ROYAL GLOBAL UNIVERSITY
GUWAHATI

ROYAL SCHOOL OF LIFE SCIENCES

DEPARTMENT OF BOTANY

PROPOSED SYLLABUS & COURSE STRUCTURE

MASTER OF SCIENCE IN BOTANY

W.E.F. SEPTEMBER 2022

2022-2023

TABLE OF CONTENTS

Preamble

Over the past decades the higher education system of our country has undergone substantial structural and functional changes resulting in both quantitative and qualitative development of the beneficiaries. The upgradation of Postgraduate programmes will play an extremely important role in promoting human as well as societal well-being and in developing India as envisioned in its Constitution - a democratic, just, socially conscious, cultured, and humane nation upholding liberty, equality, fraternity, and justice for all. A holistic and multidisciplinary education would aim to develop all capacities of human beings - intellectual, aesthetic, social, physical, emotional, and moral in an integrated manner. Such an education will help develop well-rounded individuals that possess. Such changes will further result in learning outcome based curriculum in order to maximize the benefits of the newly designed curriculum. The learning outcome based curriculum in general and in Botany in particular will definitely help the teachers of the discipline to visualize the curriculum more specifically in terms of the learning outcomes expected from the students at the end of the instructional process. It is pertinent to mention here that the purpose of education is to develop an integrated personality of the individual and the educational system provides all knowledge and skills to the learner for this.

The template as developed has the provision of ensuring the integrated personality of the students in terms of providing opportunity for exposure to the students towards core courses, discipline specific courses, generic elective courses, ability enhancement courses and skill enhancement courses with special focus on technical, communication and subject specific skills through practical and other innovative transactional modes to develop their employability skills. The template of learning outcome based framework has categorically mentioned very well defined expected outcomes for the programme like core competency, communication skills, critical thinking, affective skills, problem-solving, analytical, reasoning, research-skills, teamwork, digital literacy, moral and ethical awareness, leadership readiness and so on along with very specific learning course outcomes at the starting of each course. Therefore, this template on Learning Outcomes based Curriculum Framework (LOCF) for M.Sc. in Botany Honors under The Assam Royal Global University will be more flexible, multi-disciplinary, holistic and will definitely be a landmark in the field of outcome based curriculum construction.

1. INTRODUCTION

1.1 About the Department:

1.1.1Historical background of Department

The Department of Botany, The Assam Royal Global University, was established in 2018 with about 66 students and a few faculty members. The dynamic and visionary contributions of several renowned botanists and educationist earned the Department recognition for its teaching and research.

1.1.2 Department highlights in terms of its ranking, courses

The Department of Botany is committed to expand and absorb the wide diversity of scientific disciplines associated with the study of plants. Our B.Sc., M.Sc., and Ph.D. programmes are multi-faceted and designed to empower post-graduate students and researchers with a holistic and comprehensive education across a wide range of subject areas, which would enable them to contribute effectively to basic and applied education and research in plant biology.

1.1.3 About the programme

The M.Sc. – Botany programme includes a wide diversity of courses covering all aspects of Plant Sciences. In addition to unique combinations of basic, advanced and applied courses (as Core and Discipline-Specific Elective papers), the programme also has a strong interdisciplinary component. Emphasis is on experiential learning through hands-on laboratory exercises, field trips and projects. Current thrust areas of teaching provide students with substantial exposure and skills in plant biology. The disciplines studied include plant structure, growth and development, molecular biology, physiology, biochemistry, pathology, ecology, genetics, systematics, evolution, bioinformatics, biostatistics and transgenic technology on a variety of taxa ranging from algae, fungi and other microbes, bryophytes and vascular plants (ferns, gymnosperms and angiosperms including crop plants) at the cellular, organismal, community and ecosystem levels.

1.1.4 About Post Graduate Attributes

In addition to academic rigor and training in subject-specific areas listed above, our students are also well trained in ethics, critical thinking, reasoning and analytical skills, effective communication, laboratory safety, sensitivity to environment and sustainable living.

1.1.5 About the process of course development involving various stakeholders at different stages.

The draft course contents are finalized by the Academic Council after extensive deliberations and discussions involving all faculty members in Board of Studies Meetings. Feedback from students and alumni are obtained during their study periods. The draft courses are uploaded on the University website to invite comments and suggestions from various stakeholders and reviewed by the Council Prior to approval by the Departmental Council, Courses Committee of UG and PG in Botany and then sent to two external experts in the subject area for their critical inputs and suggestions. The finalized course contents were then discussed in school Board of Studies and submitted for administrative approval by statutory bodies of RGU.

2. Introduction to CBCS (Choice Based Credit System) Choice Based Credit System:

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on performance in examinations which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enable the potential employers in assessing the performance of the candidates.

2.1 Approach to Curriculum Planning

While designing these frameworks, emphasis is given on the objectively measurable teaching-learning outcomes to ensure employability of the graduates. In line with recent trends in education section, these frameworks foster implementation of modern pedagogical tools and concepts such as flip-class, hybrid learning, MOOCs and other e-learning platforms. In addition, the framework pragmatic to the core; it is designed such a way to enable the learners implementing the concepts to address the real world problems. A major emphasis of these frameworks is that the curriculum focuses on issues pertinent to India and also of the west; for example, biodiversity and conservation of endemic and threatened species that are found in India, Indian climatological variables, Indian biodiversity and so on. Above all, these frameworks are holistic and aim to mould responsible Indian citizen who have adequate skills in reflective thinking, rational scepticism, scientific temper, digital literacy and so on such that they are equipped to fight immediate social issues apropos to Indian milieu, including corruption and inequity.

The fundamental premise underlying the learning outcomes-based approach to curriculum planning and development is that higher education qualifications such as a Master's Degree (Hons) programmes are earned and awarded on the basis of (a) demonstrated achievement of outcomes (expressed in terms of knowledge, understanding, skills, attitudes and values) and (b) academic standards expected of graduates of a programme of study.

Learning outcomes-based frameworks in any subject must specify what postgraduates completing a particular programme of study are (a) expected to know, (b) understand and (c) be able to do at the end of their programme of study. To this extent, LOCF in MSc Botany is committed to allowing for flexibility and innovation in (i) programme design and syllabi development by higher education institutions (HEIs), (ii) teaching-learning process, (iii) assessment of student learning levels, and (iv) periodic programme review within institutional parameters as well as LOCF guidelines, (v) generating framework(s) of agreed expected graduate attributes, qualification descriptors, programme learning outcomes and course learning outcomes. HEIs, on their turn, shall address to the situations of their students by identifying relevant and common outcomes and by developing such outcomes that not only match the specific needs of the students but also expands their outlook and values.

2.2Definitions:

i. 'Academic Programme' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/ Centre
ii. 'Course' means a segment of a subject that is part of an Academic Programme
iii. 'Programme Structure' means a list of courses (Core, Elective, Open Elective) that makes up an Academic Programme, specifying the syllabus, Credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University Rules, eligibility criteria for admission
iv. 'Core Course' means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course

v. ‘Elective Course’ means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre
vi. ‘Open Elective’ means an elective course which is available for students of all programmes, including students of same department. Students of other Department will opt these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.
vii. ‘Credit’ means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 Credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course
viii. ‘SGPA’ means Semester Grade Point Average calculated for individual semester.
ix. ‘CGPA’ is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.
x. ‘Grand CGPA’ is calculated in the last year of the course by clubbing together of CGPA of two years, i.e., four semesters. Grand CGPA is being given in Transcript form. To benefit the student a formula for conversation of Grand CGPA into %age marks is given in the Transcript.

2.3 Nature and Extent of Master’s Degree Programme in Botany:

A student pursuing 2 years post-graduate programme in Botany shall be awarded an appropriate Degree in that discipline on completion of 4th Semester if he/she secures 102 Credits. An illustration of credits requirements in relation to the type of award is illustrated below:

Sl. No.	YEAR	Mandatory Credits to be secured for the Award
1	After successful completion of 1st Year	52
2	After successful completion of 2nd Year	50

Master’s Degreeis a well-recognized, structured, and specialized Post graduate level qualification in tertiary, collegiate education. The contents of this degree are determined in terms of knowledge, understanding, qualification, skills, and values that a student intends to acquire to look for professional avenues or move to higher education at the postgraduate level.

Master’s Degreeprogrammes attract entrants from the graduate level or equivalent, often with subject knowledge that are directly relevant to the field of study/profession. Thus, MSc Course in Botany aims to equip the students to qualify for joining a profession or to provide development opportunities in particular employment settings. Post Graduates are enabled to enter a variety of jobs or to continue academic study at a higher level.

2.4 Aims of Master’s DegreeProgramme in Botany:

The overall objectives of the Learning Outcomes-based Curriculum Framework (LOCF) for M.Sc.- degree in Botany are-

1. To impart the basic knowledge of Plant Sciences with theories, principles, processes, and studies of traditional and modern botany.
2. To impart more multi-disciplinary and holistic course curriculum.
3. To develop the learners providing research-based knowledge
4. To equip the students in solving the practical problems pertinent to India
5. To mould responsible citizen for nation-building and transforming the country towards the future

6. To provide an environment that ensures cognitive development of students in a holistic manner. A dialogue about plants and its significance is fostered in this framework, rather than didactic monologues on mere theoretical aspects
7. To provide the latest subject matter, both theoretical as well as practical, such a way to foster their core competency and discovery learning. A botany graduate as envisioned in this framework would be sufficiently competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.
8. To mould a responsible citizen who is aware of most basic domain-independent knowledge, including critical thinking and communication.
9. To enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination

3. Master of Science in Botany Programme Details: Programme Objectives (POs):

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

3.1 Program Learning Outcomes relating to MSc Botany degree Programme in Botany:

The student graduating with the Degree M.Sc. Botany should be able to acquire

PO 1: Knowledge of Botany : Students will acquire core competency in the subject Botany, and in allied subject areas.

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

PO 2:Critical Thinking and problem solving ability: An increased understanding of fundamental concepts and their applications of scientific principles is expected at the end of this course. Students will become critical thinker and acquire problem solving capabilities.

PO 3: Digitally equipped: Students will acquire digital skills and integrate the fundamental concepts with modern tools.

PO 4: Ethical and Psychological strengthening: Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.

PO 5: Team Player: Students will learn team workmanship in order to serve efficiently institutions, industry and society.

PO 6: Independent Learner: Apart from the subject specific skills, generic skills, especially in botany, the program outcome would lead to gain knowledge and skills for further higher studies, competitive examinations and employment. Learning outcomes based curriculum would ensure equal academic standards across the country and broader picture of their competencies.

3.2 Programme specific Learning Outcomes

Programme Specific Outcomes (PSOs):

PSO1. A student completing the course is able to understand different specializations of Botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various life-forms.
PSO2. The student completing the course is trained in various analytical techniques of plant biology, use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.
PSO3. The student completing the course is able to identify various life forms of plants, design and execute experiments related to basic studies on evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, proteomics and transgenic technology. Students are also familiarized with the use of bioinformatics tools and databases and in the application of statistics to biological data.
PSO4. The student completing the course is capable of executing short research projects incorporating various tools and techniques in any of the basic specializations of Plant Sciences under supervision.

3.3 Teaching Learning Process

Teaching and learning in this programme involve classroom lectures, Practical lab and tutorials.

It allows-

• The tutorials allow a closer interaction between the students and the teacher as each student gets individual attention.

• Written assignments and projects submitted by students

• the project-based learning

• Group discussion

• Home assignments

• Quizzes and class tests

• PPT presentations, Seminars, interactive sessions

• Diversity survey

• Co-curricular activity etc.

• Industrial Tour or Field visit

3.4 Assessment Methods

Methods	**Weightage**
Semester End Examination	70%
Internal Assessment	30%
Total	**100%**

4.Programme Specific Outcomes (PSOs):

PSO1: A student completing the course is able to understand different specializations of Botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various life-forms.
PSO2: The student completing the course is trained in various analytical techniques of plant biology, use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.
PSO3: The student completing the course is able to identify various life forms of plants, design and execute experiments related to basic studies on evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, proteomics and transgenic technology. Students are also familiarized with the use of bioinformatics tools and databases and in the application of statistics to biological data.
PSO4: The student completing the course is capable of executing short research projects incorporating various tools and techniques in any of the basic specializations of Plant Sciences under supervision.

5 Programme Structure:

The Master of Science in Botany programme is a two-year course divided into four semesters. A student is required to complete 102 credits for completion of the course and the award degree.

6. SCHEME OF EVALUATION

I. Theory Papers (T)	II. Practical Papers (P)	III. Combined Theory & Practical Papers (TP):
Continuous Evaluation: 15%	Continuous Evaluation: 25%	Continuous Evaluation: 15%
(Assignment, Class Test, Seminar, Quiz : Any Three)	(Skill Test, lab copy, viva, lab involvement: Any Three)	(Assignment. Class Test, Seminar, Lab Experiment, Copy and Viva: Any Three)
Mid-term examination: 10%	----------	Mid-term examination: 10%
Attendance: 5%	Attendance: 5%	Attendance: 5%
Semester End Examination: 70%	Semester End Examination: 70%	Semester End Examination: 70%

M.Sc. BOTANY (*W.E.F* SEPT 2022), 2022-2024							
1ST SEMESTER							
Sl.No.	**Subject Code**	**Names of papers**	**L**	**T**	**P**	**C**	**TCP**
Core Papers							
1	BOT144C101	Mycology & Plant pathology	4	0	0	**4**	**4**
2	BOT144C102	Microbiology	4	0	0	**4**	**4**
3	BOT144C103	Cryptogams: Algae, Bryophytes & Pteridophytes	4	0	0	**4**	**4**
4	BOT144C104	Gymnosperms and Advanced morphology	4	0	0	**4**	**4**
5	BOT144C115	Mycology, Plant pathology and Microbiology (Practical)	0	0	6	**3**	**6**
6	BOT144C116	Cryptogams Gymnosperms & Advanced Morphology (Practical)	0	0	6	**3**	**6**
	Total credits for core papers					**22**	**28**
Ability Enhancement Compulsory Courses (AECC)							
6	CEN984A101	Communicative English – I	1	0	0	**1**	**1**
7	BHS984A101	Behavioural Science – I: Introduction to behavioural science	1	0	0	**1**	**1**
Discipline Specific Elective (DSE) (ANY ONE TO BE SELECTED)							
8	BOT144D101	Bioprocess Development	3	0	0	**3**	**3**
9	BOT144D102	Ethnobotany and Phytogeography	3	0	0	**3**	**3**
Total credits			**17**	**0**	**6**	**27**	**33**
2ND SEMESTER							
Sl.No.	**Subject Code**	**Names of papers**	**L**	**T**	**P**	**C**	**TCP**
Core Papers							
1	BOT144C201	Angiosperm Taxonomy	4	0	0	**4**	4
2	BOT144C202	Cytology, Genetics and Plant Breeding	4	0	0	**4**	4
3	BOT144C203	Plant Physiology	4	0	0	**4**	4
5	BOT144C215	Angiosperm taxonomy & Cytology (Practical)	0	0	6	**3**	**6**
6	BOT144C216	Plant physiology, genetics & plant breeding (Practical)	0	0	6	**3**	**6**
	Total credits for core papers					**18**	**24**
Ability Enhancement Compulsory Courses (AECC)							
6	CEN984A201	Communicative English – II	1	0	0	**1**	**1**
7	BHS984A202	Behavioural Science – II: Development of Individuals and Behavioural Skills	1	0	0	**1**	**1**
Ability Enhancement Elective Courses (AEEC)							
8	BOT144S221	**Floriculture**	2	0	0	**2**	**2**
Discipline Specific Elective (DSE) (ANY ONE TO BE SELECTED)							
9	BOT144D201	Genomics and Proteomics	3	0	0	**3**	**3**
10	BOT144D202	Biodiversity and Conservation Biology	3	0	0	**3**	**3**
11	BOT144D203	Herbal Technology	3	0	0	**3**	**3**
Total credits			**19**	**0**	**6**	**25**	**31**
3RD SEMESTER							

Sl.No.	Subject Code	Name of papers	L	T	P	C	TCP
Core Papers							
1	BOT144C301	Angiosperm anatomy and Embryology	4	0	0	**4**	**4**
2	BOT144C302	Plant Biochemistry & Molecular Biology	4	0	0	**4**	**4**
4	BOT144C313	Angiosperm anatomy, Embryology, Biochemistry & Molecular Biology (Practical)	0	0	8	**4**	**8**
Total credits for core papers						**12**	**16**
Ability Enhancement Compulsory Courses (AECC)							
5	CEN984A301	Communicative English – II	1	0	0	1	**1**
Ability Enhancement Elective Courses (AEEC)							
6	BOT144S321	Mushroom cultivation	2	0	0	2	**2**
Discipline Specific Elective (DSE) (Any one to be selected)							
7	BOT144D301	Microbiology- I	2	0	2	4	**5**
8	BOT144D302	Advanced Plant Physiology & Biochemistry - I	2	0	2	4	**5**
9	BOT144D303	Angiosperm Taxonomy- I	2	0	2	4	**5**
COMPULSORY PAPER							
10	BOT144C321	**Special paper through Dissertation based on research work (any 4 to be offered in a given semester)** 1. Plant – soil microbe interactions 2. Microbial Ecology 3. Plant Molecular Biology 4. Advanced Plant Physiology 5.Taxonomy and diversity of angiosperms 6.Development and Reproduction of angiosperms 7. Plant Biotechnology 8. Lower plants	0	0	12	**6**	**12**
Total credits			**13**	**0**	**22**	**25**	**35**

4TH SEMESTER

Sl.No.	Subject Code	Names of papers	L	T	P	C	TCP
Core Papers							
2	BOT144C401	Plant Ecology and Environment	4	0	0	**4**	**4**
3	BOT144C402	Bio Statistics and Bioinformatics	4	0	0	**4**	**4**
4	BOT144C413	Plant Ecology, Environment Biostatistics & Bioinformatics (Practical)	0	0	8	**4**	**8**
Total credits for core papers						**12**	**16**
Ability Enhancement Compulsory Courses (AECC)							
5	CEN984A401	Communicative English – II	1	0	0	1	**1**
Discipline Specific Elective (DSE) (Any one paper to be selected)							
6	BOT144D401	Microbiology - II	3	0	2	4	**5**
7	BOT144D402	Advanced Plant Physiology & Biochemistry - II	3	0	2	4	**5**
8	BOT144D403	Angiosperm Taxonomy- II	3	0	2	4	**5**
COMPULSORY PAPER							

9	BOT144C421	Special paper through Dissertation based on research work (continued from 3rd semester) 1. Plant – soil microbe interactions 2. Microbial Ecology 3. Plant Molecular Biology 4. Advanced Plant Physiology 5.Taxonomy and diversity of angiosperms 6.Development and Reproduction of angiosperms 7. Plant Biotechnology 8. Lower plants	0	0	16	8	**16**
Total credits			**12**	**0**	**26**	**25**	**38**
Total credits of the course:							**102**

SEMESTER WISE DISTRIBUTION OF COURSES AND CREDITS:

Semester	**No. Of Core papers**	**No. of DSE papers**	**No. of AECC papers**	**No. Of AEEC papers**	**Project (Minor/Major)**	**Total credit**
1st	6	1	2	none	None	27
2nd	6	1	2	1	None	25
3rd	3	2	1	1	Major	25
4th	3	1	1	none	Major	25
Total						102

1ST SEMESTER SYLLABUS
CORE PAPERS (ALL COMPULSORY)

PAPER I: MYCOLOGY & PLANT PATHOLOGY
SUBJECT CODE: BOT144C101,
CREDIT UNITS: L-T-P-C = 4-0-0-4
SCHEME OF EVALUATION: Theory Papers (T);
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objective:

The course is designed with the objectives to introduce pathological significance of various plant pathogens and to build up the knowledge among the students about host parasite interaction and the methods to develop disease free plants.

Course Outcomes:

By the end of the course the students will be able to:

CO1: **Outline** and **Classify** the Kingdoms of fungal diversity.**[BT1 &BT2]**
CO2: Review and **relate** to different types of fungal association and the recent trends in its application.**[BT2 &BT3]**
CO3:Categorizethe different types of plant pathogens and the host parasite mechanism of action. **[BT4]**.
CO4:Explain the different biotechnological techniques that can be used for disease and pest management. **[BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Fungi**: Fungal cell structure. Recent trends in classification and phylogeny, thallus organization, Different mode of Reproduction in fungi. Physiological and ecological specialization. Comparative account of Phycomycetes, Ascomycetes, Basidiomycetes and Fungi Imperfectii. Applied Mycology.	**12**
II	**Fungal Associations:** Mycorrhiza: General characteristics. Types, Structure and Reproduction. Economic importance of Mycorrhiza. Recent advances in mycorrhizal studies. **Lichens:** General characteristics. Mechanism of phycobiont and mycobiont interaction. Lichen as ecological indicator. Economic importance of Lichens. Distribution of Lichens in North east. Recent advances in lichenology.	**10**
III	**Introduction to plant pathology**: Scope and significance, Classification of plant diseases on the basis of causal agents, symptoms. Transmission of viral diseases and dissemination of plant diseases, Epidemiology **Host parasite interaction**: Mode of infection, Pathogenesis, role of enzymes and toxins in pathogenesis, defence mechanism and disease resistance. Role of environment in disease development. Case studies of economically important causative agents with specific references to crop plant such as Rice, Wheat, Tea, Potato, Cucurbits, Crucifer**s.**	**16**

IV	**Methods of control**: Cultural, Physical, chemical and biological control of plant pathogen and pests. Plant quarantines; Disease forecasting, Integrated disease and pest management. **Biotechnology and plant pathology**: techniques and application of biotechnology in plant pathology. Tissue culture techniques in plant pathology, production of disease free plants.	**10**
Total		**48**

Reference Books:

1. Paul Khurana, S. M. 2009: Pathological Problems of Economic crop plants and their management.
2. Planke, J. E. Vander. (2013) Plant Diseases Epidemics and control.
3. Sinclair W.A. and H.H. Lyon. Diseases of Trees and Shrubs. 2005. Cornell University Press.
4. Webster J and Weber R.W.S. Introduction to Fungi. 2007. Cambridge University Press.
5. Lucas J.A. Plant Pathology and Plant Pathogens. 2011. John Wiley and Sons Ltd.
6. Williamson VM, Kumar A (2006) Nematode resistance in plants: the battle underground. Trends in Genetics 22: 396–403.
7. Davis EL, Hussey RS, Baum TJ (2004) Getting to the roots of parasitism by nematodes. Trends in Parasitology 20: 134–141.
8. Plant Nematology (2006) Edited by Perry and Moens, CABI.
9. Induced responses to herbivory by R Karban and IT Baldwin (1997) Chicago University Press, Chapter 3, pg47-100.
10. Mathew's Plant Virology by Roger Hull (2001) Academic Press, NY.
11. Plant resistance mechanisms (SAR, ISR) - Strange RN, (2003) Introduction to Plant Pathology, John Wiley & Sons, USA.

PAPER II: MICROBIOLOGY
SUBJECT CODE: BOT144C102,
CREDIT UNITS: L-T-P-C = 4-0-0-4
SCHEME OF EVALUATION: Theory Papers (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objectives:

The course is designed to introduce the students on the structural and functional property of microbial diversity and to enlighten them about the ecological and economic importance of different microbes.

Course Outcomes:

By the end of the course the students shall be able to:

CO1: **Classify**the physical dimensions, forms, function and habitats of bacteria. **[BT2].**
CO2:Generalise the structure of typical viruses, their mode of replication, host ranges of typical plant and animal viruses and pathogenesis of viral diseases.**[BT2].**
CO3: Interpret the different ecological group of microoragism and select the different modes of nutrition techniques required for its growth.[**BT3 &BT4].**
CO4: Outline the various modes of industrial application for production of value-aided products**. [BT4].**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Microbiology:** Introduction, scope and classification of microorganisms. Classification of bacteria according to Berger's Manual of Determinative Bacteriology. Bacterial nutrition and growth. Genetic recombination and transformation. Economic importance of Bacteria.	**12**
II	General properties of viruses, Viral genome; their types and structure, Plant viruses – structure and replication, movement and interaction with plants, Viroids and sub-viral particles , Bacteriophages, mycophages and cyanophages: features and economic importance; Breeding for virus resistance, natural mechanisms and transgenic strategies, relevance to Indian agriculture.	**14**
III	Ecological groups of microorganisms based on O2 requirement, carbon sources, temperature (psychrophiles, mesophiles, thermophiles, hyperthermophiles), extremophiles (acidophiles, alkalophiles, halophiles, barophiles), and nutrition (saprophytism, parasitism and symbiosis); microbial growth; batch culture: synchronous and continuous culture.	**10**
IV	Microorganisms in food, food spoilage and food poisoning; fermented foods and method of food preservation (physical and chemical); microbes in industrial production of alcohol, organic acids and antibiotics; bio-fertilizers: types and mass production; microbes in bioremediation.	**12**
Total		**48**

Text Books:

1. Pelczar, M.J. 2005. Microbiology. Tata McGraw-Hill Co, New Delhi
2. Wiley, J.M., Sherwood, L.M. and Woolverton C.J., 2013. Prescott. Microbiology. McGraw Hill International. Brown A.E. and Smith H. Benson's 2014. Microbiological Applications: Laboratory Manual in General Microbiology. McGraw-Hill Education.

Reference Books:

1. Tortora G.J., Funke B.R., Case C.L., Weber D and Bair W. 2018. Microbiology: An Introduction. Pearson Publisher.
2. Madigan M.T., Martinko J.M., Bender K.S., Buckley D.H., Stahl D.A., Brock T. Brock. 2014. Biology of Microorganisms (14th Edition). Pearson Publisher.
3. Harvey R.A. and Cornelissen C.N. 2012. Lippincott Illustrated Reviews: Microbiology (Lippincott Illustrated Reviews Series) Third, North American Edition. LWW.

PAPER III: CRYPTOGAMS
SUBJECT CODE: BOT144C103,
CREDIT UNITS: L-T-P-C = 4-0-0-4
SCHEME OF EVALUATION: Theory Papers (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objective:

To teach the students about the Origin, classification, diversity, economic and ecological importance of algae, bryophytes and pteridophytes.

Course Outcomes:

By the end of the course the students shall be able to:

CO1:**Classify** algae based on habitat, structure, mode of division and reproduction. **[BT2].**
CO2: **Generalize** the different classes of bryophytes based on its habitat, mode of reproduction and its association with other microorganisms. **[BT2].**
CO3: **Discuss** the origin and classes of pteridophytes and **illustrate** the culture of fern gametophyte for experimental investigation. **[BT2].**
CO4: **Illustrate and outline** the application of phycology, bryology and pteridophytes in environment monitoring. **[BT3 &BT4].**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Algae**; Introduction to Phycology as a subject, Criteria for algal classification; classical and poly-phasic classification systems. Diversity of habitat, cell structure, thallus organization and reproduction among algae. General overview of algal divisions: diagnostic characters and reproduction of major algal divisions. Cyanobacteria, diversity of light harvesting pigments, food reserves, extracellular products and flagellar structures in algae.	**12**
II	**Bryophytes**: Origin and classification of bryophytes; vegetative and sexual reproduction; mechanism of dehiscence of capsules and dispersal of spores in bryophytes; evolution of gametophytes and sporophytes; association of bryophytes with microorganisms; anisospory and sexual dimorphism; biologically active compounds in bryophytes; ecological and economic importance of bryophytes.	**12**
III	**Applied Phycology and Bryology**: Economic, ecological and biotechnological importance of algae, algae as the most efficient CO2 fixers, algae for bioremediation and as biofertilizers. Algae in global warming – carbon capture by algae. Algal blooms and Eutrophication Bryophytes as site indicators. Role of Bryophytes in Ecosystem Dynamics and in global carbon budget, Bryogeography and conservation of bryophytes	**12**
IV	**Pteridophytes**: Origin of pteridophytes: theories of algal and bryophytean origins; classification; morphological, anatomical and reproductive diversity; telome theory; enation theory; stelar evolution; heterospory and seed habit; apogamy and apospory; ecological and economic importance of pteridophytes. Diversity of Ferns - an ecological perspective, Culture of fern gametophyte for experimental investigation.	**12**
Total		**48**

Textbooks:

1. A.V. S. S. Sambamurty 2006. A Textbook Of Bryophytes, Pteridophytes, Gymnosperms And Paleobotany. I.K. International Publishing House Pvt.Ltd.
2. Stewart W.N. and Rothwell G.W. Paleobotany and the evolution of plants. Cambridge University Press.
3. G.M. Smith. Cryptogamic Botany, vol I and II. McGraw-Hill
4. Andersen RA (2005). Algal Culturing Techniques. Physiological Society of America. Elsevier Academic Press, USA.
5. Cole KM and Sheath RG (1990). Biology of the Red Algae. Cambridge Univ. Press, Cambridge.
6. Fritsch FE (1945). The Structure and Reproduction of Algae. Vol. II. Cambridge Univ. Press. Cambridge, London.
7. Isabella A. Abbott, George J and Hollenberg (1993). Marine Algae of California. Stanford University Press. USA.
8. Lee RE (1989). Phycology. Vol. II. Cambridge Univ. Press. Cambridge, USA.
9. South GR and Whittick A. (1987). Introduction to Phycology. Blackwell Scientific Publications. London.

Reference Books:

1. R. S. Chopra. Taxonomy of Indian mosses: an introduction. Publications & Information Directorate, CSIR, New Delhi.
2. Charlotte M. W. Ross. 2018. A Manual of Cryptogamic Botany: Adapted to the Requirements of the Science and Art Department (Classic Reprint**).** Forgotten Books publisher.
3. Andersen RA (2005). Algal Culturing Techniques. Physiological Society of America. Elsevier Academic Press, USA.

PAPER IV: GYMNOSPERMS & ADVANCED MORPHOLOGY
SUBJECT CODE: BOT144C104,
CREDIT UNITS: L-T-P-C = 4-0-0-4
SCHEME OF EVALUATION: Theory Papers (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objective:

The course has been devised to impart information on various types of seed plants present, their significance and to highlight on both gymnosperms and advanced morphological structures in plant kingdom.

Course Outcomes:

By the end of the course the students shall be able to:

CO1:**Outline** the origin, evolution and salient structural features of gymnosperms.**[BT1]**
CO2:**Describe** the characteristic of living gymnosperms along with its application to overcome environmental stresses **[BT2 &BT3]**
CO3:**Sketch and examine** the differentiation phenomenon that lead to the development of advanced morphology in plants: **[BT3 &BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Gymnosperms I**: History and recent systems of classification of gymnosperms; origin and evolution of gymnosperms; affinities of gymnosperms with pteridophytes and angiosperms; distribution of gymnosperms in India; economic importance of gymnosperms; salient structural features and affinities of fossil gymnosperms; pro-gymnosperms; Pteridospermales; Cycadeoidales (Bennettitales); Pentoxylales; Cordaitales.	**14**
II	**Gymnosperms II**: General characteristics of living gymnosperms: Cycadales, Ginkgoales, Taxales, Coniferales, Ephedrales, Gnetales, and Welwitschiales. Comparative morphology and developmental anatomy of Gymnosperms, Reproductive Biology of Gymnosperms, Impact of coniferous forest on human life. Application of biotechnology in Acclimatization and adaptive responses of conifers to environmental stresses.	**14**
III	**Advance morphology I:** Origin and evolution of angiosperms sperms, inflorescence types and angiospermic flowers, evolution of pollinations vis-a-vis pollinators, concept of flower as modified shoot; 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.	**10**
IV	**Advance morphology II**: Theories and the development of leaf, stamen and carpel (Phyllode theory, Telome theory, Carpel polymorphism, Inferior ovary, placenta and placentation), seed and seed structure; role of morphology in plant classification.	**10**
Total		**48**

Text Books:

1. Bhatnagar, S.P. and Moitra A. Gymnosperms. New Age International Private Limited, New Delhi.
2. Biswas, C. and Johri, B.M. The Gymnosperms, Narosa Publishing House, New Delhi.
3. Coulter, J.M. and Chamberlain, C.J. Morphology of Gymnosperms, Central Book Depot, Allahabad

Maheshwari, P. and Vasil, V. Gnetum CSIR (Monographs).

Reference books:

Eames A. J. (1961) Morphology of angiosperms, McGraw Hill Publisher, New York.

PAPER V: MYCOLOGY, PLANT PATHOLOGY & MICROBIOLOGY (PRACTICAL)
SUBJECT CODE: BOT144C116
CREDIT UNITS: 0-0-6-3
SCHEME OF EVALUATION: Practical (P)
[Continuous Evaluation: 25%: Skill Test, lab copy, viva, lab involvement (Any Three)
Attendance: 5%, Semester End Examination: 70%]

Course Objective:

To introduce the students to the world of microbes by showing live cultures and photographs of bacteria and viruses and to enable the students to have a hands-on experience on observing algae and fungi under microscope.

Course Outcomes:

By the end of the course the students shall be able to:

CO1: Use the different laboratory equipment used in microbiology.[**BT3]**
CO2: Prepare culture media for different microoragnisms. [**BT3]**
CO2: **Perform** experiments used in identification, isolation and characterisation of bacteria, fungi and mycorhizza.[**BT4]**
CO4: **Select and outline** plant diseases bases on symptoms.[**BT4]**

Detailed syllabus:

Practicals would be based on the theory syllabus and would broadly include the following:

Module	Course content	Lecture hours
I	1. Introduction to basic Microbial Techniques and Lab. Safety. 2. Principles & working of tools, equipment's and other requirements in the microbiology, Mycology & Plant Pathology laboratory. 3. Calibration of microscope and measurement of dimension of microbial cells. 4. Gram staining of bacteria 5. Isolation, identification and enumeration of bacteria and fungi from soil, litter and air.	**09**
II	6. Preparation and maintenance of pure cultures. 7. Isolation of pathogens from diseased tissues (leaf, stem and fruit) by serial dilution method. 8. Preparation and sterilization of various microbial culture media and inoculation.	**09**
III	9. Study of morphological, anatomical and reproductive features of any 3, subjected to availability *Phytopthora, ii) Mucor, iii) Rhizopus, iii) Penicillium, iv) Pezziza, v) Saccharomyces, vi) Alternaria.* 10. Measurement of fungal growth by weight determination. 11. Make suitable micropreparations and identify the diseases mentioned with due emphasis on symptoms and causative organisms. 12. Study of mycorrhiza from available sources and their propagation and isolation in laboratory	**09**

	13. Study of morphological and anatomical features of some lichens growing in Assam.	
IV	14. Collection and identification of causal organisms from diseased plant materials. 15. Characterization of disease symptoms and identification of pathogenic organisms. 16. Collection and preservation of specimens from infected plants. Submit 5 herbarium sheets/live specimens along with a report /Preparation of disease album	**09**
Total		**36**

PAPER VI: CRYPTOGAMS, GYMNOSPERMS & ADVANCED MORPHOLOGY (PRACTICAL)
SUBJECT CODE: BOT144C116
CREDIT UNITS: 0-0-6-3
SCHEME OF EVALUATION: Practical (P)
[Continuous Evaluation: 25%: Skill Test, lab copy, viva, lab involvement (Any Three)
Attendance: 5%, Semester End Examination: 70%]

Course Objectives:

Study of diversity of algae, bryophytes and Pteridophytes w.r.t systematic position and morphology. The course also entails morphological, anatomical and reproductive features of angiosperms and the study on structure of some selected species

Course Outcomes:

By the end of the course the students shall be able to:

CO1: Use the different laboratory equipment used in microbiology: [**BT3]**
CO2: **Prepare** culture media for different microoragnisms.: [**BT3]**
CO2: **Perform** experiments used in identification, isolation and characterisation of bacteria, fungi and mycorhizza: [**BT4]**
CO4: **Select and outline** plant diseases bases on symptoms. [**BT4]**

Detailed syllabus:

Practicals would be based on the theory syllabus and would broadly include the following:

Module	Course content	Lecture hours
I	1. Study of diversity of freshwater and marine algae 2. Study of range of thallus organization and reproductive structures of algae with the help of suitable representatives (any 3, subjected to availability) *i) Nostoc, ii) Anabaena, iii) Volvox, iv) Ulva, v) Pithopthora, vi) Chara, vii) Ectocarpus, viii) Polysiphonia, ix) Fucus, x) Batrachospermum.* 3. Phytoremediation experiments (report + virtual lab)	**09**
II	*4.* Study the morphology and reproductive structures of (any 3, subjected to availability) i*) Riccia, ii) Marchantia, iii) Anthoceros, iv) Porela, v)*	**09**

	Sphagnum, vi) Polytrichum. 5. Study of morphology and reproductive structures of (any 3, subjected to availability) i*) Psilotum, ii) Lycopodium, iii) Selaginella, iv) Equisetum, v) Azolla, vi) Ophioglossum, vii) Isoetes.*	
III	6. Detailed study of distribution of cryptogams in North East India with the help of available resources. 7. Study of fossil gymnosperms from photographs and museum specimens. 8. Study of morphological, anatomical and reproductive features of gymnosperms available in the region.	**09**
IV	9. Study of morphological, anatomical and reproductive features of angiosperms available in the region. 10. Preparation of pollen grain slides by following different techniques. 11. Study of various modified structures of angiosperms from available sources. 12. Field study.	**09**
Total		**36**

DISCIPLINE SPECIFIC PAPERS (only one to be selected)

PAPER I: BIOPROCESS DEVELOPMENT
SUBJECT CODE: BOT144D101,
CREDIT UNITS: L-T-P-C = 3-0-0-3
SCHEME OF EVALUATION: Theory (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objective: The course is developed with an aim to identify and apply biological agents for the production of a specific bioproduct with the desired yield and purity.

Course Outcomes: On completion of the course the student shall be able to:

CO1:Classify PGPM and **predict** the use of specific PGPM in different areas of agriculture. **[BT2 & BT3]**
CO2:Categorize the different microbes and the raw materials that can be used for the production of different types biofuels. **[BT 4]**
CO3: **Outline** a model that can be used be tried and applied for future perspective. **[BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	Plant growth promoting microbes (PGPM) and their mass production for agriculture and forestry; principles and usage of bioreactors; types of bioreactors; microbial fermentation.	**9**

II	Environmental monitoring of GEMs; bioconversion of waste products by microbes with special reference to biogas and organic compost; steroid bio-transformations. **Biofuels Production process:** Various Biofuels production processes from renewable energy sources, merits and demerits of different biofuels production processes. Various microbes involved, Different biochemical routes for the Biofuels production.	**10**
III	**Introduction to biofilms and EPS** • Review of microbial lifestyle/basic concepts in microbiology, adhesion, occurrence and development of biofilms • Biofilm Development (attachment, differentiation and dispersal)	**7**
IV	**Biosafety, bioethics &IPR**: Biosafety and risk assessment issues; Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety. The WTO and other international agreements; Types, patents, copy rights, trade marks, design rights, geographical indications – importance of IPR – patentable and non patentables – patenting life – legal protection of biotechnological inventions – world intellectual property rights organization (WIPO). Intellectual properties, copyrights, trademarks, trade secrets, patents, geographical indications, etc; Implications of intellectual property rights on the commercialization of biotechnology products.	**10**
Total		**36**

Text Books:

1. "Biofuels from algae", 2nd edition, Elsevier (2018), Editors: Duu Jong Lee, Ashok Pandey, Jo-Shu Chang, Yusuf Chisti, Carlos Soccol, Paper back ISBN-13: 978-04446421922
2. "Process synthesis for fuel ethanol production", CRC Press (2009), C.A.Cardona, O.J.Sanchez, L.F. Gutierrez, ISBN-13: 978-1439815977Kumar, P.S.G. 2004. Research methods and statistical techniques. B.R. publishing Academy, Udaypur.
3. Crueger, W. and Crueger, A. (2000). Biotechnology: A textbook of industrial microbiology Panima Publishing Corporation, India.
4. Edward, A.B. (1992). Modern Microbiology – principles and application, WMC Brown Publishers, USA.

Reference Books:

1. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
2. Presscott, L. Harley, J. and Klein, D. 2017. Microbiology. Tata McGraw-Hill Co. New Delhi.

PAPER II: ETHNOBOTANY AND PHYTOGEOGRAPHY
SUBJECT CODE: BOT144D102,
CREDIT UNITS: L-T-P-C = 3-0-0-3
SCHEME OF EVALUATION: Theory only (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objectives: Introducing the students to traditional knowledge of plants and to give idea about the various vegetations present across India. The course will also give them an idea about the various ethnic groups present in NE states.

Course outcomes: On completion of the course the student shall be able to:

CO1: Identify the endemic and rare species that needs conservation.**[BT2]**
CO2: Locate the distribution profile of plants throughout the globe. **[BT2]**
CO3: **Prepare** world maps based on phytogeography. **[BT3]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Ethnobotany**: Nature, scope, History, Objectives and as an intra & inter-disciplinary science. Disciplines and sub-disciplines of ethnobotany. The relevance of ethnobotany in the present context: Life style, Material Culture and Indigenous Technology. Preparation of report on traditional plant knowledge.Field visit to nearby areas and compilation of field notes and identification, field notes.	**9**
II	**Ethnic groups and Ethnobotany**; Ethnic groups and their life styles. Medico-ethnobotanical resources in India with special reference to NE states. Socio-economy and other aspects of Ethnobotany with reference to: Food, Intoxicants and Beverages, Ropes and Binding Materials, Resins and Oils, Cosmetics, Ornamentals, Fodder, Medicinal and Aromatic properties. Medicinal and Aromatic plants-Abundance, conservation and utilization in respect to N.E. India,	**9**
III	**Phytogeography**: Definition, principles and objectives of phytogeography. Concepts of phytogeography. Descriptive and dynamic phytogeography. Continuous and discontinuous plant distribution. Routes and barriers to plant migration. Centers of origin (Primary and secondary centers) Preparation of India and World Maps based on phytogeography.	**9**
IV	**Endemism**: Endemism in India. Invasion and introduction of plants in India.Continental drift; Theory of tolerance. Endemism in Indian flora. Brief description of major terrestrial biomes (one each from tropical, temperate & tundra). Phytogeographical division of India. Local Vegetation. Environmental problems of N.E. India. Study and reporting of endemic vascular plants in Indian flora (at least ten).Prepare a map and study the Centres of origin of cultivated plants (Primary and secondary centres).	**9**
Total		**36**

Text Books:

1. Cotton C.M. 1996. Ethnobotany – Principles and applications. John Wiley and sons. Chichester.
2. Faulks, P.J. 2009. An introduction to Ethnobotany, Moredale Pub. Ltd., London.
3. Jain S.K., (ed.) Glimpses of Indian Ethnobotany, Oxford and I B.H., New Delhi.
4. Jain S.K., Manual of Ethnobotany, Scientific Publishers, Jodhpur
5. Martin, G.J. Ethnobotany, A methods manual, Chapman & Hall, London.
6. Schultes, R.E. Ethnobotany, Chapman and Hall. Krishnamurthy, K.V. A textbook of Biodiversity, Science Publishers Inc.,Enfield, New Hampshire, USA

Refrence Books:

Selected references from the Internet.

2ND SEMESTER SYLLABUS
CORE PAPERS (ALL COMPULSORY)

PAPER I: ANGIOSPERM TAXONOMY
SUBJECT CODE: BOT144C201
CREDIT UNITS: L-T-P-C = 4-0-0-4
SCHEME OF EVALUATION: THEORY (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objectives: The course is designed to give perspective on the historical development of plant taxonomy, its classification and the knowledge about the systematic tools used in the classification of plants at cellular and molecular level.

Course Outcomes:

CO1: **Describe** the history, origin, and diversity of plant classification and distribution.[**BT2]**
CO2: **Predict** the family of flower based on its floral structure. **[BT2]**
CO3:**Analyze** evolutionary processes of a plant based on well-founded hypotheses of evolutionary relationships.[**BT4]**
CO4: **Identify** the variation between species using different molecular techniques. **[BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Plant Taxonomy**: Historical development of plant taxonomy. Systems of classification- artificial, natural and phylogenetic; phenetic and phylogenetic systems, cladistics in taxonomy. Taxonomic hierarchy concept of taxa, species, genus and family, intraspecific categories. Plant collection, exploration, method of herbarium preparation, importance of botanic garden and herbaria in taxonomic studies, important botanic garden and herbaria in the world and India, Botanical Survey of India-organization and activities.	**12**
II	**Nomenclature:** History, Principles and Major rules, Taxonomic hierarchy, Typification, Effective and Valid Publication, Principles of Priority and Limitations. Sources of Taxonomic Characters: Morphology, Anatomy, Palynology, Embryology, Cytology, Phytochemistry, Biosystematics: Definition, importance and categories, major areas. Tools of Taxonomy: Botanical keys, Flora, Manuals.	**14**
III	**Study of families**: Description of families, affinity, range of floral structures and economic importance of Magnoliaceae, Ranunculaceae, Euphorbiaceae, Scrophuriaceae, Lamiaceae, Asteraceae, Orchidaceae, Poaceae (other families to be included: Brassicaceae, Malvaceae, Leguminoseae, Cucurbitaceae, Rubiaceae, Solanaceae, Liliaceae, Aracaceae)	**14**

IV	**Molecular Systematics**: Diagnostic tools, DNA markers, Polymerase Chain Reaction (PCR) analysis, Specific applications of RAPD, AFLP, RFLP in molecular systematics. DNA sequencing, SDS- PAGE analysis, preparation of flora construction of Dendrograms and cladogram.	**8**
Total		**48**

Text Books:

1. Davis and Heywood. 2011. Principles Of Angiosperm Taxonomy. Scientific publisher.
2. Sivarajan, V. V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
3. Stace, C. A. 1989. Plant Taxonomy and Biosystematics. Arnold Publishers, United Kingdom (online available) Stuessy, T. F. 2008. Plant Taxonomy – The Systematic Evaluation of Comparative Data. Columbia, University press, New Yor**k**

Reference Books:

1. Johnes, S. B. and Luchsinger, A. E. 1987. Plant Systematics. McGraw-Hill. London.
2. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., Donoghue, M. J. 2008. Plant Systematics-A Phylogenetic Approach. Sinauer Associates, Inc., Sunderland, Massachusetts USA.
3. Lawrence, G. H. M. 1964. Taxonomy of Vascular Plants. Oxford & IBH Publishers, Calcutta.

PAPER II: CYTOLOGY, GENETICS & PLANT BREEDING
SUBJECT CODE: BOT144C202,
CREDIT UNITS (L-T-P-C) : 4-0-0-4
SCHEME OF EVALUATION: Theory Papers (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objective: The course aims to enable the students understand the structures of plant at the cellular, sub-cellular and molecular levels

Course outcomes:

CO1: **Describe** different subcellular organelles and **elucidate** structure, growth, division, signalling, differentiation and death of plant cells. **[BT2]**
CO2: **Distinguish** the basis of prokaryotic, eukaryotic and cytoplasmic genome organisation. **[BT2]**
CO2: **Predict**the basis of inheritance and variation caused due to mutation and abberations. **[BT3]**
CO4: **Evaluate** the techniques to create new varieties with a set of desired characteristics. **[BT4]**

Detailed Syllabus:

Module	Course content	
I	**Cell components and their functions**: Structure, functions and biogenesis of cell wall, plasma membrane. Cell organelles. Cell cycle and its checkpoints	**8**
II	**Mendelism and extension of Mendelism** : Mendel and his experiments and laws. Extensions of Mendelism. Gene interactions and modifying genes. Gene interactions and modifying genes. Extranuclear inheritance and maternal effect. **Linkage and crossing**: Introduction and definition and types of Linkage. Coupling and Repulsion hypothesis. Crossing over – types and mechanism. Cytological basis of crossing over. Chromosomal aberrations.	**14**
III	**Fine structure of gene and population and evolutionary genetics**: Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism. Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, genetic drift. Genetic variation and Speciation. **Mutation and types of mutation:** Spontaneous and induced mutation. Different causes of spontaneous and induced mutation. Chromosomal aberrations: Numerical and structural abberations. Significance of chromosomal aberration in crop improvement.	**14**
IV	**Plant breeding :** Principle of plant breeding. Hybridization, heterosis & inbreeding depression. Distant hybridization. Recombination, genetic control and manipulation of breeding systems including male sterility and apomixis.. Breeding for quantitative & qualitative characters. Plant Introduction, domestication and selection(self & cross pollinated plants), gene pyramiding for multi-trait incorporation, Breeding for stress (biotic & abiotic). Mutation breeding (Special emphasis on Polyploid). Molecular markers, MAS	**12**
Total		**48**

Text Books:

1. Cooper G.M. and Hausman R.E. (2015). The Cell: A molecular approach. Oxford University Press.
2. Verma P.S. and Agarwal V.K. (2016) Cell Biology, Genetics, Molecular Biology. S. Chand & Co Ltd. India.
3. Hardin J and Bertoni G.P. Becker's (2015). World of the Cell. Pearson Publishers.
4. Bruce *et al*. (2014). Molecular Biology of the Cell. Garland Science.
5. Bruce Alberts *et al*. (2013). Essential Cell Biology. W. W. Norton & Company.
6. Gupta P.K. (2010). Cytogenetics. Rastogi Publications, Meerut.
7. Klug, W.S., Cummings Spencer M.R.C.A, Palladino M.A. (2004). Essentials Of Genetics. Pearson Education India.
8. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). VIII ed. Principles of Genetics. Wiley India.
9. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.

10. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. XI Edition. Benjamin Cummings.

Reference Books:

1. Karp G. (2013). Cell Biology (7th edition). Wiley publications.
2. Lodish H, Berk A, Kaiser C.A. (2016). Molecular Cell Biology.W. H. Freeman & Co Ltd.
3. Ayden Llyod. Essentials of Genetics. Larsen and Keller Education.
4. James D.Watson. Molecular Biology Of The Gene. Pearson Education India..
5. Russell P.J. iGenetics A Molecular Approach. Pearson Education India.

PAPER III: PLANT PHYSIOLOGY
SUBJECT CODE: BOT144C203,
CREDIT UNITS: L-T-P-C = 4-0-0-4
SCHEME OF EVALUATION: Theory Papers (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course objectives: The course is designed to acquaint the students with the various physiological processes inside the plant body, the crosstalk between different pathways/processes and the factors that affect its biosynthesis and regulation.

Course outcomes:

CO1: **Describe** the different processes – photosynthesis, mineral nutrition, respiration, transportation, and ultimately plant development and growth**[BT2]**
CO2: **List** the different plant hormones and **interpret** its application for crop improvement programs. [**BT2 and BT4]**
CO3: **Identify** the key regulating points of different processes that can be targeted for enhancing the plant trait and yield. **[BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Water relations of plants:** Properties of water as a universal solvent, Water potential (ψ): concept and significance, Transpiration and guttation. Soil-Plant-atmosphere continuum, Apoplast-symplast concept, Translocation of solutes, Mineral nutrition, Essential elements and criteria of essentiality, deficiency sympotoms,.	**12**
II	**Bioenergenetic pathways:** Mechanisms of photoexcitation of chlorophyll and electron transport chain; regulation of photosynthetic activity; Carbon fixation pathways in photosynthesis; Gycolysis and its regulation; fatty acid oxidation, mechanisms of oxidative decarboxylation of pyruvic acid; TCA cycle and its regualtion, electron transport and oxidative phosphorylation; Biological Nitrgen fixation and assimilation of ammonia; Gluconeogenesis. Causes and effect of stress due to water, temperature and salt, plant adaptation and mitigation to stress.	**16**

III	**Growth kinetics:** Compound interest law of growth, Relative growth rate, Leaf area ratio, Net assimilation rate, Harvest index, Dormancy and mechanisms of its regulation, seed ageing, senescence and its regulation Structure, function and mechanisms of action of phytochrome, vernalization	**8**
IV	**Plant Growth regulators:** Types of Plany growth regulators, Physiological; effects of auxins, gibberellins, cytokinins, abscisic acid, ethylene and brassinosteroids in plants. Mechanism of action of auxins, cytokinins, gibberellins and abscisic acid.	**12**
Total		**48**

Text Books:

1. Dennis D. T., Turpin, D. H. Lefebvre D. D. and Layzell D. B.(eds) (1997). Plant Metabolism (Second Edition) Longman, Essex, England.
2. Willium G Hopkins, Norman P Hunar (2009) Introduction To Plant Physiology, Wiley.
3. Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.

Reference Books:

1. Buchanan B.B, Gruissem W. and Jones R. L (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland,USA.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.

PAPER IV: ANGIOSPERM TAXONOMY& CYTOLOGY (PRACTICAL)
SUBJECT CODE: BOT144C214
CREDIT UNITS: 0-0-6-3
SCHEME OF EVALUATION: Practical (P)
[Continuous Evaluation: 25%: Skill Test, lab copy, viva, lab involvement (Any Three)
Attendance: 5%, Semester End Examination: 70%]

Detailed syllabus:

Practicals would be based on the theory syllabus and would broadly include the following

Module	Course content	Lecture Hours
I	1. Live plants/ flowers of the studied angiospermic families to work out, description, identification upto the rank of species (classification based on Bentham & Hooker's system) 2. Cladogram construction and analysis 3. Techniques in molecular systematics. 4. Construction of keys	**11**

II	5. Handling of Floras and Manuals 6. Basics of virtual/ digital herbarium 7. Visit of local flora and preparation of a field Report on distribution and diversity of the flora. 8. Basics of GIS and Remote sensing data – visual and digital interpretation for vegetation types, delineation of ecosystems using RS and GIS technology, temporal dynamics and models (virtual lab)	**10**
III	9. Preparation of different cytological fixatives, stains and their uses. 10. Study of chromosome behaviour in mitosis and meiosis using root tips of Onion, Lily and flower buds of Onion. 11. Preparation of permanent slides, camera lucida drawing and karyotype preparation of No. 6	**09**
IV	12. Study of Chromosome anomalies in plant cells using photographs and charts.	**06**
Total		**36**

PAPER IV: PLANT PHYSIOLOGY, GENETICS & PLANT BREEDING (PRACTICAL)
SUBJECT CODE: BOT144C215
CREDIT UNITS: 0-0-6-3
SCHEME OF EVALUATION: Practical (P)
[Continuous Evaluation: 25%: Skill Test, lab copy, viva, lab involvement (Any Three)
Attendance: 5%, Semester End Examination: 70%]

Detailed syllabus:

Practicals would be based on the theory syllabus and would broadly include the following:

Module	Course content	Lecture hours
I	1. Separation of chlorophyll by phase chromatography 2. Determination of Chlorophyll pigment from C3, C4 and CAM plants 3. Determination of RQ using various substrate 4. Study of water potential in plant tissues by gravimetric & plasmolytic method	**9**
II	5. Isolation of chloroplast and assay of Hill activity 6. Effect of membrane permeability properties on Beet roots 7. Seed viability test by TTC	**9**
III	8. To work out some genetical problems on gene interactions, linkage, crossing over and construction of genetic map based on three point cross 9. Numerical exercises on $\chi 2$ for independence of attributes and goodness of fit.	**9**
IV	10. Variation of chromosome number in plant species by chemical mutagenesis 11. Demonstration of emasculation.	**9**
Total		**36**

DISCIPLINE SPECIFIC PAPERS (only one to be selected)

PAPER I: GENOMICS AND PROTEOMICS
SUBJECT CODE: BOT144D201,
CREDIT UNITS: L-T-P-C = 3-0-0-3
SCHEME OF EVALUATION: Theory (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objectives:

The course is designed to give the students an idea about the structure and function of various genes in an organism, basic concept of functional proteins. and to give the students a basic idea on latest techniques related to genomic studies.

Course Outcomes: By the end of the course the student will know to

CO1: **Describe** the genome organisation and the advances in the field of genomics and proteomics.**[BT1 & BT2].**

CO2: **Interpret and Analyse** differential gene expression using different techniques such as -ESTs, SAGE, microarrays. [**BT3 &BT4]**

CO3:Compute and examine the structure and function of protein, the complexities of protein–protein interactions through advanced technologies. [**BT3 & BT4].**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Genome organization:** Organization of nuclear and organellar genomes, C-value paradox. Chromatin structure in eukaryotes, : Histones, DNA, nucleosome morphology and higher level organization; Functional states of chromatin and alterations in chromatin organization.; Repetitive DNA-satellite DNAs and interspersed repeated DNAs, Transposable elements, LINES, SINES, Alu family and their application in genome mapping.	**9**
II	Concept of gene: Conventional and modern views. Fine structure of gene, split genes, pseudogenes, non-coding genes, overlapping genes and multi-gene families. Genome mapping: Physical maps: -an overview and approaches. Genome evolution	**9**
III	**Pattern of genome evolution:** The origin of genomes- Origin of macromolecules, RNA world and DNA world Acquisition of new genes (By gene duplication) and Gene families – (Types, Pseudogenes, Origin of gene families (lateral gene transfer, allopolyploidy).Synthetic genomes and their applications	**9**
IV	**Tools in Genomics:,** Basics of DNA cloning: Various ways of cloning. Cloning into different vectors – plasmids, phages, and phage-derived PACs, BACs and YACs. Polymerase Chain Reaction (PCR): Concept of PCR, Various kinds of PCR, Real Time PCR. DNA sequencing by Sanger's method, Gene annotation	**9**

	Electrophoretic techniques, Southern and Northern Blotting, Preparation of probes, Isolation and purification of DNA, DNA fingerprinting and its application, Native PAGE, SDS-PAGE and two-dimensional PAGE, Western Blotting.,.	
Total		**36**

Text Books:

1. Brown,T.A. 2010. Gene Cloning: An introduction. Chapman and Hall, London.
2. Kreuzer, H. and A. Massey. 2001. Recombinant DNA and Biotechnology. ASM press, Washington DC.
3. Brown T. A. 2007, Genomes 3. Garland Science Publishing, New York.
4. Dunham, I., 2003. Genome Mapping and sequencing. Horizon Scientific
5. Graur, D and W H Li, 2000. Fundamentals of molecular evolution. Sinauer Associates.

Reference Books:

1. Micklos, D A, Freyer GA and Crotty D A (2003) DNA Science, Second edition, Cold Spring Harbour Laboratory Press, New York.
2. Primrose, S.B., R.M. Ywyman and R.W. Old. (2006). Principles of Gene manipulation and tenomics Seventh edition, Blackwell Science, U.K.

PAPER II: BIODIVERSITY AND CONSERVATION BIOLOGY
SUBJECT CODE: BOT144D202,
CREDIT UNITS: L-T-P-C = 3-0-0-3
SCHEME OF EVALUATION: Theory only (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objectives:

The aim of the course is to build up the knowledge among the students about the biodiversity of India and world and different conservation strategies used for preserving the biodiversity.

Course Outcomes:

By the end of the course the students will be able to:

CO1: **Describe and Classify** biodiversity, its types, status, hotspot and its conservation status. **[BT1 and BT2].**

CO3: Identify and categorize the plant under the different categories of threat**.[BT4]**

CO2: Evaluate strategies for biodiversity conservation. **[BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Introduction to biodiversity**: Biodiversity – types, levels, threats, value and uses; distribution and gradients of biodiversity. Agrobiodiversity outlines, megadiverse nation. Biodiversity hotspots with special emphasis on Indian hotspots. Biodiversity and Ecosystem services (BES), status of biodiversity conservation in India. Measures of Biodiversity: Alfa, Beta and Gamma	**9**

	diversities – Indices of diversity and evenness – The Simpson Index Diversity of fully censured communities – Estimating the diversity of large community – Evenness and Equitability – Hierarchical diversity.	
II	**Causes and Consequences of Biodiversity Loss** Habitat Loss and Alteration. Exotic Species. Chemical Pollutants. Loss of Genetic Diversity in Crops	**9**
III	**Introduction to Conservation**: Types of conservation. Conservation strategies, IUCN Red list of threatened Species. Extinction of species, IUCN protected area management categories. Role of organizations in the conservation of biodiversity – IUCN, WCED, UNEP, NBPGR, CBD.	**9**
III	**Conservation Strategies**: Laws and Legal Actions. Grassroots Action Programs. Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).	**9**
Total		**36**

Text Books:

1. Krishnamurthy, K.V. 2017. A textbook of Biodiversity, CRC Press.
2. Sharma, P. D. (2009). Ecology and Environment, Rastogi Publications, Meerut, India

Reference Books:

1. Bharucha, F.R. A textbook of plant geography of India, Oxford University Press, 179 pages
2. Cain, S.A. 1944. Foundations of Plant Geography, Harper & Brothers, N.Y.
3. Schulze E. D., et al. 2010. Plant Ecology. Springer.
4. Chapman, J. L. and Reiss, M. J. (1992). Ecology – Principles and Applications, Cambridge University Press, Cambridge, UK

PAPER III: HERBAL TECHNOLOGY
SUBJECT CODE: BOT144D203,
CREDIT UNITS: L-T-P-C = 3-0-0-3
SCHEME OF EVALUATION: Theory (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objectives:

The course is designed with an objectives to identify plants of medicinal values that can be used using modern techniques in the field of medicine.

Course Outcomes:

By the end of the syllabus the student will be able to:

Detailed Syllabus:

CO1: List out the different areas in the field of herbal medicine, the distribution profile of Indian medicinal plants and its diversity hotspot. **[BT1].**

CO2: Generalize and interpret the medicinal values of a plant based on its phytochemical profile **[BT2 & BT3]**

CO3: Outline the post-harvest technology of medicinal plants. **[BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	Historical background, Present status, Scope of Medicinal Botany – Indigenous medical system – Bioprospecting, Indigenous Knowledge system, Ayurveda, Siddha, Unani, Homeopathy, Tibetian and Folklore system of medicine. Need to Preserve Knowledge system.	**9**
II	Distribution of Indian medicinal plants; Introduction, Important medicinal plants, eco-distribution, mapping distribution in different biogeographic zones. Diversity hot spots – Endemism – Rare, endangered and threatened species. Conservation of medicinal plants – in-situ and ex-situ conservation. Centers of medicinal plant conservation in India – IBPGRI, CIMAP, CDRI, NBGRI, MSSRF, KFRI, TAMPCOL, TBGRI, TKDL and FRLHT.	**9**
III	General methods of phytochemical and biological screening – Natural sources – Extraction – Purification and isolation of plant constituents – Alkaloids – glycosides – Volatile oils – Study of some herbal formulation techniques as drug cosmetics.	**9**
IV	Post harvest technology of medicinal plants: Importance of post harvest technology in medicinal crops: factors responsible for deterioration of medicinal produce – pre and post harvest factors. Maturity indices for harvesting medicinal plants and pre harvest treatments. Systems of storage of harvested produce – packaging principles and methods of processing. Important medicinal products – essential oils, volatile and non volatile oils, oleo resins – active principles.	**9**
Total		**36**

Textbooks:

1. Swaminathan, M.S. and Kochar, S.L. 1989. Plants and Society. McMillan Publishers, London. Jonne Bernes – Herbal Medicines, Pharmaceutical Press, London.

Reference Books:

1. Natesh, S. 2001. The changing scenario of herbal drugs: Role of Botanists. Phytomorphology. (Golden Jubilee Issue)., Pp.75-97.
2. Sushil Kumar – Medicinal Plants in Skin care, CIMAP, Lucknow.
3. Swain, T. 1963. Chemical Plant Taxonomy, Academic Press, London.
4. Stace, C.A. 1985. Plant Taxonomy and Biosystematics, Edward Arnold, London.
5. Akerele, O.O. Heywood,V. and Singe, H. 1991. Conservation of medicinal plants. Cambridge University Press, U.K.
6. Cutler, S.J. and Cutler, S.H.G. 2000. Biologically active natural Products – Pharmaceuticals. CRC Press, USA.

3RD SEMESTER SYLLABUS
CORE PAPERS (ALL COMPULSORY)

PAPER I: ANGIOSPERM ANATOMY & EMBRYOLOGY
SUBJECT CODE: BOT144C204,
CREDIT UNITS: L-T-P-C = 4-0-0-4
SCHEME OF EVALUATION: Theory Papers (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course objectives:

This course aims to impart an insight into the internal structure and reproduction of the most evolved group of plants, the Angiosperm. It will help the student to Identify role of anatomy in solving taxonomic and phylogenetic problems.

Course outcomes:

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

CO1: Describe and explain the structure and structural adaptations of plants with respect to diverse environmental conditions. **[BT1 & BT2].**
CO2:Explain the various events which are met in during the sexual reproduction of angiosperm plants. **[BT2].**
CO3: Relate and breakdown the utility of embryological characters for the study of plant systematics. **[BT3 & BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Plant anatomy**: Introduction, importance and relationships of Plant Anatomy. Shoot Development: a) Recent views on organization of shoot Apical Meristem and types of vegetative shoot apex in Gymnosperms and Angiosperms. Root Development: Organization of root apex and significance of Quiscent center Leaf: Structure with reference to C3 and C4 plants – Kranz and CAM Syndrome. Epidermology: Epidermal cell complex and Stomatal complex. Classification of trichomes. Transfer cells: Structure, distribution, ontogeny and function.	**12**
II	**Secondary Growth**: Secondary growth with reference to Dicot stem, Monocot Stem and Roots. Significance of Dicots wood anatomy. Morphology and arrangement of Vessels, Axial Parenchyma Fibres and Ray parenchyma and their value in wood identification. Salient features of anatomical features of the following: a) *Tectona grandis* b) *Terminalia tomentosa* c) *Shorea robusta* d) *Bignonia* f), *Cucurbita,* g) *Amaranthus, h)Baugainvillea, i)Borhevia and j) Dracaena.*	**12**
III	**Embryology and Development of flower:** Transition to flowering - vegetative to reproductive evocation, axis development in flower, gender expression in monoecious and dioecious plants. ABC model of flower development.	**12**

	Developmental biology of male and female gametophytes: Regulation of anther and ovule development, microsporogenesis and microgametogenesis, megasporogenesis and megagametogenesis,	
IV	**Fertilization**: In vivo and in vitro pollen germination, pollen tube growth and guidance. Pollination mechanisms and adaptations. Fertilization: Double fertilization. Self-incompatibility, barriers of fertilization. Endosperm: Development and types of endosperms. Embryogeny of dicots. Seed-structure appendages and dispersal mechanisms. A general account of Polyembryony, Somatic embryogenesis, Apomixis and Parthenocarpy. Embryology in relation to Taxonomy.	**12**
Total		**48**

Text Books:

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
2. Evert, R.F. Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. 2006. John Wiley and Sons, Inc.
3. Johri, B.M. Reproductive biology of Angiosperms. 2001. Springer-Verlag, Netherlands
4. Katherine Esau (2006) Anatomy Of Seed Plants. Wiley Publications.
5. Raghavan, V. 1997 Molecular embryology of flowering plants. Cambridge, University Press.

Reference Books:

1. Beck, C. B. 2009. An introduction to plant structure and development (plant anatomy for 21st century). (2nd edition). Cambridge University Press.
2. Haig D., and Westoby M.. 1991. Seed size, pollination costs and angiosperm success. M. evol. Ecol. Springer-Verlag, Netherlands (journal paper).
3. Went van J.L. 1992. Fertilization in Angiosperm plants. Springer-Verlag, Netherlands.

PAPER II: PLANT BIOCHEMISTRY & MOLECULAR BIOLOGY
SUBJECT CODE: BOT144D302,
CREDIT UNITS: L-T-P-C = 4-0-0-4
SCHEME OF EVALUATION: Theory (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objectives:

The course is devised to help students understand the concept of molecular biology: understanding the process of replication, transcription and translation and learning how these are regulated

Course Outcomes: On completion of the course the student will be able to:

CO1: Reproduce and explain the study of chemical processes within and relating to living organisms. **[BT1&BT2]**
CO2: **Summarize** the Central Dogma of life and understand its regulatory aspect. [**BT2]**
CO3: **Predict and identify** the key regulators that is involved in controlling information flow through biochemical processes and signalling that give rise to the complexity of life. **[BT3 & BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	Carbohydrates and their derivatives: synthesis and inter-conversions; lipids: biosynthesis of fatty acids and their regulation; phospholipids and their role in signal transduction in cells; amino acids: structure and function, properties of amino acids; proteins: structure and function, folding and sub-unit assembly, post translational processing.	**12**
II	Enzymes: structure of active site, mechanisms of action, kinetics of enzymes catalysed reactions, regulation of enzyme activity; industrial enzymology: principles of immobilized enzyme technology; applications of immobilized enzymes.	**12**
III	Structure of nucleic acids: DNA and its A, B and Z conformations, t-RNA, r-RNAs; DNA replication: machinery and mechanism in prokaryotes and eukaryotes; RNA transcription: machinery and mechanism in prokaryotes and eukaryotes; RNA processing: processing of hnRNA; RNA editing; genetic code and exceptions to its universality.	**12**
IV	Translation: machinery and mechanism (tRNA charging, initiation in prokaryotes and eukaryotes, elongation and termination); regulation of gene expression in prokaryotes and eukaryotes; recombinant DNA technology: restriction enzymes and construction of hybrid DNA; gene cloning: cloning vehicles (plasmids, bacteriophages, YAC, BAC); construction and screening of genomic DNA and cDNA libraries; polymerase chain reaction (PCR): principle, primer designing, applications; introduction to RT-PCR, and Q RT-PCR.	**12**
Total		**48**

Text Books:

1. Alberts, B., Bray, D. and Hopkin, K. 2018. Essential Cell Biology. Garland Science, U.S.A
2. Cox, M., and Nelson, D. L. 2017. Principles of Biochemistry. Freeman and company, New York.
3. Dale, W.J. and Schontz, V.M. 2011. From Genes to Genomes. John wiley& sons ltd., England.
4. David. M. A., Freyer A.G., and Crotty, D. A. 2003. DNA Science A First Course, Cold SprindHarbor Laboratory Press, New York. Dey, P.M. and Harborne, J.B. (1997). Plant Biochemistry. Acad. Press.

Reference Books:

1. Buchanan, B.B., Gruissem, W. and Jones R.L. (2015). Biochemistry and Molecular Biology of Plants, Wiley Blackwell, Sussex, UK
2. Conn, E.E. and Stumpf, P.K. (1994). Outlines of Biochemistry. Wiley Eastern.
3. Dennis, D.T. (1998). Plant metabolism. Longman.
4. Heldt, H. (1997). Plant Biochemistry and Molecular Biology. Oxford Univ. Press.
5. Miglani G.S. 2002. Advanced Genetics, Alpha Science International Ltd.

6. Nickoloff, A.J. and Hoekstra, F.M. 2003. DNA Damage and repair. Volume I to III. Humana Press Inc., New Jersey.
7. Watson J. D., Baker, T.A., Bell, S.P., Lann, A. Levine, M. and Losick, R. 2006. Molecular Biology of the Gene, Pearson Education.

PAPER III: PLANT ANATOMY, EMBRYOLOGY, BIOCHEMISTRY &MOLECULAR BIOLOGY (PRACTICAL)

SUBJECT CODE: BOT144C313

CREDIT UNITS: 0-0-6-3

SCHEME OF EVALUATION: Practical (P)

[Continuous Evaluation: 25%: Skill Test, lab copy, viva, lab involvement (Any Three)
Attendance: 5%, Semester End Examination: 70%]

Detailed syllabus:

Practicals would be based on the theory syllabus and would broadly include the following:

Module	Course content	Lecture Hours
I	1. Study of epidermis/anatomy of leaves of selective families of Angiosperms. 2. Study of anomalous secondary growth of selective families of Angiosperms. 3. Determination of tensile strength of plant fibres	**09**
II	4. Study of microsporogenesis, megasporogenesis, embryosacs and endosperms with the help of permanent slides. 5. Study of anther and ovules by hand section. 6. Polyembryony by photographs.	**09**
III	7. Two dimensional (paper/TL) chromatographic separation of Amino Acids 8. Estimation of starch from plant tissues by iodine reaction. 9. Estimation of sugars from plant tissues by dinitrosalycilic acid. 10. Estimation of amino acids from plant tissues by ninhydrin reaction. 11. Estimation of soluble protein content from plant tissues by Lowry's method. 12. Separation of soluble proteins by (a) gel filtration (b) gel electrophreis.	**09**
IV	13. Assay of phosphatase activity in plant cells. 14. Assay of nitrate reductaseactivity in cells. 15. Extraction and purification of DNA from available plant samples and its agarose gel electrophoresis. 16. Spectrophotometric estimation of DNA.	**09**
Total		**36**

DISCIPLINE SPECIFIC ELECTIVE PAPERS (Any 1 paper to be selected)

SPECIAL PAPER I: MICROBIOLOGY I
SUBJECT CODE: BOT144D302
CREDIT UNITS: L-T-P-C = 2-0-2-3
SCHEME OF EVALUATION: THEORY & PRACTICAL (TP)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Lab Experiment, Copy and Viva (Any Three), Mid-term examination: 10%, Attendance: 5%, Semester End Examination: 70%]

Course Objectives: The course is designed to enable the students understand the microbial world and to learn about the role of microbes in day to day processes of the physical world

Course Outcomes:

CO1: **Recognise** the role of microbes in the environment and its role in biogeochemical cycles, food and industrial sector. **[BT2].**

CO2: **Evaluate and identify** the class of microorganisms that can be used for the production of high-value products such as drugs, chemicals, fuels and electricity. **[BT2-BT4]**

Detailed Syllabus: (2 hours of lecture and 2 hours of practical per week)

Module	Course content	Lecture hours
I	**Microbial ecology**: microbial interactions, microbes of extreme environments. Microbes in recovery of metal (bioleaching) and oil in soil and water.	**4**
II	**Environmental microbiology:** Aeromicrobiology: Diversity of microbes in air. Soil microbiology: Soil environment, microbial diversity in soil, , methods to detect and quantify soil microbes. Water microbiology: microbial diversity of water and waste water. Role of microorganisms for biomonitoring of various quality-parameters related to water and wastewater.	**8**
III	**Agricultural microbiology**: Agriculturally important microorganisms; microbial mineralization, Plant growth promoting rhizobacteria (PGPR) rhizosphere, phyllosphere. Biofertilizers.	**4**
IV	**Industrial microbiology**: Industrial importance of microorganisms, Fermentation methods and systems, screening and testing of new metabolites. strain development and gene technology , Industrial production of enzymes, organic acids, antibiotics, ethanol, vitamins and amino acids.	**8**
Total		**24**

Practicals: (2 hours per week)

1. Biochemical tests for the identification of bacteria
2. Estimation of BOD/COD in water samples.
3. Determination of colony forming units (CFUs) using colony counter, dimensions of microbes using ocular- and stage-micrometer.

4. Isolation and estimation of bacterial proteins AND nucleic acids from soil;
5. Isolation of Rhizobium from root nodules.
6. Isolation, identification and enumeration of AM fungal spores from soil.
7. Characterization of Plant Growth Promoting Rhizobacteria

Text Books:

1. Aneja, K. R. 2018. : Experiments in Microbiology, plant pathology and Tissue culture
2. Cooke, A. A. 1981. Diseases of Tropical and Subtropical field, Fiber and oil plants
3. Dubey, R. C &Maheswari D.K. 2013. A Text Book of Microbiology. S. Chand Publication.

Reference Books:

1. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
2. Presscott, L. Harley, J. and Klein, D. 2017. Microbiology. Tata McGraw-Hill Co. New Delhi.

DSE II: ADVANCED PLANT PHYSIOLOGY & BIOCHEMISTRY I
SUBJECT CODE: BOT144D302
CREDIT UNITS: L-T-P-C = 2-0-2-3
SCHEME OF EVALUATION: Theory & Practical (TP)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Lab Experiment, Copy and Viva (Any Three), Mid-term examination: 10%, Attendance: 5%, Semester End Examination: 70%]

Course objectives: The course is to acquaint the students with the various physiological processes inside the plant body and to help them understand the functions of various hormones as well as pigments present in plants.

Course outcomes: On completion of this course the students will have be able to:

CO1:Summarise different physiological processes of plants. **[BT2]**
CO2:Identify and interpret the different factors effecting the physiological process**.[BT3 and BT4]**
CO3:Estimate the antioxidant activity of plants.[**BT4]**
CO4: Perform various biochemistry experimets. **[BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	Biotic and abiotic stresses: Response of plants to abiotic stress: Basic principles of crop improvement programme under stress, Stress and hormones- ABA as a signalling molecule, Cytokinin as a negative signal. Oxidative stress- ROS, Role of scavenging system (SOD, Catalase etc.). High temperature stress tolerance mechanism. Chilling stress: Effect on physiological processes. Salinity: Salt tolerance mechanism. **Signal transduction:** primary and secondary signalling molecules, two component signalling, Histidine kinases, phospholipids signalling, Cyclic nucleotides, role of cyclic nucleotides as second messengers, Ca-Calmodulin cascade, specific signalling mechanisms	**12**

II	**Hormonal regulation of Plant Growth and Development:** Definition and classification of plant growth regulators, Sites of synthesis and mechanism of action of plant growth hormones, Importance of mutants and transgenic plants in understanding role of hormones. Hormone signal perception and transduction. Apical dominance, molecular aspects of control of reproductive growth and development. Synthetic growth regulators- classification, their effect on plant growth and development. practical utility in agriculture and horticulture. Endogenous growth regulating substances other than hormones viz. Tricontanol, Phenols, Polyamines, Jasmonates, Concepts of growth hormone.	**12**
III	**Senescence and ageing:** Molecular mechanism of senescence and ageing, senescence associated genes. Functional and ultra-structural changes in chloroplast membrane, mitochondria and cell wall during senescence and ripening. Role of ethylene in senescence and ripening. Biotechnological approaches to manipulate ethylene biosynthesis and action. Respiration in seeds, mitochondrial activity, seed ageing, mobilization of stored reserves, Seed viability, seed vigour, seed dormancy, types and regulation. Means to overcome seed dormancy.	**12**
IV	**Secondary metabolites**: Shikimate Pathway as the precursor to secondary metabolite biosynthesis in plants. Regulatory controls in flavonoid, flavonol and anthocyanin biosynthesis.	**12**
Total		**48**

Practicals:

1. Extraction of proteins from plant tissue and their quantitative (Bradford's) and qualitative (SDS, PAGE gel) analysis.
2. Estimation of antioxidant activity in plants
3. Estimation of total phenols, anthocyanins, sugars, etc.
4. To study the effect of inhibitors and uncouplers on the activity of succinic dehydrogenase, a marker enzyme of mitochondria (virtual lab)
5. Comparative assessment of methods for protein quantitation.
6. Assay of auxin activity by Avena hypocotyl elongation.
7. Assay of amylase induction by GA in plant tissues.
8. Assay of effect of cytokinin on chlorophyll degradation by leaf disc method.

Text Books:

1) Dennis D. T., Turpin, D. H. Lefebvre D. D. and Layzell D. B.(eds) (1997). Plant Metabolism (Second Edition) Longman, Essex, England.
2) Willium G Hopkins, Norman P Hunar (2009) Introduction To Plant Physiology, Wiley.
3) Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.

Reference Books:

1) Buchanan B.B, Gruissem W. and Jones R. L (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland,USA.
2) Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3) Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.

DSE III ANGIOSPERM TAXONOMY I
SUBJECT CODE: BOT144D303
CREDIT UNITS: L-T-P-C = 2-0-2-3
SCHEME OF EVALUATION: THEORY & PRACTICAL (TP)
Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Lab Experiment, Copy and Viva (Any Three), Mid-term examination: 10%, Attendance: 5%, Semester End Examination: 70%

Course Objective: The course is designed with the following objectives to help students learn about the historical development of plant taxonomy, classification and diversity of the plant kingdom. The course will deliver the knowledge about the systematic tools used in the classification of plants at cellular and molecular level.

Course Outcomes:

CO1: **Outline and classify** the history, origin, and diversity of plant classification and distribution.**[BT1 & BT2]**
CO2: **Predict** the evolutionary changes in angiosperms. **[BT3]**

CO3: **Categorize** medicinal plants that can be used in research and forensic science.**[BT4]**

Detailed Syllabus: (3 hours of lecture per week):

Module	Course content	Lecture hours
I	Comparative account on - artificial, natural and phylogenetic Systems of classification; Concept of phenetic, phyletic, cladistic and APG (Brief idea of I, II, III & IV); Flora and forest types of North East India; endemic and exotic elements in North East flora; Endemism and alien species.	6
II	Evolutionary trends in Angiosperms, cradle of flowering plants. Alpha & Omega Taxonomy; Phylogeny and floral evolution of following angiospermic orders: Magnoliales, fabales, Malvales, Cucurbitales, Lamiales, Asterales, Orchidales, Poales, Zingiberales (following Takhtajan).	6
III	**Plant Nomenclature:** History, Principles and Major rules of ICN, Typification, Effective and Valid Publication, Author Citations, Principles of Priority and Limitations (synonym, nomina conserva, rejection of names, illegitimate names, nomen nudum, later homonym. Taxonomic structure – taxonomic hierarchy, concept of species, genus, family and intraspecific categories; taxonomic key.	6

IV	Taxonomic literature – general reference, classical literature, icons, important state, regional and All India floras, E-flora, Journals of Taxonomy, literature on economic plants of India, Presentation of data- Flora and Manual, Monograph and revision, Preparation of flora, rich and poor floras; Planning preparation and planning of taxonomic research papers.	**6**
TOTAL		**24**

Practicals:

1. Study of different stages of floral development in some (atleast 6) taxonomically and morphologically peculiar angiospermic plants with conspicuous flowers along with qualitative and quantitative description and their systematic position.
2. Handling of Regional and national flora.
3. Construction of Keys.

Text Books:

1. Davis and Heywood. 2011. Principles Of Angiosperm Taxonomy. Scientific publisher.
2. Sivarajan, V. V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
3. Stace, C. A. 1989. Plant Taxonomy and Biosystematics. Arnold Publishers, United Kingdom (online available)
4. Stuessy, T. F. 2008. Plant Taxonomy – The Systematic Evaluation of Comparative Data. Columbia, University press, New Yor

Reference Books:

1. Johnes, S. B. and Luchsinger, A. E. 1987. Plant Systematics. McGraw-Hill. London.
2. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., Donoghue, M. J. 2008. Plant Systematics-A Phylogenetic Approach. Sinauer Associates, Inc., Sunderland, Massachusetts USA.
3. Lawrence, G. H. M. 1964. Taxonomy of Vascular Plants. Oxford & IBH Publishers, Calcutta.

COMPULSORY PAPER: PROJECT
SUBJECT CODE: BOT144C321
CREDIT UNITS: L-T-P-C = 0-0-8-4
SCHEME OF EVALUATION: Practical (P)

***BROAD AREAS FOR SPECIALIZATION THROUGH PROJECT WORK:**

1. Plant – soil microbe interactions
2. Microbial Ecology
3. Plant Molecular Biology
4. Advanced Plant Physiology
5. Taxonomy and diversity of angiosperms
6. Development and Reproduction of angiosperms
7. Plant Biotechnology 8. Lower plants

Examples of few topics for the students to pursue their studies.

(MICROBIOLOGY)

A. Assessment of antimicrobial activity of plant extracts against microbes
B. Assessment of nitrification inhibitors in agricultural soils
C. Effect of organic manures on soil microbial diversity
D. Study of microbial diversity, biochemical properties in different mediums such as soil, rhizosphere, water and air
E. Bioremediation of agricultural soils.

(PLANT PHYSIOLOGY& BIOCHEMISTRY)

A. Determination of physio-chemical properties of certain medicinal plants available in Assam/N.E.
B. Biochemical estimation of secondary metabolites/ essential oils/ active ingradients in some important economic plants
C. Determination of active ingradients present in the ethno-medicinal

(ANGIOSPERM TAXONOMY)

A. Floristic study of certain small area in and around Guwahati, making collection of their own and from these analytical drawings should be made. Describe the specimen using botanical terms and keying out the prominent characters for identification up to the rank of species for the preparation of a flora.
B. Basing on collection of locally available angiospermic plants, students may be assigned to study any one of the following branches in relation to angiosperm taxonomy- (a) External morphology, (b) Anatomy, (c) Cytology, (d) Palynology (e) Chemotaxonomy.
C. Comparative morphological studies of angiospermic plants belonging to any genus or family of local distribution. Apart from the few topics if the students want to pursue study in different topic, they can do so.

4TH SEMESTER SYLLABUS

CORE PAPERS (ALL COMPULSORY)

PAPER I: PLANT ECOLOGY AND ENVIRONMENT
SUBJECT CODE: BOT144C301
CREDIT UNITS: L-T-P-C = 4-0-0-4
SCHEME OF EVALUATION: THEORY (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objectives: The course is to acquaint the students about the environment and plant interactions and to impart a concept on biogeography and traditional knowledge in botany.

Course Outcomes:

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

CO1: **Describe and discuss** about the role of plants in the environment, the concept of biogeochemical cycles and its role in the environment. **[BT1 & BT2].**
CO2: **Outline** the eco-restoration strategies. **[BT3 & BT4].**
CO3: **Examine** the relationships of plants with the physical and biotic environment.**[BT4].**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Ecology:** Fundamental concept of Ecosystems, its kind, structure and function. Food chain, food webs and ecological pyramids. Ecological energetics & productivity, habitat and niche, Biogeochemical cycles and Biomes.	**14**
II	**Population and community ecology**: **Population and its characteristics (Attributes)**; Life tables; r and k strategies; Hardy Weinberg's law, genetic drift, gene flow. Population growth and regulation. Meta population. Population interactions, Gause's Principle. Lotka-Volterra model, co-evolution of prey-predator interactions – Red Queen hypothesis. Community Ecology – characteristics of community; Community stratification; Plant succession, species diversity, Shannon – Weiner Index	**14**
III	**Environment:** Environmental Stresses and their management, global climatic pattern and variations over time. Environmental pollution and its effect on plants. Greenhouse effect and Global warming (trends and role of GHGs). Ozone depletion. Environmental Degradation. Environmental Toxicology and its types (Chemical usage and disposal from industry and pollution). Occupational Environmental and Health Hazards – Community Environment and Health.	**12**

IV	**Environment awareness and Eco-restoration**: Environmental Organizations and Agencies. Environment protection acts and Laws. Eco Restoration: concept of Bioindicator and biomarkers. Biodegradation and bioremediation. EMS and EIA	**8**
Total		**48**

Text Books:

1. Odum E.P. 2005. Fundamentals of Ecology, 5th edition, Cengage Learning India Pvt. Ltd., New Delhi.
2. Sharma P.D. 2012. Ecology and Environment, Rastogi Publications, Meerut.
3. Conklin, A.R. Jr. 2004. Field Sampling: Principles and Practices in Environmental Analysis. CRC Press.
4. Agrawal., K.C. 2008. Environmental Biology. Nidhi Publishers (India)

Reference Books:

1. Raven, P.H., Begr, L.R., Hassenzahl D.M. 2012. Environment. John Wiley & Sons, Inc., New York.
2. Brusseau, M. L., Pepper, I. L., and Gerba C. 2019. Environmental and Pollution Science. Academic Press.
3. Fahey, T.J. and Knapp, A.K. 2007. Principles and Standards for Measuring Primary Production. Oxford.
4. Grant, W.E. and Swannack, T.M. 2008. Ecological Modeling. Blackwell.
5. Wilkinson, D.M. 2007. Fundamental Processes in Ecology: An Earth system Approach. Oxford.

PAPER II: BIOSTATISTICS AND BIOINFORMATICS
SUBJECT CODE: BOT144C402,
CREDIT UNITS: L-T-P-C = 4-0-0-4
SCHEME OF EVALUATION: Theory (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course Objective The course is designed to apply programming language to understand biological data.

Course Outcomes: By the end of the course the students will be able to:

CO1:Outline and describe the basic concepts of Bioinformatics and its significance in Biological data analysis. **[BT1 &BT2]**

CO2:Compute and model out various bioinformatic too to decipher the structural organisation, structural properties and structure determination of biological macromolecules – DNA, Protein and Carbohydrates. **[BT3 & BT4]**

CO3: Interpret and demonstrate statistical reasoning skills accurately and contextually**. [BT3]**

CO4: Apply statistical knowledge to design and **conduct** research studies and also Operate statistical software packages to conduct research studies. **[BT3 & BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Bioinformatics** Types of operating systems, concept of networking and remote login, basic fundamentals of working with Unix. Biological Databases -- Overview, modes of database search, mode of data storage (Flat file format, db-tables), flat-file formats of Gen Bank, EMBL, DDBJ, PDB	**12**
II	**Sequence Alignment and Phylogenetic Analysis** Concept of local and global sequence alignment; Basic concept of phylogenetic analysis, rooted/uprooted trees, approaches for phylogenetic tree construction. Generation and Analysis of High Throughput Sequence Data -- Assembly pipeline for clustering of HTGS data, format of '.ace' file, quality assessment of genomic assemblies; International norms for sequence data quality; Clustering of EST sequences, concept of Unigene. Structure Predictions for Nucleic Acids and Proteins -- Approaches for prediction of RNA secondary and tertiary predictions, energy minimization and base covariance models.	**12**
III	**Biostatistics** I The scope of biostatistics; Classification of study design, Observational studies and Experimental studies. Exploration and presentation of data: (Scales of measurement, Tables, Graphs, Histograms, Box and Whisker plots, Frequency polygon, Scatter Plots). Descriptive statistics: measures of central tendency, measures of dispersion, moments, Skewness and kurtosis	**12**
IV	**Biostatistics** II Probability: Definition, random variable, Probability distribution (Binomial, Poisson, and Standard Normal Distribution), Sampling: Reasons for sampling, methods of sampling. Drawing inferences from data: Confidence intervals, Hypothesis. Types of errors, P-values. Chi Square test; characteristics, degrees of freedom, test of goodness of fit. Analysis of variance (ANOVA): Variance and co-variance analyses (one way, two way, A priori comparison, Posterior or Post Hoc comparison, randomized block design, LSD, Kruskal-wallis one way ANOVA), F-test, steps involved in ANOVA. Correlation; methods of studying the correlation, scatter diagram; regression analysis. Statistical software packages and their importance in data analysis.	**12**
Total		**48**

Text Books:

1. Attwood T.K. and Parry-Smith D.J. 2007. Introduction to Bioinformatics, Pearson Education (Singapore) Pvt. Ltd.
2. David Edwards (Ed.) 2015. Plant Bioinformatics: Methods and Protocols, Humana Press, New Jersey, USA. Kulas J.T. 2008. SPSS Essential: Managing and Analyzing Social Science Data. John Wiley & Sons, New York.

Reference Books:

1. Dwyer R. A. 2004. Genomic Perl: From Bioinformatics Basics to Working Code, Cambridge University Press, 1st South Asian Edition.
2. Rosenkrantz W.A. 2009. Introduction to Probability and Statistics for Science, Engineering and Finance. CRC Press, Boca Raton.

PAPER III: PLANT ECOLOGY, ENVIRONMENT, BIOSTATISCS & BIOINFORMATICS (PRACTICAL)

SUBJECT CODE: BOT144C413

CREDIT UNITS: 0-0-8-4

SCHEME OF EVALUATION: Practical (P)

[Continuous Evaluation: 25%: Skill Test, lab copy, viva, lab involvement (Any Three) Attendance: 5%, Semester End Examination: 70%]

Course objectives: To introduce the students to the world of microbes and the methods involved in microbiology and molecular biology by showing them live cultures and photographs of bacteria and viruses.

Course Outcomes: By the end of the course, the students will be able to:

CO2: Perform hands-on-experiment on different laboratory experiments related to ecology, bioinformatics and biostatics. **[BT3]**

CO2: Compute and interpret the results and correlate the data for its application to research studies.**[BT3 & BT4]**

Detailed syllabus:

Practicals would be based on the theory syllabus and would broadly include the following:

Module	Course content	Lecture hours
I	1. Estimation of effective population size (Assessment of density, frequency and abundance of plants/animal in a community using various techniques i.e. transect, quadrate etc.) 2. Study of physico-chemical properties of soil: (a) texture, (b) porosity, (c) water holding capacity and (d) TKN 3. Study of cohort survivorship in plant populations and life-table analysis	**12**
II	4. Assessing influence of light, temperature and moisture on plant germination and growth 5. Assessing influence of soil nutrient status on plant germination and growth 6. Report on examples of environmental management and environmental impact assessment	**12**
III	7. Types of operating systems, concept of networking and remote login, 8. Biological Databases -- modes of database search, mode of	**12**

	data storage (Flat file format, db-tables), flat-file formats of Gen Bank, EMBL, DDBJ, NCBI, Pubmed, Patent databases, TAIR, PDB, ATIDB), 9. data search (BLAST, ORF finder, Primer 3, protein motif and structure prediction tools, Vector NTI, DNASTAR), sequencing methods (Bioinformatics in genome sequencing and annotation). (VIRTUAL) 10. Ramachandran plotting (VIRTUAL) 11. Fundamentals of computer programming along with practicals	
IV	12. Classification of study design and sampling methods 13. Exploration and presentation of data: (Scales of measurement, Tables, Graphs, Histograms, Box and Whisker plots, Frequency polygon, Scatter Plots). 14. Descriptive statistics: measures of central tendency, measures of dispersion, moments, Skewness and kurtosis 15. Statistical software packages and their importance in data analysis	**12**
Total		**48**

Discipline Specific Electives (Any 1 paper to be selected)

PAPER I: MICROBIOLOGY II
SUBJECT CODE: BOT144D401
CREDIT UNITS: L-T-P-C = 3-0-2-4
SCHEME OF EVALUATION: THEORY & PRACTICAL (TP)
Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Lab Experiment, Copy and Viva (Any Three), Mid-term examination: 10%, Attendance: 5%, Semester End Examination: 70%

Course Objective:

To enable the students understand the microbial world of food. To learn about thephysiological functional of microbes.

Course Outcomes:

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

CO1:**Describe and discuss** microbial genomics, microbes induced immune response and the application of microbes in the field of food spoilage and preservation. **[BT1 and BT2]**

CO2:**Apply** the knowledge obtained to select the correct micro-organism(s) for the production of value-added products. **[BT3 and BT4].**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Food and Dairy Microbiology** Recent developments in food microbiology. Fermented foods (wine, bakery products, cereals, and milk products.), Microbial spoilage of food products. Food borne diseases. Food poisoning and microbial toxins produced in food items and dairy products Microbiological examination of milk and milk products, source of their contamination and control. Legal standards of food and milk products.	**12**
II	**Microbial Genomics** Microbial Genetics (genetic materials, nuclear DNA, chloroplast DNA, mitochondrial DNA, plasmids, inheritance of traits, vertical and horizontal gene transfer, genes and chromosomes, DNA replication, RNA and protein synthesis, genome evolution). Operons and regulons, repression and activation of Lac operon, Tryptophan operon and Arabinose operon, RNA processing. Signal transduction in microbes. Feedback inhibition. Concept of genomics, metagenomics, transcriptomics, proteomics and metabolomics; Quorum and anti-quorum sensing	**12**
III	**Microbes in Enzyme Technology** Enzymes from microbial sources, Biochemical basis of actions of antimicrobial agents. Production of biofuels. Microbial toxins: Types, biochemical and molecular basis of toxin production, implications. Genetically engineered microbes, Novel medicines from microbes. Cell and enzyme immobilization	**12**
IV	**Immunology** Immunology: Humoral and cell mediated immunity; Specific and non-specific immunity; Immune responses, Primary and secondary lymphoid organs; Antigens; B and T cells and Macrophages; Major histocompatibility complex (MHC); Antigen processing and presentation; Antibodies, synthesis of antibody and secretion; Polyclonal and monoclonal antibody; Antigen- antibody reaction; Hyper sensitivity; Autoimmunity	**12**
Total		**48**

Practicals:

1. Study of amylase and protease activity in bacteria.
2. Estimation of phosphate solubilizing capacity of microorganisms;
3. Methylene blue reductase/ Phosphatase test for milk
4. Biochemical tests (phosphatase, urease, nitrate reductase, cellulase) for the activity of microbes
5. Fermentation of carbohydrates

PAPER II: ADVANCED PLANT PHYSIOLOGY& BIOCHEMISTRY II
SUBJECT CODE: BOT144D402
CREDIT UNITS: L-T-P-C = 3-0-2-4
SCHEME OF EVALUATION: Theory &practical (TP)
Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Lab Experiment, Copy and Viva (Any Three), Mid-term examination: 10%, Attendance: 5%, Semester End Examination: 70%

Course objectives: The course is designed to acquaint the students with the various molecular physiological & biochemical processes inside the plant body and to help them to nderstand the application of different techniques used in advance plant physiology.

Course outcomes: By the end of the course, the students will be able to:

CO1: **List out** the various biotic and abiotic stresses and interpret the mechanism induced by the plant to resist stress.**[BT2]**
CO2: Discuss about the mechanism of action of: Triacontanol, Brassins, Salicylic acid, Jasmonates and Polyamines in plant growth and development.
CO3: **Identif**y the key regulating points of different processes that can be targeted for enhancing the plant trait and yield. **[BT4].**
CO4: Identity the molecular tools that can be used to conduct plant physiology research. **[BT4].**

Detailed Syllabus:

Module	Course content	Lecture hours
I	**Stress Physiology:** Definition of stress, Abiotic and Biotic stresses, Adaptive responses of plants to stress, Oxidative stress, ROS, Stress responsive proteins and their regulation, Stress induced gene expression, Mineral nutrition: deficiency symptoms and disorders, Chelates, caused by abnormal metabolic pathways.	**9**
II	**Metabolic pathways and their regulation*:*** Light dependent and light independent photosynthetic pathways and their regulation, Oxidative metabolism in plants and its regulation.	**9**
III	**Plant Growth Regulators** – A brief idea about discovery, role and possible mechanism of action of Triacontanol, Brassins, Salicylic acid, Jasmonates and Polyamines.	**9**
IV	**Analytical tools in molecular physiology**: **Electrophoresis and Immunoblotting:** Analysis of proteins, Native PAGE and SDSPAGE, 2D PAGE, visualization of protein bands in agarose gel by Coomassie staining and silver staining, Determination of molecular weight of a protein using standards, semi-log graph interpretation, Western blot analysis of the proteins using antibodies. ELISA	**9**
Total		**36**

Practicals:

1.Study of enzyme kinetics for determination of Km value, nature of inhibition – competitive/non-competitive through virtual lab

2. Detection of phosphoproteins in plant (Brassica) extract by pro Q diamond staining
3. Qualitative and quantitative analysis of photosynthetic pigments and anthocyanins by spectrophotometric and chromatographic technique.
4. PAGE analysis of pigment-protein complexes from chloroplasts.
5. GC-MS and detection of phytochemicals and secondary metabolites.

PAPER III: ANGIOSPERM TAXONOMY II
SUBJECT CODE: BOT144D403
CREDIT UNITS: L-T-P-C = 3-0-2-1
SCHEME OF EVALUATION: THEORY (T)
[Continuous Evaluation: 15%, Assignment, Class Test, Seminar, Quiz (Any three); Mid-term Examination: 10%; Attendance:5%; Semester End Examination: 70%]

Course objectives: The course is designed to acquaint the students with the various molecular physiological & biochemical processes inside the plant body and to help thwm understand the application of different techniques used in advance plant physiology.

Course Outcome: By the end of the course, the students will be able to:

CO1: **Describe** the origin, and diversity of angiosperms, sources of taxonomic literature and plant identification. [**BT2]**
CO2: **Make** herbarium sheets of some of the important plants. **[BT4]**

Detailed Syllabus:

Module	Course content	Lecture hours
I	A critical study of the current ideas on the origin of angiosperms with special reference to their ancestral stock, time and place of origin, concept of primitive angiosperms; Patterns of geographical distribution, centres of taxonomic research in India; Botanical Survey of India- it's organization, activities, achievements, strengths, & weakness, opportunities and threats and publications.	**9**
II	Concept of Characters – Qualitative and quantitative characters, good and bad characters, analytical and synthetic characters, conservative characters, co-relation of characters, isolation and speciation of characters; sources of taxonomic evidences- Morphology, Anatomy, Palynology, Embryology, Cytology; Changing trends in taxonomy - Chemotaxonomy, Biosystematics, Numerical taxonomy, Molecular taxonomy, use of Computers in taxonomy; Website and softwares*viz.*, DELTA, Navikey, Lucid, XID, Actkey, IndentifyIt, Pl@ntNet systems in plant identification, Documentation and data processing.	**9**
III	Herbaria – Herbarium Techniques, particular reference to the special type of plants; kinds, role in teaching and taxonomic research; major herbaria in the world and in India. Botanic garden and its role in biodiversity conservation, teaching, research, plant introduction and plant domestication; major botanic gardens of world and India. Botanical keys -Single access and Multi-access key, their construction and use.	**9**
IV	Importance of plants in human affarirs, History of Botanical exploration in India; Rare and Endangered plants of India with reference to North east India; Role of Plant taxonomy in medicinal plant research and forensic science. Sources of	**9**

	taxonomy in medicinal information – reproductive and vegetative characters, Morphological and anatomical characters, chemical compounds useful in plant taxonomy, value of chemotaxonomy and value of characters.	
Total		**36**

Text Books:

1. Cronquist, A. 1988. Evolution and Classification of Flowering Plants. New York Botanic Gardens, Bronx, New York.
2. Hutchinson, J. 1964. Genera of flowering plants. Cambridge University Press, London. • Hutchinson, J. 1974. The families of flowering plants: Oxford University Press.
3. Hutchinson, J. Evolution and Phylogeny of flowering plants; Academic Press, London & New York.
4. Mondal, A.K.: Advanched Plant Taxonomy. Central Book Agency, Kolkata.
5. Sivarajan, V.V. and Robinson, N.K.P. 1991. Introduction to the principles of plant taxonomy. Oxforb IBH.
6. Singh, G. 2020. Plant Systematics: Theory and Practice. Completely revised and enlarged. 4th edition.
7. Takhtajan, A. Origin and dispersal of Flowering Plants.

Reference Books:

1. Cotton C.M. 1997. Ethnobotany – Principles and applications. John Wiley and sons – Chichester.
2. David, P.H. and Heywood, P.H. Principles of Angiosperms taxonomy. Oliver and Boys, London.
3. Good, R. 1974. The geography of flowering plants. Longman, London.
4. Greuter. W. et al. International Code of Botanical Nomenclature. St. Louis Code. Koeltz Scientific Books, Konigstein.
5. Hooker, J.D.1872-1897. The Flora of British India. 7 vols. Reeve & Co. Ltd. London
6. Jain, S.K. and Rao, R.R. 1977. A Hand Book of Field and Herbarium Methods. Today and Tomorrow Publications, New Delhi.
7. Jain S.K., 1995 Manual of Ethnobotany, Scientific Publishers, Jodhpur.
8. Kanjilal, U,N.*et al.* 1934-1940. Flora of Assam. 5 vols. Government Press, Shillong.
9. Mabberley, D.J. 2017. The Plant Book. Cambridge University Press,London.
10. Naik, V.N. 1984. Taxonomy of Angiosperms. Tata McGraw Hill, New Delhi.
11. Sharadwala Pan, Indira P. Sarethy. 2016. Biosystematics and Taxonomy. Intelliz Press, LLC

COMPULSORY PAPER: PROJECT DISSERTATION
SUBJECT CODE: BOT144C321
CREDIT UNITS: L-T-P-C = 0-0-12-6
SCHEME OF EVALUATION: Practical (P)

***BROAD AREAS FOR SPECIALIZATION THROUGH PROJECT WORK:**

1. Plant – soil microbe interactions
2. Microbial Ecology
3. Plant Molecular Biology
4. Advanced Plant Physiology
5. Taxonomy and diversity of angiosperms
6. Development and Reproduction of angiosperms
7. Plant Biotechnology 8. Lower plants