, rules and recommendations and related issues in plant nomenclature, Concept of taxonomic rank.

Unit-3: Methods **Lecture- 10**

- Methods of identification of different group of plants: algae, fungi, lichen, bryophytes, pteridophytes, gymnosperms and angiosperms .

Unit-4: Tools and Techniques **Lecture-10**

- Field and herbarium techniques, preservation of museum and herbarium specimens, preservation techniques for lower and higher group of plants. Botanical keys.

Unit-5: Role of different branches in plant identification **Lecture- 10**

- Morphology, anatomy, palynology, cytology, phyto-chemistry, numerical taxonomy, molecular biology.

Unit-6: Taxonomic literature **Lecture- 10**

- General reference, classical literature, Illustration, Icons; Important state, regional and all India floras, journals, manual, monograph and revision.

PRACTICAL **(Credit-2)**

1. Tools and Techniques in identification:
2. Field and herbarium techniques and preservation of museum and herbarium specimens including special types of plants (aquatic plants, succulent and xerophytes, palm, canes and bamboos).
3. Study and identification (using different techniques learned in theory) of at least two specimens of locally available plants belonging to each of the following:
   - Algae
   - Fungi
   - Lichen
   - Bryophyte
   - Pteridophytes
   - Gymnosperm
   - Angiosperm
4. Handling of floras and manuals.

Practicals should be supported by practical record, specimen and herbarium (at least ten)**.**

Suggested Readings:

a) Algae:

- John, D. M.,Whitton, B.A and Brook, A. J.(eds.) The Freshwater Algal Flora of the British Isles: An Identification guide to fresh water and terrestrial algae.
- Vashishta, B.R : Botany for degree students –Algae.

b) Fungi:

- Aneja, K. R. Experiments in Microbiology, Plant Pathology and Biotechnology. New Age International(P) Limited Punlishers. New Delhi.

- Barnett, H.L. Illustrated Genera of Imperfect Fungi. Burgess Publishing CO. 426 South Sixth Street Minneapolis 15, Minn

c) Lichen

- Dobson, F. (2011). Lichens: an Illustrated Guide to the British and Irish Species (6th edition). Richmond Publishing, Slough. 480 pp. The best overall field identification guide for Britain & Ireland.
- Huneck, S. and Yoshimura, I. (2012). Identification of Lichen Substances. Springer.

d) Bryophytes

- Rashid, A. (1998). An Introduction to Bryophyta. Vikas Publishing House.
- Chaudhary, B.L., Sharma, T. P. and Sukhadia, M.L. 2006. Bryophyte Flora Of Gujarat (India). Himanshu Publication

e) Pteridophytes:

- Rashid, A. (1979). An Introduction to Bryophyta. Vikas Publishing House PVT Limited.
- Borthakur, S.K., Deka. P. and Nath, K.K. 2001. Illustrated Manual of Ferns of Assam. M/s Bishen Singh Mahendra Pal Singh.

f) Gymnosperms:

- Vasishta, P.C : Gymnosperm.
- James W. Byng. (2015). The Gymnosperms Handbook: A practical guide to extant families and genera of the world. Plant Gateway Ltd.

g) Angiosperm Morphology:

- Singh, G. (2012). Plant Systematics: Theory and Practice. Completely revised and enlarged 3rd edition. Oxford & IBH, New Delhi.
- Simpson, M. (2018). Plant Systematics (3rd Edition). Elsevier Academic Press. Amsterdam Boston Heidelberg London, New York Oxford Paris San Diego, San Francisco Singapore Sydney Tokyo.

----------**XXXXXXXXXXXXXXXXX**----------

Semester-VI

Paper code: BOT 601C

Paper title: CYTOGENETICS & PLANT BREEDING

(Credits: Theory-4, Practical-2, type of paper: THEORY+ PRACTICAL, No. of Lectures: 60)

Course outcomes:

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

CO1-Comprehend the concept of gene, inheritance pattern, gene interactions and population genetics.

CO2-Conceptualize genetic disorder, mutation, genetic resources and gain basic knowledge on breeding methods in plants.

CO3-Develop practical skills to study chromosome morphology, karyotype analysis and chromosomal aberration in certain plants.

CO4-Solve problems on expression of hereditary characters and identify chromosomal aberrations.

a) Cytogenetics **Lectures-35**

Unit-1: Principles of inheritance:

- Mendel's law, allelic and non-allelic gene interaction.

Unit-2: Inheritance pattern:

- Nuclear, quantitative, cytoplasmic, extra chromosomal and sexlinked inheritance, epigenetics.

Unit-3: Linkage and crossing over:

- Theories of Linkage and crossing over, cytological basis of crossing over, Genetic map and genetic recombination.

Unit-4: The principles of population genetics:

- Allele and Genotype Frequencies, Hardy-Weinberg Equilibrium, Genetic Drift, Coalescent Theory, Gene Flow and Subdivision.

b) Plant Breeding **Lectures-25**

Unit-5: Principles of plant breeding

- Centre of origin of crop plants and diversity, acclimatization, introduction and domestication of crops.

Unit-6: Breeding methods:

- Selection, hybridization, back & test cross method, heterosis and inbreeding depression (genetic basis), male sterility, and mutation breeding with special emphasis on polyploidy and their significance in evolution of new species.

Practicals: **Credit-2**

1. Study of Chromosome morphology and Karyotype analysis of locally available specimen through squash preparation.
2. Study chiasma frequency through temporary squash preparation
3. Study of chromosomal aberration in plants (Translocation in *Tradescantia / Rhoeo*)
4. Chromosome mapping through three point cross
5. Study of gene interaction segregation ratios.
6. Study of Aneuploidy: Downs, Klinefelters and Turners syndromes(Photographs).
7. Photograph /permament slides showing Laggard, chromosome bridge, and inversion
8. Study of Emasculation in plants.

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

****

Paper code: BOT 602C

Paper title: PLANT BIOCHEMISTRY

(Credits: Theory-4, Practical-2, Paper title: THEORY+ Practical, No. of Lectures:60)

Course outcomes

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

CO1-Demonstrate understanding of structure, function and classification of biomolecules.

CO2-Interpret the anabolic and catabolic pathways of metabolism and its energetics.

CO3-Conceptualize basic plant metabolism, different biochemical pathways and their regulations.

CO4-Develop skills in isolation and estimation of carbohydrates, protein, amino acid, enzymes and total phenolics in plants using standard methods

CO5-Demonstrate the separation of proteins by SDS PAGE, fluorescence and absorption of isolated plant pigments.

Unit-1: Biomolecules: **Lectures-10**

- Structure, functions and classification of
  - Carbohydrates:
  - Amino acids
  - Proteins:
  - Lipids

Unit-2: Enzymes and vitamins **Lectures-10**

- Classification, properties, mechanism of action, regulation of enzyme activity, Application of enzymes, role of regulatory enzymes (allosteric, covalent modulation and isozymes).
- Vitamins: Classification and function, Vitamins as coenzyme

Unit3: Carbon Oxidation and Energy metabolism **Lectures-12**

- Introduction, anabolic and catabolic pathways, regulation of metabolism, bioenergetic, redox potential, Regulation of glycolysis and TCA cycle, amphibolic role, anaplerotic reactions, mitochondrial electron transport system, cyanide-resistant respiration, Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase- Boyers conformational model, Racker's experiment, Jagendorfs experiment; role of uncouplers.

Unit-4 Nucleic acid metabolism **Lectures-10**

- Biosynthesis of purines and pyrimidines
- Degradation of purines and pyrimidines
- Interconversion of purines and pyrimidines

Unit-5: Lipid metabolism **Lectures-10**

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

Unit-6: Nitrogen metabolism **Lectures-08**

- Nitrate assimilation, biological nitrogen fixation; Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.
- Secondary metabolites biosynthesis with special reference to phenolics

Practical : **Credit-2**

1. To determine protein in plant sample using Lowry's methods
2. To determine total sugar in plant sample using Anthrone methods
3. To determine optimum temperature of enzyme
4. Determination of amino acids by paper chromatography
5. Determination of total phenolics in plants.
6. Seperation of sugar from plant using paper chromatography
7. To determine activity of enzymes using amylase.
8. **Demonstrations**

- To separate protein isolated from plant using SDS PAGE
- Demonstration of fluorescence by isolated chlorophyll pigments.
- Demonstration of absorption spectrum of photosynthetic pigments.

Practical should be supported with practical records.

Suggested Readings:

a) **Plant Biochemistry:**

- Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons.U.S.A. 4th edition.
- Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A(2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
- Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.

- David L Nelson and Michael M. Cox (2017) (seventh edition), Leninger Principles of Biochemistry, W. H. Freeman and Company.

****

Pools of DSE papers to be opted in Semester-VI (one out of two in DSE-3 offered)

Paper	Paper code	Title of optional paper	Credit
DSE3	BOT-603DSE	1. Biotechnology, Bioinformatics and biostatistics	4+0+2
		2. Advanced plant pathology and Microbiology	4+0+2
DSE4	BOT-604DSE	Dissertation	0+0+6

****

Detail of papers:

Paper code: BOT-603 DSE-1

Paper title: BIOTECHNOLOGY, BIOINFORMATICS & BIOSTATISTICS

(Credits: Theory-4, Practical-2, Type of paper: Theory+Practical, No of Lectures: 60)

Course outcomes

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

CO1-Develop the concept of biological databases, genomics and proteomics, DNA sequencing and sequence alignment, drug designing, molecular evolution and phylogenetic analysis.

CO2-Understand rDNA technology, and perform experiments associated with in-vitro culture.

CO3-Skills in tabulation, representation, interpretation and analysis of biological data using the principles of biostatistics.

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

Unit-1 Basic Biotechnology: Lectures-10

- Scope and branches of Biotechnology, plant tissue culture technique and its application, nutrient media, somaclonal variation.

Unit -2 DNA recombinant technology **Lectures-10**

- Basic technique, restriction enzymes, vectors, DNA libraries, DNA fingerprinting, applications of DNA recombinant technology in agriculture and medicines, transgenic plants.

Unit-3 Introductory Bioinformatics **Lectures-15**

- Introduction to Bioinformatics, branches, aim &scope of bioinformatics (genomics, proteomics and transcriptomics), Biological databases, DNA data bank, biological database retrieval systems.

Unit-4 Sequencing and phylogeny **Lectures-08**

- DNA sequencing, Application of proteomics in drug discovery and drug design, basics of molecular phylogeny,

Unit-5: Basic Biostatistics **Lectures-11**

- Collection of data, Sampling theory and methods, measures of central tendency (mean, mode, median), variation and coefficient of variation, Standard deviation and Standard error.

Unit-6 Inferential statistics **Lectures-06**

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

Practical: **Credit 2**

1. To work out mean, mode, standard deviation, standard error and coefficient of variation
2. Preparation and sterilization of nutrient medium (MS medium), slant preparation & micro propagation of some important plants.
3. Study of preparation of synthetic seeds.
4. Study of genetic engineering techniques (photographs): FISH, DNA Fingerprinting, Gene gun, Ti plasmid, Bt cotton, Golden rice, Savr flavr tomato.
5. Construction of Restriction Map from the data provided.
6. Nucleic acid and protein databases, Sequence retrieval from databases
7. Sequence alignment.
8. Sequence homology and Gene annotation
9. Construction of phylogenetic tree

Practical should be supported with Practical record.

Suggested Readings:

- Harisha, S. (2007) Fundamentals of Bioinformatics. I.K. International Publishing House.
- Jogdand, S.N. Gene Biotechnology ——Himalay Publishing House
- Prasad S, Elements of Biostatics – Rastogi Publications
- Rana S.V. S, Biotechniques, Theory and Practice –,Rastogi Publications.
- Sharma, V et al., Textbook of Bioinformatics-- Rastogi Publications.
- Xiong, J. (2006) Essential Bioinformatics. Cambridge University Press.

****

Paper code: BOT-603DSE-2

Paper title: ADVANCED MICROBIOLOGY & PLANT PATHOLOGY

(Credits: Theory-4, Practical-2, Type of paper: Theory+Practical, No. of Lectures: 60)

Course outcomes

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

CO1-Develop the concept of genome organization & gene regulation in prokaryotes and cell signalling.

CO2-Understand the concept of plant diseases and the underlying genetic basis and design strategies for sustainable plant disease management.

CO3-Exhibit experimental proficiency in identification of plant diseases and isolation of the pathogens.

CO4-Perform experiments on control of plant diseases.

a) MICROBIOLOGY **Lectures-30**

Unit-1: Genome organization & regulation in prokaryotes

- Denaturation and melting curves. Genome organization in prokaryotes, translation in prokaryotes control of gene expression at transcription and translation level (regulating the expression of phages, viruses, prokaryotic),

Unit-2: Host parasite interaction:

- Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells.

Unit-3: Cell signalling

- Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component systems, light signaling in plants, bacterial chemotaxis and quorum sensing.

b) PLANT PATHOLOGY **Lectures-30**

Unit-4: Concept of plant disease:

- Concept of plant disease, Economic aspects of plant diseases, Types of plant diseases, Infectious diseases, non-infectious diseases, causative agents of plant diseases, host range of pathogens, weapons of plant pathogens, effect of pathogen on physiology of host plant

Unit-5: Genes and Diseases:

- Types of plant resistance to pathogens (Horizontal and Vertical Resistance). 'R' Genes and 'avr' genes, Genetics of virulence in pathogens and resistance in host plants. Breeding for disease resistance.
- Defence mechanisms of plants. plant disease epidemiology: elements of an epidemic and development of epidemics, plant disease forecasting

Unit-6: Disease control and management:

- Exclusion, eradication, cross protection, direct protection, integrated disease management, chemical methods of plant disease control. Biotechnological approaches to plant disease management. Gene Silencing and disease control, mechanism of gene silencing and control of viral diseases. Engineered resistance to viral, bacterial, fungal and insect diseases of crop plants.

Practical: **Credits-2**

1. Isolation of bacterial, fungal, and nematode plant pathogens of crop plants
2. Estimation of foliar infection by Stover's method.
3. Estimation of total phenols in diseased and healthy plant tissues.
4. Study of tobacco mosaic, bacterial blight; downy mildew of maize; powdery mildew of cucurbits; grain smut of sorghum; leaf rust of coffee; root knot of mulberry. bunchy top of banana, grassy shoot of sugar cane, little leaf of brinjal; potato spindle tuber disease (PSTVd)
5. Study of effect of pathogens on seed germination and vigour index.
6. Study of effect of fungicide on seed-borne pathogens.

7. Study of Fungal bio-control agents.

Practical should be supported with Practical records and permanent slides**.**

Suggested readings:

- Dickinson, M. 2003. Molecular Plant Pathology, Garland Publishing Inc, CT.
- Ingram, D.S. and Robertson, N.F. 1999. Plant Diseases, Collins Publishers, London.
- Lane, C.R., Beales P.A. and Hughes, K.J.D. 2012. Fungal Plant Pathogens, CABI Publishing, Wallingford.
- Mehrotra, R. S., 2003. Plant Pathology, 2nd edn.Tata Mc. Graw Hill Pub. Co. Ltd., New Delhi.
- Pelczar, M.J. (2001) Microbiology, 5th edition, Tata Mc Graw-Hill Co, New Delhi.
- Presscott, L. Harley, J. and Klein, D. (2005) Microbiology, 6th edition, Tata Mc Graw-Hill Co. New Delhi.
- Schumann, G. L. and D‟Arcy, C. J. 2012. Hungry Planet: Stories of Plant Diseases, APS Press, USA.

****

Paper code: BOT-604 DSE (Project Work)

(Credit:0+0+6, Type of paper: Project))

Course outcomes:

On completion of the project 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-inculcate skills in data analysis, interpretation, scientific writing, and presentation.

----------XXXXXXXXXXXXXXXX----------