UNIVERSITY OF CALICUT
DEPARTMENT OF BOTANY
Entrance Examination to Ph. D. in Botany 2023 (Model)

Time: 2 Hours **Max Marks 100**

Tag this question paper along with the answer sheets of Part II

PART I

Attempt **all** questions. Put a √ mark after correct answer. All questions carry **1** mark each.

1. The ability of component cells of a callus to form a whole plant is called
   a) Redifferentiation ☐ c) Differentiation ☐
   b) Dedifferentiation ☐ d) None of the above ☐
2. The probability distribution used to depict the occurrence of events in a large number of independent repeated trials was described by
   a) Carl Pearson ☐ c) S. D. Poisson ☐
   b) Daniel Bernoulli ☐ d) None of these ☐
3. All of the following obeys Gregor Mendel's laws, except
   a) Independant Assortment ☐ c) Linkage ☐
   b) Dominance ☐ d) Purity of gametes ☐
4. Which algae is responsible for the red color of red sea
   a)*Chlamydomonas brauii* ☐ c)*Trichodesmium erythraeum* ☐
   b)*Pleurothallis erythrium* ☐ d)*Ulothrix zonata* ☐
5. Down's syndrome is caused by
   a) Trisomy of 22nd chromosome ☐ c) Monosomy of 22nd chromosome ☐
   b) Trisomy of 21st chromosome ☐ d) Monosomy of 21st chromosome ☐
6. For union between stock and scion in grafting which one is the first to occur
   a) Production of plasmodesmata ☐ c) Formation of callus ☐
   b) Differentiation of new vascular tissues ☐ d) Regeneration of cortex & epidermis ☐
7. A fungus that exhibits alternation of generation
   a) *Puccinia* ☐ c) *Allomyces* ☐
   b) *Neocallimastix* ☐ d) *Agaricus* ☐
8. Which are the most primitive group of algae
   a) Blue green algae ☐ c) Brown algae ☐
   b) Red algae ☐ d) Green algae ☐
9. Intercalary meritem results in
   a) Secondary growth ☐ c) Primary growth ☐
   b) Apical growth ☐ d) None of the above ☐
10. Cause of speciation is
   a) Random mating ☐ c) Isolation ☐
   b) Hybridization ☐ d) Migration ☐
11. To which group would you assign a plant which produces spores and embryos, but lacks seed and vasculature
   a) Algae ☐ c) Bryophyte ☐
   b) Fungi ☐ d) Pteridophyte ☐

12. A synonym is
    a) a correct name of a species ☐
    b) a duplicate name of a species ☐
    c) a superfluous name of a species ☐
    d) an incorrect name of a species ☐
13. Which among the following exhibit seismonastic movement
    a) *Enterolobium saman* ☐
    b) *Phaseolus vulgaris* ☐
    c) *Mimosa pudica* ☐
    d) None of these ☐
14. Out of the 4 widely known systems of classification which one remains less phylogenetic & more natural?
    a) Engler and Prantl ☐
    b) Hutchinson ☐
    c) Rendle ☐
    d) Bentham and Hooker ☐
15. The sectioning of woody plant materials is made through?
    a) Rotary microtome ☐
    b) Sledge microtome ☐
    c) Cryotome ☐
    d) Rocking microtome ☐
16. Blue Litmus is obtained from the lichen
    a) *Parmelia* ☐
    b) *Usnea* ☐
    c) *Roccella* ☐
    d) *Cladenia* ☐
17. During cell cycle DNA replication takes place in
    a) G1 phase ☐
    b) G2 phase ☐
    c) S-phase ☐
    d) Prophase ☐
18. Exclusion of plant disease by legislation is known as
    a) Disease resistance ☐
    b) Plant quarantine ☐
    c) Biological control of plant ☐
    d) Cultural control ☐
19. Name the gene that has been incorporated in ‘golden’ rice
    a) Bt gene ☐
    b) nif gene ☐
    c) nod gene ☐
    d) Beta carotene gene ☐
20. When is Earth Day celebrated?
    a) 22nd April ☐
    b) 21st March ☐
    c) 22nd May ☐
    d) 21st May ☐
21. Which of the following vitamins has cobalt as a constituent?
    a) Vitamin B_1 ☐
    b) Vitamin B_2 ☐
    c) Vitamin B_6 ☐
    d) Vitamin B_{12} ☐
22. A virion is
    a) A complete inert form of a virus ☐
    b) Active virus ☐
    c) Parasitic form of a virus ☐
    d) None of these ☐
23. Who is regarded as the father of Microbiology
    a) Leeuwenhoek ☐
    b) Robert Koch ☐
    c) Louis Pasteur ☐
    d) Robert Hook ☐
24. Who coined the term Linkage
    a) Gregor Mendel ☐
    b) Carl Correns ☐
    c) T. H. Morgan ☐
    d) Hugo de Vries ☐
25. Taq polymerase is used because of its
    a) High thermal stability ☐
    b) Low thermal stability ☐
    c) High fidelity ☐
    d) High speed ☐
26. When is electrophoresis not used?
    a) Separation of proteins ☐
    b) Separation of aminoacids ☐
    c) Separation of lipids ☐
    d) Separation of nucleic acids ☐

27. Gram staining was developed by
    a) Christian Gram ☐ c) Louis Pasteur ☐
    b) Robert Koch ☐ d) Gerald Gram ☐
28. Introduction of recombinant DNA into a cell using electrical impulse is called
    a) Electroporation ☐ c) Biolistics ☐
    b) Transduction ☐ d) None of the above ☐
29. Who discovered recombinant DNA technology
    a) Stanley Cohen & Herbert Boyer ☐ c) J. D. Watson ☐
    b) Har Gobind Khorana ☐ d) Sutton & Boveri ☐
30. Which of the following is not a property or parameter of electromagnetic radiation?
    a) Wavelength ☐ c) Amplitude ☐
    b) Wavenumber ☐ d) Voltage ☐
31. Which technique separates charged particles using electric field?
    a) Electrophoresis ☐ c) Protein synthesis ☐
    b) Hydrolysis ☐ d) Protein denaturation ☐
32. Electrophoresis was developed by
    a) Tswett ☐ c) Tiselius ☐
    b) Tsvedberg ☐ d) Sanger ☐
33. In chromatography, the stationary phase can be _____, supported on a solid.
    a) Solid or liquid ☐ c) Solid only ☐
    b) Liquid or gas ☐ d) Liquid only ☐
34. Tissue culture technique was first practised by
    a) White ☐ c) Haberlandt ☐
    b) Skoog ☐ d) Halperin ☐
35. Which is the database that provides comprehensive information on mammalian microRNAs?
    a) Argonaute ☐ c) tRNADB ☐
    b) RDP ☐ d) None of these ☐
36. In photometers, the readings of the specimen are initially obtained in the form of which of the following parameters?
    a) Transmittance ☐ c) Wavelength ☐
    b) Absorption ☐ d) Volume ☐
37. Which of the following is a mismatch in polymerase chain reaction?
    a) Polymerase - Taq polymerase ☐ c) Template - DNA double strand ☐
    b) Primer - oligonucleotide ☐ d) Synthesis - 5’ to 3’ direction ☐
38. Which type of molecules are used for labeling the cellular entities in the autoradiography technique?
    a) Glycoproteins ☐ c) Enantiomers ☐
    b) Stereoisomers ☐ d) Radioisotopes ☐
39. Variable Number of Tandem Repeats (VNTRs) in the DNA molecule are highly useful in
    a) Recombinant DNA technology ☐ c) DNA finger printing ☐
    b) Monoclonal antibody production ☐ d) Stem cell culture ☐
40. Which part of compound microscope helps to gather and focus more light rays on to the specimen?
    a) Eye piece lens ☐ c) Objective lens ☐
    b) Condenser lens ☐ d) Magnifying lens ☐
41. Which of the following is used in electron microscope?
    a) Electron beams ☐ c) Light waves ☐
    b) Magnetic fields ☐ d) Electron beams & magnetic fields ☐

42. Which was the first transgenic plant?
    a) Cotton ☐ c) Potato ☐
    b) Brinjal ☐ d) Tobacco ☐
43. Quantitative variables that have only fixed or finite values are called
    a) Discrete variables ☐ c) Continuous variables ☐
    b) Absolute variables ☐ d) Quantitative variables ☐
44. Who is regarded as the father of biostatistics?
    a) Karl Fisher ☐ c) Francis Galton ☐
    b) Karl Pearson ☐ d) Francis Bacon ☐
45. When did the Government of India pass the Environment Protection Act?
    a) 1990 ☐ c) 1986 ☐
    b) 1896 ☐ d) 2000 ☐
46. Which is the level of noise that is safe to our ears?
    a) 50 dB ☐ c) 100 dB ☐
    b) 70 dB ☐ d) 120 dB ☐
47. The respiratory chain of bacteria is associated with
    a) Cytoplasmic membrane ☐ c) Nucleoid ☐
    b) Cell wall ☐ d) Cytoplasm ☐
48. Which shutter speed lets in more light in a camera?
    a) 1/30 ☐ c) 1/400 ☐
    b) 1/60 ☐ d) 1/1000 ☐
49. Resolving power of unaided human eye is
    a) 2 mm ☐ c) 0.2 mm ☐
    b) 1 mm ☐ d) 0.1 mm ☐
50. The process by which a probe is used to screen a library is known as
    a) Cybridization ☐ c) Colony hybridization ☐
    b) Southern blotting ☐ d) Western blotting ☐

50 x 1 = 50 marks

PART II

Attempt **all** questions. Each question carries **5** marks each.

51. Enumerate the major changes made in Melbourne code.
52. Give an account of vegetative incompatibility in fungi.
53. Describe the various inhibitors of mitochondrial and thylakoid electron transport systems.
54. Differentiate between independent assortment and linkage.
55. Describe cell cycle and its regulation.
56. Describe the preparation and maintenance of different types of culture media used to grow microbes.
57. Describe various blotting techniques and their significance.
58. Give an account on the various types of plagiarism and plagiarism check softwares.
59. Describe the various types of electron microscopes and their working principle.
60. Explain the uses of BLAST programme in elucidating phylogenetic relationships.

10 x 5 = 50 marks

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File Ref.No.16231/GA - IV - J1/2013/CU

UNIVERSITY OF CALICUT

Abstract

General and Academic - Faculty of Science - Scheme and Syllabus of M.Sc Applied Plant Science Programme under CCSS PG Regulations 2022 for University Teaching Department - Approved by the Vice Chancellor subject to ratification by the Academic Council - Implemented with effect from 2022 admission - Orders issued.

G & A - IV - J

U.O.No. 14730/2022/Admn Dated, Calicut University.P.O, 30.07.2022

Read:-1. U.O.No. 8481/2022/Admn dated, 11.04.2022

2. Item No.1 in the minutes of the online meeting, Board of Studies in Plant Science (Single Board) held on 05.07.2022
3. Remarks of Dean, Faculty of Science dated 03.02.2022
4. Orders of Vice Chancellor in the File of even no; dated 21.07.2022

ORDER

1. The Regulations under Choice-based Credit Semester System for Post Graduate Programmes (CCSS PG-2022) of all Teaching Departments / Schools of the University of Calicut, has been implemented with effect from 2022 admission, vide read (1) above.
2. The meeting of the Board of Studies in Plant Science (Single Board) held on 05.07.2022, vide paper read (2) above, has resolved to approve the scheme & syllabus of M.Sc Applied Plant Science Programme in tune with Regulations under Choice- based Credit Semester System for Post Graduate Programmes (CCSS PG-2022) of all Teaching Departments / Schools of the University of Calicut, w.e.f. 2022 admission.
3. The decision of Board of Studies has been approved by the Dean, Faculty of Science, vide paper read (3) above, and by the Vice Chancellor, subject to ratification by the Academic Council, vide paper read (4) above.
4. The Scheme and Syllabus of M.Sc Applied Plant Science Programme in tune with Regulations under Choice- based Credit Semester System for Post Graduate Programmes (CCSS PG-2022) of all Teaching Departments / Schools of the University of Calicut, w.e.f. 2022 admission, is therefore implemented subject to ratification by the Academic Council.
5. Orders are issued accordingly. (Syllabus appended)

Ajayakumar T.K

Assistant Registrar

To

The Head, Dept. of Botany

Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE V/EX and EG Sections/GA I F/CHMK Library/Information Centres/SF/DF/FC

Forwarded / By Order

Section Officer

Learning Outcomes-based Curriculum Framework (LOCF) for Post-graduate Programme

NAME OF THE PROGRAMME

M.Sc. APPLIED PLANT SCIENCE

(Syllabus effective from 2022 Admission)

UNIVERSITY OF CALICUT

DEPARTMENT OF BOTANY

2022

ABOUT THE DEPARTMENT

The Department of Botany was established under the University of Calicut in 1968. It is one of the leading University Botany Departments of India in the field of teaching and research in plant sciences, especially Angiosperm Taxonomy. The principal aim of the department is to promote higher education by improving human resources of the Malabar region of the Country. It is a DST-FIST (Two Cycles) and SARD funded Department and recently the University of Calicut has raised this Department as a Centre with Potential for Excellence, during the Golden Jubilee year, 2018. The Department is proud to have the largest university botanical garden in India with an area of 19.5 acres and a Touch & Feel Garden for the visually-challenged people. It is the headquarters of the Indian Association of Angiosperm Taxonomy, Prof. P.S. Krishnan Foundation and Gregor Mendel Foundation. *Rheedea* and *Eco-chronicle* are the two journals published from the Department. The State Goverment-funded Interuniversity Centre for Plant Biotechnology is also associated with the Department. Currently, the Department encompasses nine divisions, viz., Angiosperm Taxonomy, Cell and Molecular Biology, Cyanobacterial Diversity, Cryptogams Diversity, Fungal Diversity, Environmental Science, Genetics and Plant Breeding, Plant Biotechnology, Plant Physiology and Biochemistry

The Vision

- To be distinguished as a renowned academic institution recognized for its innovation, excellence and inventions; producing the best human resource in the field of Plant Sciences and help them to realize their full potential in ways that benefits the society.

The Mission

- To develop human resource with competence in frontier areas of Plant Sciences by fostering a culture of scientific and intellectual inquiry supported by critical thinking, reasoning skills and discourse.
- To educate students with the fundamental knowledge and the application of scientific methods, skills and attitudes with the help of conventional and modern tools to understand everything related to plants.
- To impart a student-centered, profession-oriented, multidisciplinary higher education in a genuine research environment and to establish collaboration with eminent institutes for the benefit of the students.
- To advance the fundamental knowledge of Plant Sciences through innovative research, thereby creating a positive impact on society and the country.

UNIVERSITY OF CALICUT

DEPARTMENT OF BOTANY

LOCF for M.Sc. Programme in Applied Plant Science (CCSS)
Programme code: FSCBOTMSC

Prerequisite

Candidates with the following BSc degrees are eligible for admission to MSc Applied Plant Science Course: B. Sc. degree of Calicut University with Botany (main) or Plant Science (main) or an equivalent degree from any other University recognized by this University.

Program Educational Objectives (PEOs)	
The **M. Sc. Applied Plant Science** program defines various achievements that graduates are expected to attain after graduation.	
PO1	The program is designed to benefit all plant science students to learn various facets of plant science together with its practical applications.
PO2	Considering that these students land up in various professions including teaching at different levels, research jobs in acclaimed institutes and or even in industry, relevant topics that can equip them to accomplish the above purposes have been included in the curriculum.
PO3	Students would have a thorough knowledge of core subjects like plant diversity, plant taxonomy, physiology and biochemistry, molecular biology, cytology, genetics & plant breeding, anatomy & microtechnique, environment biology, plant biotechnology and application of statistics etc. which are offered in various modules. Analytical techniques such as plant tissue culture, genetic engineering, bioinformatics and phytochemistry would help to add skills in doing applied research. Another major thrust is to develop an environmental concern among the students and emphasizes the urgent need to conserve nature without disturbing natural resources.
PO4	All the courses in this program are designed to prepare the students for competitive exams like CSIR NET, SET, UGC/ICAR NET, UPSC, ARS, KPSC, GATE etc. and to write research proposals for grants and various other research schemes.

Program Specific Outcomes (PSOs)	
After the successful completion of M.Sc. Applied Plant Science program, the students are expected:	
PSO1	To have knowledge about the classification and identification of plants from cryptogams to phanerogams; To gain an understanding of biodiversity in relation to habitat and correlating it with climate change, land, and forest degradation; To use plant science in agriculture by researching plant pathogens in order to increase crop productivity and thus crop improvement; To trace the evolution of plants through the study of paleobotany.
PSO2	To have knowledge of the external and internal characteristics of plants, through the study of morphogenesis, taxonomy, anatomy and embryology which will aid in the identification and classification of plants, with practical applications in biochemical and pharmaceutical aspects.
PSO3	To understand the fundamental aspects of biostatistics, bioinformatics tools, and biophysical principles, which will aid in the analysis of relevant biological situations and the development of intellectual skills on biological data and database analysis.
PSO4	To acquire skills in identifying local, medicinal, rare, endangered, endemic, and exotic plants in their natural habitats, therapeutic properties, and cultivation practices, which will help them to develop methods and means for effective conservation and future use of these plants; To Understand the role of plants in sustaining life, the interdependence of humans and nature, and the significance of biodiversity conservation in order to develop conservation strategies.
PSO5	To elucidate the molecular and functional adaptations in plants in response to both biotic and abiotic stresses; To identify genes responsible for stress tolerance and genetic engineering of plants for enhanced stress tolerance.

Program Outcomes (POs)	
Students who successfully complete the M. Sc. Applied Plant Science programme will be able to	
PO1	Sustain a high level of scientific excellence in plant science research; Develop, hand-pick and apply appropriate techniques, resources and modern techniques in the area of plant sciences.
PO2	Utilize cutting-edge, biotechnologically innovative techniques in the fields of Plant Molecular Biology and Plant Biotechnology.
PO3	Understand the issues of environmental aspects and sustainable development.
PO4	Participate in the production of plant-based medicines, food, and other plant products to advance man's holistic development and welfare.
PO5	Learn about basic scientific phenomena, fundamentals, principles, and applications of various statistical tools relevant to various biological situations.
PO6	Improve their ability to put their ideas, knowledge, and concepts into action across multiple disciplines.

The Major Features

Core Courses

Core courses are the compulsory courses designed to meet the core requirement of providing a basic understanding of the discipline. Core courses can be both theory (3 credits) and practical (1 credit).

Ability Enhancement Course (AEC)

An Ability Enhancement Course (The Process of Research) for 2 credits is offered during the first semester of the PG program by the Department.

Professional Competency Course (PCC)

Professional Competency course (Biotechniques and Instrumentation) for 2 credits is offered with an aim to provide hands-on training to develop technical skills and proficiencies in handling high-end instruments to carry out future research programs. The course is offered during the second semester of the PG program by the Department.

Open Elective Courses

Open elective courses (4 credits) are offered in the third semester of the program. An open elective course is chosen generally from an unrelated discipline to enhance the general exposure outside the main discipline. The students pursuing M.Sc. Applied Plant Science have to opt for Open Elective courses offered by other Departments based on their interest. The scope of the Open Elective Courses is to effectively enhance the horizontal mobility across diverse disciplines.

Discipline-Specific Elective Courses

Discipline-Specific Elective courses are offered by the Department to enhance the flexibility of selection of an area of specialization from a pool of courses. These courses are considered specialized or advanced with respect to M.Sc. Applied Plant Science program and provide extensive exposure in the area chosen. A total of 22 Elective courses are offered by the Department of which a student has to complete two courses from the chosen area in the fourth semester of the program.

Dissertation

The topic of the dissertation may be chosen from an area of one of the elective courses opted inthe 4th semester.

Evaluation and Grading

Calicut University Regulations for Choice-based Credit Semester System for Post Graduate Programmes of Teaching Departments/Schools of the University of Calicut (CCSS PG Regulations 2022) are to be followed for internal and external evaluation andgrading.

The evaluation scheme for each course (paper) shall contain two parts a) continuous (internal) evaluation b) end semester evaluation 50% weight shall be given to the continuous (internal) evaluation. The remaining 50% weight shall be for the end semester examination evaluation. (For all courses under CCSS PG including MBA programme). Continuous (internal) evaluation: The internal evaluation shall be based on a predetermined transparent system involving periodic written tests, viva-voce, seminars and attendance in respect of theory courses and based on written tests, viva-voce and lab skill/records in respect of practical courses as detailed below in Table 2

Table 2: Internal Evaluation

Theory Paper	Marks	Practical Paper	Marks
a. Attendance*	5	**a.** Lab skill/ Quality of Records	10
b. Seminar	5	**b.** Practical Test	30
c.Assignment	5	**c.**Viva Voce	10
d. Test Paper	30		
e. Viva-Voce / Field work	5	**Total marks**	**50**
Total marks	**50**		

*90% & above: 5 marks, 80 to 89%: 3 marks, 75 to 79%: 1 mark, below 75%: nil

End Semester Examination Evaluation:

The End Semester examination in theory courses is to be conducted with question papers set by the examiners (internal/external). The evaluation of the answer scripts shall be done by the teacher offering the course and an expert (internal/external) based on a well-defined scheme of valuation framed by them. No separate minimum is required for internal evaluation for a pass, but a minimum 40% is required for each course in the end semester examination evaluation.

The End Semester practical examination shall be conducted and evaluated by two or more examiners nominated by the Department Council.

The valuation scheme for Project/Dissertation: The valuation shall be jointly done by the supervisor of the project in the department and an External / Internal Expert from the approved panel, based on a well-defined scheme of valuation framed by them. The following break-up is suggested for the valuation. The concerned Department Council / BoS may decide on alternative break-up, if required, specific to the discipline of study.

Sl. No.	Particulars	Weightage (%)
1	Review of Literature and Formulation of the Research Problem/Objective	20
2	Methods and Description of the techniques used	15
3	Analysis and Discussion of results	30
4	Presentation of the report, organization, linguistics style, references etc.	15
5	Viva Voce examination based on the Project work/Dissertation	20
	Total	**100**

Examiners

The internal examiners of each semester shall be the teachers who actually imparted instruction in that particular semester. The externalexaminers shall be selected from a panel of external examiners approved by the Departmental Council for each semester.

Plan of Question Papers for External Examinations

Theory

Core & Elective Courses:

Part A: One essay-type questions of 8 marks to be answered out of two questions (1x8 = 8 marks).

Part B: Eight short answer questions of 4 marks each to be answered out of ten questions (8x4 = 32 marks).

Part C: Ten short answer questions of 1 marks each to be answered out of twelve questions (10x1 = 10 marks).

Practicals

The Board of Examiners for practical examinations of I to IV semesters shall decide the plan of question papers. The break-up of marks for the external examinations of practical courses will be as follows:
practical examination-40 marks;
records/submission/viva-10 marks.

Record of Practical Work

A certified record of practical work done by the student should be submitted at the time of each practical examination.

Duration of examinations

The duration for each theory and practical examination shall be three hours.

There will be two compulsory courses - Ability Enhancement Course (AEC) & Professional Competency Course (PCC) each with 2 credits, and these courses are to be done within the first two semesters. The credits will not be counted for computing the overall SGPA/CGPA

of the student. The concerned department shall conduct examination for these courses and shall intimate /upload the results of the same to the University on the stipulated date during the III Semester. The student has to obtain only minimum pass requirements *(40%) in these two courses .The Department Council will decide the evaluation criteria for the **Ability EnhancementCourse** (BOT1A01-The Process of Research-Theory) and the **Professional Competency Course** (BOT2A02-Biotechniques and Instrumentation-Practical).

Programme Structure, Credit and Mark distribution, and Scheme of Examination

Semester	Course No.	Name of the course	Credit for the course	Marks		
				Continuous evaluation (Internal) (50%)	End Semester Evaluation (50%)	Total
1	BOT1C01	Viruses, Bacteria, Cyanobacteria, Algae & Bryophytes (Theory)	3	50	50	100
	BOT1C02	Viruses, Bacteria, Cyanobacteria, Algae & Bryophytes (Practical)	1	50	50	100
	BOT1C03	Fungi and Plant Diseases (Theory)	3	50	50	100
	BOT1C04	Fungi and Plant Diseases (Practical)	1	50	50	100
	BOT1C05	Pteridophytes & Gymnosperms (Theory)	3	50	50	100
	BOT1C06	Pteridophytes & Gymnosperms (Practical)	1	50	50	100
	BOT1C07	Anatomy of Angiosperms & Microtechnique (Theory)	3	50	50	100
	BOT1C08	Anatomy of Angiosperms & Microtechnique (Practical)	1	50	50	100
	BOT1A01	The Process of Research (Theory)	2	100	-	100
2	BOT2C09	Plant Physiology (Theory)	3	50	50	100
	BOT2C10	Plant Physiology (Practical)	1	50	50	100
	BOT2C11	Biochemistry, Biophysics & Immunology (Theory)	3	50	50	100
	BOT2C12	Biochemistry, Biophysics & Immunology (Practical)	1	50	50	100

	BOT2C13	Plant Morphogenesis, Embryogenesis, Palynology & Plant Biotechnology (Theory)	3	50	50	100
	BOT2C14	Plant Morphogenesis, Embryogenesis, Palynology & Plant Biotechnology (Practical)	1	50	50	100
	BOT2C15	Environmental Biology (Theory)	3	50	50	100
	BOT2C16	Environmental Biology (Practical)	1	50	50	100
	BOT2A02	Biotechniques and Instrumentation (Practical)	2	100	-	100
3	BOT3C17	Angiosperm Taxonomy, Morphology and Phytogeography (Theory)	3	50	50	100
	BOT3C18	Angiosperm Taxonomy, Morphology and Phytogeography (Practical)	1	50	50	100
	BOT3C19	Genetics, Plant Breeding, & Biostatistics (Theory)	3	50	50	100
	BOT3C20	Genetics, Plant Breeding, & Biostatistics (Practical)	1	50	50	100
	Open Elective	Open Elective Courses offered by other Departments	4	50	50	100
	BOT3C21	Cell and Molecular Biology (Theory)	4	50	50	100
4	BOT4C22	Advances in Cell & Molecular Biology (Theory)	3	50	50	100
	BOT4C23	Advances in Cell & Molecular Biology (Practical)	1	50	50	100
	BOT4C24	Genetic Engineering & Bioinformatics (Theory)	3	50	50	100
	BOT4C25	Genetic Engineering & Bioinformatics (Practical)	1	50	50	100
	BOT.4 *	Elective 1*	4	50	50	100
	BOT.4 *	Elective 2*	4	50	50	100
	BOT4P01	Dissertation	8	--	200 (160 + 40 for viva)	200

Grand Total	2400

*__Discipline Specific Electives offered by the Department in the 4th Semester__

1) BOT4E01 Theoretical Aspects of Angiosperm Taxonomy (Theory); Credit: 4
2) BOT4E02 Applied Aspects of Angiosperm Taxonomy (Theory); Credit: 4
3) BOT4E03 Fungal Biology and Technology (Theory); Credit: 4
4) BOT4E04 Fungal Systematics (Theory); Credit: 4
5) BOT4E05 General Bryology (Theory); Credit: 4
6) BOT4E06 Applied Bryology (Theory); Credit: 4
7) BOT4E07 Cytogenetics (Theory); Credit: 4
8) BOT4E08 Cytotechniques (Theory); Credit: 4
9) BOT4E09 Ecological Aspects of Plant Functions (Theory); Credit: 4
10) BOT4E10 Physiology of Plants under Stress (Theory); Credit: 4
11) BOT4E11 Basic Environmental Science (Theory); Credit: 4
12) BOT4E12 Applied Environmental Science (Theory); Credit: 4
13) BOT4E13 Principles of Ethnobotany (Theory); Credit: 4
14) BOT4E14 Applied Ethnobotany (Theory); Credit: 4
15) BOT4E15 Plant Tissue Culture (Theory); Credit: 4
16) BOT4E16 Plant Biotechnology (Theory); Credit: 4
17) BOT4E17 Basic Pteridology (Theory); Credit: 4
18) BOT4E18 Applied Pteridology (Theory); Credit: 4
19) BOT4E19 Biology and Taxonomy of Algae and Cyanobacteria (Theory); Credit: 4
20) BOT4E20 Applied Aspects of Algae and Cyanobacteria (Theory); Credit: 4
21) BOT4E21 Genetics and Crop Improvement I (Theory); Credit: 4
22) BOT4E22 Genetics and Crop Improvement II (Theory); Credit: 4

Course code, Credit and Mark distribution for the open elective course offered for other departments

Semester	Course code	Corse Name	Credits	Marks		
				Internal	External	Total
3	BOT3E01	Horticulture	4	50	50	100

There shall be provisions for the addition or deletion of discipline specific elective courses to be offered, if necessary, in subsequent years of admission, subject to approval by the departmental council and other bodies concerned. In the fourth semester, there will be four electives (theory) courses. In the fourth semester, each student is required to submit a dissertation in one of the areas of elective courses that he or she has chosen. The project work related to the chosen areas of elective papers should begin during the third semester.

SEMESTER I

COURSE CODE: **BOT1C01**	NAME OF THE COURSE: **Viruses, Bacteria, Cyanobacteria, Algae and Bryophytes (Theory)**	CREDITS: **3**

Course Objectives:

The main objectives of this course are to:

1. The objective of this core paper is to enable the students to gain analytical skills at an advanced level.
2. The program envisages to apply knowledge about prokaryotic and eukaryotic cellular processes, interaction of microorganisms among themselves, with physical and chemical agents and higher order organisms in environment and biological systems at various conditions.
3. Laboratory training is also included so that the students will acquire the skills to qualify for a broad range of assignments in research, industry, consultancy, education and public administration.
4. The basic information gained from this core paper can be utilized by the students to address broad range of fields including biotechnology, food science, microbiology, microbial genetics, molecular biology and systems biology.

Expected Course Outcomes:

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

1	Understand research ethics so as to contribute to application, advancement and impartment of knowledge in the field of microbiology, algology and bryology. The laboratory training will empower them to prepare for careers in broad range of fields.	K1
2	Can compete in national level competitive exams such as NET-JRF or GATE and can pursue career in higher studies.	K2
3	Develop ability to independently carry out a complete scientific work process, including the understanding of theoretical background, hypothesis generation, collection and analysis of data, and interpretation and presentation of results	K3
4	Will be able to evaluate and apply relevant theory, methods and analytic approaches within the fields coming under this paper.	K4
5	Will attain high competence and multidisciplinary project experience within selected topics related to microbiology, algology and bryology and will also acquire ability to contribute in a multidisciplinary research team.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Bacteria

1. History of microbiology:
2. Morphology and ultra structure - shapes, arrangements, cell organization, cell

envelopes, capsules, slime layers, cytoskeleton, inclusions, plasmids; external structures - pili, fimbriae, ultra structure of flagella, flagellar movements and motility - flagellar motility, spirochete motility, twitching motility and gliding motility; endospore and its formation; nutritional types of bacteria; modes of genetic exchange - transformation, transduction and conjugation.

3. Applied aspects: major industrial products from bacteria (Amino acids, Biopolymers, and recombinant products), wastewater treatment, biodegradationm and bioremediation
4. Association with vascular plants: symbiotic nitrogen fixation- *Rhizobium*, stem-nodulating rhizobia, actinorhizae,*Agrobacterium.*
5. General account on actinomycetes, mycoplasmas, chlamydiae, spirochaetes, Rickettsia and Deinococcus-Thermus.

Viruses

1. Detailed study of the structure and morphology plant viruses with special reference to TMV; viral envelopes and enzymes; viral genomes; multiplication and virion release; types of viral infections; cultivation and enumeration of viruses (hemagglutination assay and plaque assay); types of viral infections (lysogenic and lytic cycles);
2. Brief account on viroids, prions, virusoids and bacteriophages; animal viruses and diseases caused by them; tools for studying viral structure.
3. Methods in microbiology: Culture media and their preparation, methods of sterilization, isolation of pure cultures, cultivation of anaerobic bacteria, estimation of microbial number and biomass.

Cyanobacteria

1. Classification (Komereck et al. 2014)
2. Diversity, structure of cell, akinete, heterocyst, pigments, chromatic adaptation, thallus organization and reproduction.
3. Applied aspects: Biofuel production, carbon dioxide sequestration, cyanobacteria as biofertilizer, mass production (Laboratory culture, Trough method, Pit method, Field production, Photobioreactors, Raceway ponds) and field application, bioactive compounds. from cyanobacteria, bioremediation, food supplements, other industrial applications
4. Fossil cyanobacteria.
5. Cyanobacterial associations: with algae, fungi, bryophytes, pteridophytes, gymnosperms and angiosperms.

Algae

1. Classification of Algae (Van den Hoek et al. 1995). Brief account of the recent development in molecular phylogenetics and DNA barcoding of algae.
2. Diversity, range of thallus structure, reproduction and life history.
3. Collection, identification, preservation (including herbarium techniques) of algae.
4. General account of the structure, reproduction and relationships in the following group Chlorophyta; Xanthophyta; Phaeophyta, Bacillariophyta, Euglenophyta and Rhodophyta.
5. Industrial Phycology: bioactive compounds from algae, sea weed polysaccharides like

Agar, carrageenin and alginates, diatomite, funori.

6. Applied aspects: biofuel production, food supplements, pharmaceutical industries, algal blooms, commercial cultivation of algae.
7. Fossil algae.

Bryophytes

1. General characters and systems of classification of bryophytes. Brief account of the recent developments in molecular phylogenetics and DNA barcoding of bryophytes.
2. Origin and evolution of Bryophytes
3. General account of the anatomy, reproduction and life history of Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Andreales, Funariales and Polytrichales
4. Applied bryology: ecological uses, household uses, medicinal uses, horticultural uses.
5. Fossil bryophytes : a general account

References:

- Chapman, V. J. & Chapman, D. J. 1973. The Algae. Macmillan.
- Desikachary, T. V. 1959. Cyanophyta. Indian Council of Agricultural Research.
- Fritsch, F. E. 1961. The Structure and Reproduction of Algae. Vol. 2. Cambridge University Press.
- Glime, J. M. & Saxena, D.1991. Uses of Bryophytes. Today and Tomorrows Printers & Publishers.
- Irvine, D. E. & D. M. John. 1984. Systematics of the Green Algae. Academic Press.
- Krishnamurthy, V. 1998. Algae of India and Neighboring Countries. 1. Chlorophycota. Oxford & IBH publishing Co. Pvt. Ltd.
- Madigan, M. T. et al. 2008. Brock Biology of Microorganisms. Benjamin Cummings
- Nair, M. C. et al. 2005. Bryophytes of Wayanad, Western Ghats. MNHS, Calicut.
- Pollack, R. A. et al. 2004. Laboratory Exercises in Microbiology. Wiley.
- Prescott, G. W.1969. The Algae. A Review. Thomas Nelson and Sons Ltd
- Prescott, L. M. et al. 2005. Microbiology. McGraw Hill
- Schofield, W. B. 2001. Introduction to Bryology. The Blackburn Press.
- Shaw, A. J. & Goffinet, B. (eds.). 2000. Bryophyte Biology, Cambridge University Press.
- Singleton, P. 2004. Bacteria in Biology, Biotechnology and Medicine. Wiley.
- Smith, A. J. E. (ed.). 1982. Bryophyte Ecology. Chapman & Hall.
- Smith, G. M. 1978. Manual of Phycology. The Ronald Press Company.
- Stevensen, J. *et al.* 1996. Algal Ecology. Fresh water benthic ecosystems. Academic Press.
- Trainor, F. R. 1978. Introductory Phycology. John Wiley and Sons.
- Van Den Hock, Mann, D.G. and Jahns, H.M. 1995. Algae: An introduction to Phycology. Cambridge University press.
- Venkataraman, G. S., Goyal, S. K., Kaushik B. D., and Roychaudhary, P. 1974. Algae form and function. Today and Tomorrow's printers.
- Vijayaraghavan, M. R. & Bhatia, B. 1997. Red Algae: Structure, Ultrastructure and Reproduction. APH Publishing Corporation.

COURSE CODE: **BOT1C02**	NAME OF THE COURSE: **Viruses, Bacteria, Cyanobacteria, Algae and Bryophytes (Practical)**	CREDIT: **1**

Course Objectives:

The main objectives of this course are to:

1. Acquire advanced practical skills in the use of instruments, techniques and methods in microbiology.
2. Master the technical skills in sterilizing, culturing, sectioning, staining and characterizing microorganisms.
3. Apply the practical knowledge in understanding the structural and functional diversity of these groups.
4. Acquire advanced practical skills in systematic collection, preservation and herbarium methods of Algae, Cyanobacteria and Bryophytes.
5. Provide opportunities to get deep insights on the extent of diversity of microhabitats of Algae, Cyanobacteria and Bryophytes; and to collect and examine samples from various major habitats.
6. To compare the structural diversity of fossil and extant plant species.

Expected Course Outcomes:

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

1	Demonstrate practical skills in microbiology including isolate, culture and characterize microorganisms from different substrates; and classify bacteria based on staining techniques	K1, K2
2	Describe the structure, apply practical knowledge in understanding the diversity and the importance of structural diversity in the evolution of plant forms.	K2, K3, K5
3	Acquire practical skills in systematic collection, processing, preservation, herbarium techniques of Algae, Cyanobacteria and Bryophytes.	K2, K3
4	Acquire skills in undertaking detailed study on these groups.	K4
5	Master the concept of microhabitats and the role played by these groups in the ecosystem.	K2, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Viruses & Bacteria

1. Preparation of culture media
2. Isolation of bacteria from soil by dilution-plate method.
3. Isolation of bacterial pure culture by streak-plate method.
4. Staining of bacteria: simple staining, Gram staining, spore staining, and negative staining.

Cyanobacteria:

Oscillatoria, Nostoc, Anabaena, Scytonema, Westielliopsis, Phormidium, cylindrospermum, Lyngbya, Calothrix, Chroococcous, Gleocapsa, Microcoleus, Aphanocapsa, Pseudanabaena Stigonema,Trichormus, Hapalosiphon, Rivularia

Algae:

1. Collection, preparation and presentation of algal herbarium (minimum 5 herbarium sheets).
2. Field collection and study of the types mentioned below and their classification up to generic level.

- Chlorophyta: *Chlorella, Hydrodictyon*, *Pediastrum, Enteromorpha, Ulothrix, Ulva, Cladophora, Pithophora, Bulbochaete, Oedogonium, Chara, Bryopsis, Codium, Zygnema, Halimeda*, Desmids (*Cosmarium, Closterium, Micrasterias, Staurastrum, Euastrum, Pleuotaenium, Senedesmus, pleurotaenium*), *Mougeotia, Zygnema, Caulerpa, spirogyra.*
- Xanthophyta: *Botrydium, Vaucheria*. Bacillariophyta:*Pinnularia*, *Navicula, Gyrosigma.*
- Phaeophyta: *Ectocarpus, Dictyota, Padina, Sargassum, Turbinaria*.
- Rhodophyta: *Gracilaria, Batrachospermum*.

Bryophytes:

Field collection, Morphological and structural study of the following genera:
Riccia, Marchantia, Lunularia, Asterella, *Plagiochasma, Cyathodium, Targionia, Anthoceros, Porella, Riccardia, Pallavicinia, Notothylas, Spahagnum, Pogonatum, Bryum* and *Funaria.*

References:

- Beck, J. V. et al. 1968. Laboratory Manual for General Microbiology. Burgess Pub. Co.
- Desikachary, T. V. 1959. Cyanophyta. Indian Council of Agricultural Research.
- Fritsch, F. E. 1961. The Structure and Reproduction of Algae. Vol. 2. Cambridge University Press.
- Irvine, D. E. & D. M. John. 1984. Systematics of the Green Algae. Academic Press.
- Krishnamurthy, V. 1998. Algae of India and Neighboring Countries. 1. Chlorophycota. Oxford & IBH publishing Co. Pvt. Ltd.
- Kumar, H. D. 1990. Introductory phycology. East West Press Pvt. Ltd.
- Madigan, M. T. et al. 2008. Brock Biology of Microorganisms. Benjamin Cummings
- Nair, M. C. et al. 2005. Bryophytes of Wayanad, Western Ghats. MNHS, Calicut.
- Pollack, R. A. et al. 2004. Laboratory Exercises in Microbiology. Wiley.
- Prescott, L. M. et al. 2005. Microbiology. McGraw Hill
- Schofield, W. B. 2001. Introduction to Bryology. The Blackburn Press.
- Shaw, A. J. & Goffinet, B. (eds.). 2000. Bryophyte Biology, Cambridge University Press.
- Singleton, P. 2004. Bacteria in Biology, Biotechnology and Medicine. Wiley.
- Smith, A. J. E. (ed.). 1982. Bryophyte Ecology. Chapman & Hall.
- Smith, G. M. 1978. Manual of Phycology. The Ronald Press Company. Trainor, F. R. 1978. Introductory Phycology. John Wiley and Sons.
- Stevensen, J. *et al.* 1996. Algal Ecology. Fresh water Benthic ecosystems. Academic Press.
- Van Den Hock, Mann, D.G. and Jahus, H.M. Algae: An Introduction to Phycology. Cambridge University press.
- Venkataraman, G. S., Goyal, S. K., Kaushik B. D., and Roychaudhary, P. 1974. Algae form and function. Today and Tomorrow's printers.
- Vijayaraghavan, M. R. & Bhatia, B. 1997. Red Algae: Structure, Ultrastructure and Reproduction. APH Publishing Corporation.

COURSE CODE: **BOT1C03**	NAME OF THE COURSE: **Fungi and Plant Diseases (Theory)**	CREDITS: **3**

Course Objectives:		
The main objectives of this course are to: 1. To acquire knowledge of diverse groups of fungi 2. To gain knowledge of the classification, structural organization and reproduction ofFungi. 3. To obtain knowledge of the life cycle patterns of fungi and their significance. 4. To obtain a basic knowledge of the principles and methods of plant pathology and to learn the symptoms andcontrol measures of diseases of crop plants of Kerala.		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Grasp the basic concepts of fungal biology and classification	K1
2	Understand the diversity in habits, habitats and organization of fungi.	K2
3	Acquire knowledge on the exploitation of useful products from fungi for the betterment ofhuman welfare	K3
4	Apply their acquired knowledge to know better about the diseases of crop plants of Kerala, their causative organisms and their control measures.	K4
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze		

1. An overview of true fungi and fungal analogues (stramenopilan fungi and protistan fungi): biodiversity, significance and phylogenetic relationships.
2. General characteristics of true fungi: thallus organization, hyphal structure; wall composition and construction; hyphal elongation and growth; dimorphism; haustoria; rhizomorphs; appressoria; sclerotia and stromata; fungal organelles, modes of nutrition, process of extracellular digestion, storage materials, reproduction and spores, vegetative incompatibility and sexual compatibility, parasexuality. A brief account of radiotrophic fungi and radiosynthesis. An overview of mycoloop.
3. Characters used in fungal classification; species concepts; updated phylum-level classification of true fungi by Tedersoo et al. 2018; current taxonomic concepts regarding stramenopilan fungi and protistan fungi. An outline of Ruggiero et al., (2015) classification of fungal analogues. Brief account of DNA barcoding in fungi.
4. General characteristics of the following categories of fungi and fungal analogues: chytridiomycetes, zygomycetes, ascomycetes, basidiomycetes, oomycetes and myxomycetes.
5. Asexual fungi (deuteromycetes): general characteristics, habit and importance of asexual fungi, somatic structures, structures associated with asexual reproduction, conidiomata, conidia and conidium ontogeny, other asexual propagules, teleomorph- anamorph connections. Nomenclature and classification of asexual fungi.
6. Lichens: thallus structure, nutrition, reproduction, water relation and growth, cultural studies, mutualistic interaction, ecologicaland economic significance.
7. Importance of the plant diseases; concept of plant disease; disease triangle and disease tetrahedron; causes of plant diseases; classification of plant diseases; parasitism and pathogenesis; Koch's postulates; effect of pathogen on the plants; symptoms of plant

diseases; development of epidemics; major plant pathogens: fungi, bacteria, viruses, mycoplasmas, nematodes and phanerogams; plant disease management and disease control; major crop diseases of Kerala.

References

- Agrios, G. N. 2005. Plant Pathology, 5th edition. Academic Press.
- Alexopoulos, C. J. et. al. 1996. Introductory Mycology, 4th Edition, Wiley.
- Hudler, G. W. 1998. Magical Mushrooms, Mischievous Molds. Princeton University Press.
- Kagami, M., Miki, T. & Takimoto, G. 2014. Mycoloop: chytrids in aquatic food webs. Frontiers in Microbiology 5: https://doi.org/10.3389/fmicb.2014.00166
- Kavanagh, K. 2017. Fungi, Biology and Applications 3rd edition. Wiley.Kirk, P. M. et al. 2008. Dictionary of the Fungi, 10th edition. CABI.
- Manimohan, P. 2022. An overview of the diversity and classification of fungi. In: Seethalakshmi KK, Haridasan K, Maya C Nair & Rekha Vasudevan A (Eds.), Conspectus on Realms of Biodiversity, Victorian Botany Alumni Association, Government Victoria College, Palakkad, pp. 353-367.
- Nash, T. H. 2008. Lichen Biology 2nd edition. Cambridge University Press.
- Rangaswami, G. 1999. Diseases of Crop Plants of India, 4th edition. Prentice Hall of India.
- Ruggiero, M. A, Gordon, D. P. & Orrell, T. M. 2015. A higher-level classification of all living organisms. Plos One, 10(4), e0119248.
- Singh, R. S. 2017. Introduction To Principles Of Plant Pathology 5th edition. Medtech. Tedersoo, L. et al. 2018. High-level classification of the Fungi and a tool for evolutionary ecological analyses. Fungal Diversity 90(1): 135–159.
- Webster, J. & Weber, R. 2007. Introduction to Fungi. Cambridge University Press.

Related Online Contents (Websites)

- http://www.fungikingdom.net/
- https://oxfordmedicine.com/view/10.1093/med/9780198755388.001.0001/med-9780198755388-chapter-4
- http://www.tolweb.org/tree?group=fungi&msclkid=e154af6cc1f611ecbace2bf5d40c1fca
- http://www.myxomycetes.net/#image-banner-141
- https://www.britishlichensociety.org.uk/?msclkid=c66b9221c1f311ec9159fc3510c54c10
- https://www.apsnet.org/edcenter/disandpath/Pages/default.aspx

COURSE CODE: **BOT1C04**	NAME OF THE COURSE: **Fungi and Plant Diseases (Practical)**	CREDIT: 1

Course Objectives:		
The main objectives of this course are to: 1. To gain knowledge of the morphology and anatomy of the diverse groups of fungi 2. To know about the symptoms and signs and the causative agent of common plant diseases seen in Kerala 3. To acquire skills in the isolation of fungi from soil and dung. 4. To obtain experience in pure culturing of fungi		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	To identify the listed fungi at least up to the genus level based on the morphological and anatomical characters.	K1
2	To identify the listed plant diseases and their pathogens using signs and symptoms.	K2
3	To detect, isolate, identify, and quantify fungi from the listed substrates.	K3
4	To define the nutritional, chemical, and environmental requirements for the growth and metabolism of fungi.	K4
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze		

1. Preparation of culture media
2. Isolation of fungi from soil by dilution-plate method.
3. Isolation of fungi from dung.
4. Study of morphology and anatomy of the reproductive structures of the following genera of fungi : *Stemonitis, Hemitrichia, Arcyria, Synchytrium, Saprolegnia, Phytophthora, Pythium, Albugo, Pilobolus, Glomus, Mucor, Rhizopus, Saccharomyces, Taphrina, Ascobolus, Xylaria, Trichoglossum, Phomopsis, Drechslera, Aspergillus, Penicillium, Alternaria, Cercospora, Fusarium, Tremella, Auricularia, Auriculoscypha, Puccinia, Hemileia, Coleosporium, Ustilago, Agaricus, Entoloma, Marasmius, Hexagonia, Ganoderma, Lenzites, Lycoperdon, Geastrum, Dictyophora, Cyathus, Parmelia* and *Usnea*.
5. Study of the symptoms and signs of the following plant diseases in the laboratory and in the field and identification of the pathogens: abnormal leaf fall of rubber, coffee rust, plumeria rust, blister-blight of tea, quick wilt of pepper, white rust of amaranth, *Cercospora* leaf-spot of okra, powdery mildew of any locally available crop, rice blast, brown spot of rice, whip-smut of sugar cane, soft rot of carrot, sesamum phyllody, cassavamosaic.
6. Isolation of pure culture of a fungal plant pathogen from a diseased plant.

References

- Alexopoulos, C. J. 1962. Laboratory manual for Introductory Mycology. Burgess Pub. Co.
- Beck, J. V. et al. 1968. Laboratory Manual for General Microbiology. Burgess Pub. Co.
- Koneman, E. W. 1985. Practical Laboratory Mycology. Williams & Wilkins.Pollack, R. A. et al. 2004. Laboratory Exercises in Microbiology. Wiley.

- Rangaswami, G. 1999. Diseases of crop plant of India, 4th edition. Prentice Hall of India.
- Roberts, G. 1979. Mycology Laboratory Procedure Manual. Mayo Clinic.

Related Online Contents (Websites)

- https://ag.arizona.edu/classes/plp427L/lab2.html
- https://www.adelaide.edu.au/mycology/laboratory-methods#culture-techniques-and-media

COURSE CODE: **BOT1C05**	NAME OF THE COURSE: **Pteridophytes and Gymnosperms (Theory)**	CREDITS: **3**

Course Objectives:		
The main objectives of this course are to: 1. To attain knowledge on diverse groups of vascular cryptogams and vascular phanerogams. 2. To gain knowledge on the diversity, structural organization and reproduction of Pteridophytes and Gymnosperms. 3. To comprehend on the life cycle patterns of pteridophytes and Gymnosperms.		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Grasp the knowledge on the phylogeny of Pteridophytes and Gymnosperms.	K1
2	Know better regarding the alternation of generations.	K2
3	Attain knowledge on the ecological and economic significance of Pteridophytes and Gymnosperms.	K3
4	To know about the distribution pattern of living and fossil Gymnosperms in India	K4
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze		

Pteridophytes

1. Introduction: A brief account of the origin and general characteristics of Pteridophytes.
2. DNA barcoding in Pteridophytes. The Pteridophyte Phylogeny Group (PPG 1).
3. Classification: An outline of recent system of classification of Pteridophytes (Smith et al. 2006).
4. Habitat diversity with special reference to South Indian Pteridophytes and their conservation. Endemic and endangered pteridophytes of South India.
5. Evolution of steles in Pteridophytes. Telome theory.
6. Soral and sporangial characters, evolution of sorus and sporangium. Heterospory and seed habit.
7. Gametophyte: Patterns of spore germination; patterns of gametophyte development in homosporous and heterosporous pteridophytes. Apogamy, apospory and apomixis.
8. Cytogenetics and speciation: Pteridophytes with low and high chromosome number; polyploidy in Pteridophytes.
9. Ecological and economic significance of Pteridophytes.
10. A brief account on the diversity, distribution, habitat, external and internal morphology, reproduction of sporophytes, gametophytic generation, sexuality and embryogeny of the following orders as per PPG (2016) classification:
    i. Lycopodiopsida - Lycopodiales (Lycopodiaceae), Isoetales (Isoetaceae);
    ii. Polypodiopsida - Equisetidae – Psilotales (Psilotaceae)
    iii. Ophioglossidae - Ophioglossales
    iv. Marattiidae - Marattiales
    v. Polypodiidae - Osmundales (Osmundaceae), Hymenophyllales (Hymenophyllaceae), Salviniales (Salviniaceae), Cyatheales (Cyatheaceae), Polypodiales (Pteridaceae, Blechnaceae, Thelypteridaceae)

11. Study of the the following orders in brief:
    a). Psilophytales; b). Lepidodendrales; c). Sphenophyllales; d). Cladoxylales;

Gymnosperms

1. General characters, classification. Brief account of the recent developments in molecular phylogenetics and DNA barcoding of gymnosperms.
2. Geological horizon, distribution, general account including morphology, anatomy, phylogeny and interrelationship of the following orders with special emphasis on the genera specified:
    a) Pteridospermales: *Lyginopteris, Heterangium, Sphenopteris, Sphaerostoma, Lagenostoma. Medullosa, Trigonocarpus, Pachytesta, Codonotheca*.
    b) Glossopteridales: *Glossopteris*
    c) Caytoniales : *Caytonia*
    d) Cycadeoidales: *Cycadeoidea*
    e) Pentoxylales: *Pentoxylon*.
    f) Cycadales: *Zamia*
    g) Ginkgoales: *Ginkgo*
    h) Coniferales: *Cedrus, Cryptomeria, Cupressus, Agathis, Podocarpus*.
    i) Taxales: *Taxus*
    j) Ephedrales: *Ephedra*
    k) Welwitschiales: *Welwitschia*
    l) Gnetales: *Gnetum*.
3. Evolution of gymnosperms
4. Distribution of living and fossil gymnosperms in India.
5. Economic importance of gymnosperms.

References

- Agashe S.N. 1995. *Palaeobotany*. Oxford and IBH Publishing House, New Delhi.
- Arnold C.A. 1947*. Introduction to Palaeobotany*. Mc-Graw Hill Book Com., London
- Baker, J.G. 1887. *Handbook to the ferns of British India*. Reprint (1995). Bishan Singh Mahendra Pal Singh, Dehradun
- Beddom, R.H. 1865-1870. *The ferns of British India*. Vol 1 & 2. Reprint (1976). Oxford and IBH, New Delhi.
- Beddome R.H. 1863-1865. *Ferns of South India*. Reprint (1970). Today & Tommorrow's Publ., New Delhi
- Chandra, S, Fraser-Jenkins, C.R., Alka, K & A. Srivastava. 2008. A Summary of the Status of Threatened Pteridophytes of India. *Taiwania* 53(2): 170-209.
- Chandra S. & Srivastava M. (Eds.). 2003. *Pteridology in the New Millennium*. NBRI Golden Jubilee Volume, india.
- Christenhusz M.J.M. & M.W. Chase. 2014. Trends and concepts in fern classification. Annales of Botany 113: 571-594.
- Dyer A.F. 1979. *The experimental biology of ferns*. Academic Press, London.
- Eams, A.J. 1936. Morphology of Vascular Plants.

- Fraser-Jenkins, C.R. 2012. Rare and Threatened Pteridophytes of Asia 2. Endangered Species of India — the Higher IUCN Categorie. Bull. Nat. Mus. Nat. Sci. Ser. B. 38(4): 153–181.
- Gifford E.M. & A.S. Foster 1989. *Morphology and evolution of Vascular plants*
- (III Edn). W H Freeman & Co.
- Khullar S.P. 2000. An illustrated fern flora of West Himalayas (Vol I & II). International Book Distributers, Dehradun.
- Kubitzki K. 1992. The families and Genera of Vascular plants: Vol. I Pteridophytes. Vikas publishing house.
- Louis J.D. 1977. Evolutionary patterns and processes in ferns: Advances in Botanical Research
- Nayar B.K. & S. Kaur 1971. Gametophytes of homosporous ferns. The Botanical Review: 295
- PPG 1. 2016. A community-derived classification for extant lycophytes and ferns. Plant Systematics and evolution 54(6): 563–603.
- Rashid A. 1976. *An introduction to Pteridophyta*. Vikas Publishing House, New Delhi.
- Smith, A.R., Pryer, K.M., Schuettpelz, E., Korall, P., Schneider, H. Wolf, P.G. 2006. A classification for extant ferns. Taxon 55: 705-731
- Sporne K.R. 1982. The *Morphology of Pteridophytes*. Hutchinson University Press.
- Surange K. R. 1966. *Indian Fossil Pteridophytes*. Bot. Monograph, CSIR.

- Andrews Jr., H. N. 1961. Studies in Paleobotany. John Wiley, New York
- Arnold, C. A. 1953. Origin and relationships of the cycads. Phytomorphology 3: 51-65
- Beck, C. B. 1985. Gymnosperm phylogeny: A commentary on the views of S.V.Meyen. Bot. Rev. 51: 273-294
- Chamberlain, C. J. 1919. The Living Cycads. Chicago University Press, Chicago. Chemberlain, C. J. 1935. Gymnosperms: Structure and Evolution .Chicago University Press.
- Crepet, W. L. 1972. Investigations of North American cycadeoids: Pollination mechanisms in Cycadeoidea. Amer. J. Bot. 59: 1048-1056
- Dallimore, W. & Jackson, A. B. 1966. A Handbook of Coinfera. 4th edn, E. Arnold. Delevoryas, T. 1962. Morphology and evolution of fossil plants. New York.
- Favre-Duchartre, M. 1958. *Ginkgo*, an oviparous plant. Phytomorphology 8: 377-390
- Freedman, W.E. 1992a. Double fertilization in non-flowering seed plants and its relevance to the origin of flowering plants. Intl. Rev. Cytol. 140: 319-355.
- Freedman, W. E. 992b. Evidence of a pre-angiosperm origin of endosperm: Implicationsfor the evolution of flowering plants. Science 235: 336-339.
- Greguss, P. 1955. Identification of Living Gymnosperms on the Basis of Xylotomy.Akad Kiado.
- Harris, T. M. 1951. The relationships of the Caytoniales. Phytomorphology 1: 29-39.
- Mehra, P. N. 1988. Indian Conifers: Gnetophytes and Phylogeny of Gymnosperms. Pramodh P. Kapur, Raj Bandhu Ind. Complex, New Delhi
- Meyen, S. V. 1984. Basic features of gymnosperm: Systematics and phylogeny as

evidenced by the fossil record. Bot. Rev. 50: 1-111

- Meyen, S. V. 1986. Gymnosperm systematics and phylogeny: A reply to commentaries by CB Beck, CN Miller, and GW Rothwell. Bot. Rev. 52: 300-320
- Millay, M. A., & Taylor, T. N. 1976. Evolutionary trends in fossil gymnosperm pollen. Rev. Palaeobot. Palynol. 21: 65-91.
- Miller Jr., C.N. 1977. Mesozoic confers. Bot. Rev. 43: 217-280
- Pant, D. D. 1975. The classification of gymnospermous plants. Palaebot. 6: 65-70 Pearson HHW (1929) Gnetales, Cambridge Univ. Press, London
- Madhulata, Sanwal. 1962. Morphology and embryology of *Gnetum gnemon* L. Phytomorphology 12: 243-264
- Scott, D. H. 1909. Studies in Fossil Botany, 2nd edn. Vol 1 A and C Black, LondonScott, D. H. 1923. Studies in Fossil Botany, Vol 2. A and C Black, London.
- Sharma, B. D. 1994. Gymnosperms: Morphology, Systematics, Reproductive Biology, In: Johri, B.M. (ed.), Botany in India: History and Progress. Vol. 2. Oxford & IBH, New Delhi. pp 1-23.
- Singh, H. 1978. Embryology of Gymnosperms. Geb Borntrager, Berlin.
- Stewart, W.N. 1981. The Progymnospermospsida: The construction of a concept. Can. J.Bot. 59: 1539-1542.
- Stewart, W. N. 1983. Palaeobotany and the evolution of plants. Cambridge University Press.

COURSE CODE: **BOT1C06**	NAME OF THE COURSE: **Pteridophytes and Gymnosperms (Practical)**	CREDIT: 1

Course Objectives:		
The main objectives of this course are to: 1. To gain knowledge of the morphology and anatomy of the pteridophytes and gymnosperms 2. To acquire skills in the identification of pteridophytes in local flora. 3. To obtain experience in identification of fossil types		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	To develop an understanding of the range of variation in structural and reproductive diversities of Pteridophytes	K1
2	To identify the fossil types of gymnosperm taxa	K2
3	To impart knowledge on the distribution, conservation status, and economic and ecological importance of Pteridophytes and gymnosperms.	K3
4	To analyze the biology and diversity of Pteridophytes and gymnosperms	K4
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze		

Pteridophytes

1. Study of morphology and anatomy of vegetative and reproductive organs of the following genera: *Lycopodium, Isoetes, Psilotum, Angiopteris, Ophioglossum, Osmunda, Trichomanes, Salvinia, Pteris, Cyathea, Blechnum, Christella*
2. Study of fossil Pteridophytes: *Lepidodendron, Spenophyllum, Cladoxylon.*
3. Field trips to familiarize with the diversity of Pteridophytes in natural habitats. Submission of 10 identified herbarium specimens.

Gymnosperms

1. Identification of petrifactions, compressions, impressions, slides of fossil types included in gymnosperm groups mentioned above
2. Comparative study of vegetative and reproductive structures of all living gymnosperm genera mentioned above.
3. Morphological and anatomical studies of above-mentioned taxa.

References

- Agashe S.N. 1995. *Palaeobotany*. Oxford and IBH Publishing House, New Delhi.
- Arnold C.A. 1947. *Introduction to Palaeobotany*. Mc-Graw Hill Book Com., London
- Baker, J.G. 1887. *Handbook to the ferns of British India*. Reprint (1995). Bishan Singh

Mahendra Pal Singh, Dehradun

- Beddome, R.H. 1865-1870. *The ferns of British India*. Vol 1 & 2. Reprint (1976). Oxford and IBH, New Delhi.
- Beddome R.H. 1863-1865. *Ferns of South India*. Reprint (1970). Today & Tomorrow's Publ., New Delhi
- Chandra S. & Srivastava M. (Eds.). 2003. *Pteridology in the New Millennium*. NBRI Golden Jubilee Volume, India.
- Dyer A.F. 1979. *The experimental biology of ferns*. Academic Press, London.Eams, A.J. 1936. Morphology of Vascular Plants.
- Gifford E.M. & A.S. Foster 1989. *Morphology and evolution of Vascular plants* (III Edn). W H Freeman & Co.
- Khullar S.P. 2000. An illustrated fern flora of West Himalayas (Vol I & II). International Book Distributers, Dehradun.
- Kubitzki K. 1992. The families and Genera of Vascular plants: Vol. I Pteridophytes.Vikas publishing house.
- Louis J.D. 1977. Evolutionary patterns and processes in ferns: Advances in Botanical Research
- Nayar B.K. & S. Kaur 1971. Gametophytes of homosporous ferns. The BotanicalReview: 295
- Rashid A. 1976. *An introduction to Pteridophyta*. Vikas Publishing House, New Delhi.
- Smith, A.R., Pryer, K.M., Schuettpelz, E., Korall, P., Schneider, H. Wolf, P.G. 2006. A classification for extant ferns. Taxon 55: 705-731
- Sporne K.R. 1982. The *Morphology of Pteridophytes*. Hutchinson University Press.
- Surange K. R. 1966. *Indian Fossil Pteridophytes*. Bot. Monograph, CSIR.

- Andrews Jr., H. N. 1961. Studies in Paleobotany. John Wiley, New York
- Arnold, C. A. 1953. Origin and relationships of the cycads. Phytomorphology 3: 51-65
- Beck, C. B. 1985. Gymnosperm phylogeny: A commentary on the views of S.V.Meyen. Bot. Rev. 51: 273-294
- Chamberlain, C. J. 1919. The Living Cycads. Chicago University Press, Chicago. Chemberlain, C. J. 1935. Gymnosperms: Structure and Evolution. Chicago University Press.
- Crepet, W. L. 1972. Investigations of North American cycadeoids: Pollination mechanisms in Cycadeoidea. Amer. J. Bot. 59: 1048-1056
- Dallimore, W. & Jackson, A. B. 1966. A Handbook of Coinfera. 4th edn, E.Arnold. Delevoryas, T. 1962. Morphology and evolution of fossil plants. New York.
- Favre-Duchartre, M. 1958. Ginkgo, an oviparous plant. Phytomorphology 8: 377-390
- Freedman, W.E. 1992a. Double fertilization in non-flowering seed plants and its relevance to the origin of flowering plants. Intl. Rev. Cytol. 140: 319-355.
- Freedman, W. E. 992b. Evidence of a pre-angiosperm origin of endosperm: Implicationsfor the evolution of flowering plants. Science 235: 336-339.
- Greguss, P. 1955. Identification of Living Gymnosperms on the Basis of Xylotomy. Akad Kiado.
- Harris, T. M. 1951. The relationships of the Caytoniales. Phytomorphology 1: 29-39.
- Mehra, P. N. 1988. Indian Conifers: Gnetophytes and Phylogeny of Gymnosperms. Pramodh P. Kapur, Raj Bandhu Ind. Complex, New Delhi

- Meyen, S. V. 1984. Basic features of gymnosperm: Systematics and phylogeny as evidenced by the fossil record. Bot. Rev. 50: 1-111
- Meyen, S. V. 1986. Gymnosperm systematics and phylogeny: A reply to commentaries by CB Beck, CN Miller, and GW Rothwell. Bot. Rev. 52: 300-320
- Millay, M. A., & Taylor, T. N. 1976. Evolutionary trends in fossil gymnosperm pollen. Rev. Palaeobot. Palynol. 21: 65-91.
- Miller Jr., C.N. 1977. Mesozoic confers. Bot. Rev. 43: 217-280
- Pant, D. D. 1975. The classification of gymnospermous plants. Palaebot. 6: 65-70 Pearson HHW (1929) Gnetales, Cambridge Univ. Press, London
- Madhulata, Sanwal. 1962. Morphology and embryology of *Gnetum gnemon* L. Phytomorphology 12: 243-264
- Scott, D. H. 1909. Studies in Fossil Botany, 2nd edn. Vol 1 A and C Black, LondonScott, D. H. 1923. Studies in Fossil Botany, Vol 2. A and C Black, London.
- Sharma, B. D. 1994. Gymnosperms: Morphology, Systematics, Reproductive Biology, In: Johri, B.M. (ed.), Botany in India: History and Progress. Vol. 2. Oxford & IBH, New Delhi. pp 1-23.
- Singh, H. 1978. Embryology of Gymnosperms. Geb Borntrager, Berlin.
- Stewart , W.N . 1981. The Progymnospermospsida: The construction of a concept. Can. J. Bot. 59: 1539-1542.
- Stewart, W. N. 1983. Palaeobotany and the evolution of plants. Cambridge University Press.

COURSE CODE: **BOT1C07**	NAME OF THE COURSE: **Anatomy of Angiosperms & Microtechnique (Theory)**	CREDITS: **3**

Course Objectives:

The main objectives of this course are to:

1. To classify meristems and to identify their structure, function, and role of apical vs. lateral meristems in plant growth.
2. To describe the function and organization of woody stems derived from secondary growth in dicot and monocot plants.
3. To highlight and learn deeply about the structure and function of vascular tissues.
4. To learn the mechanism of secretion in plants and their significance.
5. To have firsthand information on various aspects of the microtechnique.

Expected Course Outcomes:

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

1	Understand the intricacies involved in the anatomy of plants.	K1
2	Gain awareness about the various techniques adopted in the study of anatomy	K2
3	To explain the importance of secondary growth and to state the location of tissues involved in secondary growth in dicot and monocot plants	K3
4	Understand the process of secretion in plants and its significance	K2
4	To state the types of growth and to compare their structure and functions and processes of floristic growth	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** – Analyze

Anatomy

1. Meristems: Shoot apical meristem and functional zones, axillary floral and inflorescence meristems – structural diversity of the vegetative meristems.
2. Cell differentiation: tracheary element differentiation, secondary wall formation,
3. Vascular cambium structure and function; unusual features of structure and development in stem and roots; primary peripheral thickening meristem; anomalous stem and root structure.
4. The role of cambium in wound healing and grafting.
5. Structure and function of vascular tissues: xylem - structure and water movement. phloem - structure and mechanism of transport, nature and function of companion cells, Strasburger cells and transfer cells.
6. Secretion in plants – substances secreted by plants- mechanism of secretion- internal and external secretory structures
7. Root: Lateral root development. The Root cap – its function and role in gravitropism, root nodules and nitrogen fixation.
8. Leaf: development, structural diversity, anatomy of C3 and C4 plants. Ecological leaf anatomy, sun and shade leaves, halophytic and xeromorphic leaves.
9. Stomata – major types – development of stomata.
10. Stress anatomy: anatomy and pollution, anatomical response to water stress and mineral deficiency, effects of pollution, insecticides and herbicides.

Microtechnique

1. Microscopes: Light microscope, Phase contrast and electron microscope, Micrometric measurements and camera lucida.
2. Microtomes: Rotary, Sledge, and Cryostat.
3. Processing procedure for micropreparation:
    i. Killing and fixing: Principle and purpose, Common chemical fixatives, their preparation and specific uses; FAA, Carnoy's fluid, acetic alcohol, CRAF, Nawashins fluid, and Zircle's fluid.
    ii. Dehydration: Principle and procedure, Dehydrating agents – Ethyl alcohol, n-Butyl alcohol, Tertiary butyl alcohol, Isopropyl alcohol and Chloroform. Different dehydrating series: Alcohol-Xylene method, Alcohol-TBA method & Alcohol Chloroform method.
    iii. Paraffin infiltration – use of embedding oven
    iv. Embedding: Preparation of blocks. 'L' block and paper boat.
    v. Sectioning of paraffin blocks using rotary microtome: Trimming individual blocksand section cutting.
    vi. Adhesives and their preparations.
    vii. Mounting and spreading of paraffin ribbons on micro slides.
4. Staining: Stains used in microtechnique;
    - Classification – Natural – Hematoxylene, Carmine, Orcein.Synthetic (coal tar) –
    - Basic: Safranin, Crystal violet, Basic fuchsin, Cotton blue
    - Acidic: Fast green, Orange G, Erythrosine, Eosin, and Toluedin blue.
    - Staining procedure: Single, double and triple staining
    - Staining combination: safranin and fast green /cotton blue crystal violet and orange-G/erythrosine, Hematoxyline, and safranin.
5. Techniques of clearing, mounting, labeling and storing of permanent slides.
6. Whole mounts, Vein clearing, and tissue maceration.
7. Histochemical staining: Localization of proteins, nucleic acids, insolublecarbohydrates & lipids. Enzyme histochemistry – General account.
8. Vital staining: Principle, procedure, and applications.

References

- Beck, C. B. (2005) An Introduction to Plant structure and Development. Cambridge UniversityPress.
- Dickison, W. C. (2000) Integrative Plant Anatomy, Academic Press.
- Esau, K. (1977) Anatomy of Seed Plants. 2nd edition. John Wiley & Sons
- Fahn, A. (1990) Plant Anatomy. 4th edition. Butterworth-Heinemann Ltd;
- Gahan, P. B. (1984) Plant Histochemistry. Academic Press.
- Khasim, S. M. (2002) Botanical Microtechnique: Principles and Practice. Capital PublishingCompany.
- Mauseth, J. D. (1988) Plant Anatomy. The Benjamin Cummings Publishing Co.
- Miksche, J. P. (1976). Botanical Microtechnique and Cytochemistry. Iowa State University Press.
- Pearse, A. G. E. (1980) Histchemistry, Theoretical and Applied. 4th Edition, Vol. 1 & 2. Churchhill Livingstone.
- Raghavan V. (1999) Developmental Biology of Flowering Plants. Springer.
- Sanderson, J. B. (1994). Biological Microtechnique. Bios Scientific Publishers.

COURSE CODE: **BOT1C08**	NAME OF THE COURSE: **Anatomy of Angiosperms & Microtechnique (Practical)**	CREDIT: 1

Course Objectives:

The main objectives of this course are to:

1. To identify the anomalous secondary thickening in stems and roots
2. To compare the C3, C4, xeromorphic, and halophytic leaf anatomy
3. To identify the major stomatal types and to calculate stomatal index.
4. To develop the skills of preparing permanent preparations of whole mounts, free hand sections and serial sections.

Expected Course Outcomes:

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

1	Identify plants with normal and anomalous secondary thickening in stem and roots	K2
2	Identify C3, C4, Xeromorphic, and halophytic leaves based on their anatomy	K2
3	To develop practical skills in microtome sectioning and mounting	K3
4	To develop practical skills in double, triple and histochemical staining procedures	K4

K2 - Understand; **K3** - Apply; **K4** – Analyze

Anatomy

1. Anomalous secondary growth in stems: *Amaranthus, Aristolochia, Strychnos, Bauhinia, Dracaena, Bignonia, Nyctanthes,Mirabilis, Boerhaavia.*
   Roots: *Ipomoea batatas* and *Beta vulgaris*
2. Leaf anatomy: C3 and C4 plants, xeromorphic leaves and halophytic leaves.
3. Stomata: major types, stomatal index.
4. Internal secretory cells – raphides, druses, cystoliths.

Microtechnique:

Preparation of stained permanent slides of the following:

- Whole mounts, free hand sections, maceration and serial microtome sections using double, triple, and histochemical staining procedures.

✓ At least twenty permanent micropreparations representing whole mounts, free hand sections and serial sections should be submitted for evaluation

References

- Beck, C. B. (2005). An Introduction to Plant structure and Development. Cambridge UniversityPress.
- Dickison, W. C. (2000) Integrative Plant Anatomy, Academic Press.
- Esau, K. (1977) Anatomy of Seed Plants. 2nd edition. John Wiley & Sons Fahn, A. (1990) Plant Anatomy. 4th edition. Butterworth-Heinemann Ltd;

- Gahan, P. B. (1984) Plant Histochemistry. Academic Press.
- Jensen, W. A. (1962) Botanical Histochemistry. WH Freeman & Company.
- Johansen, D. A. (1940) Plant Microtechnique. McGraw Hill.
- Khasim, S. M. (2002) Botanical Microtechnique: Principles and Practice. Capital Publishing Company.
- Krishnamoorthy K. V. (1999) Methods in Cell Wall Cytochemistry. C.R.C. Press.
- Mauseth, J. D. (1988) Plant Anatomy. The Benjamin Cummings Publishing Co.
- Miksche, J. P. (1976). Botanical Microtechnique and Cytochemistry. Iowa State University Press.
- Pearse, A. G. E. (1980) Histchemistry, Theoretical and Applied. 4th Edition, Vol. 1 & 2. Churchill Livingstone.
- Raghavan V. (1999) Developmental Biology of Flowering Plants. Springer.
- Sanderson, J. B. (1994). Biological Microtechnique. Bios Scientific Publishers.

COURSE CODE: **BOT1A01**	NAME OF THE COURSE: **Ability Enhancement Course (AEC): The Process of Research (Theory)**	CREDITS: **2**

Course Objectives:

The main objectives of this audit course are to:

1. Enable the students to gain research skills at an advanced level and to acquire knowledge reg. the primary principles of scientific research.
2. Empower students regarding literature survey, so that they may learn how to analyse earlier research and writings related to a particular research problem and utilize them.
3. Allow students to effectively communicate the findings of a systematic investigation to the scientific community through research reporting.
4. Learn ethics in scientific research work so as to promote mutual respect and fairness in research.
5. Envisage steps to get the know-how about the biosafety measures during research work and how to protect and safeguard the intellectual research output.
6. Effectively utilize the basic information gained from this audit course so as to excel in research in future.

Expected Course Outcomes:

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

1	Acquaint with the knowledge of research methodology and the various steps involved in the research process.	K1
2	Realize how literature survey and compilation of bibliography helps in connecting new research with that of the earlier know-how on the subject concerned.	K2
3	Disseminate the knowledge of research output to the wider scientific community via reporting the research work through scientific publications.	K3
4	Assess various ethics in scientific research work and to promote mutual understanding and esteem in research.	K4
5	Scrutinize the various biosafety measures while doing research work and how to protect oneself from different biohazards.	K5
6	Attain scientific knowledge about intellectual property protection, it's infringement and rights to defend and to look after the intellectual research output.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. **The primary principles that define the scientific method**: Metascience, Empiricism, Rationalism Determinism, Parsimony, Skepticism, Cynicism, Testability; Basic and applied research; An outline of the steps in the research process: i) Developing a research question, ii) Conducting a literature review, iii) Developing a hypothesis, iv) Designing the study, v) Conducting the study, vi) Analysing the data, and vii) Reporting the results.

2. **Literature Survey**: Sources of information - Primary, secondary & tertiary sources, Grey literature; Journals: Journal abbreviations, abstracts, monographs, Biological Abstracts: Web resources, E-journals, e-books, Search engines, Google Scholar, Wiki- Databases, Science

Direct, PubMed, Scopus. The Internet and the World Wide Web. Internet resources for biosciences, Finding and citing published information, Reference management software.

3. **Literature review**: Type of reviews, systematic review, review journals in plant science.

4. **Reporting Research**: Journal Article writing, Styles and formats, Title, Abstract, Key Words, Introduction, Materials and methods, Results, Figures & Tables, Discussion, List of References. Oral Presentations. Poster Presentations. Writing project proposals to funding agencies. Constructing Research Questions, Methods: FINER criteria, PICOT criteria

5. **Ethics in research**: Bioethics, Scientific misconduct, Ghost writing, Ethical Guidelines for animal subjects. Media ethics in science, Ethics in reporting research: data errors & plagiarism. Checking documents for plagiarism; Conflict of Interest (COI) in academic publishing

6. **Safety in the laboratory**: Biosafety level (BSL), Occupational safety and Health (OSH), General Safety and lab-safety procedures, Chemical, electrical and UVsafety, safe handling of toxic and hazardous chemicals, storage and disposal of chemicals.

7. **Intellectual Property (IP):** An overview of Intellectual property protection (IPP) and Intellectual property rights(IPR); copyright, copyleft, indigenous intellectual property, brand protection, patent, trademark, license, intellectual property infringement.

References

- Anonymous. 2019. The Chicago Manual of Style. University of Chicago Press.
- Barbara Gastel & Robert Day. 2016. How to Write and Publish a Scientific Paper, 8th Edition. Greenwood.
- Bright Wilson Jr.1991. An Introduction to Scientific Research. Dover Publications.
- Christopher M.Gillen. 2007. Reading Primary Literature: A Practical Guide to Evaluating Research Articles in Biology. Pearson.
- Gauch 2012. Scientific Method in Brief. Cambridge University Press.
- Glazunov N M 2012. Foundations of Scientific Research. National Aviation University.
- Harrison W. Ambrose & Katharine Peckham Ambrose 1987. A Handbook of Biological Investigation, 4th edition, Hunter Text books Inc,Winston-Salem.
- Kate L. Turabian et al. 2018. A Manual for Writers of Research Papers, Theses, and Dissertations, Ninth Edition: Chicago Style for Students and Researchers. University of Chicago Press.
- Mildred L. Patten & Michelle Newhart. 2017. Understanding Research Methods 10th Edition. Routledge.
- Victoria E. McMillan1997.Writing Papers in the Biological Sciences, Bedford Books, Boston.
- Wayne C. Booth et al. 2016. The Craft of Research, Fourth Edition. University of Chicago Press.

SEMESTER II

COURSE CODE: **BOT2C09**	NAME OF THE COURSE: **Plant Physiology (Theory)**	CREDITS: **3**

Course Objectives:		
The main objectives of this course are to: 1. To know about the physiology of plants 2. To obtain knowledge on metabolism of plants 3. To analyze the seed dormancy 4. To have in-depth knowledge about stress physiology		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Recognize the plant, water and mineral interaction	K1
2	Understand the remarkable metabolic pathway in plants.	K2
3	Improve the knowledge about phytohormones in plants.	K3
4	Estimate the stress resistance mechanism for the better yield of the crops.	K4
5	To have a better understanding about seed germination.	K5
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate		

1. **Water and plant cells**: Water in plant's life, Diffusion and facilitated diffusion. Absorption and short-distance transport, pressure driven bulk flow and long-distance transport. Osmosis driven by water potential gradient. Water absorption by roots via apoplastic, symplastic and transmembrane pathways. Role of aquaporins. Water movement through xylem. Mechanism and the theories of transport. Cavitation and embolism. Soil-plant- atmosphere-continuum; physiology of stomatal function-blue light effect.

2. **Plants and inorganic nutrition**: Nutrient elements: Classification based on biochemical functions. Physiological roles. Nutrient uptake: interaction between roots and microbes. Ion uptake by roots: diffusion, facilitated diffusion and apparent free space. Apoplastic and symplastic pathways. Membrane potential and its role. Passive and active transport. Transport proteins: carriers, Michaelis-Menten Kinetics. Channels: Voltage dependent K+ channels, voltage gated channels, Calcium calmodulin channels, vacuolar malate channels. ATPase activity and electrogenic pumps. Active transport and electrochemical potential gradients

3. **Assimilation of mineral nutrients:** Nitrogen and bio-geocycle, nitrate assimilation, reduction, biological nitrogen fixation. Symbiosis: nitrogenase activity, assimilation of ammonia; pathways and enzymes - GS, GOGAT and GDH. Transport of amides and

ureides. Sulphur assimilation, bio-geocycle, reduction of sulphates. Importance of phosphorus, iron, magnesium, calcium and potassium assimilation. Energetics of nutrient assimilation, molecular physiology of micronutrient acquisition.

4. **Photosynthesis**: Light absorption and energy conversion, electron transfer system in chloroplast membranes: Photoinhibition and acclimation to high light, ATP synthesis in chloroplast. Photosynthetic carbon reduction, carbon oxidation and photorespiratory cycles. C4 and CAM metabolism. Physiological and environmental consideration of photosynthesis. Distribution of photo assimilates- export. Starch and sucrose synthesis. Allocation and partitioning: Phloem loading and unloading. Concept of osmotically generated pressure flow. Importance of plasmodesmata in symplastic transport.

5. **Respiration**: Glycolytic reactions: Pyruvate entry into mitochondria and citric acid cycle. Electron transfer system and ATP synthesis. Transporters involved in exchange of substrates and products, ATP synthesis, unique electron transport enzymes of plant mitochondria: external NAD(P)H dehydrogenase, rotenone and cyanide insensitive cytochrome C oxidases. Interaction between mitochondrial and other cellular components. Metabolites and specific transporters. Lipid metabolism.

6. **Growth and development**: Analysis of plant growth: production of cells, growth velocity profile. Cytological and biochemical events. Development: initiation and regulation of development, genes involved in the control of development, role of protein kinases. Types of development: flowering-floral induction, evocation and morphogenesis. Floral organ identity genes. Biochemical signaling: Theories of flowering. Control of flowering-phytochrome, cryptochrome and biological clock. Factors affecting flowering: Photoperiodism and thermoperiodism.

7. **Fruit development and ripening**: physiology of ripening- cell wall architecture and softening, enzymes involved in biochemical changes, climacteric and non-climacteric fruits-signaling pathways involved.

8. **Seed development**: deposition of reserves during seed development, desiccation of seeds: hormones involved, desiccation tolerance, seed dormancy

9. **Germination physiology**: Imbibition, germination and reserve mobilization.- metabolism of carbohydrates, lipids, proteins and phytins, physiology of seed dormancy.

10. **Plant growth regulators**: auxins - biosynthesis, transport, physiological roles. Role in signal transduction pathways. Gibberellin biosynthesis, physiological roles, signal transduction. Amylase activity in germinating seeds. Cytokinin – biosynthesis, biological role,; mode of action. Ethylene–biosynthesis, physiological role, commercial uses, and mode of action. Abscisic acid: biosynthesis and metabolism, physiological effects, role in seed dormancy and senescence. Brassinosteroid: biosynthesis, metabolism, transport, effect on growth and development. Hormonal balance concept and mechanism.

11. **Photoreceptors**: Phytochromes-photochemical and biochemical properties, localisation in cells and tissues, phytochrome induced whole plant responses, Ecological functions. Mechanisms of phytochrome regulated differentiation. Signal transduction pathways, role in gene expression. Cryptochromes: blue light hormones, photo physiology, effect on stem elongation, gene expression, stomatal opening, proton pumps, photo tropism, role of carotenoids.

12. **Senescence and programmed cell death**: Apoptosis and necrosis. Programmed celldeath in relation to reproductive development, and stress response. Genes associated with senescence, metabolism during senescence.

13. **Stress physiology**: Biotic stress, Water deficit and drought resistance, heat stress and heat shock, chilling and frost, salinity stress, high light stress, oxygen deficiency stress and heavy-metal pollution stress. Signaling pathways activated in response to abiotic stress. Salicylic acid and jasmonic acid mediated stress tolerance. Stress-associated changes in metabolites and metabolomics, homeostasis events under stress. Role of heat shock proteins (Hsp) in stress tolerance (Classification, role in protein refolding and resolubilizing, major functions). Model plants used for studying abiotic stress. QTL mapping and stress tolerance. Transgenic plants for stress tolerance.

14. **Signal transduction**. Classes of signals; receptors, signal perception, signal amplification and transduction reactions, role of Ca++ as second messengers, role of Calmodulin. Cross regulations in signal transduction pathways.

References

- Anderson, J. W. and Boardall, J. (1991) Molecular Activation of Plant cells- An Introduction to Plant Biochemistry. Blackwell Scientific Publishers.
- Beck, C. B. (2005). An Introduction to Plant Structure and Development. Cambridge University Press.
- Bewley, J. D. and Black E. (1994) Seeds: Physiology of Development and Germination. 2nd Edn. Plenum Publishing Corporation.
- Bidwell, R.G. S. (1979) Plant Physiology. 2nd Edn. Macmillan Publishing Corporation.
- Buchanan, B. B, Gruissem, W. and Jones, R. L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists.
- Devlin, R. M. and Witham, F. H. (1986). Plant Physiology. IVth Edn. CBS Publishers & Distributers.
- Hopkins, W. G. (2004). Introduction to Plant Physiology. John Wiley & Sons Inc.
- Karp G. (1996). Cell and Molecular Biology – Concepts and Experiments. John Wiley & Sons, Inc.
- Mayer and Poljakoff- Mayber. (1989). The Germination of Seeds. IVth Edn. Pergmon Press.
- Moore. T. C. (1981) Research Experience in Plant Physiology. A Laboratory Manual. Springer Verlag.
- Niyogi, K. K. (2000). Safety valves for photosynthesis. Current opinion in plant biology,

3(6), 455-460.
- Noggle, G. R. and Fritz G. J. (1992). Introductory Plant Physiology. Prentice Hall ofIndia Pvt. Ltd.
- Salisbury, F. B. and Ross C. W. (1992) Plant Physiology. 4th Edn. WordsworthPublishing Corporation.
- Steward, F. C. Plant Physiology – A Treatise. Vol. I to X. Academic. Press.
- Stumpf, P. K. and Conn, E. E (1980). The Biochemistry of Plants: A Comprehensive Treatise. Academic Press.
- Taiz, L. and Zeiger, E. (2002). Plant Physiology. The Benjamin Cummings Publishing Corporation Inc.
- Vinocur, B., & Altman, A. (2005). Recent advances in engineering plant tolerance to abiotic stress: achievements and limitations. Current opinion in biotechnology, 16(2), 123-132.
- Wang, W., Vinocur, B., Shoseyov, O., & Altman, A. (2004). Role of plant heat-shock proteins and molecular chaperones in the abiotic stress response. Trends in plant science, 9(5), 244-252.
- Wilkins, M. B. (1984). Advances in Plant Physiology. Longman Scientific & Technical.

Web Resources

- https://fmipa.umri.ac.id/wp-content/uploads/2016/03/K.V. Madhava Rao A.S. Raghavendra K. Janardhan BookFi .org .pdf
- https://www.pdfdrive.com/introduction-to-plant-physiology-4th-edition-e43384728.html
- https://www.pdfdrive.com/plant-hormones-physiology-biochemistry-and-molecular-biology-d157624762.html
- https://www.ctahr.hawaii.edu/oc/freepubs/pdf/pnm3.pdf
- https://www.asps.org.au/wp-content/uploads/Chapter-11-Fruit-growth-ripening-and-post-harvest-physiology.pdf
- https://krishi.icar.gov.in/jspui/bitstream/123456789/17925/1/Physiology%20of%20fruit%20ripening%20%28JHA%202018%29.PDF
- https://www.uv.mx/personal/tcarmona/files/2010/08/Moglich-et-al-2010.pdf
- https://www.frontiersin.org/articles/10.3389/fpls.2017.01181/full
- file:///C:/Users/hp/Downloads/Plant%20stress%20physiology%20(%20PDFDrive%20)%20(1).pdf

COURSE CODE: **BOT2C10**	NAME OF THE COURSE: **Plant Physiology (Practical)**	CREDIT: **1**

Course Objectives:		
The main objectives of this course are to: 1. To know about the physiology of plants 2. To obtain knowledge on metabolism of plants 3. To analyze the physiology related to seed dormancy 4. To have indepth knowledge about stress physiology of plants		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Understand the preparation method of different solutions using molal, molar, normal and percentage methods.	K1
2	Understand the various metabolic processes in plants.	K2
3	Take students to higher level of learning about nutrients and its uptake in plants.	K3
4	Imparts an insight into the plant water relations.	K4
5	Able to differentiate and understand the mechanism of plant stress through antioxidative responses.	K5
6	The demonstration experiments will create a sense of inquisitiveness in students	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

1. Preparation of molal, molar, normal, and percentage solutions and their dilutions.
2. Determination of moisture content of plant materials,
3. Determination of osmotic potential by plasmolytic method.
4. Separation of plant pigments by paper chromatography/thin layer chromatography and absorption spectra of pigments separated.
5. Quantitative estimation of chlorophyll content using spectrophotometry.
6. Measurement of Light Intensity and Light Transmission Ratio.
7. Measurement of growth rate using various parameters
8. Demonstration of Amylase activity and gibberellic acid effect in germinating cereal seeds.
9. Regulation of Seedling Growth by Plant Hormones
10. Protein estimation by dye binding method.
11. Estimation of proline in plant tissues under various abiotic stresses.
12. Determination of peroxidase activity in plant tissues affected by biotic/abiotic stresses
13. Estimation of free amino acids in senescing leaves to understand the source to sink transformation phenomenon.

Demonstration experiments

1. Estimation of leaf osmotic potential using Osmometer.
2. Variations in Chlorophyll a fluorescence in plant tissues affected by abiotic stresses.
3. Analysis of Photosystem activity of thylakoids.

References

- Anderson, J. W. and Boardall, J. (1991) Molecular Activation of Plant cells- An Introduction to Plant Biochemistry. Blackwell Scientific Publishers.
- Beck, C. B. (2005). An Introduction to Plant Structure and Development. Cambridge University Press.
- Bewley, J. D. and Black E. (1994) Seeds: Physiology of Development and Germination. 2nd Edn. Plenum Publishing Corporation.
- Bidwell, R.G. S. (1979) Plant Physiology. 2nd Edn. Macmillan Publishing Corporation.
- Buchanan, B. B, Gruissem, W. and Jones, R. L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists.
- Devlin, R. M. and Witham, F. H. (1986). Plant Physiology. IVth Edn. CBS Publishers & Distributers.
- Hopkins, W. G. (2004). Introduction to Plant Physiology. John Wiley & Sons Inc.
- Karp G. (1996). Cell and Molecular Biology – Concepts and Experiments. John Wiley & Sons, Inc.
- Mayer and Poljakoff- Mayber. (1989). The Germination of Seeds. IVth Edn. Pergmon Press.
- Moore. T. C. (1981) Research Experience in Plant Physiology. A Laboratory Manual. Springer Verlag.
- Niyogi, K. K. (2000). Safety valves for photosynthesis. Current opinion in plant biology, 3(6), 455-460.
- Noggle, G. R. and Fritz G. J. (1992). Introductory Plant Physiology. Prentice Hall ofIndia Pvt. Ltd.
- Salisbury, F. B. and Ross C. W. (1992) Plant Physiology. 4th Edn. WordsworthPublishing Corporation.
- Steward, F. C. Plant Physiology – A Treatise. Vol. I to X. Academic. Press.
- Stumpf, P. K. and Conn, E. E (1980). The Biochemistry of Plants: A Comprehensive Treatise. Academic Press.
- Taiz, L. and Zeiger, E. (2002). Plant Physiology. The Benjamin Cummings Publishing Corporation Inc.
- Vinocur, B., & Altman, A. (2005). Recent advances in engineering plant tolerance to abiotic stress: achievements and limitations. Current opinion in biotechnology, 16(2), 123-132.
- Wang, W., Vinocur, B., Shoseyov, O., & Altman, A. (2004). Role of plant heat-shock proteins and molecular chaperones in the abiotic stress response. Trends in plant science, 9(5), 244-252.
- Wilkins, M. B. (1984). Advances in Plant Physiology. Longman Scientific & Technical.

COURSE CODE: **BOT2C11**	NAME OF THE COURSE: **Biochemistry, Biophysics and Immunology (Theory)**	CREDITS: **3**

Course Objectives:		
1. To have a comprehensive knowledge of the biochemical organization of cells and different types of macromolecules, their structure and function. 2. To understand the plant biomolecules and their metabolism. 3. To understand the different metabolic pathways. 4. To know the functions of enzymes and their regulation. 5. To understand the principles of various biophysical techniques available for the characterization of biological molecules. 6. To understand the components and mechanism of the human immune system		
Expected Course Outcomes:		
On the successful completion of the course, students will be able to:		
1	Explain the basic metabolic pathways of plants and the formation of metabolites through various biosynthetic pathways in plants	K1
2	Understand the types of chemical bonds present in biological macromolecules and the concept of bioenergetics	K2
3	Impart knowledge of the immune system and immune responses	K3
4	Analyze the applications of various immunological techniques	K4
5	Employ the appropriate biophysical tools and techniques for the characterization of biomolecules in specific situations	K5
6	Formulate specific plans for studying biological molecules	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

BIOCHEMISTRY

1. **Introduction**: History and significance of Biochemistry and biomolecules. Indian contributors of Biochemistry: Ramachandran and Bhargava.

2. **pH and buffers** – properties of water, acids, bases and buffers, Henderson-Hasselbalch equation, pH, pKa, Kw, proton hopping.

3. **Carbohydrates**: introduction to mono, di, oligo and polysaccharides, linear and ring structures, homo and heteroglycans, artificial sweeteners, structure and function of major homo and heteropolysaccharides, metabolism of starch, cellulose and glycogen. Glycolysis, TCA cycle, terminal oxidation, gluconeogenesis, glyoxylate pathway, PPP pathway, glycoproteins and proteoglycans, biosynthesis of peptidoglycan, metabolic mill.

4. **Amino acids and proteins**: amino acids – classification, properties, optical activity, unusual amino acids; classification and conformation proteins, Ramachandran plot, structure, function, mechanism and allosteric regulation of haemoglobin, abnormal

haemoglobin, structure and function of leghaemoblobin, Brief account on the biosynthesis of protein.

5. **Enzymology**: structure, function and classification of enzymes, coenzymes, substrate specificity, regulation of enzyme activity, active sites, inhibitors, allosteric enzymes, enzyme kinetics, Michaelis-Menten constant, Lineweaver-Burk plot; multienzyme, isoenzymes, ribozyme, abzyme, detailed study of FAS and Rubisco, penicillin and magic bullet, suicidal inactivators.

6. **Lipids**: classification, brief account on compound and derived lipids with examples, classification of fatty acids, biosynthesis of fatty acids; alpha, beta and omega oxidation of fatty acids, omega fatty acid and functional food, trans fatty acids and their dangers, study of coconut oil.

7. **Nucleic acids**: purines and pyrimidines; Brief account onthe types and conformation of DNA and RNA.

8. **Vitamins and hormones**: classification, structure, function and source of vitamins, vitamins as coenzymes, phytohormones: classification, structure and function.

9. **Secondary metabolites**: Classification, biosynthesis and functions of terpenoids, alkaloids and phenolics.

BIOPHYSICS

1. **Chemical bonds**- Forces responsible for molecular conformation - Hydrogen bonds, ionic/electrostatic interactions, Covalent bonds, Van der Waals interaction, hydrophobic interactions

2. **Energy metabolisms** – the concept of free energy, entropy, enthalpy, chemical equilibria, principles of thermodynamics, kinetics and mechanisms of membrane transport, energy-rich bonds, redox reactions, synthesis of ATP, substrate level-, oxidative-and photo-phosphorylation.

3. **Centrifugation-** Basic principles of centrifugation, RCF (relative centrifugal force), sedimentation coefficient, Ultra centrifugation - Differential centrifugation, density gradient centrifugation (zonal and isopycnic).

4. **Electrophoresis-** Principles, Horizontal & Vertical gel electrophoresis, PAGE, SDS-PAGE, Agarose Gel Electrophoresis, Isoelectric focusing, 2 D Gel electrophoresis

5. **Chromatography**- Basic concepts of Adsorption and Partition Chromatography, Principles and applications of paper, thin layer, gel filtration, ion exchange, and affinity chromatography, GC, GC-MS, HPLC, FPLC, LC-MS, and HPTLC.

6. **Spectroscopy**- Basic Principles, The Laws of Absorption, Instrumentation, principles, and applications of UV & Visible absorption spectrophotometry, Fluorescence Spectroscopy, IR spectroscopy; Fourier transform techniques.

7. **Macromolecular Structure Determination-** X-Ray Crystallography, Principles of magnetic resonance spectroscopy - Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR) Spectroscopy

8. **Principles of Microscopy -** Atomic Force Microscopy, Scanning Tunneling Microscopy, Scanning Probe Microscopy, Fluorescent Microscopy, Flow- cytometry.

9. Radio isotopes and their applications in biology, radioactive decay, liquid scintillation.

IMMUNOLOGY

1. **Immune system** – antigens, antibodies, structure and function of different classes of immunoglobulins, primary and secondary immune response, lymphocytes and accessory cells, lymphokines, antibody diversity, humoral and cell-mediated immunity, MHC, antigen presentation, complement fixation, hypersensitivity and allergy, opsonisation, mechanism of immune response and generation of immunological diversity, genetic control of immune response, superantigens.

2. **Applications of immunological techniques** – ELISA, immunodiffusion, immunoelectrophoresis. Monoclonal and polyclonal antibodies, HAT medium.

REFERENCES

- Berg, J. M., Tymoczko, J. L., & Stryer L. 2006. Biochemistry (6th Edn). WH Freeman &Co.
- Daniel, M. 1989. Basic Biophysics for Biologists. Agro-Botanica Publishers and Distributors.
- Daniel, M. 1989. Basic Biophysics for Biologists. Agro-Botanica Publishers and Distributors.
- Delves, P., Martin, S., Burton, D. & Roitt, I. 2008. Roitt's Essentials of Immunology(11th Edn). Blackwell Publishing.
- Delves, P., Martin, S., Burton, D. & Roitt, I. 2008. Roitt's Essentials of Immunology
- Glaser, R. 2001. Biophysics (5^{th} Edn). Springer.
- Hammes, G.G. 2005. Thermodynamics and Kinetics for Biological Sciences. John Wiley & Sons Inc.
- Jain, J. L., Sanjay, J. & Nithin, J. S. 2006. Fundamental of Biochemistry (6th Edn). S. Chand & Co. Ltd.
- Jain, J.L., Sanjay, J. & Nithin, J.S. 2006. Fundamental of Biochemistry (6^{th} Edn). S. Chand & Co. Ltd.
- Kindt, T.J., Goldsby, R.A. & Osborne, B.A. 2008. Kuby Immunology (6^{th} Edn). WH Freeman and Co.
- Lewin B. 2008. Genes IX. Pearson Educational International.
- Nelson, D. L. & Cox, M. M. 2008. Lehninger Principles of Biochemistry (4th Edn). W.H. Freeman and Co.
- Rao, C. V. 2005. Immunology: A Text Book. Narosa Publishing House.
- Rao, C.V. 2005. Immunology: A Text Book. Narosa Publishing House.
- Sambrook, J. & Russel, D.W. 2008. Molecular Cloning – A laboratory manual (5^{th}

Edn). Cold Springer Harbor Laboratory Press.
- Upadhay, A., Upadhay, K. & Nath, N. 2008. Biophysical Chemistry – Principles and Techniques. Himalaya Publishing House.
- Upadhay, A., Upadhay, K. & Nath, N. 2008. Biophysical Chemistry – Principles and Techniques. Himalaya Publishing House.
- Voet, D. J. & Voet, J. J. 2005. Biochemistry (5th Edn). John Wiley & Sons Glaser, R. 2001. Biophysics (5th Edn). Springer.

Web resources:

- https://onlinecourses.nptel.ac.in/noc20_cy10/preview
- https://www.classcentral.com/course/swayam-biochemistry-5229
- https://swayam.gov.in/nd2_cec20_bt12/preview
- https://onlinecourses.swayam2.ac.in/cec22_bt01/preview
- https://onlinecourses.nptel.ac.in/noc21_bt48/preview
- http://priede.bf.lu.lv/grozs/AuguFiziologijas/Augu_biokimija/Plant%20Biochemistry%204.pdf
- https://www.biorxiv.org/content/10.1101/660639v2
- https://www.scribd.com/document/378882955/Plant-Biochemistry-Lecture-Notes-Study-
- Materials-and-Important-questions-answers
- http://www.brainkart.com/subject/Plant-Biochemistry_257/

COURSE CODE: **BOT2C12**	NAME OF THE COURSE: **Biochemistry, Biophysics and Immunology (Practical)**	CREDIT: **1**

Course Objectives:

The main objectives of this course are to:

1. To understand the basic principles and methodology of biochemical experiments.
2. To develop practical skills in the identification and quantitative estimation of biomolecules.
3. To familiarize the various biophysical techniques used for the characterization of biomolecules.
4. To undertake basic immunological technics.

Expected Course Outcomes:

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

1	Explain and demonstrate basic biochemical techniques; Demonstrate the principles/working of biophysical techniques/instruments.	K1, K2, K3
2	Identify biomolecules from plant extracts	K3, K4
3	Estimate quantitatively the biomolecules in plant extracts	K3, K4, K5
4	Perform basic immunological experiments	K1, K2, K3
5	Separate the biomolecules employing suitable biophysical techniques	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. Preparation of standard solutions of BSA, Glucose and Catechol.
2. Detection of non-reducing sugar in the presence of reducing sugar.
3. Quantitative estimation of reducing sugar from plant tissue by any suitablemethod.
4. Extraction and estimation of starch from plant tissue by a suitable method.
5. Colorimetric estimation of protein by Biuret method.
6. Colorimetric estimation of protein by Lowry et al. method.
7. Determination of Substrate saturation and Michaelis-Menten curve of any enzyme.
8. Preparation of buffers and measurement of pH using pH meter.
9. Determination of isoelectric pH of proteins.
10. Paper chromatographic separation of sugars.
11. Thin layer chromatography of amino acids.
12. Electrophoretic separation of DNA and proteins.
13. Separation of subcellular particles by sucrose density gradient centrifugation.
14. Human Blood typing
15. Immunodiffusion
16. Immunoprecipitation

REFERENCES

- Banerjee, P.K. 2014. Introduction to Biophysics (2 nd edition). S. Chand &Company Pvt. Ltd.
- Berg, J. M., Tymoczko, J. L., & Stryer L. 2006. Biochemistry (6th Edn). WH Freeman & Co.
- Daniel, M. 1989. Basic Biophysics for Biologists. Agro-Botanica Publishers and

Distributors.
- Delves, P., Martin, S., Burton, D. & Roitt, I. 2008. Roitt's Essentials of Immunology(11th Edn). Blackwell Publishing.
- Glaser, R. 2001. Biophysics (5th Edn). Springer.
- Hammes, G.G. 2005. Thermodynamics and Kinetics for Biological Sciences. John Wiley & Sons Inc.
- Jain, J.L., Sanjay, J. & Nithin, J.S. 2006. Fundamental of Biochemistry (6th Edn). S. Chand & Co. Ltd.
- Kindt, T.J., Goldsby, R.A. & Osborne, B.A. 2008. Kuby Immunology (6th Edn). WH Freeman and Co.
- Nelson, D. M. and Cox, M. M. (2017) Lehninger Principles of Biochemistry. 7th edition. W. H. Freeman & Co.
- Rao, C.V. 2005. Immunology: A Text Book. Narosa Publishing House.
- Rodney Cotterill. 2014. Biophysics - An Introduction. Wiley Publications
- Sambrook, J. & Russel, D.W. 2008. Molecular Cloning – A laboratory manual (5th Edn). Cold Springer Harbor Laboratory Press.
- Tinoco. I. et al. 2014. Physical Chemistry: Principles and Applications in Biological Sciences. Pearson Education
- Upadhay, A., Upadhay, K. & Nath, N. 2008. Biophysical Chemistry – Principles and Techniques. Himalaya Publishing House.
- Voet, D., Voet, J. G. and Pratt, C. W. (2016) Fundamentals of Biochemistry: Life at the Molecular Level. 5th edition. Wiley.
- Volkenstein. M. V. 2012. Molecular Biophysics. Academic press.

COURSE CODE: **BOT2C13**	NAME OF THE COURSE: **Plant Morphogenesis, Embryogenesis, Palynology & Plant Biotechnology (Theory)**	CREDITS: **3**

Course Objectives:

The main objectives of this course are to:

1. Make awareness about fundamental aspects of plant biotechnology
2. Successfully develop tissue culture methods using various explants and maintain aseptic cultures, technique of hardening and mass propagation of important plants.
3. Perform supportive tasks relevant to cell culture, including preparation and evaluation of media, cryopreservation and recovery, and assessment of cell growth/health.
4. The use of biotechnological tools for developing disease resistance, herbicide tolerance and higher nutritive and increasing the shelf life of plants
5. To highlight the physiological role of endosperm in the morphogenesis of embryo.
6. To assess the process of seed setting.

Expected Course Outcomes:

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

1	To introduce key concepts of cell biology as they relate to manipulating cells in culture, to demonstrate the specific skills used by tissue culture technicians, and to provide the student with information on the applications of tissue culture in modern laboratory settings.	K1
2	Students will also learn about basic plant micropropagation in tissue culture, with attention to differences in culture requirements for different plants	K2
3	Apply the technique of micropropagation such as somatic embryogenesis, organogenesis and protoplast culture for *ex-situ* conservation and mass multiplication of endangered and economically important plants	K3
4	Analyze and relate morphological, physiological and somaclonal variations for crop improvement	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** – Analyze

Plant Morphogenesis:

Unit. I. Basic concepts of plant morphogenesis.
Unit II. Totipotency, symmetry, polarity, differentiation
Unit III. Factors influencing morphogenesis.
Unit IV. Organisation of shoot and root apical meristem
Unit V. Floral meristems and floral development in *Arabidopsis*

Embryogenesis

Unit. I. Microsporogenesis-. pollen morphology. structure and function of wall layers.
Unit II. Megasporogenesis- development of female gametophyte in angiosperms, embryosac.
Unit III. Endosperm
Unit IV. Pollination, pollen-pistil interaction, fertilization.
Unit V. Embryo, polyembryony

Palynology

Unit 1. Introduction and scope of palynological science.

Unit II. Morphology of pollen – polarity, symmetry, size and shape, apertural pattern and classification, exine structure and ornamentation of pollen wall, pollen viability

Unit III. Pollen kit

Unit IV. Role of palynology in taxonomy.

Plant Biotechnology:

Unit I **Tissue Culture**

Introduction to cell and tissue culture-Tissue culture media (composition, preparation) - growth hormones- Initiation and maintenance of callus and cell suspension culture- organogenesis- Protoplast isolation culture and fusion.

Unit II **Tissue Culture Applications- I**

Production of haploids, triploids and endosperm culture-Somaclonal variations -Germplasm conservation (Cryopreservation).

Unit III **Tissue Culture Applications -II**

Production of secondary metabolites from plant cell cultures - Processes for enhancing the production of secondary metabolites- Technology of plant cell culture for production of chemicals- Bioreactors systems and models for mass cultivation of plant cells.

Unit IV **Plant Transformation Technology**

Agrobacterium-mediated gene transfer- Agrobacterium based vectors - viral vectors and their application. Direct gene transfer methods- chemical methods, electroporation, microinjection, particle bombardment.

Unit V **Plant Genetic Engineering For Productivity And Performance I (Biotic Stress)**

Herbicide resistance- Insect resistance- Disease resistance- virus resistance.

Unit VI **Plant Genetic Engineering for Productivity and Performance II (Abiotic Stress)**

Abiotic stress tolerance -Drought, temperature and salt tolerance.

Unit VII **Molecular Farming & Industrial Products**

Application of Plant biotechnology for the production of quality oil- Industrial enzymes- paper -biodegradable plastics-antigens (edible vaccine) and plantibodies.

Unit VIII **Metabolic Engineering**

Metabolic engineering for plant secondary metabolites.

References

- Bhojwani, S. S. and Razdan, M. K. 2004. Plant Tissue culture: Theory and Practice. Elsevier.
- Bhowjwani, S.S., Plant Tissue Culture: Application and Limitations. Amsterdam, Elsevier,1990.
- Crispeels, M.J. and Sadava, D.E. 2003. Plants, Genes and Crop Biotechnology, Jones andBartlett Publishers (2nd Edition).
- Cunningham, C. and Porter, A.J.R. 1997. Recombinant Proteins from Plants: Production and Isolation of Clinically Useful Compounds (Methods in Biotechnology), Humana Press.
- Doods, J. H. and Roberts, L. W. 1985. Experiments in Plant Tissue culture, Cambridge University Press.

- Erdtman, G. (1952). Pollen morphology and Plant taxonomy. Amquist&Wiksell, Stockholm.
- George, E. F. 1993-96. Plant propagation by Tissue culture-2 vols. Exegetics Ltd.
- Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology, CRC Press.
- Gresshoff, P.M. 1994. Plant Genome Analysis: Current Topics in Plant Molecular Biology. CRC Press.
- Halbritter, H., Ulrich, S., Grímsson, F., Weber, M., Zetter, R., Hesse, M., Buchner, R., Svojtka, M., Frosch-Radivo, A. (2018). Illustrated Pollen Terminology, Springer International Publishing DOI: 10.1007/978-3-319-71365-6
- Hammond, J., McGarvey, P., Yusibov,V. 1999. Plant Biotechnology: New Products andApplications, Springer Verlag.
- Harrison, J. (1971). Pollen development and physiology. Butterworths, London.
- Harrison, J. H. (1975). The physiology of pollen grain surface. Proc. Roy. Soc. London Series-b 190: 275-299.
- Johri, B.M. and Shivanna, K.R. (1985). The Angiosperm pollen structure and function. Wiley Eastern, New Delhi.
- Kashinath, K., Manjundar, M.R and Bhattacharya S.G. (2006) A Textbook of Palynology New Central Book Agency (P) LTD.Kolkota
- Nair, P.K.K. (1966). Essentials of Palynology. Today and Tomorrow's Printers and Publishers, New Delhi.
- Nair, P.K.K. (1970). Pollen morphology of Angiosperms – A Historical and Phylogenetic Study. Vikas Publishing House, Delhi.
- Narayanaswamy, S. 1994. Plant cell and Tissue culture. Tata McGraw Hill Ltd.De, K. K. 1995. Plant Tissue Culture. New Central Book Agency.
- Potrykus I.and G. Spangenberg, G. 1997. Gene Transfer to Plants (Springer Lab Manual),Springer Verlag.
- Razdan, M. K. 1995. An Introduction to Plant Tissue Culture. Oxford & IBH Publishing Co. Pvt. Ltd.
- Slater, A., Scott, N.W. and Fowler, M. R. 2008. Plant biotechnology: the genetic manipulation of plants. Oxford University Press.
- Smith, R. 2000. Plant Tissue Culture: Techniques and Experiments. 2nd ed., Academic Press.

COURSE CODE: **BOT2C14**	NAME OF THE COURSE: **Plant Morphogenesis, Embryogenesis, Palynology & Plant Biotechnology (Practical)**	CREDIT: **1**

Course Objectives:		
The main objectives of this course are to: 1. To analyze the general morphology and structure of pollen grains 2. To identify the different growth stages of plant embryos 3. To develop practical skills in tissue culture techniques		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Identify various types of pollen grains based on their morphology; Evaluate the palynological characters in solving taxonomic problems.	K1, K4, K5
2	Prepare stock solutions and working concentrations of different plant growth media	K2
3	Utilize the micropropagation technique for the mass multiplication of medicinally and horticulturally important species; Employ various *in vitro* culture techniques suitably; Appraise the role of cryopreservation in PGR conservation	K3, K4, K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** – Analyze; K5- Evaluate; K6- Create		

1. Acetolysis of pollen grains and study of pollen morphology.
2. Dissecting out embryos of different stages; types of embryogeny
3. Preparation of stock solutions: different media -
4. Preparation of solid and liquid media.
5. Inoculation technique: Culture of different explants.
6. Introduction of callus and organogenesis.
7. Anther, ovary, embryo culture; Meristem culture.
8. Cryopreservation
9. Production of synseed.
10. *In vitro* fertilization

References:

- Bhojwani, S.S. and Razdan, M.K. 1983. Plant Tissue culture: Theory and Practice. Elsevier.
- Doods, J.H. and Roberts, L.W. 1985. Experiments in Plant Tissue culture, Cambridge University Press.
- George, E.F. 1993-96. Plant propagation by Tissue culture-2 vols. Exegetics Ltd.
- Narayanaswamy, S. 1994. Plant cell and Tissue culture. Tata McGraw Hill Ltd. De, K.K. 1995. Plant Tissue Culture. New Central Book Agency.
- Razdan, M.K. 1995. An Introduction to Plant Tissue Culture. Oxford & IBH PublishingCo. Pvt. Ltd.

COURSE CODE: **BOT2C15**	NAME OF THE COURSE: **Environmental Biology (Theory)**	CREDITS: **3**

Course Objectives:		
The main objectives of this course are to: 1. To recognize the concept of environmental domains and their relative contribution to the functioning of Earth 2. To obtain knowledge on species, their interrelationships, measures of estimation and strategies for conservation. 3. To understand the effects of pollution and measures for its control.		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Comprise the concept of earth and its functioning	K1
2	Understanding of various domains of the earth (living and non-living) and their inter relationships	K2
3	Use of acquired knowledge in assessing the inter-relationship of species with the ecosystem.	K3
4	Monitor and register the biodiversity and its changes through latest methodologies.	K4, K6
5	Apply strategies for the conservation of ecosystems which are undergoing threats like resource depletion and pollution	K5
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Module I: **Physical processes associated with Earth**

- Sun-Earth System: planetary motion and seasons; Solar radiation - global distribution; climate and weather, climate classification (Köppen climate classification) and climatic controls.

Module II: **Domains of the Earth**.

- **Lithosphere**: Types of rocks, Soil formation and development, soil minerals, Soil horizon,Textural classification of soil and Soil types of India, Physico-chemical and biological properties of soil.
- **Hydrosphere**: Distribution of water on Earth, Types of water, Surface and groundwatersources, Aquifers, Hydrological cycle, Physico-chemical and biological properties of water.
- **Atmosphere**: Stratification, Composition, Thermal profile of atmosphere, Physico chemical characteristics of atmospheric strata.
- **Biosphere**: origin of life (Abiogenesis); Biodiversity: status, monitoring and documentation; major threats to biodiversity; hot spots of biodiversity, Red Data Book, biodiversity management approaches.
- **Conservation Biology**: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Conservation Projects, Sanctuaries, National Parks and Biosphere reserves).

Module III **Living organisms and their environment**

- **Ecosystem Ecology**: Ecosystem structure; ecosystem function; ecosystem services; energy flow and mineral cycling (C, N, P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine).
- **Habitat and Niche**: Concept of habitat and niche; niche width and overlap; fundamental
- and realized niche; resource partitioning; character displacement.
- **Population Ecology**: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations. Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
- **Community Ecology**: Nature of communities; community structure and attributes; levelsof species diversity and its measurement; edges and ecotones.
- Ecological Succession: Types; mechanisms; changes involved in succession; concept ofclimax.
- **Biogeography**: Major terrestrial biomes; theory of island biogeography; biogeographicalzones of India.

Module IV **Global environmental issues and people's participation**

- **Environmental pollution**: Soil, Water and Air pollution - causes, consequences and control measures.
- **Major Environmental issues**: Global warming and Greenhouse effect, Sea level rise, Oceanic oscillations, Global climate change, Desertification and habitat loss, Loss of biodiversity, Acid rain, Photochemical smog; Resource depletion; Role of individuals and organizations (governmental and non-governmental) in natural resource conservation andmanagement.

References

- Barry R. G. (2003), Atmosphere, weather and climate, Rutledge Press, UK
- Chapman, J.L. and Reiss, M.J. (1992). Ecology-Principle and Application, CambridgeUniversity Press.
- Cunningham, W.P. and Saigo, B.W. (1999). Environmental Science (5th Edition)McGraw Hill.
- David H. F. Linn, Bela G.Liptak (2000) Air Pollution, Lewis Publishers.
- Dobson A.P. (1996), Conservation and Biodiversity, Scientific American Library, NewYork
- Firor J., and J. E. Jacobsen (2002), The crowded greenhouse: population, climate changeand creating a sustainable world, Yale University Press
- Glantz M. H. (2003), Climate Affairs: a primer, Island Press
- Groom bridge B., and M. Jenkins (2000), Global Biodiversity: Earth's Living Resources in the 21st Century, World Conservation Press, Cambridge, UK
- Harvey D. (2000), Climate and Global Climate Change, Prentice Hall Inter-governmental Panel of Climate Change (IPCC) Reports
- IUCN (2004), Red list of threatened species - a global species assessment, IUCN, Gland,

Switzerland
- Klee G. A. (1991), Conservation of natural resources, Prentice Hall
- Kump L.R., Kasting J.F. and Carne R. G. (2004), The Earth System (3rd Edition),Prentice-Hall
- Loreau M., and P.Inchausti (2002), Biodiversity and Ecosystem functioning: Synthesisand Perspectives, Oxford University Press, Oxford
- Mackenzie A. Ball, A.S. and Virdee, S.R. (2002). Ecology (2nd Edition). Viva BooksLtd.
- Marquita K. Hill (2004), Understanding environmental Pollution (Second edition), Cambridge University Press, New Delhi
- Mike R.Leeder, Marta Pérez-Arlucea (2006) Physical Processes in Earth and Environmental Sciences, Blackwell publishers.
- Mirsal I. A. (2004), Soil Pollution, Springer Publications
- Misra R. (1968). Ecology workbook, Oxford & IBH Publishing Co.Odum E.P. (1976). Fundamentals of Ecology, W.B. Sanders Co.
- Park C. (1997). The Environment-Principles and Applications, Routledge.
- Peter Smithson, Kenneth Addison, Kenneth Atkinson (2012) Fundamentals of thePhysical Environment, Rutledge.
- Primack R.B. (2002), Essentials of Conservation Biology (3rd Edition), SinauerAssociates, Sunderland, SA
- Saxena H. M. (2006) Environmental Studies, Rawat Publications
- ShilpaShyam, H. N.Verma, S. K.Bhargava (2006), Air Pollution and its impact on plantGrowth, New India Publishing Agency
- Smil V. (1997). Cycles of Life. Civilization and Biosphere W.H. Freeman and Co. N.Y. Smith R.L. and Smith T.M. (1998). Elements of Ecology (4th Edition). The Benjamin Cummings Publishing Co.
- Wilson E. O. (1993), Diversity of Life, Harvard University Press, Cambridge, MA.

COURSE CODE: **BOT2C16**	NAME OF THE COURSE: **Environmental Biology (Practical)**	CREDIT: **1**

Course Objectives:		
The main objectives of this course are to: 1. Familiarize the use of weather instruments for meteorological observations 2. Equip students to perform soil, water and air quality analysis 3. Understand the quadratic method of diversity analysis and diversity indices 4. Appraise the significance of ecological interactions at different levels		
Expected Course Outcomes:		
On the successful completion of the course, the student will be able to:		
1	Use the weather equipment for meteorological observations	K1
2	Analyze various parameters of soil and water samples and measure air quality indices	K2, K4
3	Perform quadratic method of diversity analysis and estimate the diversity indices.	K3, K6
4	Evaluate and interpret the various kinds of species level interactions	K4, K6
5	Estimate the extent of pollution in land, water and air	K5, K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create		

1. Use of weather instruments and meteorological observations (temperature, pressure, humidity, wind, rainfall etc.) using standard procedures and preparation of windrose diagram, climatogram etc.
2. Determination of the physico-chemical and biological characteristics of soil samples (colour, density, porosity, permeability, soil separates and texture, structure, size class, pH, organic carbon, nutrients, soil organisms etc.) using standard methods.
3. Determination of selected physico-chemical and biological parameters in water samples (pH, conductivity, turbidity, hardness, chloride, dissolved oxygen, free carbon dioxide, Biological Oxygen Demand, microorganisms etc.) using standard methods.
4. Determination of selected air quality parameters (SPM, oxides of carbon, oxides of nitrogen, oxides of sulphur etc.) using standard methods.
5. Determination of the minimum size and number of quadrats required for the analysis of vegetation using species-area curve method.
6. Determination of frequency (including heterogeneity), density and abundance of species in a given area using quadrat method.
7. Determination of the Importance Value Index (IVI) of plant species in a community by quadrat / line / belt transect method.
8. Assessment of the biodiversity associated with heterogeneous ecosystems and estimation of diversity indices (eg. Simpson index, Shannon index etc.)
9. Determination of various species level interactions in nature, their evaluation and interpretations.
10. Estimation of primary productivity associated with aquatic and terrestrial ecosystems

using standard methods.

11. Estimation of various domains (land, water and air) and assessment of the extent of pollution in comparison with standard norms.
12. Visit to a meteorological station, site of pollution, waste treatment plant or to a wildlife sanctuary /national park or biosphere reserve and preparation of a report.

References

- APHA, AWWA and AWF (2005). Standard methods for the estimation of water and waste water, 21st ed. American Public Health Association, Washington DC.
- General Meteorology (1974): H. R. Byers; McGraw-Hill.
- ISI, Indian Standard specification for drinking water, New Delhi (1983).
- Misra, R. 1968. Ecology workbook, Oxford & IBH Publishing Co.
- Patrick R. Dugan, Biochemical Ecology of Water pollution. Plenum Publishing Corporation, 1975.
- Trivedy, R.K., Goel, P.K. & Trisal, C.L. Practical Methods in Ecology and Environmental Science. Environmental Publications, Karad, India, 1987, 340 pp.
- Wallace J. M. and P. V. Hobbs (1977). Atmospheric Science – An introductory survey.

COURSE CODE: **BOT2A02**	NAME OF THE COURSE: **Professional Competency Course: Biotechniques and Instrumentation (Practical)**	CREDITS: **2**

Course Objectives:		
The main objectives of this course are to: 1. Familiarize the use of cutting-edge technologies for high end research 2. Provide hands on training in using sophisticated instruments available for biological research 3. Understand the working and principles of modern scientific instruments		
Expected Course Outcomes:		
On the successful completion of the course, the student will be able to:		
1	Understand the principles and functioning of instruments	K1, K2
2	Prepare samples for biological research employing advanced instruments	K3, K4
3	Perform experiments using selected instruments	K3, K6
4	Evaluate the role of modern scientific instruments in bringing out accurate results	K5
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create		

Hands-on training on sophisticated techniques and instruments used in botanical research such as gel filtration chromatography, GLC, HPLC, HPTLC and Flash chromatography high performance liquid chromatography (HPLC), Fast Protein Liquid Chromatography (FPLC), PCR, RT-PCR, Agarose gel electrophoresis, Polyacrylamide gel electrophoresis (PAGE), two dimensional gel electrophoresis, LCMS, GCMS, ELISA, blotting techniques, Microarray techniques. UV-Vis NIR Spectroscopy, Differential Interference Contrast (DIC) Microscopy, Fluorescence microscopy, Transmission electron microscopy (TEM), Scanning electron microscopy (SEM, FESEM-EDX), CHNS/O Analyser, AAS and Inductively Coupled Plasma Mass Spectrometry (ICPMS), Ultracentrifuge, Cryostat.

References

- Bioinstrumentation, L. Veerakumari, 1st edition 2011, MJP publishers.
- Principles and techniques of practical biochemistry, Keith Wilson and John walker, 5th edition 2000, Cambridge University press.
- Crystallography Made Crystal Clear: Guide for Users of Macromolecular Models, 3rd edition (2010), Gale Rhodes, Academic Press. ISBN: 9780080455549
- Physical Biochemistry: Principles and Applications, 2nd edition (2009), David Sheehan, John Wiley. ISBN-13: 978-0470856031.
- The Physics of Proteins: An Introduction to Biological Physics and Molecular Biophysics, 1st edition (2010), H. Frauenfelder, S.S. Chan and W.S. Chan, Springer, ISBN-13: 978- 1441910431.
- Principles of Instrumental Analysis, 6th edition (2006), D.A. Skooget. al., Saunders College Publishing. ISBN-13: 978-0495012016.
- Principles of Physical Biochemistry, 2nd edition (2005), K.E. Van Holde, W.C. Jhonson and P. Shing Ho, Prentice Hall Inc. ISBN-13: 978-0130464279.

SEMESTER III

COURSE CODE: **BOT3C17**	NAME OF THE COURSE: **Angiosperm Taxonomy, Morphology and Phytogeography (Theory)**	CREDITS: **3**

Course Objectives:

The main objectives of this course are to:

1. To study about the classification and nomenclature of Angiosperms
2. To understand the theory and practices involved in Plant Systematics
3. To learn the striking affinities of different plant families

Expected Course Outcomes:

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

1	Classify Plant diversity and recognize the importance of herbarium	K1
2	Utilize the information from herbarium resources, and knowledge on botanical gardens in future studies, and in plant based industries.	K2
3	Comprehend the idea about plant names and the rules governing its application at various levels. The reasons for name changes, and on the need for correct usage of names.	K3
4	Understand terms and concepts related to Phylogenetic Systematics	K4
5	Gain practical knowledge on identification of plant species using taxonomic literature and to understand local flora.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate

ANGIOSPERM TAXONOMY

1. Taxonomy and systematics: Definitions, Objectives, Importance, Scope.
2. Historical development of theories and concepts of plant classification and classificatory systems.
3. Conceptual bases of the classifications of the following: Bentham & Hooker, Engler & Prantl, Hutchinson & APG System of classification with emphasis on major clades.
4. Historical development of plant taxonomy in India with special reference to the contribution by William Roxburgh, J.D. Hooker, J.S. Gamble and K.S. Manilal. Major centers of taxonomic and floristic studies in India; organization and functions of Botanical Survey of India (BSI).
5. Taxonomic structure, taxonomic hierarchy, taxonomic categories – supraspecific and infraspecific categories; concept of species, genus and family.
6. Modern trends in Plant Taxonomy: Biosystematics, Numerical Taxonomy: Phenetics and Cladistics; Cladistic methodology; methods of Molecular Taxonomy.
7. Molecular Phylogeny principles and procedure, classification of tree building methods: Maximum Likelihood and Bayesian analysis. Cladogram analysis. Brief account of DNA bar coding in plants.
8. Taxonomic characters: Concept of character, character variations and their taxonomic

implications.

9. Plant description terminologies; method of describing a plant species using morphological characters. Practical identification of plants: Different kinds of Identification keys, Construction of dichotomous keys – Indented and bracketed keys. Various kinds of Taxonomic literature: General indices, Floras, Revisions, Manuals, Icons, Monographs, Reviews, Periodicals and Journals; online resources and databases, eFlora. Usage of floras and brief account on Flora of the British India, Flora of the Presidency of Madras and *Hortus Malabaricus*. Important Floristic works on Kerala region. Familiarization of technical terms associated with the following: habit, habitat; root, stem, leaf, inflorescence; bract and bracteoles; flowers; fruits and seeds.
10. General account on the sources of taxonomic characters: Morphology, Anatomy, Embryology, Cytology, Phytochemistry.
11. Plant Nomenclature: Brief History on the origin and development of nomenclature; detailed study of the major provisions of the International Code of Nomenclature for Algae, Fungi and Plants (ICN) Major changes from the preceding Code - Effective and Valid Publication, Rule of Priority and its limitations, Typification, Different kinds of types, Author citation, Rejection and retention of names, Conserved names; Nomenclature of hybrids; Nomenclature of cultivated plants. Common technical terms used in Plant nomenclature.
12. Problems in Evolutionary taxonomy: concept of primitive and advanced characters/groups, monophyly and polyphyly, parallelism and convergence, homology andanalogy.
13. Methods of plant exploration; Management of Herbaria; Major Herbaria in India and the World; Role of Herbaria in taxonomy.
14. Botanical Gardens. Role of taxonomy in biodiversity conservation.

MORPHOLOGY

1. General concepts of morphology. The concept of primitive angiosperms and the current ideas of the origin of angiosperms with reference to their ancestors; origin and evolution of flower, the concept of primitive flower; co-evolution of flowers vis-a-vis pollinators.
2. Stamen evolution and evolution of androecium. – haplo-, obhaplo-, diplo- and obdiplostemounous condition.
3. Evolution of carpels: concepts of foliar origin of carpels, alternative concepts and approaches, gonophyll theory; evolution of ovary **–** poly and syncarpy **–** superior, semi-inferior and inferior ovary - appendicular and receptacular theories **–** evolution of placentation types.
4. Role of floral anatomy in interpreting the origin and evolution of flower and floral parts. Morphology of nectaries.

PHYTOGEOGRAPHY

1. Introduction to Biogeography. Aims and major approaches to the study of Phytogeography.Static and dynamic Phytogeopgraphy.
2. Types of plant distribution: Continuous distribution; cosmopolitan, circumpolar, circumboreal, circum-austral, and pantropical. Discontinuous distribution; theory of land-bridge, theory of continental drift, theory of polar oscillations or Shifting of poles, glaciations. Endemics: Neoendemics and relics.

3. Centers of origin and diversity of plants;methods of dispersal, migrations and isolation.
4. Theories on the distribution of plants: theory of age and area, theory of tolerance. Factors influencing plant distribution.
5. Floristicregions of the world: Vegetation Zones in relation to latitudes and altitudes; a brief accountof the phytogeographical regions of India (recent classification by BSI).

References

- Barnard C. 1901. The interpretation of Angiosperm flower. Aust. J. Sci. 24; 64-72.
- Cox, C. B., Healey, I. N. & Moore, P. D. (1976). Biogeography. An Ecological and Evolutionary Approach. 2nd Edition. Blackwell Scientific Publications.
- Cronquist, A. 1988. The evolution and classification of flowering plants. New York Botanical Garden Press.
- Dahlgren, R.M.T., Clifford, H.T. & Yeo, P.F. 1985. The Families of Monocotyledons. Springer-Verlag.
- Daniel, P. (Ed.) 2005. The Flora of Kerala, BSI, Kolkatta.
- Eames A.J. 1961. Morphology of Angiosperms. Macmillan Company.
- Harris J.G. & M.W. Harris 2007. Plant Identification Terminology. Spring Lake Publishing.
- Hills, D.M. et al. 1996. Molecular Systematics (Ed. 2). Sinauer Associates, USA.
- Hutchinson, J. 1959. The Families of Flowering plants. Oxford.
- Janick, J. et al. 2002. International Code of Nomenclature of Cultivated Plants. International Society for Horticulture Science.
- Judith, E.W. 2002. Describing Plant Species. Bishen Singh Mahendrapal Singh, Dehra Dun.
- Kitching, I.J. et al. 1998. Cladistics – the theory and practice of Parsimony Analysis. Oxford University Press.
- Lomolino, M V et al., 2017. Biogeography: Biological Diversity across Space and Time, (Ed.5) Sinaeur Associates Inc. USA.
- MacDonald, G. (2003). Biogeography: Introduction to Space, Time and Life. John Wiley & Sons, Inc.
- Manilal K.S. 1981. Vascularisation of corolla of Compositae. J. Ind. Bot. Soc. 50: 189 - 196.
- McNeill, J. et al. (Eds.) 2012. International Code of Nomenclature for Algae, Fungi and Plants (Melbourne Code). Regnum Vegetabile 154, Koeltz Scientific Books.
- Meeuse A.D.J. 1974. Some fundamental principles of interpreting floral morphology. Intl. Biosci. Pub. Hissar.
- Naqshi, A.R. 1993. An introduction to Botanical Nomenclature. Scientific Publishers, Jodhpur.
- Purl V. 1952. Inferior Ovary. Phytomorphology, 2: 122.
- Sasidharan, N. 2004. Biodiversity documentation for Kerala: Part 6: Flowering plants, Kerala Forest Research Institute, Peechi, Kerala.
- Sivarajan, V.V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd.
- Stuessy, T.F. 1990. Plant Taxonomy - The Systematic evolution of Comparative data. Columbia University Press.

- Steussey, T.F. 2002. Case studies in Plant Taxonomy. Bishen Singh Mahendrapal Singh, Dehra Dun.
- Turland, N.J. et al. (Eds.) 2018. International Code of Nomenclature for Algae, Fungi and Plants (Shenzhen Code). Koeltz Botanical Books.

COURSE CODE: **BOT3C18**	NAME OF THE COURSE: **Angiosperm Taxonomy, Morphology and Phytogeography (Practical)**	CREDIT: **1**

Course Objectives:		
The main objectives of this course are to: 1. Understand and practice the basic principles and procedures in the flowering plant systematics 2. Create a relation between the geography of a region and its floristic diversity 3. Develop the practical skills for identifying the local flora, sketching scientific illustrations, preparing herbaria		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Systematically identify, name and classify flowering plants	K1
2	Construct artificial keys for the identification of flowering plants of a flora.	K2, K6
3	Distinguish taxonomic categories of a flowering plant specimen by anlysing its diagnostic characters.	K3, K4
4	Appraise the evolutionary status and phytogeographic distribution of taxon by analyzing correlated characters.	K5
5	Describe new flowering plant taxa.	K6
K1 - Remember; **K2** - Undestand; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; K6- Create		

1. During the course of this study, the student shall get familiar with the local flora.
2. The students should get familiar with the method of dissecting and studying plants in the laboratory, describing them in technical terms, preparing scientific illustrations, constructing artificial keys and identify them based on Bentham and Hooker's system of classification. For this purpose, each student shall work out at least 2 members of each of the following families of angiosperms available in the area: Menispermaceae, Polygalaceae, Caryophyllaceae, Sterculiaceae, Meliaceae, Rhizophoraceae, Melastomataceae, Aizoaceae, Oleaceae, Gentianaceae, Boraginaceae, Verbenaceae, Scrophulariaceae, Lentibulariaceae, Pedaliaceae, Lauraceae, Loranthaceae, Urticaceae, Commelinaceae, Zingiberaceae, Cyperaceae and Orchidaceae.
3. During the course of this study, each student shall undertake a field study tour for at least 3 days, at a place ecologically and floristically different from their place of regular study. Each one shall also collect plant specimens for herbarium preparation and shall submit at least thirty, well preserved, correctly identified and labeled herbarium specimens along with the field book and reportfor evaluation during the course of their practical examination.
4. Exercises in nomenclatural citations and solving nomenclatural problems.
5. Cladogram construction using molecular sequences using MEGA.
6. Preparation of cleared whole mounts of floral parts to show vasculature.
7. With the help of dissections and hand sections, examine: Different types of ovaries and placentation.

8. Interpretation of maps, dendrograms, Landsat images pertaining to the vegetation distribution, continental drift.

References

- Barnard C. 1901. The interpretation of Angiosperm flower. Aust. J. Sci. 24; 64-72.
- Cox, C. B., Healey, I. N. & Moore, P. D. (1976). Biogeography. An Ecological and Evolutionary Approach. 2nd Edition. Blackwell Scientific Publications.
- Cronquist, A. 1988. The evolution and classification of flowering plants. New York Botanical Garden Press.
- Dahlgren, R.M.T., Clifford, H.T. & Yeo, P.F. 1985. The Families of Monocotyledons. Springer-Verlag.
- Daniel, P. (Ed.) 2005. The Flora of Kerala, BSI, Kolkatta.
- Eames A.J. 1961. Morphology of Angiosperms. Macmillan Company.
- Harris J.G. & M.W. Harris 2007. Plant Identification Terminology. Spring Lake Publishing.
- Hills, D.M. et al. 1996. Molecular Systematics (Ed. 2). Sinauer Associates, USA.
- Hutchinson, J. 1959. The Families of Flowering plants. Oxford.
- Janick, J. et al. 2002. International Code of Nomenclature of Cultivated Plants. International Society for Horticulture Science.
- Judith, E.W. 2002. Describing Plant Species. Bishen Singh Mahendrapal Singh, Dehra Dun.
- Kitching, I.J. et al. 1998. Cladistics – the theory and practice of Parsimony Analysis. Oxford University Press.
- Lomolino, M V et al., 2017. Biogeography: Biological Diversity across Space and Time, (Ed.5) Sinaeur Associates Inc. USA.
- MacDonald, G. (2003). Biogeography: Introduction to Space, Time and Life. John Wiley & Sons, Inc.
- Manilal K.S. 1981. Vascularisation of corolla of Compositae. J. Ind. Bot. Soc. 50: 189 - 196.
- McNeill, J. et al. (Eds.) 2012. International Code of Nomenclature for Algae, Fungi and Plants (Melbourne Code). Regnum Vegetabile 154, Koeltz Scientific Books.
- Meeuse A.D.J. 1974. Some fundamental principles of interpreting floral morphology. Intl. Biosci. Pub. Hissar.
- Naqshi, A.R. 1993. An introduction to Botanical Nomenclature. Scientific Publishers, Jodhpur.
- Purl V. 1952. Inferior Ovary. Phytomorphology, 2: 122.
- Sasidharan, N. 2004. Biodiversity documentation for Kerala: Part 6: Flowering plants, Kerala Forest Research Institute, Peechi, Kerala.
- Sivarajan, V.V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd.
- Stuessy, T.F. 1990. Plant Taxonomy - The Systematic evolution of Comparative data. Columbia University Press.
- Steussey, T.F. 2002. Case studies in Plant Taxonomy. Bishen Singh Mahendrapal Singh, Dehra Dun.
- Turland, N.J. et al. (Eds.) 2018. International Code of Nomenclature for Algae, Fungi and Plants (Shenzhen Code). Koeltz Botanical Books.

COURSE CODE: **BOT3C19**	NAME OF THE COURSE: **Genetics, Plant Breeding, and Biostatistics (Theory)**	CREDITS: **3**

Course Objectives:		
The main objectives of this course include: 1. A thorough understanding of the fundamental concepts of genetics, as well as the development of analytical, quantitative, and problem-solving abilities 2. Critical understanding of traditional and modern crop breeding techniques. 3. A Basic understanding of biostatistical principles and application of appropriate statistical measures in the context of genetics and plant breeding		
Expected Course Outcomes:		
On the successful completion of the course, students will be able to:		
1	• Conceptualize and explain the genetic basis of inheritance, linkage and gene mapping • Comprehend the significance of plant genetic resources	K1
2	• Comprehend the effect of gene interactions and allelic variations	K2
3	• Apply the knowledge and skills to conduct minor research works and to evaluate the outcome • Determine the advantages and disadvantages of various kinds of experimental designs • Test hypotheses by applying appropriate test statistics	K3
4	• Analyze the genetic data from classical Mendelian to molecular and population genetic levels as well as from Pedigree data	K4
5	• Critically evaluate the conventional and modern methodologies for crop improvement efforts	K5
6	• Construct genetic maps based on recombination frequency	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Genetics

1. **Mendelism**: Mendel's experimental approach, Monohybrid cross- The Principles of dominance and segregation, Dihybrid cross- The principle of independent assortment, Punnet Square method, forked-line method, Laws of probability, Chi-square analysis

2. **Extensions of Mendelism**: Incomplete Dominance and codominance, Multiple alleles, Lethals, Penetrance and Expressivity, Gene interactions, Epistasis, Pleiotropy

3. **Chromosomal Basis of Mendelism**: Chromosome Theory of Heredity, Sex-Linked Traits, Sex-influenced traits, Sex-limited traits, Sex Determination, Dosage compensation of X-linked genes; Sex- Linked inheritance

4. **Human Pedigree Analysis-** Autosomal recessive disorders, Autosomal dominant disorders, X-linked recessive disorders

5. **Linkage analysis**: Linkage and recombination - Genetic mapping- Two-point test cross, Three-point test cross, Mapping with molecular markers

6. **Quantitative genetics**- Inheritance of complex traits- continuous, meristic and threshold traits, Statistical tools for measuring quantitative variation- Genetic and Environmental Variances - QTL Mapping- Broad sense and Narrow sense Heritability
7. **Extranuclear inheritance**: cytoplasmic inheritance, mt DNA, mitochondrial mutations in human disorders, cp DNA, maternal effect

8. **Genetics of photosynthesis**- chloroplast encoded genes, nuclear-encoded genes, genes encoding components of PET, Calvin cycle and other regulatory genes

9. **Genetics of Bacteria and bacteriophages**: Bacterial mutants, Mechanism of genetic exchange in bacteria - transformation, conjugation and transduction, Lytic and lysogenic cycles

10. **Developmental genetics**: Genetic control of development in plants (*Arabidopsis*) – Genes involved in meristem function, embryogenesis and floral development

11. **Molecular basis of mutations**- Tautomeric shifts, transitions and transversions, back mutations, suppression mutations, Silent mutations, Neutral mutation, Missense mutations, Nonsense mutations and Frame shift mutations.

12. **Regulation of gene expression in prokaryotes**: Prokaryotic gene regulation strategies, Constitutive, Inducible and Repressible Gene Expression, Positive and Negative control of gene expression, Operons, *Lac* operon in *E. coli*- Negative control and Catabolite Repression, *Tryptophan* operon in *E. coli*- Repression and Attenuation

13. **Gene Regulation in Eukaryotes**: Transcriptional Regulation- Transcription Factors, Enhancers; Post-transcriptional control- RNA interference; Chromatin Remodelling, DNA methylation

14. **Population Genetics**: Genetic composition of Mendelian populations- estimating allelic and genotypic frequency, Hardy Weinberg Law of genetic equilibrium, Factors affecting HWE- Migration, Mutation, Selection, Random genetic drift, Founder effect

Plant Breeding

15. **Introduction**- Objectives of plant breeding- History-Biological foundations of plant breeding- conventional techniques- advanced techniques- special methods.
16. **Biological foundations of Plant breeding**- Role of heredity and environment in character expression- Systems of reproduction in plants- Mating systems in sexually reproduced plants.
17. **Crop genetic resources and centres of diversity**- Classification of genepool-

Components of genetic resources- Centres of crop genetic diversity- Germplasm activities- Exploration and collection- Conservation, Evaluation, Documentation, Distribution and Utilization- Role of NBPGR- Quarantine.

18. **Plant propagation**- sexual, pseudosexual and asexual methods- special methods of plant propagation- micropropagation.
19. **Conventional methods of plant breeding**- plant domestication, plant introduction, selection and hybridization.
20. **Modern methods of plant breeding**- mutation breeding, polyploidy breeding and distanthybridization. Biotechnological approaches in plant breeding.
21. **Breeding for special purposes**- breeding for pest, disease and stress resistance. Quality breeding- Heterosis breeding. Breeding synthetic varieties. Breeding composite varieties.

Biostatistics

1. Quantitative methods in biology- An introduction
2. Methods of data collection- primary and secondary data- census and sampling methods.
3. Tabulation and presentation of numerical data- diagrammatic and graphical presentation.
4. Measures of central tendencies- mean, median and mode. Skewness and kurtosis.
5. Measures of variations- range, quartile deviation, mean deviation- variance and standard deviation. Standard error and Coefficient of variation.
6. Tests of significance- z, t and χ^2 tests.
7. Analysis of variance.
8. Correlation and regression analysis.
9. Factor analysis
10. Cluster analysis.
11. Experimental designs.

References

- Allard R. W. - Principles of Plant Breeding. John Wiley & Sons.
- Brooker R. 2017. Genetics: Analysis and Principles, 5th edition. McGraw-Hill Higher Education
- Brooker R. J. Genetics: Analysis and Principles. Addison Wesley Longman Inc.Hedrick P. W. Genetics of Populations. Jones and Bartlett Publishers.
- Chahal G. S. and Gosal S. S. Principles and Procedures of Plant Breeding. Narosa Publishing House.
- Crow JF, Kimura M. 2009. An Introduction to Population Genetics Theory. The Blackburn Press.
- Dabholkar A. R. Elements of Biometrical Genetics. Concept Publishing Company.
- Elrod S, Stansfield W. 2010. Schaum's Outline of Genetics, 5th edition. McGraw-Hill Education
- Frankel O. H. and Bennet E. Genetic Resources in Plants. Blackwell.
- Griffiths A. J. F., Gelbbart W. M., Lewontin R. C., Miller J. H. Modern Genetic Analysis. WH Freeman & Company.

- Gupta S.K. Plant Breeding. Agrobios.
- Hartl DL and Jones EW. Genetics: Analysis of Genes and Genomes, 7th edition. USA: Jones and Barlett Publishers.
- Hartl DL, Clark AG. 2006. Principles of Population Genetics 4th edition. Sinauer Associates is an imprint of Oxford University Press
- Hayward M. D., Bosemark N. O. and Romagosa I. Plant Breeding- Principles and Prospects. Chapman and Hall.
- Hotter P. Text Book of Genetics. Ivy Publishing House.Satpathy G. C. Genetics. Kalpaz Publications.
- Jain H. K. and Kharkwal M. C. Plant Breeding. Narosa Publishing House.
- Jasra P. K. Biostatistics. Krishna Prakashan Media (P) Ltd.
- Joshi R. M. Biosafety and Bioethics. Isha Books.
- Khan M. A. Plant Breeding. Biotech Books.
- Klug WS, Cummings MR, Spencer CA, Palladino MA, Darrell Killian. Concepts of Genetics, 12th edition. Pearson
- Mathew PM. Fundamentals of population genetics with emphasis on human inbreeding, 1st edition. Southern book star
- Mohanan K.V. Essentials of Plant Breeding. PHI Learning Private Limited, New Delhi.
  Roy D. Plant Breeding. Narosa Publishing House.
- Pagano M. and Gauvreau K. Principles of Biostatistics. Duxbury.
- Panse V. G. and Sukhatme, P. V. Statistical Methods for Agricultural Workers. ICAR.
- Phundan Singh. Essentials of Plant Breeding. Kalyani Publishers, New Delhi.
- Pierce BA. Genetics: A Conceptual Approach 6th edition. W. H. Freeman
- Radhakrishnan V.V., Hrideek T.K., Raghu A.V. and Chandramohanan K.T. Crops of Kerala - An overview. Gregor Mendel Foundation, Calicut University, Kerala.
- Rangaswamy R. A Text Book of Agricultural Statistics. New Age International Publishers.
- Sadhu M. K. Plant Propagation. New Age International Publishers.
- Sambamurthy A. V. S. S. Genetics. Narosa Publishing House.
- Sharma J. R. Plant Breeding. Tata McGraw Hill.
- Sharma J. R. Statistical and Biometrical Techniques in Plant Breeding. New Age International Publishers.
- Snustad PD, Simmons MJ. Principles of Genetics, 7th edition. Wiley.
- Strickberger MW. 2015. Genetics, 3rd edition. Pearson.

COURSE CODE: **BOT3C20**	NAME OF THE COURSE: **Genetics, Plant Breeding, and Biostatistics (Practical)**	CREDIT: **1**

Course Objectives:		
The main objectives of this course include: Inculcation of problem-solving ability using genetic datasets. Analysis of variables in order to make finite conclusions about their interrelationship Judging the suitable plant breeding techniques appropriate for a specific situation		
Expected Course Outcomes:		
On the successful completion of the course, students will be able to:		
1	Cite the genetic principles pertaining to specific situations of genetic analysis	K1
2	Understand the floral biology of various crop plants	K2
3	Apply the genetic principles to solve the problems related to Mendelian and population genetics	K3
4	Analyze the results of genetic experiments pertaining to classical and modern genetics	K4
5	Evaluate the use of different statistical tools in stating appropriate conclusions with statistical data	K5
6	Carryout specific plant breeding activities	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Genetics:

1. Problems based on independent assortment, gene interactions, and multiple allelism.
2. Problems based on linkage and chromosome mapping.
3. Problems based on quantitative genetics
4. Problems based on population genetics.

Plant Breeding:

1. Floral biology of rice, legumes, cashew, *Capsicum* and *Solanum*.
2. Emasculation and hybridization in plants like rice, legumes, cashew, *Capsicum* and *Solanum*.
3. Special methods of plant propagation- budding, layering and grafting.

Biostatistics:

1. Diagramatic and graphic representation of data using programmes like MS Excel,Open office Calc or Statistica.
2. Analysis of numerical data for mean, median, mode, variance, standard deviation,standard error and coefficient of variation.
3. Analysis of variance between data from different samples using MS Excel.
4. Calculation of correlation coefficient between groups of data and calculation of critical difference.

References

- Brooker R. 2017. Genetics: Analysis and Principles, 5th edition. McGraw-Hill Higher Education
- Crow JF, Kimura M. 2009. An Introduction to Population Genetics Theory. The Blackburn Press.
- Dabholkar A. R. Elements of Biometrical Genetics. Concept Publishing Company.
- Elrod S, Stansfield W. 2010. Schaum's Outline of Genetics, 5th edition. McGraw-Hill Education
- Frankel O. H. and Bennet E. Genetic Resources in Plants. Blackwell.
- Griffiths A. J. F., Gelbbart W. M., Lewontin R. C., Miller J. H. Modern Genetic Analysis. WH Freeman & Company.
- Gupta S.K. Plant Breeding. Agrobios.
- Hartl DL and Jones EW. Genetics: Analysis of Genes and Genomes, 7th edition. USA: Jones and Barlett Publishers.
- Hartl DL, Clark AG. 2006. Principles of Population Genetics 4th edition. Sinauer Associates is an imprint of Oxford University Press
- Hayward M. D., Bosemark N. O. and Romagosa I. Plant Breeding- Principles and Prospects. Chapman and Hall.
- Jain H. K. and Kharkwal M. C. Plant Breeding. Narosa Publishing House.
- Jasra P. K. Biostatistics. Krishna Prakashan Media (P) Ltd.
- Joshi R. M. Biosafety and Bioethics. Isha Books.
- Khan M. A. Plant Breeding. Biotech Books.
- Klug WS, Cummings MR, Spencer CA, Palladino MA, Darrell Killian. Concepts of Genetics, 12th edition. Pearson
- Mathew PM. Fundamentals of population genetics with emphasis on human inbreeding, 1st edition. Southern book star
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- Panse V. G. and Sukhatme, P. V. Statistical Methods for Agricultural Workers. ICAR.
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- Radhakrishnan V.V., Hrideek T.K., Raghu A.V. and Chandramohanan K.T. Crops of Kerala - An overview. Gregor Mendel Foundation, Calicut University, Kerala.
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- Roy D. Plant Breeding. Narosa Publishing House.
- Sadhu M. K. Plant Propagation. New Age International Publishers. Allard R. W. - Principles of Plant Breeding. John Wiley & Sons.
- Sambamurthy A. V. S. S. Genetics. Narosa Publishing House.
- Sharma J. R. Plant Breeding. Tata McGraw Hill.
- Sharma J. R. Statistical and Biometrical Techniques in Plant Breeding. New Age International Publishers.
- Snustad PD, Simmons MJ. Principles of Genetics, 7th edition. Wiley.
- Strickberger MW. 2015. Genetics, 3rd edition. Pearson.

COURSE CODE: **BOT3C21**	NAME OF THE COURSE: **Cell and Molecular Biology (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. Understand the structures and functions of cell junctions and other sub-cellular components of prokaryotic and eukaryotic cells, especially cell barriers, junctional complexes, cell envelopes and extra cellular matrix.
2. Grasp knowledge about different types of cell organelles, microbodies, nucleus, chromosomes and sub-nuclear components.
3. Recognize how these cellular components and sub-cellular structures are formed, and how they generate and utilize energy in cells.
4. Trigger awareness about the structure of cytoskeleton, mechanism of cell cycle, it's regulation and also mitotic and meiotic cell divisions.
5. Perceive knowledge on the molecular structure of nucleic acids like DNA and RNA & associated mechanisms viz., DNA replication, gene expression, gene regulation, mutation, DNA recombination and repair in prokaryotes and eukaryotes.

Expected Course Outcomes:

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

1	Generate adequate knowledge about cell biology and basic concept of molecular biology, structure of extra-cellular components and intra-cellular organelles and advanced molecular mechanisms.	K1
2	Discern the structure and function of basic components of prokaryotic and eukaryotic cells, especially its membrane organization, cell junction complexes, cell envelope and organelles.	K2
3	Exploit the rapid contemporary developments witnessed in plant cell biology and molecular biology.	K3
4	Relate the basic organization of genetic material and the realms of events associated with replication, gene expression, DNA repair and recombination.	K4
5	Appraise the information about different mechanisms of cell-cell interactions, organellar science and molecular biology of genetic material, it's structural and functional aspects.	K5
6	Generate knowledge about the basic and fundamental organization of the basic units of life, the cell, it's genetic material and their applications.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. **Cell Junctions & Barriers** - plasmodesma, tight, gap, adherens & other junctions, cell polarity, cell junction signalling; cell envelops - bacterial, archaeal, fungal and plant cell walls; cytorrhysis, hectian strands, organization of biomembranes, podosomes, invadopodia, synaptosome, acrosome, argosome, melanosome; paracytophagy, ion channels, membrane channels, membrane nanotubes, cytoneme, membrane fluidity, potential & transport, carrier proteins, ECM, intracellular & extracellular receptors, porosomes, ABC & SLC transporters.
2. **Cell Organelles & Microbodies** - mitochondria, plastids, GERL complex: mitochondrial import, export, chondrome, ATPsynthase, chaperones & chaperonins, kinetoplast;

plastid - types, photosynthetic domains, chloroplast import, plastome, CAB binding proteins, statoliths, chlorosomes, stromules, phycobilisomes; cell vacuoles, endocytosis & exocytosis, endosomes, exosomes, mitosomes, ejectosomes, cellular trafficking, microvesicles, parenthesome; prokaryotic organelles; Microbodies – glyoxisomes, peroxisomes, hydrogenosomes, oxalosomes, glycosomes, nif & senescence microbodies, Weibel-Palade body; proteasome; melanosome, tannosome, magnetosome, stress granule, vault.

3. **Cell nucleus & chromosomes** - nuclear membrane, pore complex, nucleoporins & transport; eu-, hetero-, pro- & anti-chromatin, CAF, centric heterochromatin, RSC complex, nucleolus, nucleolin, perinucleolar compartment (PNC) & Cajal body; nuclear matrix, lamina & PML body, paraspeckle, clastosomes, condensin, cohesin, prokaryotic & eukaryotic SMCs, transition nuclear proteins; nucleoid & nucleomorph; Chromosomes-chromosome territories, centromere (point & regional), centromere proteins, monopolin, telomere & mega-telomere, telomerase & telomere-binding proteins, nucleosomes, chromatosome, DNA packing & ratio, chromosomal proteins, repetitive sequences; SAT chromosomes, chromomeres, telomere & aging, chromosome knobs, core, scaffold, histone modifying enzymes, non-histone & HMG proteins, protamine & protamine-like (PL) proteins, MCM proteins.
4. **Cytoskeleton & cellcycle** - micro & intermediate filaments, microtubules & microtrabeculae; spindle apparatus & pole body & MTOC, actin, tubulins, vimentin, MAP, septin, spectrin; motor proteins-dynein, dynactin, kinesin, kinectin; intra- & inter-cellular kinetics, Phases & checkpoints of cell cycle, cell cycle proteins, cyclins & CDKs, cyclosomes, cell cycle inhibitors, INK4a/ARF, cip/kip,p53, p63 & p73, CAS, E2F, MPF, Wee, Culin; cyclosome, cell cycle regulation, mitosis & meiosis, mechanisms, orthomitosis & pleuromitosis, synaptonemal complex, centrosome & cancer, undulipodium; prokaryotic cytoskeleton, cytoskeletal drugs.
5. **Nucleic Acids** - DNA: molecular structure & associated mechanisms - types (linear, circular, super helical, nicked, satellite, selfish), forms of DNA- A, B, C, D, E, H, Z,RL helix & triple helix; organellar DNA (ct DNA & mt DNA), ms DNA, extracellular DNA (eDNA); DNA bending & binding, G-quadruplex, DBD & DNA binding proteins; RNA: RNA genomes, structure of RNA- rRNA, mRNA, tRNA (clover leafmodel & 'L'-shaped tertiary model), pre-mRNA/hnRNA, eRNA, signal recognition particle RNA, tmRNA, scaRNA, smYRNA, snRNA, snoRNA, miRNA, piRNA, siRNA, tasiRNA, shRNA, stRNA, gRNA, sgRNA, sutherland RNA & YRNA; Extrachromosomal nucleic acid - structure; organellar (cpDNA, mtDNA) & cloning vector (phagemid, plasmid, lambda phage, cosmid, fosmid, PAC, BAC, YAC,HAC), Secondary chromosomes.
6. **DNA Replication**- events & enzymes of replication, replisome, concurrent, simultaneous & bidirectional replication, rolling circle model, θ replication, DNA synthesis *InVitro*; DNA re-replication; enzymology of initiation, elongation & termination, multiple replicons, pulse chase analysis, cpDNA-, mtDNA- & plasmid-DNA replication, CNV,VNTR, Y-STR, tandem exon duplication, segmental duplication, big gene, oscillating gene, nucleosome duplication, pseudogene, chromosome termini replication, telomerase (TERT,TERC).
7. **Gene Expression in Eukaryotes & Prokaryotes**–transcription, RNA processing, cis-splicing, spliceosomes & trans-splicing, introns, exons, RNA editing, aminoacylation of tRNA; genetic code & exceptional codons; reporter genes, GUS reporter, promoters, enhancers, enhanceosome, transcription factors, transcriptosome, transcriptional bursting, transcriptional memory, polycistronic messengers, RNA- binding proteins;

ribosomes, biogenesis, types(prokaryotic, eukaryotic, cytoplasmic, organellar), structure, components & activesites, ribosomal dimers, polysomes, RRF, ribosome shunting & inactivators; translation & regulation, inhibitors; protein sorting & targeting; gene silencing.

8. **Gene Regulation in Eukaryotes & Prokaryotes**: operon concept, metabolite & aminoacid operons, epigenetic regulation, transcriptional & post-transcriptional regulation(sequestration, alternative splicing, miRNA), translational & post-translational regulation (reversible, irreversible), regulatory sequences in eukaryotic genes, Natural antisense transcripts (NATs), coordinate gene regulation, transcription activators & repressors, regulons, modulon, stimulon, constitutive mutants, bacterial & eukaryotic transpositions.
9. **DNA Recombination in Eukaryotes & Prokaryotes** - recombination models, legitimate & illegitimate recombination, achiasmy & heterochiasmy, recombination activating genes & hotspots, Holliday & double Holliday junction, cruciform DNA, recombination by replication, homologous recombination, site-specific recombination, gene conversion & hetero duplexes; V(D)J/somatic, Cre-Lox & FLP-FRT recombination, Role of rec. A in recombination of DNA, meiotic recombination checkpoint, mitotic recombination.
10. **DNA repair** - role of rec. A in DNA repair, base excision repair, photolyase, DNA glycosylase, nucleotide excision repair, DNA mismatch repair, transcription-coupled repair, homology directed repair, non-homologous end joining, microhomology-mediated end joining, post-replication repair & recombinational repair, DNA repair mechanisms (light-dependant-, excision-, mismatch-, postreplication- & SOS-repair), PARP.

References

- Agatha Wilson 2017. Essential Plant Cell Biology, Syrawood Publishing House, USA.
- Geoffrey M. Cooper 2018.The Cell: A Molecular Approach, 8th Edition, Sinauer Associates, Inc.,Oxford, New York.
- George Plopper 2016.Principles of Cell Biology. Jones & Bartlett, Burlington, USA.
- Gloria Doran 2016. Molecular Cell Biology, Syrawood Publishing House, USA.
- John Wilson and Tim Hunt 2015. Molecular Biology of the Cell-The Problems Book. 6th Edition, Garland Publishing Inc., New York.
- Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Kelsey C. Martin, Michael Yaffe & Angelika Amon 2021.Molecular Cell Biology. 9th Edition, W.H. Freeman publishers.
- Peter Nick and Zdeněk Opatrny 2014. Applied Plant Cell Biology-Cellular Tools and Approaches for Plant Biotechnology. Springer, New York, USA.
- Ram Dixit, Elizebath Haswell & Charles Anderson 2020. Plant Cell Biology. Ist Edition, Elsevier, Amsterdam, Netherlands.
- Ron Miloand Rob Phillips 2015.Cell Biology by the Numbers.1st Edition, CRC Press, USA.
- Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz and Graham T. Johnson 2017. Cell Biology, Second edition. Philadelphia, P A Saunders/Elsevier.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

- https://www.khanacademy.org/test-prep/mcat/cells/cell-cell-interactions/v/cell-junctions
- https://nptel.ac.in/courses/102106025
- https://www.ncbi.nlm.nih.gov/books/NBK26857/
- https://nptel.ac.in/courses/104102016
- https://nptel.ac.in/courses/102108086
- https://www.edx.org/learn/cellular-biology
- https://www.ibiology.org/educators-resources/flipped-courses/cell-biology-flipped-course
- https://www.open.edu/openlearn/science-maths-technology/science/biology/nucleic-acids-and-chromatin/content-section-2.2
- https://www.mooc-list.com/course/molecular-biology-part-1-dna-replication-and-repair-edx
- https://ocw.mit.edu/courses/7-03-genetics-fall-2004/pages/lecture-notes/

SEMESTER IV

COURSE CODE: **BOT4C22**	NAME OF THE COURSE: **Advances in Cell & Molecular Biology (Theory)**	CREDITS: **3**

Course Objectives:

The main objectives of this course are to:

1. Disclose recent knowledge about biomembranes & cell junction signaling, current advances in organellar studies and organellar engineering as well as a new organelle, TIGER domain.
2. Acknowledge how the various cellular disorders affect ion chanelles, cell membranes & cell junctions and their major causes are also considered.
3. Explore the recent advances of organellar science including organellar heterosis and engineering, along with organelle sequence transfer as well as transplastomics.
4. Discern knowledge on the disorders and diseases associated with ribosomes, mitochondria, peroxisomes and lysosomes as well as nuclear envelopathies and laminopathies are also encompassed.
5. Seize expertise in topics like cell death & cell renewal, advanced cytogenetic characterization techniques, advances in cell biology and mobilome, current advances in nucleic acids and molecular biology, genetically modified products and techniques for genetic improvement.

Expected Course Outcomes:

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

1	Bring about adequate knowledge about current advances in cell biology and molecular biology, and related advanced topics of cell membrane and organelles.	K1
2	Apply knowledge of cell and molecular biology to selected examples of changes or losses in cell function, affecting various subcellular components. These can include responses to environmental or physiological changes, or alterations of genetic material, cell membrane and cell junction malfunction brought about by mutations.	K2
3	Make use of the high-speed ultra-modern developments observed in plant cell biology and molecular biology.	K3
4	Investigate on the contemporary progress in plastids and mitochondria including hybrid vigour and engineering, along with transfer of mitochondrial and chloroplast gene sequences and cloning of organellar genes.	K4
5	Evaluate the knowledge on the disorders and diseases associated with organelles & microbodies, nuclear membrane & nuclear lamina and defects in cell cycle, cytoskeleton as well as cytoskeletal appendages.	K5
6	Fabricate knowledge about the complex molecular mechanisms of apoptosis & cytodiagnosis of cancer, advanced cellular and molecular delineation techniques, transposons and their significance, current advances in DNA science and advanced molecular technologies, genetically modified organisms and products and the latest technologies for genetic advancements.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

1. **Biomembranes & cell junction signalling**: cell–cell contact-dependent signalling, Cell–cell signalling via secreted molecules & electrical signalling, calcium-calmodulin cascade; signal transduction across membranes, biological crosstalk, intracellular trafficking; SRP; channel-linked, enzyme-linked & GPC receptors, messengers, & plant signals, protein sorting, vesicular transport; signal peptide, channelome, protein translocation & secretory pathway; bacterial S-layer; channelopathy, cell membrane disorders & cell junction disorders.
2. **Advances in organellar studies**: organellar heterosis, mitochondrial heterosis, chloroplast heterosis, Organellar engineering using nanoblade technology,mitochondrial engineering& plastid engineering, organelle sequence transfer; transplastomics, ribosome profiling, ribonomics, ribosomopathies, plant mitochondrial abnormalities, human mitochondrial dysfunction & diseases, Leigh syndrome, peroxisomal disorder & lysosomal storage diseases (LSDs); nuclear envelopathies & laminopathies; biomolecular condensate & TIGER domain.
3. **Cell death and cell renewal**: programmed cell death, necrosis, autophagy, apoptosis in plants, apoptosis in fungi, Anoikis, Pseudoapoptosis, paraptosis, pyroptosis & Parthanatos, efferocytosis,: cellular growth & growth retardation, DNA laddering, salt-and-pepper chromatin, Klerokinesis; chemical effects on microtubule dynamics & cell cycle defects; human cytoskeletal defects & ciliopathy; senescence, Hayflick type senescence, telomestatin, Signal interfering DNA in anticancer therapy; cell ablation.
4. **Advanced cytogenetic characterization techniques** : image cytometry, magnetic-activated cell sorting, electrophoretic karyotyping, cytological markers, cytological maps, chromosome combing, ISH, multicolor FISH (mFISH),Q-FISH, GISH & CISH, comparative genomic hybridization (CGH), chromosome painting, whole chromosome painting probe, Harlequin staining, digital karyotyping & spectral karyotyping (SKY); array-comparative genomic hybridization, SNP array & virtual karyotyping; DECIPHER & Cellular deconvolution.
5. **Advances in cell biology**: chromosome engineering, chromosome uptake, chromosome library, centromere activation, centromere mapping in eukaryotes, extrachromosomal array, stem cells, stem cell markers, current progress in embryonic stem cells, plant stem cells & applications, cell therapy; single-cell analysis, biomarkers & artificial cell; biomimetics, synthetic membrane, nano membrane & membrane technology; high through put cell biology, cell bank, cellomics & cytomics; dbCRID & cancer-associated neochromosomes.
6. **Mobilome**-TEs(replicative, non-replicative & RNA mediated), bacterial TEs (Is elements, composite elements & Tn elements), eukaryotic TEs (Ac &Ds elements, P elements, Mariner elements, Mu phage elements, Tn3- & Tn10 elements); retrotransposons, LTR & non-LTR elements, Ty-, copia-, F-, L1 & Alu elements; LINEs & SINEs; Polinton & repeatome; adaptive TEs,TEs & genome organisation, TEs & mutation, TEs & evolution.
7. **Advances in Nucleic acids: nucleic acid analogs** (XNA, GNA, TNA,HNA, LNA, PNA, Morpholino), bridged nucleic acid, DNA Synthesis *In Vitro,* DNA profiling & footprinting, ribotyping, chromosome walking & jumping; DNA amplification, DNA microarray, whole genome sequencing, SHOM, FAIRE-seq & snRNA-seq; hachimoji DNA, RNA interference & Post-Transcriptional Gene Silencing, exon connection, intron homing, exon shuffling, repeated DNA sequences, microDNA, cDNA, gDNA;

chromosome conformation capture; chromatin immunoprecipitation (ChIP); trans-splicing, fusion transcript &genome skimming.

8. **Advances in molecular biology**: reverse genetics & recombinase-mediated cassette exchange; HGT, gene theft & gene diagnostics, Human Variome Project, Histome; TILLING; branched DNA assay, recombineering & recombinational probes; transposon mutagenesis, sleeping beauty transposon system, gene tagging with transposons & transgenesis by transposons, trinucleotide repeat disorders, gene expression / regulation disorders; DNA repair-deficiencydisorders, DNA duplication-replication disorders.
9. **Genetically modified products** – GMOs, GMCs & GM foods, genoceuticals, fusion biopharmaceuticals, biopharming, novel antibiotics & phytovaccines, antiviral compounds, artificial sweetners, artificial enzymes, nanozymes, biocosmetics & biopesticides; biosteel & genetically modified bioplastics; GURT, detection of GMOs, GMO controversies, genetic pollution; biowarfare, biosensor, DNA nanotechnology, DNA origami & RNA origami.
10. **Techniques for genetic improvement**: cloning of organellar genes, site directed & signature-tagged mutagenesis, gene knockout & knock-in, gene editing, zinc finger nucleases (ZFNs), genome editing, TALEN, CRISPR; artificial gene synthesis, gene therapy & nano gene therapy, gene doping & gene enhancement, sperm-mediated gene transfer, bioluminescence, spermtyping, cisgenesis, intragenic & subgenic technology, antisense technology; nucleomics, epigenomics, lipidomics, glycomics & pharmacogenomics.

References

- Brad Fitzpatrick 2011. Cells: The Building Block of Life – Plant Cells. Chelsea House Publishers, NewYork, USA.
- Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts and Peter Walter 2015. Molecular Biology of the Cell. 6th Edition, Garland Science, Newyork.
- Bruce Alberts, Karen Hopkin, Alexander D Johnson, David Morgan, Martin Raff, Keith Roberts and Peter Walter 2018. Essential Cell Biology. 5th Edition, Garland Science, NY, USA.
- Burton E. Tropp 2012. Principles of Molecular Biology. Ist Edition, Jones and Bartlett Publishers, USA.
- Geoffrey Cooper 2019. The Cell: A Molecular Approach. 8th Edition, New York: Sinauer Associates: Oxford University Press.
- Gerald Karp 2016. Cell and Molecular Biology: Concepts and Experiments. 8th Edition,Wiley, NJ, USA.
- Gerald Karp, Janet Iwasa & Wallace Marshall 2019. Karp's Cell and Molecular Biology. 9th Edition, Wiley, Hoboken, New Jersey.
- Harvey Lodish, Arnold Berk, Chris A. Kaiser and Monty Krieger 2016. Molecular Cell Biology. 8th Edition, W. H. Freeman, NY, USA.
- Leland Hartwell, Michael L. Goldberg, Janice A. Fischer 2015. Genetics: from genestogenomes. McGraw-Hill Education, New York, NY
- Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz, Graham T. Johnson 2017. Cell Biology. Elsevier, Amsterdam.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

- https://www.edx.org/course/cell-biology-mitochondria
- https://www.mooc-list.com/course/cell-biology-cytoskeleton-and-cell-cycle-edx
- https://onlinecourses.nptel.ac.in/noc21_cy15/preview
- https://web.iitd.ac.in/~amittal/SBL101_Essentials_Cell_Biology.pdf
- https://www.britannica.com/video/73105/cell-cycle-events-division-process
- https://www.britannica.com/video/73106/Time-lapse-photography-mitosis-plant-cell-nucleus
- https://www.britannica.com/video/213698/Organelles-animal-plant-cells
- https://www.coursera.org/lecture/extracellular-vesicles/introduction-to-the-field-of-extracellular-vesicles-7XLvW

Animations: https://www.videezy.com/free-video/genetic
Lecture Notes: https://www.mysciencework.com/publication/download/lecture-notes-cell-biology
Plant Breeding; https://www.youtube.com/watch?v=1WuwwYcDHMg
PPT slides: https://www.slideshare.net/earshadshinichi/cell-biology-the-cell-its-structure-and-history
Video lecture: https://www.youtube.com/watch?v=OIN4keY8q3k

COURSE CODE: **BOT4C23**	NAME OF THE COURSE: **Advances in Cell & Molecular Biology (Practical)**	CREDIT: **1**

Course Objectives:

The main objectives of this course are to:

a. Reveal current knowledge about the structural and functional aspects of cellular envelope in plants.
b. Realize the various mechanisms of cellular growth and development taking place in the somatic and germ line cells of plants.
c. Explore the features and consequences of different types of induced structural and numerical chromosomal aberrations in plants.
d. Ascertain information on the type of chromonemal coiling especially during somatic cell division.
e. Provide knowledge on recent advances in imaging and karyotyping of normal chromosomes as well as structural aspects of giant chromosomes.
f. Procure expertise in topics like nucleic acid separation from plant cells and it's isolation as well as to achieve competence in techniques for it's approximation and staining.

Expected Course Outcomes:

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

1	Bring about adequate knowledge about the structure and interconnections between cell wall and cell membrane.	K1 & K2
2	Perceive the different stages and mechanism of mitotic and meiotic cell division in plants.	K1 & K2
3	Differentiate clastogenic and non-clastogenic chromosomal aberrations and their consequences in plants.	K1 & K3
4	Demarcate the variations among plectonemic and paranemic chromonemal coiling, observed in plant chromosomes.	K1 & K4
5	Employ the proficiency on chromosome image analysis system for karyotyping and karyomorphometry as well as utilize the knowledge on polytene chromosomes.	K1 & K5
6	Generate knowledge about the extraction and estimation of nucleic acids (DNA and RNA) in plants.	K1 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. Study of Hectian strands in the leaf epidermal peel of *Tradescantia/ Rhoeo spathacea*
2. Study of pollen mitosis using aceto-carmine smear techniques in the pollen grains of
3. *Impatiens balsamina*.
4. Chromosome counting & study of the meiotic chromosomes in the PMC of
5. *Tradescantia* using aceto-carmine smear techniques.
6. Study of reciprocal translocations in the translocation heterozygote, *Rhoeo spathacea*
7. Using aceto-orcein smear techniques.
8. Study of mitotic waves and synchronized cell division in *Tephrosia/Crotalaria* using Aceto-carmine squash techniques.
9. Study of induced chromosome aberrations (clastogenic & non-clastogenic) in *Allium sativum/Vicia faba.*
10. Study of induced chromosome breakages in *Allium cepa* var. *aggregatum* using hydroxyquinoline-orcein technique.
11. Study of induced polyploidy in *Allium cepa* var. *cepa/ Hippeastrum* using colchicine-orcein technique.
12. Study of the spiral coiling of macromolecules in the chromosomes of *Haemanthus*
13. Using nitric acid vapour technique.
14. Chromosome image analysis of karyotype from the specimen supplied using CHIAS technique.
15. Study of polytene chromosomes in the 4th in star larvae of the fruit fly *Drosophila melanogaster*.
16. Extraction of DNA/RNA from plant tissues.
17. Isolation of DNA/RNA from plant tissues.
18. Feulgen staining of nuclear DNA in eukaryotic cells.
19. Colorimetric estimation of DNA by Diphenylamine method.
20. Colorimetric estimation of RNA by Orcinol method.

References

- Barch, M. J. et al. 1997. The AGT Cytogenetics Laboratory Manual (3rd edn), Lippencott-Raven Publishers.
- Bonifacino, J. S. 2003. Short Protocols in Cell Biology. John Wiley & Sons Inc.
- Boris M. Sharga, Diana B. Pylypiv, Volodymir P. Feketa (2020) Feulgen staining of nuclear DNA in eukaryotic cells. In book: MOLECULAR BIOLOGY PRACTICALS (pp.1-4), Chapter: Practical 1., Publisher: Uzhhorod National University
- Celis, J.E. 1994. Cell Biology: A Laboratory Hand Book.Vol.1-3 Academic press,Inc.
- Jahier, J.1996.Techniques of Plant Cytogenetics. Oxford & IBH Publishing Co. Pvt. Ltd.
- Lloyd, R. V. 2004. Morphology Methods: Cell and Molecular Biology Techniques. HumanaPress.
- Rickwood, D. & Harris, J. R. 1996. Essential Techniques: Cell Biology. Promega.
- Sharma, A. K. & Sharma A. 1990. Chromosome Techniques– Theory & Practice. Butterworths & Co.
- Sharma, A. K. & Sharma A. 2001. Chromosome Painting – Principles, Strategies & Scope. Kluwer Academic Publishers.
- Taylor G. R. 1997. Laboratory Methods for the Detection of Mutations & Polymorphisms in DNA. CRC Press.

COURSE CODE: **BOT4C24**	NAME OF THE COURSE: **Genetic Engineering & Bioinformatics (Theory)**	CREDITS: **3**

Course Objectives:

The main objectives of this course are to:

1. To provide the knowledge on bioinformatics and its applications and to familiarize students with nucleotide and protein databases and how to evaluate the sequences for homology
2. To understand and develop phylogenetic tree construction using various tools and prediction of nucleotide sequences to develop primers for PCR reaction, the computational biology of sequencing and gene mining and visualization of biomolecules
3. To impart knowledge on computer aided drug design and molecular docking
4. To understand the basic principles of cell function and its role of genetic material
5. To understand heterologous gene expression and development of novel gene constructs for the betterment of human life

Expected Course Outcomes:

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

1	To apply the basic concepts of cell and molecular biology in modern biology. Acquire the knowledge of biological databases	K1
2	To analyse the gene sequences for homologies and other statistical tools	K2
3	To perform experiments on phylogenetic tree construction, molecular modeling, primer designing , secondary structure prediction etc.	K3
4	To explain how genetic engineering involves the use of recombinant DNA technolog for crop improvement and to identify the molecular markers for the selection of superior genotypes; Execute appropriate algorithms to identify the similarities and dissimilarities in biological samples.	K4, K6
5	To acquire fundamental knowledge on the application of various molecular tools and techniques for improvement of microbes and higher plants; Practice with idea generation techniques; Learn how to manage the creative process	K5, K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Genetic Engineering

1. **Molecular Techniques**: DNA markers & DNA probes, Reporter genes, DNA Sequencing methods (Maxam & Gilbert, Sanger *et al.*, capillary), RNA Sequencing, Sequanator, *In situ* hybridization (DIRVISH & FISH), PRINS, colony hybridization, dot & slot blots; blotting (Southern, Northern, Western, South-Western & North-Western), RFLP, RAPD,
2. STS & PCR (Variants in PCR), Real-time quantitative PCR, PCR, LCR), DNA- & RNA fingerprinting, genomic library, cDNA library & gen bank; chromosome walking; protein sequencing-MALDI.
3. **Recombinant DNA Technology**: Tools in genetic engineering; prokaryotic and eukaryotic vectors; shuttle-, expression-, dominant selectable-, amplifiable-, integrating-, broad host range vectors; positive and negative selection; enzymes involved; gene cloning & gene farming; single cell protein, shotgun cloning,

comparison of cloning vectors.

4. **Gene transfer in prokaryotes and eukaryotes**: Recombinant viral method; DNA-mediated gene transfer; protoplast fusion, micro-cell fusion; metaphase chromosometransfer; organelle engineering.
5. **Transgenesis in plants**: Somaclones; plant cell - bacterium hybrids; biociders; biological control; star link cotton, improvement of photosynthesis; post harvest preservation; selection of auxotrophs & secondary metabolite production.
6. **Genetic Engineering** – Merits & Demerits: SCP; Protein engineering, fusion proteins & designer enzymes, Production of biopharmaceuticals, commodity & industrial chemicals, food & beverages; Metabolite engineering & nif-engineering; Anti-sense technology; IPR& patenting; Biological risks, GM food and terminator technology; Biosafety & biohazards, physical & biological containment; Genetic screening & privacy; Ethical, economic& legal issues.

Bioinformatics

UNIT - 1

DATABASES & TOOLS: Introduction to Bioinformatics, Need for informatics tools and exercises, Significance of databases towards informatics projects. The nucleotide and protein sequence Databases: GenBank, DDBJ,EMBL, PIR, Primary and Secondary Databases; Format of databases, Gene bank flat file. Protein Data Bank (PDB) flat file; FASTA Format, PIR Format; Structure file formats, PDBSUM, PDB Lite, MMDB, SCOP, Pfam; Database of structure viewers. Specialized databases: NCBI, Pubmed, OMIM, Medical databases, KEGG, EST databases; Overview of other popular tools for bioinformatics exercises.

UNIT - 2

SEQUENCE ALIGNMENT AND DATABASE SEARCHES: Introduction, The evolutionary basis of sequence alignment, the Modular Nature of proteins, Optional Alignment Methods, Dot matrix analysis, Dynamic programing, global and local alignment, Smith- Waterman Algorithm, Needleman- Wunsch algorithm Substitution scores, substitution matrices, PAM, BLOSUM, Gap penalties, Statistical significance of Alignments, Database similarity searching, FASTA, BLAST, Low-Complexity Regions, Repetitive Elements. Practical Aspect of Multiple Sequence Alignment, Progressive Alignment Methods, CLUSTALW
,Motifs and Patterns, PROSITE, 3DPSSM. Conceptual numericals.

UNIT - 3

PHYLOGENETIC ANALYSIS: Introduction to Phylogenetic analysis, rooted and unrooted trees, Elements of phylogenetic Models, Phylogenetic Data Analysis: Alignment, Substitution Model Building, Tree Building, and Tree Evaluation, Building the Data Model (Alignment), Determining the Substitution Model, Tree - Building Methods, Searching for Trees, Rooting Trees, Evaluating Trees and Data, Phylogenetic software (CLUSTALW, PHYLIP etc), Conceptual numericals.

UNIT - 4

PREDICTIVE METHODS: Predictive Methods using Nucleotide sequences: Framework, Masking repetitive DNA, Database searches, Codon Bias Detection, Detecting Functional Sites in the DNA (promoters, transcription factor binding sites, translation initiation sites), Integrated Gene Parsing, finding RNA Genes, Web based tools (GENSCAN, GRAIL, GENEFINDER). Predictive Methods using Protein

sequences: Protein Identity based on composition, Physical properties Based on sequence, secondary structure and folding classes, specialized structures or features, tertiary structure. Related web based software (JPRED, PROSEC, NNPREDICT, and SOPMA)

UNIT - 5

PLASMID MAPPING AND PRIMER DESIGN: Restriction mapping, Utilities, DNA strider, MacVector and OMIGA, gene construction KIT, Vector NTI, Web based tools (MAP, REBASE); Primer design – need for tools, Primer design programs and software (PRIME3). Conceptual numericals.

UNIT - 6

GENOME BIOINFORMATICS: Sequencing methods (qualitative), Bioinformatics tools and automation in Genome Sequencing, analysis of Raw genome sequence data, Utility of EST database in sequencing, Bioinformatics in detection of Polymorphisms, SNPs andtheir relevance, Bioinformatics tools in microarray data analysis, tools for comparative genomics.

UNIT - 7

MOLECULAR VISUALIZATION: Generation or Retrieval, Structure Visualization, Conformation Generation. Graphical representation of molecular structures: small molecules (low molecular weight – peptides, nucleotides, disaccharides, simple drugs molecules) and macromolecules (high molecular weight molecules - proteins, DNA, RNA, membranes). Usages of visualization software available in public domain like VMD, Rasmol, Pymol, Spdb Viewer, Chime, Cn3D.Rotameric Structures of Proteins (Conformational Flexibility), Canonical DNA Forms (DNA Sequence Effects). Systematic methods of exploring conformational space.

UNIT - 8

***IN SILICO* MODELING & DRUG DESIGN**: Scope and applications of in silico modeling in modern biology. Comparative modeling, Constructing an initial model, refining the model, manipulating the model, molecule superposition and structural alignment, concept of energy minimization, different types of interactions and formulation of force fields. Basic MD algorithm, its limitations, treatment of long range forces. Molecular modeling in drug discovery, deriving bioactive conformations, molecular docking, quantitative structure-activity relationship (QSAR), deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Ligand – Receptor Interactions: Docking, Conceptual numericals.

References

Genetic Engineering

- Engdahl, S. (2006). Genetic Engineering-Contemporary Issues. Greenhaven Press, San Diego, USA.
- Flynne WG (2008). Biotechnology and Bioengineering. Nova Science Publishers
- Fox, M. W. (2000). Beyond Evolution: The Genetically Altered Future of Plants,Animals, the Earth ... and Humans. Lyons Press.
- Ho, R. J. Y. & Gibaldi, M. (2003) Biotechnology and Biopharmaceuticals:Transforming Proteins and Genes into Drugs. Wiley-VCH.
- Lewin B (2009). Genes IX. Humana Press.
- Lipps, G. (2008). Plasmids: Current Research and Future Trends. Caister Academic Press.

- Magnien, E. & De Nettancourt, D. (1985). Genetic Engineering of Plants and Micro-Organisms Important for Agriculture. Springer Verlag.
- Torr, J. D. (2006). Genetic Engineering-Current Controversies. Greenhaven Press.

Bioinformatics

- Bioinformatics – Andreas D Baxevanis. Wiley Interscience, 1998.
- Bioinformatics –David W Mount, Cold spring harbor, 2001.
- Introduction to Bioinformatics – Arthur Lesk, Oxford, 2006.
- Bioinformatics – Stuart M Brown, NYU Medical Center, NY USA. 2000.
- Fundamental Concepts of Bioinformatics – D E Krane & M L Raymer, Pearson, 2006.
- Structural Bioinformatics – PE Bourne and H Weissig, Wiley – Liss, 2003.
- Computational methods for macromolecular sequence analysis – R F Doolittle. Academic Press, 1996.
- Computational methods in Molecular Biology – S.L.Salzberg, D B Searls, S Kasif, Elsevier, 1998.
- Bioinformatics, Methods And Applications – Genomics, Proteomics And Drug Discovery – S C Rastogi, N Mendiratta & P Rastogi, PHI, 2006.
- The Molecular Modeling Perspective in Drug Design – N Claude Cohen – Academic Press, 1996.
- Analytical Tools for DNA, Genes & Genomes: – Arseni Markoff, New Age, 2007.
- Introduction to Bioinformatics – Anna Tramontano Taylor & Francis. (2007)
- Bioinformatics – Des Higgins & Willie Taylor – Oxford. (2005)
- Discovering Genomics, Proteomics and Bioinformatics – A M Campbell and L JHeyer, Pearson education, 2007.

COURSE CODE: **BOT4C25**	NAME OF THE COURSE: **Genetic Engineering & Bioinformatics (Practical)**	CREDIT: **1**

Course Objectives:

The main objectives of this course are to:

- Develop practical skills in genomic and plasmid DNA isolation, purification, quantification, electrophoretic separation, and restriction mapping
- Develop technical skills to retrieve nucleic acid and protein sequence data, align them and identify sequence similarities
- Analyze the bioinformatics resources in the public domain for deriving phylogenetic relationships

Expected Course Outcomes:

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

1	To perform genomic and plasmid DNA isolation, purification and quantification	K1, K2
2	To identify restriction fragment length polymorphisms	K3
3	To perform nucleotide and protein sequences retrieval from respective databases ar identify homologous sequences	K4, K6
4	To construct a dendrogram to infer the evolutionary relatedness of unknown samples based on sequence data	K5, K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Genetic Engineering

1. Genomic DNA isolation by CTAB method from plant tissues.
2. Isolation of bacterial genomic DNA.
3. Molecular weight determination of DNA by Agarose gel electrophoresis
4. Restriction fragment analysis of DNA.
5. Plasmid DNA isolation.
6. Estimation of DNA concentration by Spectrophotometric method.
7. Estimation of RNA concentration by Spectrophotometric method.
8. Lac induction by X-Gal method.

Bioinformatics

9. Retrieval of nucleotide sequences from NCBI
10. Protein sequence retrieval from protein database
11. Bibliographic search using Pubmed, SCIRUS and MEDMINER
12. Similarity search using BLAST
13. Multiple sequence alingnment using Multalin and CLUSTAL-W
14. Phylogenetic analysis
15. Primer designing
16. Secondary structure prediction of proteins
17. PDB structure retrival and Molecular visualization
18. Restriction mapping

References

Genetic Engineering

- Ausubel, F. M. *et al*. (2002) Short protocols in Molecular Biology. Vol. 1, 2 JohnWiley & Sons.
- Innis, M. A., Gelfand, D. H. & Sninsky, J. J. (1999). PCR Applications: Protocols for Functional Genomics. Academic Press.
- Lodish, H. (2007). Students Solutions Manual for Molecular Cell Biology. W. H.Freeman Co.
- Mitra, S. (1996) Genetic Engineering. Macmillan India Ltd.
- Reed, R. *et al*. (2007) Practical Skills in Biomolecular Sciences. Benjamin Cummings.
- Wilson, J. & Hunt, T. (2007) Molecular Biology of the Cell - Problems Book: 5thEdition. Garland Science.

Bioinformatics

- Bioinformatics – Andreas D Baxevanis. Wiley Interscience, 1998.
- Bioinformatics –David W Mount, Cold spring harbor, 2001.
- Introduction to Bioinformatics – Arthur Lesk, Oxford, 2006.
- Bioinformatics – Stuart M Brown, NYU Medical Center, NY USA. 2000.
- Fundamental Concepts of Bioinformatics – D E Krane & M L Raymer, Pearson, 2006.
- Structural Bioinformatics – PE Bourne and H Weissig, Wiley – Liss, 2003.
- Computational methods for macromolecular sequence analysis – R F Doolittle. Academic Press, 1996.
- Computational methods in Molecular Biology – S.L.Salzberg, D B Searls, S Kasif, Elsevier, 1998.
- Bioinformatics, Methods And Applications – Genomics, Proteomics And Drug Discovery – S C Rastogi, N Mendiratta & P Rastogi, PHI, 2006.
- The Molecular Modeling Perspective in Drug Design – N Claude Cohen – Academic Press, 1996.
- Analytical Tools for DNA, Genes & Genomes: – Arseni Markoff, New Age, 2007.
- Introduction to Bioinformatics – Anna Tramontano taylor & francis. (2007)
- Bioinformatics – Des Higgins & Willie Taylor – Oxford. (2005)
- Discovering Genomics, Proteomics and Bioinformatics – A M Campbel and L JHeyer, Pearson education, 2007.

ELECTIVE COURSES

COURSE CODE: **BOT4E01**	NAME OF THE COURSE: **Theoretical Aspects of Angiosperm Taxonomy (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. To develop a clear concept about different taxonomic categories.
2. To understand plant diversity, its classification as per the latest system.
3. To develop observation skills and to identify various floral mechanisms operating in nature for pollination, isolating mechanisms and speciation.
4. To understand the pattern of plant distribution, and to understand the significance of ecological and phytogeographical data for the interpretation.

Expected Course Outcomes:

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

1	Can utilize their expertise in biodiversity assessment studies; preparation of biodiversity register at Village/Panchayath level; help to prepare floristic account of selected regions.	K3
2	Help to determine plant species systematically at local and regional level, also able to understand various threat categories of plants species, and to develop conservation strategies if required.	K5
3	Threat category of plant species can be determined as per accepted norms, and can propos plant species that require immediate attention for conservation.	K3
4	Can utilize the expertise gained for various kinds of ecological impact assessment studies where existing flora need to be documented.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. Taxonomy-objectives and scope.
2. Comparative analysis of the theories and concepts of Angiosperm classifications.
3. Methods and Principles of Phylogenetic systematics.
4. Diversity and classification of Angiosperms recognized by APG
5. Units of classification: Concepts of various units; supraspecific and infraspecific categories.
6. Taxonomic characters: good and bad characters, qualitative and quantitative characters, analytical and synthetic characters, character weighting.
7. Structural and chemical data in Taxonomy: Reproductive and vegetative characters andtheir variations; Chemical compounds useful in taxonomy: Secondary metabolites, Semantides.
8. Origin of species: Ideal species, Isolation and speciation.
9. Phytgeographic and Ecological data in Taxonomy; Patterns of distribution, Vicariance

biogeography.

10. Critical study on the current views on the origin of Angiosperms.
11. Evolutionary taxonomy: Concepts of plesiomorphic and apomorphic characters/groups.

References

- Agashe, S. N. 2006. Palynology and its applications. Oxford and IBH Publishing Co. Pvt. Ltd.
- Cronquist, A. 1978. The evolution and classification of flowering plants. New York Botanical Garden Press.
- Davis, P.H. & V.H. Heywood. 1973. Principles of Angiosperm Taxonomy. Robert R Krieger Publishing Co.
- Douglas, E. & Soltis et al. 2005. Phylogeny and Evolution of Angiosperms. Sinauer Associates Inc.
- Harris J.G. & M.W. Harris. 2007. Plant Identification Terminology. Spring Lake Publishing.
- Heywood, V.H. & D.M. Moore. 1984. The Current concepts in Plant Taxonomy. Hutchinson, J. 1959. The Families of Flowering Plants. Oxford.
- Janick, J. et al. 2002. International Code of Nomenclature of Cultivated Plants. International Society for Horticulture Science.
- Judd, Campbell, Kellogy & Stevens. 1999. Plant Systematics – A phylogenic approach. Judith, E.W. 2002. Describing Plant Species. Bishen Singh Mahendrapal Singh.
- Kitching, I. J. et al. 1998. Cladistics – the theory and practice of Parsimony Analysis. Oxford University Press.
- Lawrence, G.H.M. 1951. Taxonomy of Vascular Plants. Oxford & IBH PublishingHouse.
- Manilal, K.S. & A.K. Pandey. 1996. Taxonomy and Plant Conservation. CBS Publishers and Distributors.
- Manilal, K.S. & M.S. Mukthesh Kumar. 1998. A handbook of taxonomy Training. Dept.of Science & Technology.
- Nair, P.K.K. 1971. Pollen Morphology of Angiosperms. Vikas Publications
- Naqshi, A.R. 1993. An introduction to Botanical Nomenclature. Scientific Publishers. Radford, E.A. 1986. Fundamentals of Plant Systematics. Harper & Row Publishers.
- Sasidharan, N. 2004. Flowering Plants. Kerala Forest Research Institute.Simpson, M.G. 2006. Plant Systematics. Elsevier Academic Press.
- Sivarajan, V.V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd.
- Smeath, P.H.A. & Sokal, R.R. 1973. Numerical Taxonomy. WH Freeman & Co.
- Sporne, K.R. 1974. Morphology of Angiosperms. New Delhi. Cambridge University Press.
- Stace, C.A. 1989. Plant Taxonomy and Biosystematics. Edward Arnold.
- Stebbin, G.L. 1963. Variation and evolution in plants. Columbia University Press.
- Steussey, T.F. 2002. Case studies in Plant Taxonomy. Bishen Singh Mahendrapal Singh.
- Stuessy, T.D. 1990. Plant Taxonomy - The Systematic evolution of Comparative data. Columbia University Press.
- Turland, N.J. et al. (Eds.) 2018. International Code of Nomenclature for Algae, Fungi and Plants (Shenzhen Code). Koeltz Botanical Books.

COURSE CODE: **BOT4E02**	NAME OF THE COURSE: **Applied Aspects of Angiosperm Taxonomy (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. To familiarize with the local flora and to train in field identification of flowering plants, their scientific documentation.
2. To acquaint with the procedure of recording plant data and field data scientifically for future reference.
3. To train on the scientific collection of all major groups of plants for herbarium documentation.
4. To provide adequate training in writing plant description, preparation of identification keys, and on proper utilization of databases for correct application of plant names.
5. To equip on the methods and procedure to be adopted for publishing the discovery of new taxa in scientific journals.
6. To prepare students on the method of drafting research proposal for submission for financial assistance from various funding agencies.

Expected Course Outcomes:

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

1	Can independently carryout floristic studies, prepare reports on plant diversity in ecological impact assessment studies; can assist forest personnel's in identifying ecologically fragile lands (EFL's).	K2
2	Herbarium specimens prepared on various plant groups can enrich the holding of Herbaria in the country.	K3
3	Will be able to communicate the new discoveries if any in scientific journals	K6
4	Can prepare scientific account on plant species of a given region with technical descriptions and identification keys.	K4
5	Research proposal submission for financial support in an appropriate manner.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

1. Field study and collection of specimens: General collections, Special collections; Recording of data in the field; Collection of special groups of plants: AquaticPlants, Succulents, Banana, Bamboos, Palms; Preparation and preservation of Specimens: Herbarium, Pickled specimens. Wood samples. Pollen, Seeds; Major herbaria of the world; Herbarium Ethics.
2. Identification of plants: Important vegetative and floral characters; Technical description of plants; Preparation of analytical illustrations. Brief account of DNA barcoding in plants.
3. Construction of keys for identification of plants: Different kinds of keys,
4. Computer application in Taxonomy; data bases, IPNI, POWO, WCSP, The Plant List, Tropicos, GBIF, Digitizing herbaria.
5. International Code of Nomenclature for Algae, Fungi and Plants (ICN): How to publish

a new combination, names at new rank or replacement name. Best practices for publishing new names.

6. How to designate a type. Basic rules for types, the typification process, best practices for designating a type.
7. Procedure involved in the recognition and publication of new plant species.
8. Preparation of taxonomic research articles for publication: format and major components of the article. Publication ethics.
9. Preparation of Floras, e-floras, Monographs and Revisions; common format of nomenclatural citations, Components of a reliable e-flora.
10. Major sources of general Taxonomic references: TaxLit. (Taxonomic Literature), Kew Record of taxonomic Literature, BPH- Botanico- Periodicum Huntianum, Index Herbariorum, Author's of Plant Names.
11. IUCN Red List Categorization: Procedures of Evaluation and categorization
12. Establishment and Organization of a herbarium: Selection of site, Plan of thebuilding, nature of construction, Administration.
13. Taxonomic Research projects: Plan and presentation of project proposals.

References

- Agashe, S. N. 2006. Palynology and its applications. Oxford and IBH Publishing Co. Pvt. Ltd.
- Cronquist, A. 1978. The evolution and classification of flowering plants. New York Botanical Garden Press.
- Davis, P.H. & V.H. Heywood. 1973. Principles of Angiosperm Taxonomy. Robert R Krieger Publishing Co.
- Douglas, E. & Soltis et al. 2005. Phylogeny and Evolution of Angiosperms. Sinauer Associates Inc.
- Harris J.G. & M.W. Harris. 2007. Plant Identification Terminology. Spring Lake Publishing.
- Heywood, V.H. & D.M. Moore. 1984. The Current concepts in Plant Taxonomy. Hutchinson, J. 1959. The Families of Flowering Plants. Oxford.
- Janick, J. et al. 2002. International Code of Nomenclature of Cultivated Plants. International Society for Horticulture Science.
- Judd, Campbell, Kellogy & Stevens. 1999. Plant Systematics – A phylogenic approach.
- Judith, E.W. 2002. Describing Plant Species. Bishen Singh Mahendrapal Singh.
- Kitching, I. J. et al. 1998. Cladistics – the theory and practice of Parsimony Analysis. Oxford University Press.
- Lawrence, G.H.M. 1951. Taxonomy of Vascular Plants. Oxford & IBH PublishingHouse.
- Manilal, K.S. & A.K. Pandey. 1996. Taxonomy and Plant Conservation. CBS Publishers and Distributors.
- Manilal, K.S. & M.S. Mukthesh Kumar. 1998. A handbook of taxonomy Training. Dept.of Science & Technology.
- Nair, P.K.K. 1971. Pollen Morphology of Angiosperms. Vikas Publications
- Naqshi, A.R. 1993. An introduction to Botanical Nomenclature. Scientific Publishers. Radford, E.A. 1986. Fundamentals of Plant Systematics. Harper & Row Publishers.
- Sasidharan, N. 2004. Flowering Plants. Kerala Forest Research Institute.Simpson, M.G.

2006. Plant Systematics. Elsevier Academic Press.
- Sivarajan, V.V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd.
- Smeath, P.H.A. & Sokal, R.R. 1973. Numerical Taxonomy. WH Freeman & Co. Sporne, K.R. 1974. Morphology of Angiosperms. New Delhi. Cambridge UniversityPress.
- Stace, C.A. 1989. Plant Taxonomy and Biosystematics. Edward Arnold.
- Stebbin, G.L. 1963. Variation and evolution in plants. Columbia University Press.
- Steussey, T.F. 2002. Case studies in Plant Taxonomy. Bishen Singh Mahendrapal Singh.
- Stuessy, T.D. 1990. Plant Taxonomy - The Systematic evolution of Comparative data. Columbia University Press.
- Turland, N.J. et al. (Eds.) 2018. International Code of Nomenclature for Algae, Fungi and Plants (Shenzhen Code). Koeltz Botanical Books.

COURSE CODE: **BOT4E03**	NAME OF THE COURSE: **Fungal Biology and Technology (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are:

1. To study the various aspects of the biology of fungi
2. To have an insight on some unique aspects of fungal genetics
3. To obtain knowledge of fungi of medical interest
4. To understand the significance and use of fungi in biotechnology

Expected Course Outcomes:

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

1	Have an understanding of the cell structure, growth, and nutrition of fungi	K1
2	Have knowledge about some unique genetic phenomena such as heterokaryosis, sexual compatibility, vegetative incompatibility, and parasexuality in fungi	K2
3	To have an understanding about the different kinds of fungal spores and their discharge mechanisms	K3
4	Gain adequate knowledge on the roles of fungi as saprophytes and mutualistic symbionts	K4
5	To gain awareness about the application of fungi in biotechnology especially in fermentation technology	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

1. Fungal cell structure: cell wall, cell membranes, organelles, reserve materials.
2. Fungal growth and nutrition: growth of yeasts and mycelial fungi, nutrient acquisition-extracellular digestion of nutrients, movement of nutrients into the cell,enzymeinduction and repression, nutritional requirements – essential macro- and microelements, vitamins, growth factors, environmental requirements – pH, moisture, temperature, light. A brief account of radiotrophic fungi and radiosynthesis. An overview of mycoloop.Fungal genetics: Heterokaryosis, sexual compatibility and mating types, parasexuality,vegetative incompatibility.
3. Fungal spores: diversity, passive and active mechanisms of spore discharge, spore dispersal.
4. Fungi as saprotrophs: role of fungi in the decomposition of cellulose and lignin, wood-decay fungi, soft rot, white rot, brown rot, dry rot, fungal succession.
5. Fungi in pathological relations of agricultural importance: fungi as parasites of plants, fungi as parasites and predators of nematodes, fungi as parasites of arthropods, biologicalcontrol utilising fungi.
6. Fungi of medical interest: mycoses, mycotoxins, and mycetism.
7. Fungi as mutualistic symbionts: lichens, mycorrhizae, endophytes, fungi as insect symbionts, anaerobic chytrids in herbivores.
8. Fungal technology: fermentation technology - fermentor design and operation, upstream and downstream processes, solid substrate fermentation; fungi and soybeans products; role of fungi in cheese preparation; cultivation of fungi for food - mushrooms and other macro fungi, edible biomass from yeasts and moulds – single cell proteins; fungiand production of alcoholic beverages: wine, beer, distilled spirits; fungal pigments; fungal enzymes of commercial importance; production of primary

metabolites of economic importance by fungi - industrial ethanol, citric acid; production of secondary metabolites of economic importance by fungi - antibiotics, ergot alkaloids; fungi and biotransformation of useful metabolites; applications of gene cloning in fungi.

References

- Anke, T. 1998. Fungal Biotechnology. Chapman & Hall.
- Carlile, M. J. and Watkinson, S. C. 2001. The Fungi. Academic Press.Deacon, J.W. 2006. Fungal Biology. Blackwell.
- Esser, K. (Series Ed.). The Mycota. A Comprehensive Treatise on Fungi as Experimental Systems for Basic and Applied Research. 13 Vols. Springer.
- Gow, N.A. & Gadd, G. M. 1994. The Growing Fungus. Springer.
- Jennings, D. H. and Lysek, G. 1999. Fungal Biology. Bios Scientific Publishers.
- Kagami, M., Miki, T. & Takimoto, G. (2014) Mycoloop: chytrids in aquatic food webs. Frontiers in Microbiology 5: https://doi.org/10.3389/fmicb.2014.00166
- Kavanagh, K. (ed.) 2018. Fungi – Biology and Applications Third Edition. Wiley.
- Moore, D. & Novak-Frazier, L. 2002. Essential Fungal Genetics. Springer.
- Moore-Landecker, E. 1996. Fundamentals of Fungi. Cambridge University Press.
- Webster, J. and Weber, R. 2007. Introduction to Fungi. Cambridge University Press.

Related Online Contents (Websites)

- https://oxfordmedicine.com/view/10.1093/med/9780198755388.001.0001/med-9780198755388-chapter-4
- https://www.anbg.gov.au/fungi/mycorrhiza.html?msclkid=a573da1ec1f611ec8bcf709c69d0679f
- https://www.adelaide.edu.au/mycology/mycoses
- https://www.australasianmycologicalsociety.com/

COURSE CODE: **BOT4E04**	NAME OF THE COURSE: **Fungal Systematics (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. To gain knowledge of diverse groups of true fungi and fungal analogues
2. To know the principles if fungal taxonomy and nomenclature and the current status of systematics of true fungi and fungal analogues.
3. To understand the methods of collection and preservation of different groups of fungi.
4. To get accustomed to the fungal taxonomic literature.

Expected Course Outcomes:

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

1	To have a strong grasp on rules and application of ICN with reference to fungi	K1
2	To know about the various modern techniques available for fungal taxonomy	K2
3	To acquire the knowledge on phylogeny of fungi and fungal analogues	K3
4	To attain knowledge on collection, examination and preservation of different groups of fungi	K4
5	To have a better understanding about naming, describing, and publishing of fungal species.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

1. Diversity of true fungi and fungal analogues: magnitude, significance and conservation.
2. Taxonomic ranks: eukaryotic kingdoms - modern views, kingdom Chromista/ Stramenopila, kingdom Fungi, and kingdom Protozoa. The concept of 'Domains' in biological classification. Ranks above family, families, subfamilies and tribes, genera, species, subspecies, varieties, form, special form, morphotype, chemotype, ecotype, strain and race, teratological forms; concepts of anamorph, teleomorph and holomorph; sources of taxonomic characters.
3. International Code of Nomenclature for algae, fungi and plants: detailed study of the rules and its application. Major changes in the Melbourne Code (2012) and Shenzhen Code(2018) that will affect fungal nomenclature.
4. Modern techniques available for fungal taxonomy: chemotaxonomy, cytogenetics, electrophoresis, serology, ultra-structure, nucleic acid analysis. Brief account of DNA barcoding in fungi.
5. Principles of numerical taxonomy.
6. Cladistics and their application in fungal taxonomy: practical reasons for studying phylogeny; the structure of phylogenetic relationships; species trees and gene trees; making and testing phylogenetic trees, sequence characters as evidence for relationships; methods of inferring trees.
7. Phylogeny of fungi and fungal analogues based on ultra-structure and nucleic acid analysis.
8. Collection, examination, and preservation of different groups of fungi, techniques and methods used to maintain fungal herbaria and culture collections, major fungal culture collections and herbaria of the world.
9. Naming, describing, illustrating, and publishing; monographs and revisions, keys, floras,

maps.

10. Fungal taxonomic literature, sources of references, catalogues of names, tracing incomplete and incorrect references, dates of publication, major mycological libraries, citation of literature. Online fungal systematics resources and depositories: Index Fungorum and MycoBank.
11. Updated classification of true fungi by Tedersoo et al. 2018; current taxonomicconcepts regarding straminipilan fungi and protistan fungi. An outline of Ruggiero et al., (2015) classification of fungal analogues.

References

- Alexopoulos, C. J. et. al. 1996. Introductory Mycology, 4th Edition, Wiley.
- Crous, P. W., Verkley G. J. M., Groenewald J. Z. & Samson R. A. (2009) CBS Laboratory
- Manual Series. CBS-KNAW- Fungal Biodiversity Centre Utrecht, The Netherlands.
- Frisvad, J. C. (1998). Chemical Fungal Taxonomy. CRC Press.
- Hawksworth D.L. 1974. Mycologist's Handbook. CMI.
- Hawksworth, D.L. (1991). The fungal dimension of biodiversity: magnitude, significance, and conservation. Mycological Research 95: 641-655.
- Hibbett D.S. et al. 2007. A higher-level phylogenetic classification of the Fungi. Mycological Research 111 (2007) 509–547.
- Kirk, P. M., Cannon, P. F., Minter, D. W. & Stalpers, J. A. (eds.). 2008. Dictionary of the Fungi, 10th edition. CABI Publishing.
- Manimohan, P. 2022. An overview of the diversity and classification of fungi. In: Seethalakshmi KK, Haridasan K, Maya C Nair & Rekha Vasudevan A (Eds.), Conspectus on Realms of Biodiversity, Victorian Botany Alumni Association, Government Victoria College, Palakkad, pp. 353-367.
- McNeill, J. et al. 2012. International Code of Nomenclature for Algae, Fungi and Plants
- (Melbourne Code). Koeltz Scientific Books. 240 p.
- McNeill, J. & Turland, N. J. 2011. Major changes to the Code of Nomenclature—Melbourne, July 2011. Taxon 60 (5): 1495–1497
- Mueller, G.M. et al. 2004. Biodiversity of Fungi: Inventory and Monitoring Methods. Academic Press.
- Oliver, R.P. and Schweizer, M. 1999. Molecular Fungal Biology. Cambridge University Press.
- Reynolds, D. R. & Taylor, J. W. 1996. The Fungal Holomorph: Mitotic, Meiotic and Pleomorphic Speciation in Fungal Systematics. CABI Publishing.
- Ruggiero, M.A, Gordon, D. P & Orrell, T.M (2015). A higher-level classification of all living organisms. Plos One, 10(4), e0119248.
- Sneath, P. H. A. & Sokal, R. R. 1973. Numerical Taxonomy. WH Freeman & Co. Talbot, P. H. B.1971. Principles of Fungal Taxonomy. Macmillan.
- Tedersoo L. et al. 2018. High-level classification of the Fungi and a tool for evolutionary ecological analyses. Fungal Diversity 90(1): 135–159.
- Weber, R. W. S. 2009. Recent Developments in the Molecular Taxonomy of Fungi. In: T.Anke and D. Weber (Eds.). The Mycota XV. Springer. pp1-15.

Related Online Contents (Websites)

- https://www2.clarku.edu/faculty/dhibbett/tftol/index.html

- http://www.tolweb.org/tree?group=fungi&msclkid=e154af6cc1f611ecbace2bf5d40c1fca
- http://website.nbm-mnb.ca/mycologywebpages/EssaysOnFungi/Collecting_mushrooms_for_scientific_study/Collecting_mushrooms_for_scientific_study.html
- https://www.mycobank.org/
- http://www.indexfungorum.org/

COURSE CODE: **BOT4E05**	NAME OF THE COURSE: **General Bryology (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are:

1. Make the students acquire skills in identification of the Bryophytes of the various habitats of Southern India, with special reference to Kerala.
2. Make them aware of the extent of diversity of this unique plant group in the world.
3. Make them equipped to plan and execute further studies on applied and utilitarian aspects of this group.
4. Impart concrete concepts on the ecological role played by this group in the local and global habitats.
5. Impart concrete concepts on the significance of this group in understanding the evolutionary trend among the plants.

Expected Course Outcomes:

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

1	The student shall acquire skills in identification of the Bryophytes of Kerala, and Southern India at large.	K1
2	They will get a strong idea about the diversity of this unique plant group in Southern India, and other parts of the world.	K2
3	They also get a clear idea of the progress of bryological studies in India and elsewhere. It would be helpful for them in planning future lines of action in utilising this plant group	K3
4	It provides deep insights on the significance of this plant group in the ecosystem, and the need for considering and conserving them.	K4
5	Imparts concrete concepts on the ecological role played by this group in the local and global habitats.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. General morphology, anatomy, and reproduction of bryophytes.
2. Methods of collection and sampling techniques of bryophytes.
3. Origin and evolution of bryophytes; antithetic and homologous theories; Evolution of gametophyte; evolution of sporophyte.
4. Classification of bryophytes; classification for hornworts, liverworts, and mosses; Historical account, recent trends. Brief account of DNA barcoding in bryophytes.
5. Phytogeography of bryophytes; major centres of distribution and diversity.
6. Macro habitats and microhabitat preferences of Bryophytes with special reference to South India
7. Fossil bryophytes; fossil Hepaticopsida, fossil Bryopsida, Naiadita.

8. Morphological and Anatomical studies on: Marchantiales (*Asterella, Reboulia, Marchantia, Dumortiera, Targionia, Cyathodium*); Ricciales {*Riccia*); Fossomb roniales (*Fossombronia*); Metzgeriales (*Pallavicinia, Riccardia, Metzgeria*); Jungermann iales (*Jungermania*); Porellales (*Porella, Lejeunea/Cololejeunea*); Polytrichales (*Pogona tum*); Bryales (*Bryum*); Dicranales (*Garckea, Campylopus, Octoblepharum*); Funariales (*Funaria*); Pottiales (*Hyophila*), Sphagnales (*Sphagnum*).
9. Reproduction: Vegetative, Sexual; alternation of generations.

References

- Smith, A. J. E. (ed.). 1982. Bryophyte Ecology. Chapman & Hall.
- Shaw, A. J.& Goffinet, B. (eds.). 2000. Bryophyte Biology, Cambridge University Press.
- Glime, J. M. & Saxena, D.1991. Uses of Bryophytes. Today and Tomorrows Printers & Publishers.
- Nair, M. C., Rajesh, K. P. & Madhusoodanan P. V. 2005. Bryophytes of Wayanad in Western Ghats. Malabar Natural History Society.
- Schofield, W. B. 2001. Introduction to Bryology. The Blackburn Press.
- Glime, J.M. 2017. *Bryophyte Ecology.* Michigan Tech. Univ., Bot. Soc. America, Inter. Ass. Bryologists.
- Manju, C.N. & K.P. Rajesh. 2017. *Bryophytes of Kerala, Liverworts Vol.1* Malabar Natural History Society & Centre for Research in Indigenous Knowledge Science & Culture. ISBN 978-81-903430-3-9.
- Mufeed B., Manju C.N. and K.P. Rajesh 2021. Bryophytes of Anamudi shola National Park in the Western Ghats of Kerala, India. Centre for Research in Indigenous Knowledge Science & Culture & Malabar Natural History Society, pp. 455.
- Manju C.N. 2022. Habitat diversity, distribution patterns and Conservation of Bryophytes in Kerala. *In:* Conspectus of Realms of Biodiversity; Commemorative volume to Prof. R. Vasudevan Nair (eds). Seethalakshmi K.K., Haridasan K., Nair M.C. & Rekha Vasudevan A. pp. 334-352; Victorian Alumni Association (VIBA) & Department of Botany, Govt. Victoria College, Palakkad.

COURSE CODE: **BOT4E06**	NAME OF THE COURSE: **Applied Bryology (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are:

1. Make the students acquire skills in identification and applications of the Bryophytes
2. Make them aware about the conservation of bryophyte diversity, the unique plant group.
3. Make them equipped to plan and execute further studies on applied and utilitarian aspects of this group.
4. To make an understanding in recent advancements in the field of bryology.

Expected Course Outcomes:

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

1	The student shall acquire skills in identification of the Bryophytes.	K1
2	They will get a strong idea about the ecology of this unique plant group	K2
3	They also get a clear idea about the importance of bryophytes	K3
4	Provides deep insights on the significance of this plant group in the ecosystem, and the need for considering and conserving them.	K4
5	Gives information on bryological research centres of the world, bryological literature and resources	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate

1. Habitat studies: Aquatic (*Riccia fluitans*), Terrestrial (*Hyophila, Bryum*), Epiphytic (*Octoblepharum*) Epiphyllous (*Lejeunea*).
2. Ecology of bryophytes- habit, habitat, associated vegetation, and role of bryophytes in ecosystem dynamics.
3. Importance of bryophytes- medicinal, horticultural, antimicrobial, antifungal, active constituents, pollution monitoring (IAP), peat moss, etc.
4. Conservation of bryophytes- the need for conservation, IUCN & Red Data Book; Bryophyte garden.
5. Recent advances in the field of bryology- molecular studies, chemicalconstituents and physiological ecology,
6. Bryological Research Centres of the world; major Herbaria.
7. Bryological literature and resources;- Index Muscorum, Index Hepaticum, Floras, Monographs, Journals etc.
8. Bryologists-Historical account, their contributions.
9. Bryology in India-History, contribution by Indian bryologists such as Kashyap, Ram Udar, Gangulee, Chopra, Virendra Nath, and Srivastava.
10. South Indian bryophytes; diversity, distribution; Habit and microhabitat.

References

- Glime, J. M. & Saxena, D.1991. Uses of Bryophytes. Today and Tomorrows Printers & Publishers.
- Nair, M. C., Rajesh, K. P. & Madhusoodanan P. V. 2005. Bryophytes of Wayanad in Western Ghats. Malabar Natural History Society.
- Schofield, W. B. 2001. Introduction to Bryology. The Blackburn Press.
- Shaw, A. J.& Goffinet, B. (eds.). 2000. Bryophyte Biology, Cambridge University Press.
- Smith, A. J. E. (ed.). 1982. Bryophyte Ecology. Chapman & Hall.

COURSE CODE: **BOT4E07**	NAME OF THE COURSE: **Cytogenetics (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. The students can understand the various techniques used in Cell Biology for the detailed analysis of cell and cell organelles.
2. They can learn about the organization of biomembranes and the various signaling pathways within the cell.
3. To study the different aspects of cell cycle *viz.,* the proteins involved in cell cycle regulation, programmed cell death as well as cell cycle defects.
4. To learn the various aspects of karyomorphology along with the different structural and numerical mutations in chromosomes.
5. To understand what is cancer, the different types, various carcinogens, the genes involved and the cancer gene therapy.
6. The students will get in-depth knowledge on various cytogenetic characterization techniques of hybridization and karyotyping. They can also learn about the recent advances in the field of cell biology.

Expected Course Outcomes:

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

1	The course will facilitate the adequate knowledge about the various techniques used in Cell Biology which would include the different hybridization techniques, staining techniques as well as karyotyping procedures.	K1
2	The subject provides knowledge about cell, its functioning, its division and regulation and the various factors influencing the cell cycle	K2
3	Students will be introduced to novel cytological techniques, thus helping them to understand better cell biology mechanisms.	K3
4	Basic cellular organization and advances in cell biology will be examined and analyzed	K4
5	Techniques to study cell and recent information on various aspects of the cell will be evaluated	K5
	Creative knowledge of the students will be enhanced by inculcating recent cytogenetic characterization techniques	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6**- Create

1. Cell composition: Intracellular and extracellular composition (proteoglycans, non-proteoglycans, structural & adhesion proteins); cellular differentiation &cellular metabolism: cell signaling molecules (ecAMP and H_2S), cellular waste products, allelopathic molecules (e.g., antibiotics, quorum signalling molecules & hormones).
2. Cellular communication: cell signaling types (paracrine, synaptic, autocrine, & endocrine), classes of signalling molecules (lipids, phospholipids, amino acids, monoamines, proteins, glycoproteins, or gases) peptide, gap junction, quorum sensing, biofilm, plasmodesmata, proteins, plasma membrane, exosomes.
3. Cell mechanics & kinetics: celltracking, cell biophysics, biomechanics, elasticity of

cell membranes & mechanobiology; Cell molecular motors, cytoskeletal motors, polymerisation motors, rotary motors, nucleic acid motors, enzymatic motors, synthetic molecular motors & molecular machines, helical nanomotors & enzymatic nanomotors.

4. Chromosomes & genomes: prokaryotic & eukaryotic chromosomes, autosomes and allosomes, parts of a chromosome & their role;prokaryotic & eukaryotic cell division, phases & checkpoints, mitotic & meiotic behaviour of chromosomes; prokaryotic, eukaryotic & viral genomes; types & various roles of genes, gene replication, expression, regulation and recombination in prokaryotes & eukaryotes.
5. Numerical variations in chromosomes: polysomy, chromosome elimination, chromosome doubling, Homoeologous chromosomes, doubled haploidy, polyhaploidy, polyploidy, polyploid complex, aneuploidy, partial aneuploidy, mixoploidy, paleopolyploidy; cytostasis and significance, cytostatic agents, aneugen, aneuploidogens; human genetic variation, haplotype, human numerical syndromes & genetic testing.
6. Structural variations in chromosomes: chromosome diminution, translocation heterozygotes, Renner complex (α- & β complex), breakage-fusion-bridge cycle; genetic consequences of cytotoxicity, cytotoxic agents, clastogen; genetic time bombs & genetic sterilization; human structural syndromes, isochromosome, Ph chromosome, fragile sites, hot spots & cold spots; prenatal diagnosis - amniocentesis, chorionic biopsy & umbilical sampling; chromosomal effects of radiations & genetic disease diagnosis.
7. Special types of chromosomes: polytene, lamp brush & prokaryotic nucleoids; B-chromosomes, double minute, micro-, mini- & mega-chromosomes, parasitic chromosomes, neocentric & holocentric chromosomes; small supernumerary marker chromosomes (sSMC) in human beings & sSMC-associated disorders, plant polytene chromosomes (in cells of embryo suspensor & anther tapetum) & lampbrush-type chromosomes in plants.
8. Mutation - mutationism, types of mutations - somatic & germinal mutations, spontaneous & induced mutations, beneficial mutations, mosaicism, error-prone replication / repair mutation, direct and indirect DNA damage, mutagenic agents & environmental mutagens, molecular basis of mutation, homeobox, trinucleotide repeat expansion, human somatic variation & mutation rate, homeo box & types of homeobox genes.
9. Cytology of cancer: benign & (hyperplasia, cyst, pseudocyst, hamartoma), malignant (dysplasia, adenoma, carcinoma, lymphoma, sarcoma, melanoma, blastoma, papilloma & leukemia), metastasis, transformation & differentiation; precancerous condition & paraneoplastic syndrome; interaction with normal cells, chromosome rearrangements & cancer, genetic tumors, chemical carcinogenesis & teratogenesis, carcinogens & teratogens, tumor suppressor genes, oncogenes, oncovirus & cancer bacteria, radiation & DNA repair in carcinogenesis & cancer gene therapy; FNAC.
10. Radiation cytology: isotopes, radioactive labels, radioactive tracers & applications, biological, physiological & chromosomal effects of radiations, radiation chimeras, radiation hazards, nuclear and radiation accidents, background radiation, radiation hazard assessment, banana equivalent dose (BED), radiation assessment detector, molecular imaging of radioactive material, radiation protection, safety guidelines;

acute radiation syndrome, nuclear medicine & radiation therapy; radioactive waste disposal & nuclear reprocessing.

References

- Brian Nation & Guy Orchard 2015. Cell Structure & Function, OUP Oxford, UK.
- Daniel L Hartl and Bruce j Cochrane 2017. Genetics analysis of genes and genomes 9 th edition , Jones and Bartelet publications.
- Felix Mitelman & Sverre Heim 2015. Cancer Cytogenetics Chromosomal and Molecular Genetic Aberrations of Tumor Cells, Wiley, New Jersey, USA.
- Gary Whitson 2012. Concepts in Radiation Cell Biology, Elsevier/ Academic Press, New York.
- Geoffrey M Cooper 2019. The cell A molecular approach eighth edition, Oxford University Press.
- Giuseppina tommonaro 2019. Quoram sensing Molecular mechanism and biotechnological application Academic press Elsevier.
- Harvey Lodish, Arnold Berk 2021. Molecular biology 9 th Edition Freeman.
- John T Hancock 2016. Cell signalling fourth edition Oxford University Press.
- Mason Anders 2018. DNA, Genes, and Chromosomes, Capstone, Minnesota, USA.
- S.Kemper 2019. The cell,CBC Publishers and distributors pvt ltd.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

- https://www.coursera.org/learn/basic-principles-of-cell-signaling
- https://www.cshl.edu/counting-chromosomes-plant-scientists-solve-a-century-old-mystery-about-reproduction/
- https://www.le.ac.uk/biology/phh4/chrmod.htm
- https://botany.one/2014/09/plant-molecular-cytogenetics-genomic-postgenomic-era/
- https://study.com/academy/lesson/physical-features-of-a-chromosome.html
- https://dth.ac.in/medical/courses/pathology/8/5/index.php#
- https://www.coursera.org/lecture/genes/the-genetics-of-cancer-q1keo

COURSE CODE: **BOT4E08**	NAME OF THE COURSE: **Cytotechniques (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. To understand the molecular basis of chromosomes and chromosomal proteins and to study the structure of nucleic acids, their biosynthesis and the different classes.
2. The students can learn the various mechanisms involved in the replication of the genetic material in prokaryotes and eukaryotes, the enzymes, proteins and genes acting in the process and the various disorders concerned with it.
3. Students can understand the mechanism of gene repair and the various models of gene recombination and the different gene regulation processes within the organisms.
4. To learn the various techniques involved in the characterization of nucleic acids viz., DNA profiling, foot printing, DNA microarray, whole genome sequencing, protein sequencing, gene diagnostics etc.
5. To educate the students about the new techniques of genetic modifications for the production of foods, therapeutics, vaccines, cosmetics, pesticides and even organisms for genetic enhancement.

Expected Course Outcomes:

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

1	The course will help the students to get a better understanding of the genetic and molecular basis of organism development	K1
2	The subject focuses on educating the students on the various molecular techniques being used in the recent scientific studies.	K2
3	Students will be made aware about the trending scientific concepts of gene modifications that play great role in genetic improvement.	K3
4	Basic molecular level organization of the cell and advances in molecular biology will be analyzed	K4
5	Techniques for the development of genetically modified products will be evaluated	K5
6	Creative knowledge of the students will be enhanced by inculcating nucleic acid characterization techniques and genetic improvement techniques	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6**- Create

1. Cell visualization techniques: cytophotometry, microscopes-digital, interference, reflection, super-resolution, TIRF, confocal microscopy & atomic force microscopy; biophotonics; time-lapse microscopy & micro-cinematography, live single cell imaging, sarfus imaging technique, electron cryotomography & ptychography.
2. Cell counting techniques: cell counting (manual, automated & indirect), cell-culture & viable cell counting, hemocytometer & hematology analyzers; cell sorting, flow cytometer & cell-sorters, fluorescence activated cell sorting; automated differential cell counter, Coulter counter & CASY cell counting technology; viability assay & clonogenic assay.
3. Cell fractionation techniques: cell-fractionation, cell disruption, beadmethods,

Dynabeads, mhigh pressure cell disruption, homogenization, differential centrifugation, buoyant density centrifugation, homogenization (grinding, mincing, chopping, pressure changes, osmotic shock, freeze-thawing, and ultra-sound), nitrogen decompression, cryopulverization.

4. Techniques to study cell wall & cell membrane: Electron microscopy, scanning (SEM) & transmission (TEM), fluorescence microscopy (FM), laser scanning or spinning disk confocal microscopy, expansion microscopy, PAINT (point accumulation for imaging in nanoscale topography) technique & FRAP (fluorescence recovery after photobleaching) technique.
5. Techniques to isolate & study cell organelles: Cell membrane lysis, differential gradient centrifugation, rate zonal centrifugation, Percoll technique, microfluidic isolation, immunoaffinity isolation of organelles; stimulated emission depletion microscopy (STED), soft X-ray microscopy & stretched time-encoded amplified imaging microscopy (STEAM).
6. Staining techniques used in cytogenetics: stains used in light microscopy & electron microscopy, cell wall staining by Dyar's method, cell membrane staining by Burdon's method, Feulgen staining for nuclear material, Janus green staining of mitochondria, acridine orange/ethidium bromide (AO/EB) staining in apoptosis & Diff-Quik and Pap stain.
7. Nucleic acid extraction & characterisation techniques: DNA extraction & RNA extraction protocols, isopycnic centrifugation, density gradient centrifugation, nucleic acid electrophoresis, DNA separation by silica adsorption Booms method, C-value, C-value paradox, different classes of DNA, DNA reassociation kinetics & Cot-values; flow-FISH.
8. Cytometry: mass cytometry, micro-densitometry, image cytometer, time-lapse cytometer, cytophotometry, pulse cytophotometry, optical tweezers, fluorescence optical tweezers, micro-fluorimetry, Micro-computed tomography (MCT), ultrasonic microscopy, scanning acoustic microscopy, Optical interferometry & optical coherence tomography (OCT).
9. Cytotoxicity techniques: Allium cepa assay, Induced cell cycle arrest, Dye exclusion assays (Trypan blue, eosin, Congo red, erythrosine B), Colorimetric assays (MTT, MTS, XTT, SRB, LDH, NRU, WST & Crystal Violet), Fluorometric assays (alamarBlue & CFDA-AM assay), Luminometric assays (ATP & real-time viability assay), TUNEL assay, Single cell gel electrophoresis / Comet assay, wound healing assay, cell cycle analysis & Nicoletti assay.
10. Karyotype and chromosome banding techniques: common stains used for cytological studies, flurochromes, chromosomal nomenclature, karyomorphometrical techniques & centromeric indices (TF%, DI & VC; Syi index & Rec index; AI, A, A1 & A2) centromere number (acentric, monocentric, dicentric & polycentric), chromosomal polymorphism & Chromosome banding techniques (H, G, C, T, N, R, Pr, Q, F & replication banding); chromosome microdissection.

References

- Ewa Paluch 2015. Biophysical Methods in Cell Biology, Elsevier / Academic Press, New York.
- Guy Cox 2006. Optical Imaging Techniques in Cell Biology, CRC Press, New York.
- James V. Watson 2004. Introduction to Flow Cytometry, Cambridge University Press,

UK.
- Kim Trainor 2015. Karyotype, Brick Books, Ontario, Canada.
- Morgan Key 2015. Cytogenetics: Techniques and Applications, Callisto refernce
- P. Michael Conn 2013. Laboratory Methods in Cell Biology: Imaging. Elsevier / Academic Press, New York.
- P. Michael Conn 2021. Laboratory Methods in Cell Biology: Biochemistry and Cell Culture. Elsevier / Academic Press, New York.
- Phong Tran 2020. Methods in Cell Biology, Elsevier / Academic Press, New York.
- Susan Mahler Zneimer 2014. Cytogenetic Abnormalities: Chromosomal, Fish And Microarray Based Clinical Reporting, John Wiley Publications, Hoboken, New Jersey, U.S.
- Tulay Askin Celik 2018. Cytotoxicity, IntechOpen, London, UK.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

- https://archive.nptel.ac.in/courses/113/106/113106064/
- https://nptel.ac.in/courses/102107075
- https://www.jove.com/v/1512/chromosomal-spread-preparation-human-embryonic-stem-cells
- https://www.intechopen.com/chapters/75292
- https://www.nagwa.com/en/videos/175159374396/
- https://medlineplus.gov/lab-tests/karyotype-genetic-test/
- https://study.com/academy/lesson/chromosome-banding-definition-techniques.html

COURSE CODE: **BOT4E09**	NAME OF THE COURSE: **Ecological Aspects of Plant Function (Theory)**	CREDITS: **4**

Course Objectives	
The main objectives of this course are to:	
1. To know plant water relations 2. To obtain knowledge about plant- biotic interaction in mineral acquisition 3. To acquire knowledge on carbon assimilation and photoprotection 4. To get an understanding on respiration and photosynthesis 5. To know about various plant defense mechanisms 6. To get deeper knowledge on ecosystem and biomass productivity	
Expected Course Outcome	
1. Will help to recognize plant water interaction	K1
2. Will help to find out metabolic pathways involved in plant defense mechanisms	K2
3. Can correlate various metabolic pathways functioning in various organisms of an ecosystem	K3
4. Will help to analyze the importance of plants in maintaining equilibrium and homeostasis in ecosystem	K4
5. Evaluate the biotic influences on plant life cycle	K5
6. To understand the physiological basis of productivity and maintain the net carbon balance of ecosystems	K6
K1- Remember**, K2-** understand**, K3-** Apply **K4-** Analyze **K5-** Evaluate**, K6-** Create	

1. Water relations – transpiration as an inevitable consequence of photosynthesis, water availability and field capacity of different soils, effect of soil and drying on leaf conductance, effect of vapour pressure difference on transpiration rate of leaf, effect of irradiance and CO2 on leaf conductance, cuticular conductance and the boundary layer conductance, compromise between carbon gain and water loss, water storage in leaves of aquatic angiosperms, resurrection plants, winter water relations.
2. Mineral nutrition –plant microbes interaction, role of soil microorganisms in nutrition acquisition, changes in the soil physiochemical properties, exertion of organic chelates, root proliferation in nutrient rich patches, biotic influences – symbiotic association, mycorrhiza and actinomycetes, mechanics of enhanced uptake of phosphorus, carbon cost of mycorrhizal symbiosis, agricultural and ecological perspectives, association with nitrogen fixing organism, symbiotic, legume-rhizobium association, carbon costs of legume-rhizobium symbiosis at low PH and in the presence of large supply of combined nitrogen, endosymbiosis, ecological effects of non symbiotic association with nitrogen fixing organisms.
3. Photosynthesis - carbon cycle and ecosystems, supply and demand of CO2 in the photosynthetic process, stomatal and boundary layer conductance, the internal conductance. Physiological and anatomical differences between sun and shade leaves, light response curve of sun and shade leaves, environmental signal for shade acclimation in chloroplasts, effect of excess irradiance, photo inhibition-protection by carotenoids of xanthophylls, chloroplast movement in response to changes in irradiation, photosynthesis under high activation of rubisco, post illumination CO2 assimilation and sunfleck utilization efficiency. effect of soil nutrient supply on

photosynthesis.

4. Respiration: Role of respiration in plant carbon balance, ecological aspect and concern of plant respiration, ATP production in isolated mitochondria and in vivo oxidative phosphorylation, regulation of electron transfer via cytochrome and alternative pathways,ecological functions of alternative pathway, heat production.
5. Ecological biochemistry: allelopathy and defense mechanism, defense against herbivores, qualitative and quantitative defense compounds, mode of mechanism forplants not being killed by their own poisons, environmental effect on the production of secondary plant metabolites, induced defense and communication between neighboring plants, chemical defense and secondary metabolites.
6. Ecosystem and biomass productivity: Biomass productivity and its variations within different ecosystem, scaling from plants to ecosystem, physiological basis of productivity, net carbon balance of ecosystems, global carbon cycle, bioenergy crops and applications, effect of different environmental factors on the biomass productivity.
7. Ecosystem global process: Ecosystem and biomass productivity, scaling from plants to ecosystem, physiological basis of productivity, net carbon balance of ecosystems, and global carbon cycle.

References

- Kvesitadze, G., Khatisashvili, G., Sadunishvili, T. and Ramsden, J.J. 2006. Biochemical Mechanisms of Detoxification in Higher Plants: Basis of Phytoremediation. Springer-Verlag.
- Lecrec, J.C. 2003.Plant Ecophysiology.Science publishers Inc.
- MadhavaRao, K.V., Raghavendra, A.S. and Janardhan Reddy, K. 2006. Physiology and Molecular Biology of Stress Tolerance in Plants. Springer.
- Orcutt, D.M. and Nilsen, E.T. 2000. Physiology of Plants under Stress: Soil and Biotic Factors. John Wiley & Sons, Inc.
- Prasad, M.N.V. 1997. Plant Ecophysiology. John Wiley & Sons, Inc.
- Prasad, M.N.V. 2004. Heavy Metal Stress in Plants: From Biomolecules to Ecosystems.IInd Ed. Springer-Verlag.
- Prasad, M.N.V. and Strzalka, K. 2002. Physiology and Biochemistry of Heavy Metal Detoxification and Tolerance in Plants.Kluwer Academic Publishers.
- Shaw, A.J. 1990. Heavy Metal Tolerance in Plants: Evolutionary Aspects. CRC Press. Chakraborty, U. and Chakraborty B. 2005. Stress Biology. Narosa Publishing House.

Web Resources

- http://globecarboncycle.unh.edu/CarbonCycleBackground.pdf
- https://lecturenotes-classroom-assignment-and-submission.s3.ap-south-1.amazonaws.com/m9xiwx-af3a5a4a3d-terrestrial-carbon-cycle.pdf
- https://www.gbv.de/dms/bs/toc/147967562.pdf
- https://www.mdpi.com/1420-3049/24/15/2737/htm
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3493419/pdf/psb-7-1306.pdf

COURSE CODE: **BOT4E10**	NAME OF THE COURSE: **Physiology of plants under stress (Theory)**	CREDITS: **4**

Course Objectives:	
The main objectives of this course are to:	
1. To know about the various abiotic and biotic stresses to which plants are exposed 2. To know about the adverse effects of various stresses on plants 3. To obtain knowledge on various strategies (morphological, anatomical, biochemical and molecular) adopted by plants to overcome the stresses 4. To know the effect of various pollutants on plant and the response of plants to tolerate it 5. To obtain a thorough knowledge on various priming techniques for stress tolerance 6. To obtain knowledge about the molecular mechanism of action during priming to impart stress tolerance	
Expected Course Outcomes	
On the successful completion of the course, students will be able to	
1. Will help to recognize various stresses and its adverse effect in plants.	**K1**
2. Will aid in understanding various strategies (morphological, anatomical, biochemical and molecular) adopted by plants to encounter stress, which will enlighten the students to solve new research problems	**K2**
3. To understand various new priming agents and techniques and its impact on various stresses	**K3**
4. To analyze the antioxidant process in plants	**K4**
5. To equip students to interact with farmers so as to solve the adverse effects of various stresses on crop plants	**K5**
6. To help the farmers to improve crop production and yield by applying various priming techniques	**K6**
K1- Remember: **K2**- Understand; **K3**- Apply; **K4**- Analyze; **K5**- Evaluate; **K6**- Create	

1. Stresses: Principal environmental stresses to which plants are subjected, plant responses to stresses. Strategies: stress escapers, avoidance, tolerance, adaptations, acclimation, and hardening.
2. Water stress: Physiological effects – Reduction of leaf area, leaf abscission abscisic acid formation and stomatal changes, photosynthesis limiting, Wax deposit on leaf surface, Energy dissipation from leaves, induction of CAM metabolism, loss of membrane integrity, Osmotic adjustments and its role in tolerance to drought. Impact of water deficit on aquaporins ion carriers channels and pumps. Induction of additional gene action. Chilling and freezing stresses: Freezing tolerance due to membrane stabilization, role of osmolytes and antifreeze protein in promoting freezing tolerance. Ice crystalformation and protoplast dehydration.
3. Heat stress and heat shock: Inhibition of photosynthesis, synthesis of heat shock protein, heat shock protein mediated thermo tolerance.
4. Salinity stress: Effect on soil structure and plant function, depression in

photosynthetic rate and growth, Effect on osmolality and resultant ion uptake. Plants strategies to avoid salt injury: ion exclusion as adaptation. Importance of sodium transport across membranes.

5. Flood and Oxygen deficiency stress: Active growth of aerobic soil microbes, damage of roots. Intolerance of plant tissue towards anoxia, acclimation to oxygen deficit involving synthesis of anaerobic stress proteins. Generation of ATP from glycolysis and fermentation, which involves changes in gene expression. Increase of ethylene production and related anatomic changes in stem: aerenchyma formation and stem elongation.
6. Environmental pollutants: Air pollution: Effect of atmospheric sulphur dioxide, carbon monoxide, peroxyl nitrate, ozone and green house gases. Oxidative damage of biomolecules by ozone, synthesis of antioxidants and antioxidant enzymes, induction of tolerance to oxidative stress. Mechanism of detoxification in different plant parts. Anthropogenic pollutants: Industrial and agricultural: Heavy metals: Metal accumulator plants, avoidance and amelioration mechanisms. Synthesis of phytochilatins: biosynthesis of glutathione, characterization. Pesticides: metabolic effect of xenobiotics, residual effect on plant metabolism.
7. Nutrient deficiency stress: Soil characteristics and mineral stress: nutrient acquisition, root modification and ion uptake, plant homoeostasis and ionic balance, ion compartmentation and PH control. Nutrient deficiencies and growth: root shoot ratio, development of lateral shoots tillers and leaves, reproduction. Improving plant nutrition deficiency, genetic potential, morphological and biochemical changes.
8. UVstress: morphological and physiological adaptation uv absorbing compound, PAL activity, xanthophyll cycle, wax deposition.
9. Priming: definition, classification of priming, mode of action, molecular mechanisam, pros and cons of priming, priming and stress tolerance.
10. Role of antioxidant enzymes in stress alleviation, phytohormonal change during stress.
11. Stress due to plant pathogen: Host parasite interaction: Growth requirements, plant pathogen in host tissue, response of host metabolism to phytopathogens. Plant defense against pathogen attack: Physical and chemical factors. Water relations, nutrient and water flow in diseased plants, nutrition and plant diseases.
12. Stress due to weeds and other competitors: Resource characteristics, intra specific and inter specific competitions; models of competitions, different theories. different theories and molecular mechanisms. Competition and other biotic influences: Mycorrhiza and herbivory.

References

- Jisha, K. C., Vijayakumari, K., & Puthur, J. T. (2013). Seed priming for abiotic stress tolerance: an overview. Acta Physiologiae Plantarum, 35(5), 1381-1396.
- Kvesitadze, G., Khatisashvili, G., Sadunishvili, T. and Ramsden, J.J. 2006. Biochemical Mechanisms of Detoxification in Higher Plants: Basis of Phytoremediation. Springer-Verlag.
- Lecrec, J.C. 2003.Plant Ecophysiology. Science publishers Inc.
- MadhavaRao, K.V., Raghavendra, A.S. and Janardhan Reddy, K. 2006. Physiology and

Molecular Biology of Stress Tolerance in Plants. Springer.
- Orcutt, D.M. and Nilsen, E.T. 2000. Physiology of Plants under Stress: Soil and Biotic Factors. John Wiley & Sons, Inc.
- Prasad, M.N.V. 1997. Plant Ecophysiology. John Wiley & Sons, Inc.
- Prasad, M.N.V. 2004. Heavy Metal Stress in Plants: From Biomolecules to Ecosystems. IInd Ed. Springer-Verlag.
- Prasad, M.N.V. and Strzalka, K. 2002. Physiology and Biochemistry of Heavy Metal Detoxification and Tolerance in Plants. Kluwer Academic Publishers.
- Shaw, A.J. 1990. Heavy Metal Tolerance in Plants: Evolutionary Aspects. CRC Press. Chakraborty, U. and Chakraborty B. 2005. Stress Biology. Narosa Publishing House.
- TT, D. T., &Puthur, J. T. (2017). UV radiation priming: A means of amplifying the inherent potential for abiotic stress tolerance in crop plants. Environmental and Experimental Botany, 138, 57-66.

Web Resources

- https://bp.ueb.cas.cz/pdfs/bpl/2017/02/01.pdf
- https://core.ac.uk/download/pdf/52476704.pdf
- https://www.bnl.gov/envsci/testgroup/pubs/pdfs/jagadish_2021.pdf
- https://www.agriculturejournals.cz/publicFiles/01024.pdf
- https://www.cell.com/the-innovation/pdf/S2666-6758(20)30017-5.pdf
- https://www.ars.usda.gov/ARSUserFiles/20360500/pdf_pubs/P2246.pdf
- https://www.iris.sssup.it/retrieve/handle/11382/514151/24988/2016%20Curr%20Op%20Pl%20Biol%20flooding.pdf
- https://www.bp.ueb.cas.cz/pdfs/bpl/2008/03/01.pdf
- http://cimfr.csircentral.net/2231/1/Chapter%202.pdf
- https://link.springer.com/content/pdf/10.1007/s40502-021-00636-7.pdf
- https://www.bhu.ac.in/research_pub/jsr61/_pdf_files/06.%20Ksharma%20Rai%20&%20SB%20Agrawal.pdf
- file:///C:/Users/hp/Downloads/MenkaSingh.pdf
- https://onlinelibrary.wiley.com/doi/epdf/10.1111/pce.13526

COURSE CODE: **BOT4E11**	NAME OF THE COURSE: **Basic Environmental Science (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. To obtain knowledge on the type, functioning and distribution of various ecosystems and their ecological contributions.
2. To have an understanding on species diversity, levels of threat and strategies for their conservation.
3. To understand the basic nature of populations, their interrelationships and methods of its assessment.

Expected Course Outcomes:

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

1	To gather information on basic principles of ecology	K1
2	To understand the functioning of diverse ecosystems with respect to various ecological principles	K2
3	Use of acquired knowledge in assessing the inter-relationship of species within heterogeneous ecosystems.	K3
4	To study the characteristics of populations and their inter relationships	K4
5	Monitor and register the biodiversity and the changes associated with them over a period of time. To develop environmental concern and practise Reduce, Reuse and Recycle.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

1. Environmental Science- Ecology- Introduction - multidisciplinary Science- Environment- Definition Scope, Application- Environmental awareness
2. Ecosystems-concept-functional and structural components-Energy flow- Biogeochemical cycles - C, N, P, H_2O and sedimentary cycles- Food chain and food web- Producers, consumers and decomposers- Ecological Pyramids- Ecological succession.
3. Ecosystem diversity- Terrestrial and aquatic Biomes- Forest, -Grassland, Desert, Tundra Marine and Fresh water (lentic and lotic) ecosystems- characteristic features, structure and function; Forest types of India, Kerala.
4. Biodiversity- species, genetic and ecosystem diversity- global, national and local levels- Value of biodiversity- Consumptive and productive use, social, ethical, aesthetic and option values- Hot spots and warm spots- Endangered and Endemic species of India.
5. Biodiversity conservation strategies; in situ and ex situ conservation-Protected areas of India, WLS, NP and Biosphere Reserves-Gene bank, seed bank, IBPGR, Cryopreservation- Biotechnology biodiversity conservation; IUCN categories, Red data book.
6. Population ecology- Population growth, Population characteristics- density- frequency, dominance, IVI, natality and mortality, fertility and fecundity; Reproductive potential, age distribution, population.

References

- Chapman, J.L. and Reiss, M.J. 1992. Ecology-Principle and Application, Cambridge University Press.
- Cunningham, W.P. and Saigo, B.W. 1999. Environmental Science (5th Edition) McGrawHill.
- Mackenzie, A. ball, A.S. and Virdee, S.R. 2002. Ecology (2nd Edition). Viva Books Ltd.
- Misra, R. 1968. Ecology workbook, Oxford & IBH Publishing Co.
- Nayar, M.P. and Sastry, A.R.K. 1987,1989,1990. Red Data Book of Indian Plants. 3 vols. Botanical Survey of India.
- Odum, E.P. 1976. Fundamentals of Ecology. W.B. Sanders Co.Puri, G. Indian Forest Ecology, Oxford Book & Stationery Co.
- Park, C. 1997. The Environment-Principles and Applications, Routledge.
- Smil, V. 1997. Cycles of Life. Civilization and Biosphere W.H. Freeman & Co.
- Smith, R.L. and Smith, T.M. 1998. Elements of Ecology (4th Edition). The Benjamin Cummings Publishing Co.

COURSE CODE: **BOT4E12**	NAME OF THE COURSE: **Applied Environmental Science (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. To obtain knowledge on the type of natural resources.
2. To have an understanding on the quantitative and qualitative (pollution) issues associated with natural resources.
3. To develop knowledge on various management measures to control depletion of natural resources.
4. To have an understanding on various national and international treaties and organizations in resources conservation and their mode of action.

Expected Course Outcomes:

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

1	To gather information on various natural resources and the issues faced by them.	K1
2	To understand the ways and means of controlling the quantitative and qualitative (pollution) depletion of natural resources	K2
3	Use of acquired knowledge in assessing the need for appropriate technologies in pollution control and resource recovery	K3
4	To gather information on the causes and consequences of various environmental issues / disasters, citing reasons.	K4
5	To study the role of national and international organizations in natural resources management.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate

1. Natural Resources and associated problems; Forests of World/India/Kerala; water resources; Mineral resources; Food resources; Energy sources; Land resources
2. Environmental pollution-definition, causes, effects and control, measures of
   a) air pollution b) water pollution c) land pollution
   d) marine pollution e) noise pollution f) thermal pollution
   g) Nuclear (Radioactive) pollution; Case studies; Minamata, Love Canal, Bhopal tragedy, Chernobyl, Tsunami 3.
3. Solid waste management- urban and industrial wastes; Role of individual- prevention of pollution.
4. Disaster management.
5. Environmental Impact Assessment (EIA)
6. Bioremediation, Bio flocculation
7. Society and Environment- sustainable development –concept.
8. Gia hypothesis- Water conservation- rain water harvesting- water shed management
9. Climatic change- global warming, ozone depletion. Green house effect, Glaciation
10. Environment Protection Act- Air (Pollution and control) Act- Water (Pollution and control) Act- Earth summit (UNCED) Rio+5, Rio+10
11. (Ramsar conservation, Ramsar sites of India- Kyoto agreement.
12. IPH and Patents.
13. NGOs and conservation movements.

References

- Chapman, J.L. and Reiss, M.J. 1992. Ecology-Principle and Application, Cambridge University Press.
- Cunningham, W.P. and Saigo, B.W. 1999. Environmental Science (5th Edition) McGraw Hill.
- Mackenzie, A. ball, A.S. and Virdee, S.R. 2002. Ecology (2nd Edition). Viva Books Ltd.
- Misra, R. 1968. Ecology workbook, Oxford & IBH Publishing Co.
- Nayar, M.P. and Sastry, A.R.K. 1987,1989,1990. Red Data Book of Indian Plants. 3 vols. Botanical Survey of India.
- Odum, E.P. 1976. Fundamentals of Ecology, W.B. Sanders Co.Puri, G. Indian Forest Ecology, Oxford Book & Stationery Co.
- Park, C. 1997. The Environment-Principles and Applications, Routledge.
- Smil, V. 1997. Cycles of Life. Civilization and Biosphere W.H. Freeman & Co
- Smith, R.L. and Smith, T.M. 1998. Elements of Ecology (4th Edition). The Benjamin Cummings Publishing Co.

COURSE CODE: **BOT4E13**	NAME OF THE COURSE: **Principles of Ethnobotany (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. To make an understanding on the importance of traditional scientific knowledge
2. To gain knowledge from the traditional society for the sustainable development.
3. To develop knowledge on various management measures to conserve the tribes and tribal medicines.
4. To make the students to scientifically validate the traditional values and preserve it for future.

Expected Course Outcomes:

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

1	The student shall acquire knowledge of traditional scientific knowledge	K1
2	They will get a strong idea about the traditional societies and the sustainable development	K2
3	They also get a clear idea about the measures to conserve the tribes and tribal medicines.	K3
4	Provides deep insights for scientifically validating the traditional values and preserve it for future.	K4
5	Will help to create measure for the upliftment of the tribal people.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. Ethnobotany: Definitions.
2. Scope and functions.
3. History and development of Ethnobotany: Development of Ethnobotany in Asia with special reference to that in India, Ethnobotany outside Asia.
4. Traditional Scientific knowledge: Indigenous technical knowledge (ITK): Indigenous Agricultural knowledge (IAK), Traditional ecological knowledge (TEK), Rural people's knowledge (RPK), Traditional botanical knowledge (TBK), Integrated knowledge system(IKS).
5. Documentation and interpretation of Traditional Botanical Knowledge: Basic approaches to the study of Traditional Botanical Knowledge - Utilitarian, Cognitive, and Ecological.
6. Scientific validation of traditional plant use: Nutritional quality, Pharmacological properties. Insect repellent activity.
7. Ecology of Culture and Cultural Ecology: Functional interpretations of culturally determined behaviour - Human sacrifice. Male supremacy. Pollution taboos, In-law avoidance. Evil spirit homes. Sacred groves. Drug preparation.
8. Collecting Ethnobotanical Evidence: The dynamics and distribution of traditional botanical knowledge.
9. Sources of knowledge: The dissemination of traditional botanical knowledge, differential distribution of traditional botanical knowledge: Socio-cultural influence on knowledge distribution - Intercultural influences (Mode of production. Biological environment. Level of external contact (acculturation), Ethnicity, Religion), Intracultural

influences - Gender, Age, Class, Place of birth, Literacy, Occupation, Migration for work or marriage. Age at marriage. Kinship and marriage relations. Number of children, Number of generations in the household. Language ability.

10. Dynamics of Knowledge: Observation, Experimentation and Adaptation.
11. Traditional Botanical Knowledge in Rural Development: The origins of participatory research. Partnership in practice.
12. Ethnobotany and sustainable utilization of plant resources.
13. Protection of Traditional Botanical Knowledge.
14. Major subdisciplines of Ethnobotany.
15. Major tribes of Kerala and their dependence on plants.

References

- Chaudhuri, Rai, H. N., Guha, A., Roychowdhury, E. & Pal, D. C. 1980. Ethnobotanical uses of Herbaria-II. J. Econ. Tax. Bot. 1:163-168.
- Chaudhuri, Rai, H. N., Banerjee, D. K. & Guha, A. 1977. Ethnobotanical uses of herbaria. Bull. Bot. Surv. India19:256-261.
- Faulks, P.J. 1958. An Introduction to Ethnobotany. Moredale Publications Ltd., London.
- Ford, R. I.(Ed.). 1978. The Nature and Status of Ethnobotany. Anthropological Paper no.67. Museum of Anthrop., Univ. of Michigan.
- Harshberger, J. W. 1896. The Purpose of Ethnobotany. Bot. Gazette 31 : 146-154.
- Jain, S. K. & Rao, R. R. 1983. Ethnobotany in India-An Overview. Botanical Survey of India.
- Jain, S. K. (Ed.). 1981. Glimpses of Indian Ethnobotany. Oxford & IBH Publishing Co. Jain, S. K. 1964. The role of a Botanist in folklore Research. Folklore 5:145-150
- Jain, S. K. 1967a. Ethnobotany – Its scope and study. Indian Museum Bull. 2:39-43.
- Jain, S. K. 1995. A Manual of Ethnobotany. Scientific Publishers.
- Jain, S. K., Mudgal, V., Banerjee, D. K., Guha, A., Pal, D. C. & Das, D.1984. Bibliography of Ethnobotany. Botanical Survey of India.
- Ranfrew, Jane. 1973. Paleoethnobotany. Columbia University Press.

COURSE CODE: **BOT4E14**	NAME OF THE COURSE: **Applied Ethnobotany (Theory)**	CREDITS: **4**

Course Objectives:		
The main objectives of this course are to: 1. To make an understanding on the methods in ethnobotanical study 2. To gain knowledge about ethnobotanical methods. 3. To develop knowledge on archaeobotanical data 4. To make the students to aware of ppractical applications of Ethnobotanical data		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	The student shall acquire knowledge of methods in ethnobotanical study.	K1
2	They will get a strong idea about the ethnobotanical methods.	K2
3	They also get a clear idea about the archaeobotanical data	K3
4	Provides deep insights for plant collection and taxonomy studies.	K4
5	Will help to document and analyze ethnobotanical data.	K5
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create		

1. Methods in ethnobotanical study: General ethnobotanical techniques- Anthropological field methods. Quantitative approach (Open-ended and semi-structured interviews, 'Hands on' learning of traditional techniques) and Qualitative approach (Structured interviews and questionnaires, Free-listing, Pile sorting and preference ranking: triadic and paired, Systematic surveys -e.g., of transects or hectare plots); Quantification and verification: Free-listing, Preference ranking. Direct matrix ranking. Utilization surveys.
2. Interview techniques and elicitation methods: Choosing participants. Linguistic and other symbolic analyses - Symbolic and Empirical analysis of Myths and Folklore; Plant labels and cultural significance.
3. Plant collection and taxonomy: Nature and uses of voucher specimens, Plantidentification. Classification.
4. Archaeobotanical data: Observation of archaeobotanical remains and collection of data. Evidences from specialized archaeological contexts. Dating methods and data presentation
5. Specialist ethnobotanical methods: Nature and applications of specialist methods - Languages and linguistics. Art, history, Agricultural science. Ecology, Phytochemistry, Pharmacognosy, Molecular biology, Applied anthropology, Environmental economics. Ethical analysis and law. Communication and education. Information systems.
6. Practical applications of Ethnobotanical data: External benefits - National and Global interests in ethnobotany: Ethno-directed sampling in Biodiversity Prospecting: Plant derived drugs used in orthodox medical practice; Traditional Plant management and Environmental conservation; Traditional germplasm management : in situ and ex situ conservation; Local benefits: Cultural survival and community development: Ethnomedicine and Primary health care; Renewable plant products: Sustainable source ofincome; Protecting local resources.

7. Commercialization and conservation: Sustainable development - Economic growth andresource conservation.
8. Documentation and analysis of ethnobotanical data.

References

- Chaudhuri, Rai, H. N., Guha, A., Roychowdhury, E. & Pal, D. C. 1980. Ethnobotanical uses of Herbaria-II. J. Econ. Tax. Bot. 1:163-168.
- Chaudhuri, Rai, H. N., Banerjee, D. K. & Guha, A. 1977. Ethnobotanical uses ofherbaria. Bull. Bot.Surv. India19:256-261.
- Faulks, P.J. 1958. An Introduction to Ethnobotany. Moredale Publications Ltd., London.
- Ford, R. I.(Ed.). 1978. The Nature and Status of Ethnobotany. Anthropological Paper no.67. Museum of Anthrop., Univ. of Michigan.
- Harshberger, J. W. 1896. The Purpose of Ethnobotany. Bot. Gazette 31 : 146-154.
- Jain, S. K. & Rao, R. R. 1983. Ethnobotany in India-An Overview. Botanical Survey of India.
- Jain, S. K. (Ed.). 1981. Glimpses of Indian Ethnobotany. Oxford & IBH Publishing Co.
- Jain, S. K. 1964. The role of a Botanist in folklore Research. Folklore 5:145-150 Jain, S. K. 1967a. Ethnobotany – Its scope and study. Indian Museum Bull. 2:39-43.Jain, S. K. 1995. A Manual of Ethnobotany. Scientific Publishers.
- Jain, S. K., Mudgal, V., Banerjee, D. K., Guha, A., Pal, D. C. & Das, D.1984.Bibliography of Ethnobotany. Botanical Survey of India.
- Ranfrew, Jane. 1973. Paleoethnobotany. Columbia University Press.

COURSE CODE: **BOT4E15**	NAME OF THE COURSE: **Plant Tissue Culture (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. Understand the basic methods used in plant tissue culture
2. Develop and utilize various modes of adventitious regeneration for developing complete plants
3. Understand the methods used for developing haploids, diploids and protoplast isolation
4. Possibilities of developing secondary metabolites from the *in vitro* cultures

Expected Course Outcomes:

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

1	To understand the basic concepts of plant tissue culture	K1
2	Understand how secondary metabolites are produced in plants and the pathways can be manipulated to produce using various methods	K2
3	Apply the technique of micropropagation such as somatic embryogenesis, organogenesis and protoplast culture for ex situ conservation and mass multiplication of endangered and economically important plants	K3
4	Analyze and relate morphological, physiological and somaclonal variations for crop improvement	K4
5	Use these technique to mass propagate the plants for agriculture and afforestation programs	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

1. Plant cell and tissue culture: introduction, history, scope.
2. Basic aspects of plant tissue culture; totipotency, morphogenesis, differentiation and polarity; different culture media; components; growth
3. regulators; growth retardants; undefined supplements; explants; sterilization; Inoculation; subculturing, etc.
4. Different types of cultures: callus- different types; cell culture; suspension culture- different types; culture methods of single cells; testing of viability of cells; application of cell and callus culture with special reference to medicinal and aromatic plants. *In vitro* morphogenesis; differentiation.
5. Organogenesis- different types; factors effecting; problems related to micropropagationof woody (Medicinal) plants. Different stages of micropropagation, Somaclonal variation and its importance with special reference to medicinal and aromatic plants.
6. Somatic embryogenesis: direct and indirect; Factors effecting; embryo maturation; application. Synseeds and its significance.
7. Production of Pathogen free plants: Different methods; Meristem culture and its importance in commercialization especially of Medicinal and Aromatic plants.
8. Protoplast: Isolation and culture methods; Factors effecting; Somatic hybridization: Different types; Fusion methods. Application with special reference to Medicinal and Aromatic plants.
9. Haploids: Different types: Androgenesis and gynogenesis, Advantages; Significance in crop improvement with special emphasis on Medicinal and Aromatic plants.

10. Ovary, ovule, endosperm and embryo culture; importance. *In vitro* fertilization (recent advances) and its significance.
11. Secondary metabolites: Different classes; methods of production- factors effecting yield. Biotransformation; Different types with examples. Immobilization: Different approaches: Advantages.
12. Tissue culture in India with special reference to Kerala. Exploitation of medicinalplants of Kerala by Tissue culture.
13. Application of Plant Tissue Culture: Clonal propagation, artificial seed production of hybrids and somaclones, drugs, products, cryopreservation and germplasm storage.

References

- Bhojwani, S. S. and Razdan, M. K. 1983. Plant Tissue culture: Theory and Practice. Elsevier.
- De, K. K. 1995. Plant Tissue Culture. New Central Book Agency.
- Doods, J. H. and Roberts, L. W. 1985. Experiments in Plant Tissue culture, Cambridge University Press.
- George, E. F. 1993-96. Plant propagation by Tissue culture-2 vols. Exegetics Ltd.
- Narayanaswamy, S. 1994. Plant cell and Tissue culture. Tata McGraw Hill Ltd.
- Razdan, M. K. 1995. An Introduction to Plant Tissue Culture. Oxford & IBH Publishing Co. Pvt. Ltd.

COURSE CODE: **BOT4E16**	NAME OF THE COURSE: **Plant Biotechnology (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. Understand the molecular basis of gene expression and protein coding
2. Understand the mechanism of heterologous gene expression by using various agents
3. Understand the methods used for developing environment adaptive quality plants
4. Understand the environmental risks due to transgenic technology

Expected Course Outcomes:

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

1	To understand the basic concepts of heterologous gene transfer	K1
2	Understand the mechanism of different types of gene construction and development of transgenic plants for human welfare	K2
3	Apply the technique of transgenics for developing important products like growth factors, hormones etc. in plants	K3
4	Analyze the pros and cons of transgenic technology with reference to the new products released for human consumption	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

1. Plant gene structure and expression; Regulation of structure and expression, Regulation of plant gene expression, Protein coding genes, Translational control, RNA- coding genes.
2. Gene Transfer to plants; Target plant cells for transformation, Transformation approaches, *Agrobacterium*-mediated genetic transformation of plants, Molecular mechanism of T-DNA transfer, Vector based the Ti plasmid, Protocol for *Agrobacterium*-mediated genetic transformation of plants.
3. Direct genetic transformation of DNA into protoplasts; Biolistic process (particle Bombardment mediated), Transformation of protoplast by electroporation, microinjection, macroinjection and microprojectiles; Virus vectors for gene transfer to plants
4. Crop improvement through gene transfer technology; Projectiles of transformed plants;Plant variety improvement: addition of useful trait; Genetic mapping and gene cloning.
5. Developing resistance in crops; Herbicide resistance, Insect resistance, Virus resistance, Fungal pathogen resistance, Bacteria resistance, Nematode resistance, Parasiteresistance.
6. Improvement of crop quality; Nutritional quality, Post-harvest quality, Extension of flower life, Pigmentation, Fragrance; Male sterility for hybrid seed production.
7. Engineering the plant cell factory for secondary metabolite production; Oligopeptides and proteins, sugar polymers, alkaloids and phenolics, degradable polymers-.
8. Uses and applications of transgenic plants; New products, Pharmaceuticals, Bioremediation, Plant quality and protection, Edible vaccines, Antiviral proteins (PAP), Antigens antibodies
9. Bio risks of producing transgenic plant; Bio-safety and product labeling, Trade

secrecy and material transfer agreements patenting of plant varieties.

10. Environmental Biotechnology: Cleaner technologies- Fermentation, Paper and Plastic industries. Bioremediation. Bio flocculation. Biosensors. Biochips. Biofertilizers- significance. Biological Nitrogen Fixation- nif genes- structure, transfer prospects. Nitrogenase biochemistry, function.

References

- Chawla HS. Laboratory manual for Plant Biotechnology. Oxford WH Freeman & Co.
- Jha TB & Ghosh B. Plant Tissue Culture: Basic and Applied. Universities Press (India) P. Ltd.
- Karanth B. Selected Readings in Plant Genetics and Biotechnology. Book Enclave.
- Philipose PM. Experimental Biotechnology. Dominant Publishers & Distributors.
- Purohit SS. Biotechnology: Fundamentals and application. Agrobios.
- Razdan MK. Introduction to Plant Tissue culture. Oxford and IBH Publishing Co. Pvt.
- Sambrook J & Russel DW. Molecular Cloning. Cold Springer Harbor Lab Press.
- Slater A, Scott N, Fowler M. Plant Biotechnology: The Genetic manipulation of Plants. Oxford University Press.
- Smith RH. Plant Tissue Culture: Techniques and Experiments. Academic Press.
- Sudhir M. Plant Biotechnology. Dominant Publishers & Distributors.

COURSE CODE: **BOT4E17**	NAME OF THE COURSE: **Basic Pteridology (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are:

1. Make the students acquire skills in identification of the Pteridophytes of the various habitats of Kerala, and Southern India.
2. Make them aware of the extent of diversity of this unique plant group in the world.
3. Make them aware of the contribution by major Pteridologists of India
4. Make them equipped to plan and execute further studies on applied and utilitarian aspects of this group.
5. Impart concrete concepts on the ecological role played by this group in the local and global habitats.
6. Impart concrete concepts on the significance of this group in understanding the evolutionary trend among the plants.

Expected Course Outcomes:

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

1	The student shall acquire skills in identification of the Pteridophytes of Kerala, and Southern India at large.	K1
2	They will get a strong idea about the diversity of this unique plant group in Southern India, and other parts of the world.	K2
3	They will get a strong foundation on the works done by major pteridologists of India.	K3
4	They also get a clear idea of the progress of Pteridological studies in India and elsewhere. It would be helpful for them in planning future lines of action in utilising this plant group.	K4
5	It provides a strong foundation in the basic biology of this group, which is essential in understanding the major concepts of biology, especially evolution	K5
6	Can create strategies for conserving them.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

1. Origin and Phylogeny of Pteridophytes; Homologous theory, antithetic theory, Phyton concept, Telome theory.
2. Life Cycle of Pteridophytes-alternation of generations; apogamy, apospory, agamospory and parthenogenesis.
3. Morphological diversity-Rhizome, leaf, sporophylls (heterophylly) - soral evolution-phyletic slide, sporangial evolution-phyletic swing-primitive and advanced morphological characters.
4. Anatomy- stele, structure, stelar evolution, protostele, siphonostele, solenostele, Dictyostele. Special types of steles-Dictyoxylic (*Osmunda*), Dicyclic (*Pteridium*)-Dicyclic siphonostele (*Matonia*) Tricyclic dictyostele (*Stenochlena*) anchor-shaped stele (*Isoetes*)_ Amphiphloic-siphonostele (*Marsilea*)- Dictyostele with accessory bundles (*Cyathea*). Leaf trace-secondary thickening-vessels.

5. Spore morphology-Trilete and Tetrahedral spores-structure-ornamentation-heterosporyand seed habit, spore germination- *in vitro* spore culture.
6. Gametophyte-patterns of development-homosporous and heterosporous ferns-fern allies-Morphology of mature gametophyte-ultrastructure-photoperiodism.

References

- Bierhost, D.W. 1971. Morphology of Vascular Plants. Macmillan Co.
- Dyer, A.C. 1979. The experimental Biology of Ferns. Academic Press, London
- Hameed, C.A., Rajesh, K.P. and Madhusoodanan, P.V. 2003. Filmy Ferns of South India.Penta Book Publishers & Distributors.
- Jermy, A.C. et al. (Ed.) 1973. The Phylogeny and Classification of Ferns. Academic Press.
- Kramer, K.U. & Green, P.S. 1991. The families and genera of Vascular Plants, Narosa.
- Nampy, S. and Madhusoodanan, P.V. 1998. Fern Flora of South India-Taxonomic Revision of Polypodioid Ferns. Daya Publishing House.

COURSE CODE: **BOT4E18**	NAME OF THE COURSE: **Applied Pteridology (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are:

1. Make the students acquire skills in identification of the Pteridophytes of the various habitats of Kerala, and South India.
2. Make them aware about the conservation of pteridophytes
3. Impart concrete concepts on the ecological role played by this group in the local and global habitats
4. To make the students to scientifically validate the traditional values and preserve it for future.

Expected Course Outcomes:

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

1	The student shall acquire skills in identification of the Pteridophytes	K1
2	They will get a strong idea about the diversity of this unique plant group and the need for conservation.	K2
3	They will get a strong foundation on the ecological role played by this group in the local and global habitats.	K3
4	They will come to know about important pteridologists in India	K4
5	It provides information on applied pteridology in horticulture, Food, Medicinal, Biofertilizers, Weeds (aquaticand terrestrial), Ecological Indicators, Pollution amelioration	K5
6	Can create strategies for conserving them.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. Habitat ecology-Hydrophytes, Halophytes, Rheophytes, Epiphytes, Xerophytes, Sciophytes, Climbers, Filmy Ferns, Tree Ferns, Saprophytes – Adaptation of Pteridophytes-RET Pteridophytes, Conservation.
2. Cytology of pteridophytes-polyploidy and high chromosome number-origin of polyploids cytology and reproduction.
3. Fossil pteridophytes-Psilophytales, Lepidodendrales, Calamitales, Sphenophyllales, Primofilicales-Fossil Marattiales and Osmundales. Evolution of plant body-Indian fossil Pteridophytes.
4. Classification of pteridophytes by Foster and Glifford, Holttum, Pichi Sermolli, B.K. Nayar, and Kubitzki. Brief account of recent developments in molecular phylogenetics and DNA barcoding in pteridophytes.
5. General characters of extant pteridophytes.
6. Psilopsida – Psilotales.
7. Lycopsida – Lycopodiales, selaginellales, Isoetales
8. Sphenopsida – Equisetales
9. Filicopsida – Ophioglossales, Marattiales, Osmundales, Schizaeales, Cyatheales, Gleicheniales, Marsileales, Salviniales

10. Contribution by Indian Pteridologists – S.S. Bir, B. K. Nayar, Fr. V.S. Manickam, and A. Abraham.
11. Applied Pteridology – horticulture – Food – Medicinal – Biofertilizer – Weeds (aquatic and terrestrial) – Ecological Indicators – Pollution amelioration.
12. Molecular Taxonomy – Methodology, application

References

- Bierhost, D.W. 1971. Morphology of Vascular Plants. Macmillan Co.
- Dyer, A.C. 1979. The experimental Biology of Ferns. Academic Press, London
- Hameed, C.A., Rajesh, K.P. and Madhusoodanan, P.V. 2003. Filmy Ferns of South India. Penta Book Publishers & Distributors.
- Jermy, A.C. et al. (Ed.) 1973. The Phylogeny and Classification of Ferns. AcademicPress.
- Kramer, K.U. & Green, P.S. 1991. The families and genera of Vascular Plants, Narosa.
- Nampy, S. and Madhusoodanan, P.V. 1998. Fern Flora of South India-Taxonomic Revision of Polypodioid Ferns. Daya Publishing House.

COURSE CODE: **BOT4E19**	NAME OF THE COURSE: **Biology & Taxonomy of Algae and Cyanobacteria (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. The objective of this elective paper is to enable the students to gain basic knowledge about lower groups of plants.
2. The program envisages to apply knowledge about prokaryotic and eukaryotic cellular processes, interaction of microorganisms among themselves, with physical and chemical agents and higher order organisms in environment and biological systems to various conditions.
3. Laboratory training is also included so that the students will acquire the skills to about identification and processing which will help in their higher studies such as in research, industry, consultancy, education and public administration.
4. The basic information gained from this elective paper can be utilized by the students to address broad range of fields including biotechnology, microbiology, microbial genetics, molecular biology and systems biology.

Expected Course Outcomes:

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

1	Understand research ethics so as to contribute to the advancement and impartment of knowledge in the field of microbiology and algology. The laboratory training will empower them to prepare for careers in broad range of fields.	K1
2	Can compete in national level competitive exams such as NET-JRF or GATE and can pursue career in higher studies.	K2
3	Develop ability to independently carry out a complete scientific work process, including the understanding of theoretical background, hypothesis generation, collection and analysis of data, and interpretation and presentation of results	K3
4	Will be able to evaluate and apply relevant theory, methods and analytic approaches within the fields coming under this paper.	K4
5	Will attain high competence and multidisciplinary project experience within selected topics related to microbiology and algology and that will also acquire ability to contribute in a multidisciplinary research team.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate

1. Diversity of algae.
2. Brief account of recent developments in molecular phylogenetics and DNA barcoding of algae.
3. Algal habitats –distribution, symbiosis and parasitism. Algae as ecological indicators.
4. Algal literature; Monographs; Revisions; Floras, *etc*.
5. Describing, illustrating, naming and publishing algal taxa.
6. Reproduction and evolution of algae – Chlorophyceae, Phaeophyceae and Rhodophyceae.
7. General account on structure, reproduction and relationships of Dinophyta, Chrysophyta and Bacillariophyta and Rhodophyta
8. Cyanobacteria: pioneers of planet earth-Role in oxygenation of the primitive earth's atmosphere.

9. Classification of Cyanobacteria according to Komereck et al. 2014 and NCBI Taxonomic browser.
10. Contributions of Indian cyanobacteriologists
11. Diversity of cyanobacteria
12. Morphology of cyanobacteria.
13. Preservation of cyanobacteria- freezing, freeze drying
14. General account on the structure, heterocyst, akinete, pigments, reproduction photosynthesis, respiration and relationships of cyanobacteria.

References

- Anand, N. 1989. Hand book of blue –green algae. Bishen Singh and Mahendrapal Singh, Dehradun.
- Arun K. Sharma. 2002.Biofertilizers for sustainable agriculture. Agrobios Publishers
- Ashwani.K. Rai.1997. Cyanobacterial nitrogen metabolism and environmental biotechnology. Narosa publishing house.
- Chapman, V. J. & Chapman, D. J. 1973. The Algae. Macmillan publications
- Chapman, V.J. 1941. An introduction to the Study of Algae. Cambridge University Press.
- Desikachary, T.V. 1959. Cyanophyta. Indian Council of Agricultural Research.
- Fritsch, F.E. 1961. The structure and reproduction of Algae. Vol. 2. Cambridge University Press.
- Irvine, D.E. & D.M. John. 1984. Systematics of the green algae. Academic Press.
- Jan Stevensen et al. 1996. Algal ecology. Fresh water Benthic ecosystems. Academic Press.
- Krishnamurthy, V. 1998. Algae of India and neighboring countries. 1. Chlorophycota. Oxford & IBH publishing Co. Pvt. Ltd.
- Kumar, H.D. 1990. Introductory phycology. East West Press Pvt. Ltd.
- Prescott, G.W. 1969. The Algae, A Review. Thomas Nelson and Sons Ltd
- Round, F. E. 1975. The Biology of Algae. Edward Arnold.
- Sandhu, S.S.2013. Biofertilizer technology. Black print publishers, New Delhi.
- Sivakumar P.K., Joe, M.M., Sukesh, K. 2010. An introduction to Industrial microbiology. S. Chand and co.
- Smith, G.M. 1978. Manual of Phycology. The Ronald Press company.
- Subramanian, G., Kaushik, B.D., Venkataraman, G.S. 1996. Cyanobacterial biotechnology. Oxford and IBH publ. co.
- Trainor, F.R. 1978. Introductory Phycology. John Wiley and Sons.
- Van Den Hock, D.G. Mann and Jahus, H.M. Algae: An introduction to Phycology. Cambridge University press.
- Venkataraman, G. S., Goyal, S. K., Kaushik, B.D. & Roychaudhary, P. 1974. Algae, form and function. Today and Tomorrow's Printers &Publishers.
- Venkataraman, G.S. 1972. Algal Biofertilizers and rice cultivation. Today and Tomorrow's Printers & Publishers.

COURSE CODE: **BOT4E20**	NAME OF THE COURSE: **Applied Aspects of Algae and Cyanobacteria (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. The objective of this elective paper is to enable the students to gain technical skills at an advanced level.
2. This programme helps to study the importance as biofertilizers and other modern aspects about these microorganism
3. Laboratory training is also included so that the students will acquire the skills and to implement their knowledge in research and industry.

Expected Course Outcomes:

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

1	Understand research ethics so as to contribute to application, advancement and impartment of knowledge in the field of microbiology and algology The laboratory training will empower them to prepare for careers in broad range of fields.	K1
2	Can compete in national level competitive exams such as NET-JRF or GATE and can pursue career in higher studies.	K2
3	Develop ability to independently carry out a complete scientific work process, including the understanding of theoretical background, hypothesis generation, collection and analysis of data, and interpretation and presentation of results	K3
4	Will be able to evaluate and apply relevant theory, methods and analytic approaches within the fields coming under this paper.	K4
5	Will attain high competence and multidisciplinary project experience within selected topics related to microbiology and algology and will also acquire ability to contribute in a multidisciplinary research team.	K5

K1 - Remember; **K2** - Undestand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

1. Collection, identification and preservation of different groups of algae. Indian work on algae.
2. Laboratory culture and staining of algae.
3. Methods of commercial cultivation of algae.
4. Economic importance of algae: fodder and fertilizer, phycocolloids, energy and chemicals, H_2 production, sewage disposal, toxicity, eutrophication
5. Media for cyanobacterial culture (BG-11 medium, Allen and Arnon'smedium)
6. Cyanobacterial biofertilizer for problem soils, Reclamation of wastelands
7. Cyanobacterial biofertilizer technology: Nitrogen fixing cyanobacteria and their nitrogen fixation potential, Production and application of cyanobacterial biofertilizer for rice crop, Production technology for commercial purposes- Trough method and Pit method, Factors affecting cyanobacterial growth (light intensity, temperature, soil pH, soil quantity, competitiveness of strains), bioactive compounds from cyanobacteria, Quality criteria for cyanobacterial inoculants, Inoculum carriers, Recommendations for field applications, Packing and storage of biofertilizer.

8. Applications of Cyanobacteria: Biofertilizer, feed, industrial applications, food supplement, biofuel, pharmaceuticals, pigments, cosmetics, bioactive molecules, antioxidants, lipids, fine chemicals, H_2 production, bioremediation, biodegradation, toxicity, eutrophication and blooms.
9. Engineered Cyanobacteria: Applications- Protein products, chemical products, challenges and promises of engineered cyanobacteria.
10. Physiology, biochemistry and genetics of nitrogen fixation by cyanobacteria.
11. Cyanobacterial associations with fungi (lichens), bryophytes, pteridophytes (*Azolla*), gymnosperms (Cycads), angiosperms (*Gunnera*).

References

- Chapman, V. J. & Chapman, D. J. 1973. The Algae. Macmillan publications
- Chapman, V.J. 1941. An introduction to the Study of Algae. Cambridge University Press.
- Desikachary, T.V. 1959. Cyanophyta. Indian Council of Agricultural Research.
- Fritsch, F.E. 1961. The structure and reproduction of Algae. Vol. 2. Cambridge University Press.
- Irvine, D.E. & D.M. John. 1984. Systematics of the green algae. Academic Press.
- Jan Stevensen et al. 1996. Algal ecology. Fresh water Benthic ecosystems. Academic Press.
- Krishnamurthy, V. 1998. Algae of India and neighboring countries. 1. Chlorophycota. Oxford & IBH publishing Co. Pvt. Ltd.
- Kumar, H.D. 1990. Introductory phycology. East West Press Pvt. Ltd.
- Prescott, G.W. 1969. The Algae, A Review. Thomas Nelson and Sons Ltd
- Round, F. E. 1975. The Biology of Algae. Edward Arnold.
- Venkataraman, G. S., Goyal, S. K., Kaushik, B.D. & Roychaudhary, P. 1974. Algae, form and function. Today and Tomorrow's Printers &Publishers.
- Venkataraman, G.S. 1972. Algal Biofertilizers and rice cultivation. Today and Tomorrow's Printers & Publishers.

COURSE CODE: **BOT4E21**	NAME OF THE COURSE: **Genetics and Crop Improvement I (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are:

1. To understand the floral biology and breeding methods for different crops.
2. To obtain comprehensive knowledge on genetic resources of crop plants for conducting plant breeding experiments and to understand the roles of National and International institutes in crop improvement efforts.
3. Comprehend the crop management strategies of various crops of commercial significance

Expected Course Outcomes:

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

1	Remember the Headquarters and regional stations of various National and International crop improvement Institutions.	K1
2	Understand different types of mating systems in plants	K2
3	Students will become well versed in practical emasculation and pollination methods of different crops.	K3
4	Analyze the problems and difficulties associated with crop improvement in specific crops.	K4
5	Evaluate the superior traits of economic significance among different accessions of a particular crop	K5
6	Create genetic diversity in horticultural and commercial crops of significance by employing specific and appropriate breeding techniques	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

1. General account of origin, variability, floral biology, propagation, breeding techniques and crop management in the case of the following crops.
   a.rice; b. wheat; c. maize; d. jowar; e. tea; f. coffee; g. rubber; h. cardamom; i. coconut; j. arecanut; k. oil palm; l. cocoa; m. cashew; n. pepper; o. ginger; p. turmeric; q. vanilla.
2. Detailed account of crop research institutes under CGIAR, ICAR and Commodity Boards ; Crop research institutes in Kerala and their mandate
3. Thrust areas of crop research and major bottlenecks in R & D activities in the case of the above crops.

References

- Allard R.W. - Principles of Plant Breeding. John Wiley & Sons.
- Chahal G.S. and Gosal S.S. Principles and Procedures of Plant Breeding. Narosa Publishing House.
- Dabholkar A.R. Elements of Biometrical Genetics. Concept Publishing Company.
- Frankel O.H. and Bennet E. Genetic Resources in Plants. Black Well.
- Gupta S.K. Plant Breeding. Agrobios India. Khan M.A. Plant Breeding. Biotech Books.
- Hayward M.D., Bosemark N.O. and Romagosa I. Plant Breeding- Principles and prospects. Chapman and Hall.

- Jain H.K. and Kharkwal M.C. Plant Breeding. Narosa Publishing House.
- Jasra P.K. Biostatistics. Krishna Prakashan Media (P) Ltd.
- Mohanan K.V. Essentials of Plant Breeding. PHI Learning Private Limited, New Delhi.
- Mohanan K.V. Essentials of Plantation Science. Penta Books, Calicut. Radhakrishnan V.V., Hrideek T.K., Raghu A.V. and Chandramohanan K.T. Crops ofKerala - An overview. Gregor Mendel Foundation, Calicut University, Kerala.
- Pagano M. and Gauvreau K. Principles of Biostatistics. Duxbury.
- Panse V.G. and Sukhatme, P.V. Statistical methods for Agricultural Workers. ICAR.
- Rangaswamy R. A Text Book of Agricultural Statistics. New Age International Publishers.
- Roy D. Plant Breeding. Narosa Publishing House.
- Sadhu M.K. Plant Propagation. New Age International Publishers.
- Sharma J.R. Plant Breeding. Tata-McGraw Hill.Joshi R.M. Biosafety and Bioethics. Isha Books.
- Sharma J.R. Statistical and biometrical techniques in Plant Breeding. New Age International Publishers.

COURSE CODE: **BOT4E22**	NAME OF THE COURSE: **Genetics and Crop Improvement II (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course include:

1. Attainment of comprehensive knowledge on the significance and utilization of plant genetic resources
2. Critical understanding of IPRs in crop breeding.
3. Understanding the traditional and modern methods of crop improvement.

Expected Course Outcomes:

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

1	Understand the Centres of origin & diversity for major crop plants	K1
2	Comprehend the advantages of different measures of conservation for crop genetic diversity; Understand the procedures for seed production and certification	K2
3	Compare and assess the conventional and modern methods of crop breeding techniques	K3
4	Assess the crop genetic diversity employing various tools	K4
5	Critically evaluate the different omics approaches in crop improvement programmes	K5
6	Integrate the different breeding approaches in a sustainable manner for the improvement of major crops	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

1. **Crop genetic resources**- conservation and utilization. Centres of origin of cultivated plants- primary and secondary centres of diversity. Gene banks- international and national networks of gene banks.
2. **PGR** - classification, role in crop improvement, characterization and evaluation, Impact of climate change on PGR
3. **Molecular characterization of PGR** – DNA markers in PGR characterization, Molecular Data analysis
4. **Crop genetic diversity assessment**- morphological, biochemical, molecular markers; Analysis of genetic diversity - analysis of genetic relationships among samples
5. Systems of reproduction and mating systems in crop plants
6. Conventional methods of plant breeding- plant domestication, introduction, selection and hybridization.
7. Modern methods of plant breeding- Mutation breeding, polyploidy breeding, distant hybridization and biotechnological approaches in crop improvement.
8. Resistance breeding- breeding for pest, disease and stress resistance.
9. Production of improved seeds- seed certification- the procedure of variety release.
10. **IPRs in plant breeding**: UPOV, plant breeders rights (PBRs); essentially derived varieties and farmers rights (FRs); protection of plant varieties and farmers rights act (PPV & FRA) 2001; intellectual property rights- patents, copyrights, trademarks, geographical indications; GATT and TRIPs, biodiversity act 2002

11. Omics Technologies for crop improvement- A general account

References

- Allard R.W. - Principles of Plant Breeding. John Wiley & Sons.
- Chahal G.S. and Gosal S.S. Principles and Procedures of Plant Breeding. Narosa Publishing House.
- Dabholkar A.R. Elements of Biometrical Genetics. Concept Publishing Company.
- Frankel O.H. and Bennet E. Genetic Resources in Plants. Black Well.
- Gupta S.K. Plant Breeding. Agrobios India. Khan M.A. Plant Breeding. Biotech Books.
- Hayward M.D., Bosemark N.O. and Romagosa I. Plant Breeding- Principles and prospects. Chapman and Hall.
- Jain H.K. and Kharkwal M.C. Plant Breeding. Narosa Publishing House.
- Jasra P.K. Biostatistics. Krishna Prakashan Media (P) Ltd.
- Mohanan K.V. Essentials of Plant Breeding. PHI Learning Private Limited, New Delhi.
- Mohanan K.V. Essentials of Plantation Science. Penta Books, Calicut. Radhakrishnan V.V., Hrideek T.K., Raghu A.V. and Chandramohanan K.T. Crops ofKerala - An overview. Gregor Mendel Foundation, Calicut University, Kerala.
- Pagano M. and Gauvreau K. Principles of Biostatistics. Duxbury.
- Panse V.G. and Sukhatme, P.V. Statistical methods for Agricultural Workers. ICAR.
- Rangaswamy R. A Text Book of Agricultural Statistics. New Age International Publishers.
- Roy D. Plant Breeding. Narosa Publishing House.
- Sadhu M.K. Plant Propagation. New Age International Publishers.
- Sharma J.R. Plant Breeding. Tata-McGraw Hill.Joshi R.M. Biosafety and Bioethics. Isha Books.
- Sharma J.R. Statistical and biometrical techniques in Plant Breeding. New Age International Publishers.

Web resources

- https://www.frontiersin.org/articles/10.3389/fpls.2021.563953/full
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4714296/#:~:text=Omics%20has%20provi ded%20insights%20to,of%20insect%20and%20weed%20resistance.
- https://www.fao.org/3/be655e/be655e.pdf

OPEN ELECTIVE COURSES OFFERED BY THE DEPARTMENT

Open elective courses significantly improve horizontal mobility across disciplines. For students pursuing PG programmes from other disciplines, the Department of Botany offers an open elective course "Horticulture". Open elective courses are offered in the third semester of the programme with the goal of providing non-plant science students an understanding of the fundamentals of plant science and it is more related to the ornamental uses of plants.

Course Structure, Credit and Mark distribution, and Scheme of Examination

Semester	Course code	Corse Name	Credits	Marks		
				Internal	External	Total
3	BOT3E01	Horticulture	4	20	80	100

COURSE CODE: **BOT3E01**	NAME OF THE COURSE: **Horticulture (Theory)**	CREDITS: **4**

Course Objectives:

The main objectives of this course are to:

1. To make the students aware of the importance of horticulture, its branches and landscaping.
2. To impart knowledge about the important gardens in the world and the types of gardens.
3. To inculcate knowledge about essential garden tools, implements and plant growing structures.
4. To attain knowledge about garden practices and the usage of fertilizers and soil conditioners.
5. To give an awareness to students regarding the common diseases and pests of garden plants.

Expected Course Outcomes:

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

1	Remember the scope, importance and branches of horticulture as well as the types of gardens.	**K1**
2	Understand about the cultural practices for management of insect pests of garden plants.	**K2**
3	Apply the knowledge of various plant propagation practices that can be used in day-to-day life.	**K3**
4	Analyze the uses of essential garden tools and implements as well as the plant growing structures.	**K4**
5	Evaluate the various pre-planting, planting and post-planting cultural practices as well as the usage of fertilizers, soil conditioners and ameliorants.	**K5**
6	Develop creative knowledge on indoor horticulture and commercial horticulture as well as landscaping.	**K6**

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1: 16 hrs

1. Concept, scope and importance of horticulture – as an art, science and business: branches of horticulture; classification of horticultural plants.
2. Famous gardens in the world and in India: types of gardens based on country of origin, Basic styles of gardens: formal, informal and wild gardens.
3. Botanical and ornamental gardens: butterfly garden, herbal garden, kitchen garden, rock garden, roof garden, sensory garden, vertical garden, water garden, container garden.

Unit 2: 16 hrs

4. Indoor horticulture and hydroponics: wicking, deep water culture (DWC), nutrient film technique (NFT), ebb and flow, aeroponics, and drip systems.
5. Commercial Horticulture: Nurseries, Orchards, Herb farm; Floriculture: Production of cut flowers; Floral decorations, indoor plants.

6. Arboriculture: Pruning, bracing, feeding and transplanting; Terrarium and Bonsai: Principles; Landscape horticulture, olericulture, pomology, viticulture, post-harvest technology.

Unit 3: 20 hrs

7. Developing the landscape**:** Plan (general), components and features of landscaping – plant components (lawn, shrubbery, flower beds and borders, rockery, carpet beds, topiary, hedges; non plant components (garden adornments, arches, pergolas, trellises, garden walls, gates, garden fences, footpaths, seats, tables, and garden houses).
8. Plant growing structures – Shade house, green house, poly house, glasshouse, mist chamber /mist beds, hot beds, lath houses.
9. Pre-planting, planting and post-planting cultural practices; Cultural practices to increase productivity: thinning, training, trimming and pruning; Plant propagation practices - Seed propagation and vegetative propagation - natural and artificial. Artificial methods of vegetative propagation: cuttage, layerage, graftage, budding, micropropagation.

Unit 4: 20 hrs

10. Essential garden tools and implements - Hand trowel, hoe, spade, fork, shovel, rake; different types of cutting tools – shears: long-handled, short-handled, lawn shears, secateurs, sickles, saw, wheel barrow, watering cans, lawn mower (electric and petrol mower), grass cutters, sprayers and procedure.
11. Fertilizers - Organic fertilizers: biofertilizers, compost, vermicompost, agricultural waste, livestock manure, municipal sludge; inorganic fertilizers: NPK fertilisers; natural and synthetic soil conditioners and soil ameliorants.
12. Common diseases and pests of garden plants, symptoms and causative agents; integrated pest management, physical and biological control, push-pull technology.

References

- Acquaah, G. 2015. Horticulture Principles and Practices, Pearson Education, Noida.
- Adams, C., Early, M., Brook, J. & Bamford K. 2015. Principles of Horticulture, Taylor & Francis Ltd, UK.
- Chadha, K. L. 2019. Handbook of Horticulture, Indian Council of Agricultural Research, New Delhi.
- Dixon, G. R. & Aldous, D. E. 2014. Horticulture: Plants For People And Places, Springer.
- Kathy F. 2015. Manual of Interior Plantscaping, Timber Press, Portland, Oregon.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

- https://au.f-interviews.com/6304-horticulture-mooc.html
- https://www.swayamprabha.gov.in/index.php/program/archive_he/18
- https://nptel.ac.in/courses/126105014
- https://nptel.ac.in/courses/126105009
- http://www.hillagric.ac.in/edu/coa/horticulture/lecture/Hort-351-Lectures/Hort-351-Lecture-1&2.pdf
- http://ecoursesonline.iasri.res.in/course/view.php?id=164

FIRST SEMESTER M.Sc. DEGREE EXAMINATION
(CCSS-OBE)
APPLIED PLANT SCIENCE
BOT1CO1-VIRUSES BACTERIA, CYANOBACTERIA,ALGAE AND BRYOPHYTES

Time : 3 Hours **Maximum : 50 Marks**

Part A

*Answer any **one** of the following. Each answer should not exceed 500 words.*

1. Define alternation of generation in algae and discuss different life history with suitable examples.
2. Write an essay on endospore formation in bacteria with suitable illustrations

(1 x 8 = 8 marks)

Part B

*Answer any **eight** of the following. Each answer should not exceed 250 words.*

3. Give a note on Euglenophyceae.
4. Explain the lysogenic and lytic cycles in viral infections.
5. Enumerate different types of vegetative reproduction in Polytrichales
6. Distinguish the thallus of Riccia with that of Marchantia
7. Write a short note on the reproduction in Rhodophyceae
8. Discuss the importance of algal bloom
9. Explain the different methods for the mass production of cyanobacteria
10. Describe the morphological features of bacteriophages with suitable diagram
11. Write a short note on stem nodulating bacteria
12. Investigate the role of cyanobacteria as a biofertilizer **(8 x 4 =32 marks)**

Part C

*Answer any **ten** of the following. Each answer should not exceed 3 sentences.*

13.Explain bryophytes as the bioindicators of pollution
14. Write few uses of chlorella
15. Explain pasteurisation
16. Write a short note on diatomaceous earth
18. Compare mycoplasma from chlamydae
17.Write a note on carrageenin
18. Discuss nitrogen fixation in cyanobacteria
19. Give a short note on medicinal uses of bryophytes
20. Describe stromatolites
21. Differentiate virusoids from bacteriophage
22. Describe the ultra structure of flagella
23. Explain axenic culture of bacteria

(10 x 1 = 10 marks)

FIRST SEMESTER M. Sc. DEGREE EXAMINATION

(CCSS-OBE)

APPLIED PLANT SCIENCE

BOT 1C 03 FUNGI AND PLANT DISEASES

Time: Three Hours **Maximum: 50 marks**

Part A

*Answer any **one** question. Each answer should not exceed 500 words.*

1. Point out the characteristics of phylum Basidiomycota.
2. Give an account of the major crop diseases of Kerala.

(1 x 8 = 8 marks)

Part B

Answer any eight questions. Each answer should not exceed 250 words.

3. Differentiate between true fungi and fungal analogues.
4. Provide a note on DNA Barcoding in fungi.
5. Describe crozier formation in ascomycetes with suitable diagrams
6. Give an account of parasexuality in fungi.
7. Enumerate the modern ideas of fungal phylogeny.
8. Illustrate various types of asexual propagules of deuteromycetes.
9. Explain the major symptoms of plant diseases.
10. Point out the composition of fungal cell wall.
11. Summarize the general characters of zygomycetes.
12. Describe in detail the recent classification of true fungi. **(8 x 4 = 32 marks)**

Part C

*Answer any **ten** questions. Each answer should not exceed 3 sentences.*

13. Write a short note on significance of fungal biodiversity.
14. Recall the concept of ‘disease triangle’.
15. Define dimorphic fungi with examples.
16. Give an account on hyphal elongation.
17. Describe the current taxonomic concepts regarding the stramenopilan fungi.
18. Outline the order Agaricales giving its salient features.
19. Provide a note on ‘free cell formation’.
20. Illustrate the telomorph-anamorph connections.
21. Provide a short note on economic importance of lichens.
22. Characterize the features of radiotrophic fungi.
23. Describe Koch’s postulates.
24. Explain systemic fungicides with two examples.

(10 x 1 = 10 marks)

FIRST SEMESTER M.Sc. DEGREE EXAMINATION
(CCSS-OBE)

APPLIED PLANT SCIENCE

BOT1 C07 – ANATOMY OF ANGIOSPERMS AND MICROTECHNIQUE

Time: Three Hours **Maximum: 50 Marks**

Part A

*Answer any **one** question. Each answer should not exceed 500 words.*

1. Increase in size by secondary growth occurs in certain monocotyledons - explain with suitable examples how it happens in the absence of a definite vascular cambium.

2. Explain the principles and procedures involved in the histochemical localization of biomolecules.

(1 × 8 = 8 marks)

Part B

*Answer any **eight** questions. Each answer should not exceed 250 words.*

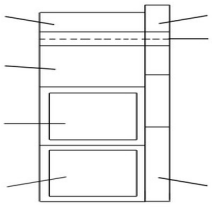
3. Examine the following two diagrams illustrating vegetative shoot apex. Differentiate the type of shoot apical organization in **A** and **B** and comment on the derivatives produced by each zone.

4. Enumerate the functions of xylem and compare the water movement in xylem vessels with that of tracheids.

5. "In all tracheary elements the protoplast disappears at maturity" – evaluate this statement and correlate it with functional efficiency of tracheary elements.

6. With suitable diagrams compare the leaf structure of C3 and C4 plants.

7. Critically interpret the following schematic drawing of production of secondary xylem and secondary phloem by the periclinal divisions of cambial initials. Copy the diagram and label Mature xylem cells, immature xylem cell, immature phloem cell, ray cell initial, immature phloem ray cell.



8. "Physiologically, protoplasm is a hindrance to the rapid ascent of water and dissolved ions"- Analyze this statement and explain how this hindrance is overcome by unusual structural specialization of tracheary elements.

9. Explain the purpose of using xylene before mounting. Give some other examples that can be used for this purpose. What is the term used for this process?

10. A plant biologist wants to study the nature of cell wall thickening, which method do you suggest? Why? Explain the protocol to be followed.

11. Explain the principle behind phase contrast microscopy and enumerate its scopes in comparison to electron microscopy.

12. Write an account on the applications of vital stains in medical diagnosis.

(8 × 4 = 32 marks)

Part C

*Answer any **ten** questions. Each answer in not more than three sentences.*

13. In conifers, cells similar in function to the companion cells of Angiosperms are found – name the type of cells, and differentiate it from companion cells.

14. Read the characters of leaves given below and categorize them in to Hydromorphic, xeromorphic and halophytic types.

a. Large tightly packed multiple rows of specialized hypodermal cells,
b. Reduction in protecting, conducting and supporting tissues,
c. Well- developed sclerenchyma, compact and strongly developed palisade.

15. Examine the following combination of histological alterations in leaves and identify the probable pollutant for the cause of injury to the plant.

d. Surface lesions
e. Smaller mesophyll cells
f. Fewer intercellular space
g. Collapse of epidermal, palisade and spongy mesophyll cells.

16. Determine the type of anomaly in the secondary growth in Nyctaginaceae, and explain how it differs from the stem anatomy of *Nyctanthus.*

17. Correlate oxygen starvation with aerenchyma formation.

18. Enumerate sequentially the events taking place in Secondary wall formation.

19. Identify the type of tissue playing a significant role in grafting, and explain its role in wound healing process in plants.

20. “Transfer cells are specialized parenchymatous cells” – explain how they are specialized and what do they perform.

21. Explain the necessity of killing and fixing.

22. Link the vital stain with the action it performs. Give examples

23. Cotton blue can specifically stain fungal structures. Justify?

24. Explain how staining procedures vary between each other?

(10 × 1 = 10 marks)

Model Question paper-2022

SECOND SEMESTER P.G. DEGREE EXAMINATION
(CCSS-OBE)
APPLIED PLANT SCIENCE
BOT2C 09 PLANT PHYSIOLOGY

Time: 3 hours **Maximum Marks: 50**

Part A

Answer any one question. Answer not exceeding 500 words

1. Elaborate with appropriate figures on organelle membrane electron transport resulting in ATP synthesis.
2. "Partitioning of photosynthetic assimilates occur in every direction of the plant". Comment on the statement and elaborate on the translocation of photosynthates.

(1x8=8 marks)

Part B

*Answer any **eight** questions. Each answer not exceeding 250 words.*

3. Nitrogen fixation is sensitive to oxygen. Explain the measures that can be taken to overcome this dilemma.
4. Elaborate the function of plasma membrane H^+-ATPase influencing the diffusion of potassium ions *via* membrane channels.
5. Summarise the fate of glucose in the plant roots in flooded soil.
6. Why does a dark-grown seedling show etiolation characterized by elongated hypocotyl and lack of chlorophyll? If this seedling is moved to light, what happens? Explain the mechanism behind this.
7. Explain the calcium-calmodulin signal cascade in plants, citing some of the plant functions influenced by this signaling mechanism.
8. Plants exposed to drought can sense and can close their stomata, to reduce water loss. Discuss the role of plant growth regulators and their mechanism of action in the above-described process.
9. Red light and far-red light can induce specific responses in plants. Write a note on role of Pr and Pfr.

10. Compile the physio-chemical changes in rice plants exposed to two different types of abiotic stresses.
11. You have observed that some of the plants in your premise shows sleeping movements. What is the mechanism behind it?
12. Explain the statement “At some conditions, seed dormancy becomes advantageous for plants”.

(8x4=32 marks)

Part C

*Answer any **ten** questions. Each answer not more than 3 sentences*

13. Briefly explain the processes through which the plant's roots absorb iron.
14. ‘Loss of class C activity in the ABC model of floral identity genes produces flowers with only nonessential whorls’. Critically evaluate the statement and give a brief account of the ABC model.
15. Evaluate the role of gibberellin in seed germination by designing an experiment with wheat seeds.
16. Analyse the major physiological alterations of a plant in response to the salinity.
17. Construct a flow chart of ATP synthesis *via* respiration.
18. Plants growing in temperate and tropical regions possess specific structural features. Comment on ecological significance of C4 plants.
19. Chloroplast movements are influenced by light. What is the role of photoreceptors in chloroplast movements?
20. Enumerate the function played by the influence of ethylene in post-harvesting technology.
21. Mention the function of mitochondria in programmed cell death.
22. Identify any two metabolic processes for which mineral nutrition is necessary.
23. Define water potential.
24. Differentiate between recalcitrant and orthodox seeds with examples.

(10x1=10 marks)

SECOND SEMESTER PG DEGREE EXAMINATION (CCSS-OBE)
APPLIED PLANT SCIENCE
BOT 2C 11 - BIOCHEMISTRY, BIOPHYSICS AND IMMUNOLOGY
(2022 Admission)

Time: 3 Hours **Maximum: 50 Marks**

PART A

*Answer any **one** of the following. Each answer not exceed 500 words.*

1. Explain the principles and techniques of colorimetry and spectrophotometry.
2. Appraise the important carbohydrates that occur in nature with a short note on their basic structure.

(1 x 8 = 8 Marks)

PART B

*Answer any **eight** of the following. Each answer not exceed 250 words.*

3. Demonstrate the biological importance of water with reference to its molecular structure.
4. Explain the regulation of enzyme action.
5. Analyse glycolytic pathway.
6. Describe the biosynthesis fatty acids.
7. Outline the biosynthesis of purines and pyramidines.
8. Summarize the growth and movement in plants with respect to phytohormones.
9. Explain the role of high energy phosphate compounds in metabolism.
10. Analyse the genetic control of immune response in man.
11. Describe different types of centrifuges and their applications.
12. Illustrate the structure of an enzyme with reference to its action.

(8 x 4 = 32 Marks)

PART C

*Answer any **ten** of the following. Each answer not exceed 3 sentences.*

13. Define ribozyme.
14. Define PPP pathway.
15. Explain how enzyme is used in curing trypanosomiasis.
16. Evaluate the use of coconut oil in daily diet.
17. Define enthalpy.
18. Define radio carbon dating.

19. Explain immunoelectrophoresis.
20. Point out the principle of chromatography.
21. Define pH.
22. Demonstrate the use of buffer.
23. Detail the principle of MRI.
24. Differentiate monoclonal and polyclonal antibodies.

(10 x 1 = 10 Marks)

SECOND SEMESTER PG DEGREE EXAMINATION (CCSS-OBE)
APPLIED PLANT SCIENCE
BOT 2C 11 - BIOCHEMISTRY, BIOPHYSICS AND IMMUNOLOGY
(2022 Admission)

Time: 3 Hours

Maximum: 50 marks

PART A

*Answer any **one** of the following. Each answer should not exceed 500 words.*

1. Illustrate the structure of protein. Analyze the major components of the synthesis of proteins.
2. Explain various techniques and principles used in the separation of microscopic particles and macromolecules.

(1 x 8 = 8 Marks)

PART B

*Answer any **eight** of the following. Each answer should not exceed 250 words.*

3. Derive the Henderson-Hasselbalch equation.
4. Discuss the structure and function of enzymes.
5. Illustrate TCA cycle and explore its significance.
6. Describe the classification of lipids.
7. Explain the principles of thermodynamics with respect to the metabolic activities in living systems.
8. Analyse the mechanism of immune response in human body.
9. Explore the structural similarities and differences in DNA and RNA.
10. Construct a chart of food items to be included in our diet to get required vitamins for a healthy living.
11. Explain Ramachandran plot.
12. Explore the tools used in nanotechnology.

(8 x 4 = 32 Marks)

PART C

*Answer any **ten** of the following. Each answer should not exceed 3 sentences.*

13. Define allosteric enzymes.
14. Define gluconeogenesis.
15. Explore the biological importance of glycoproteins and proteoglycans.
16. Provide the role of Rubisco in photosynthesis.
17. Predict the effect of the intake of excessive oily food by man.
18. Define ELISA.
19. Demonstrate the working of monoclonal antibodies.
20. Define isoenzyme.
21. Explain energy rich bonds.
22. Describe the use of radioactivity in biology.
23. Explore the diversity of antibodies.
24. Explain proton hopping.

(10 x 1 = 10 Marks)

SECOND SEMESTER M.Sc. DEGREE EXAMINATON
(CCSS-OBE)
APPLIED PLANT SCIENCE
BOT2C15 ENVIRONMENTAL BIOLOGY

Time: 3 hours **Maximum: 50 marks**

Part A

*Answer any **one** question. Each answer should not exceed 500 words.*

1. If World's average temperature increase by 4ºC in excess of the present levels by 2050, then explain its possible socio-economic and environmental impacts on (1) Deserts of Rajasthan (2) forests of Central India and (3) coastal environments of Peninsular India.

2. A five-year survey was undertaken to assess the anthropogenic threats on mammals in two unprotected forests (Forest A and B) of Kerala. A total of 62 species of mammals were identified and the results of their threat status are given below.

Anthropogenic threat	Mammal species affected	
	Forest A	Forest B
Poaching	11	22
Hunting by locals	20	11
Habitat loss	15	9
Human Wildlife conflicts	12	20

Discuss in detail the conservation measures to be implemented in both the areas on the basis of the data.

(1 x 8 = 8 marks)

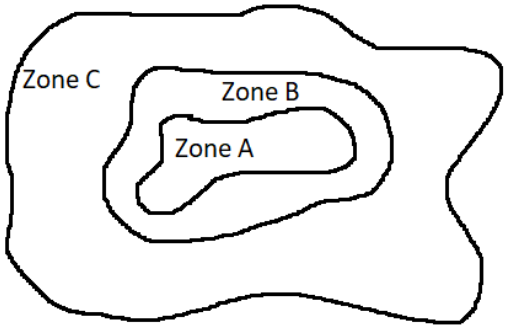
Part B

*Answer any **eight** questions. Each answer should not exceed 250 words.*

3. Explain the phenomenon of Biomagnification? How does it differ from bioaccumulation?
4. Soil samples from different land use patterns showed varying contaminants as listed below.

Soil Sample	Major contaminants	Land Use pattern
A	DDT, endosulfan, nitrates, animal manure, fertilizers and biosolids (sewage sludge), urea	Agriculture
B	Plastic, glass, human excreta, organic contaminants from food, poultry farms	Residential
C	Mercury, Cadmium, Lead	Industrial

   Suggest possible management measures for the above soil samples and discuss the impact of contaminants in soil sample A on agricultural productivity and human health.
5. "Ecosystem services varies with habitats". Evaluate this statement with the services attributed by a mangrove and a fresh water lake ecosystem.
6. Malabar Civet, a critically endangered species is endemic to the Western Ghats. Habitat destruction, habitat fragmentation, poaching, and hunting are the major threats faced by the species. Explain various *ex-situ* and *in-situ* conservation strategies to facilitate conservation of this species.
7. Explain the zonation in a Model Biosphere Reserve outline below, with a description on activities in each zone.



8. Most Indian megacities are prone to water crisis in the coming decades. As a responsible citizen, suggest water conservation policies that the State Government can adopt in their master plan for the forthcoming years.
9. Explain Koppen's climatic classification with an emphasis on the attributes used.
10. Temperature fluctuates in the Earth's atmosphere. Explain the reasons for temperature fluctuations in the atmosphere with the help of a diagram.

11. Explain accelerated eutrophication? Elaborate the role of nitrates and phosphates in eutrophication.
12. Summarize the concept of ecological succession. Explain the progressive changes in the non-living components due to succession.

(8 × 4 = 32 marks)

Part C

*Answer any **ten** questions. Each answer in not more than three sentences.*

13. Define the functionalities of the following layers in supporting plant growth.
    1) O Horizon 2) A Horizon and 3) B Horizon
14. Examine the conservational practices adopted in a Sanctuary. How it differs from a community reserve?
15. Examine the pattern in Climate, Weather and Season experienced in Kerala, and comment on its reasons.
16. Write about photo chemical smog and how it differs from ordinary smoke?
17. Expand IPCC and comment on its role in environmental protection.
18. Examine the following interactions and comment on the types to which they include.
    a) Vanda growing on a Banyan tree b) Heron on a grazing cow c) Loranthus on a Mango tree
19. Point out the role of non-Governmental organizations in environmental management
20. State the role of atmosphere as a source or sink in Carbon, Nitrogen and Phosphorus cycle.
21. Analyze the following populations and comment on the life cycle strategies involved.
    a) Elephants b) mice
22. “Energy flow in an ecosystem is unidirectional”. Explain this concept with the help of a forest and an aquatic ecosystem.
23. Summarize the term advection with an example.
24. Explain the soil types of India in accordance with the agriculture practices involved.

(10 x 1= 10 Marks)

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THIRD SEMESTER P.G. DEGREE
EXAMINATION, JANUARY 2022 (CCSS-OBE)
APPLIED PLANT SCIENCE
BOT 3C 19-GENETICS, PLANT BREEDING AND BIOSTATISTICS
(2022 Admissions)

Time: Three Hours **Maximum: 50**

Marks

Part A

*Answer any **one** question. Each answer should not exceed 500 words.*

1. Critically evaluate the methods of disease resistance breeding. Add a note on the various sources of disease resistance.
2. Demonstrate the applications of graphs and diagrams in the presentation of data.

(1 x 8 = 8 marks)

Part B

*Answer any **eight** questions. Each answer should not exceed 250 words.*

3. Interpret the *cis* and *trans* configuration of alleles.
4. Elaborate the different kinds of approaches in cluster analysis.
5. Evaluate the applications and limitations of mutation breeding.
6. Summarize the phenomenon of multiple allelism citing the mode of inheritance of ABO blood groups in human.
7. Examine the significance of quarantine protocols in the context of plant introduction procedures.
8. Differentiate primary and secondary data.
9. Distinguish between continuous and transgressive variation. Add a note on its significance.
10. 'X- Linked genes follow a criss-cross pattern of inheritance'. Justify the statement.
11. Characterize the different measures of central tendency.
12. State Hardy-Weinberg Law of Equilibrium. Enumerate the factors which cause changes in the equilibrium.

(8 x 4 = 32 Marks)

Part C

*Answer any **ten** questions. Each answer should not exceed 3 sentences.*

13. Outline the applications of Chi-square test.
14. Name the apomictic modes of plant propagation.
15. Compare the role of *nif* and *nod* genes in biological nitrogen fixation.
16. Differentiate *ex situ* and *in situ* methods of germplasm conservation.
17. Define standard error. Comment on its significance
18. Illustrate Mendel's law of segregation.
19. Differentiate between heterosis and luxuriance.
20. Design a Randomized Block Design to assess the effect of three different concentrations of an insecticide.
21. Name two cotton varieties released in India through mutation breeding.
22. Detect the major mutant classes of bacteria.
23. Differentiate disease escape and disease avoidance.
24. Define homeotic genes. Add a note on its significance.

(10 x 1 = 10 marks)

THIRD SEMESTER P.G. DEGREE EXAMINATION
(CCSS-OBE)
APPLIED PLANT SCIENCE
BOT 3C 19-GENETICS, PLANT BREEDING AND BIOSTATISTICS
(2022 Admissions)

Time: Three Hours **Maximum: 50 Marks**

Part A

*Answer any **one** question. Each answer should not exceed 500 words.*

1. Characterize the prokaryotic gene regulation with special reference to *lac* operon.
2. Elaborate the principles of experimental designs. Formulate an experimental design to assess the yield performance of five paddy varieties.

(1 x 8 = 8 marks)

Part B

*Answer any **eight** questions. Each answer should not exceed 250 words.*

3. Identify the factors operating in a population to change its genetic equilibrium.
4. Illustrate the genetic control of development in plants citing *Arabidopsis* as an example.
5. Summarize the different classes of genes involved in photosynthesis of higher plants.
6. Distinguish between oligogenic and polygenic inheritance.
7. 'Alleles of two (or more) different genes get sorted into gametes independently of one another'-Illustrate the statement suitably.
8. Enumerate the objectives of plant breeding.
9. Outline the different ways of tabulation of data.
10. Examine the differences between horizontal and vertical resistance.
11. Compare and contrast correlation and regression analysis.
12. Characterize different methods of diagrammatic representations of data.

(8 x 4 = 32 Marks)

Part C

Answer any ten questions. Each answer should not exceed 3 sentences.

13. Differentiate skewness and kurtosis.
14. Generalize the significance of amphidiploids citing a suitable example.
15. Define linkage groups. Indicate its significance in inheritance of traits.
16. Define plant introduction. Add a note on the role of NBPGR in plant introduction.
17. Tabulate the merits and demerits of mean deviation.
18. Predict F1 & F2 phenotypic and genotypic ratios when pure white flowered plants were crossed with pure red coloured plants in *Antirrhinum (Snapdragon).*
19. Demonstrate the sex-linked inheritance of eye colour in *Drosophila*.
20. 'Allopolyploidy did not enable man to create new species which are superior than the existing crop species. Examine the statement.
21. Compute the variance of a sample having the standard deviation of 1.66
22. Detect the major difference between t test and ANOVA. Add a note on Two- way ANOVA.
23. Give two examples of mechanisms in plants which promote self- pollination.
24. Differentiate transformation and transduction.

(10 x 1 = 10 marks)

THIRD SEMESTER P.G. DEGREE EXAMINATION

(CCSS-OBE)

APPLIED PLANT SCIENCE

BOT4C24- GENETIC ENGINEERING AND BIOINFORMATICS

Time: Three hours **Maximum: 50 Marks**

PART A.

*Answer any **one** question in not more than 500 words.*

1. a. Explain the impact of *nif* engineering on agriculture productivity?
   b. Do you agree with the statement that transgenic science will the next generation tool for increasing productivity in plants.
   c. Substantiate your answer with suitable examples **(4+2+2)**

2. a. Illustrate the role of selectable markers in recombinant technology. (5)
   b. Correlate Genome bioinformatics in identifying elite traits (3)

(1x8=8 Marks)

Part B

*Answer any **eight** questions in not more than 250 words.*

3. Evaluate the role of different vectors in genetic engineering
4. Discuss the advantages and disadvantages of transgenic technology
5. Analyse the effectiveness of different predictive models in elucidating the secondary structure of a protein
6. Discuss different phylogenetic models with their advantage and disadvantages
7. Apply Lipinski's rule of five to evaluate the action of Thymidine kinase
8. Describe two gene transfer protocols. Develop a grading system for the different gene transfer protocols with explanation
9. Develop a restriction map of the plasmid with three restriction sites one each for ECoRI, BamH1and Hind III with the following combinations
   a. All the enzymes individually
   b. ECORI + BamH1
   c. ECORI + Hind III
   d. BamH1+ Hind III
   e. ECORI + BamH1+ Hind III
10. Evaluate the *Abinitio* method of gene prediction for its accuracy
11. An expression vector is cloned with a gene fragment of size 490bp. Explain the strategies used for positive cloning
12. Differentiate between classical drug discoveries with insilico drug development

(8x4=32 Marks)

PART C

*Answer any **ten** questions in not than three sentences.*

13. Explain Sequenator
14. Evaluate the role of MCS in cloning
15. In an electroporation process if the AC-DC application is altered, how the cells will be affected
16. CaMV 35S is a highly effective promoter. Evaluate its demerits in transgene production.
17. Golden rice has Vitamin A content. How does the quantity of Vitamin A production is regulated?
18. Explain how composite databases are formed from secondary databases
19. Evaluate the role of *k-tupule* in homology search
20. How does bootstrap values determine the effectiveness of phylogenetic analysis
21. Can microsatellites used as marker, substantiate your answer with one example
22. How PROCHECK is used to determine the effectiveness of a protein
23. Mention the places where Hidden – Markov model is applied
24. What is the relevance of e-value?

(10x1=10 Marks)

FOURTH SEMESTER M. Sc. DEGREE EXAMINATION

(CCSS-OBE)

APPLIED PLANT SCIENCE

BOT4E03 FUNGAL BIOLOGY AND TECHNOLOGY

Time: Three Hours **Maximum: 50 marks**

Part A

*Answer any **one** question. Each answer should not exceed 500 words.*

part B

Each answer should not exceed 250 words.

1.Provide a detailed account of the use of fungi in biotechnology.

2. Give an account of the spore discharge mechanisms in fungi. **(1 x 8 = 8 marks)**

3.Give an account of parasexuality in fungi.

4.Describe the role of fungi in biotransformation of useful metabolites.
5.Write an account on lignin decomposition by fungi.
6.Provide a note on orchid mycorrhiza.
7.Characterize the structure and chemical composition of fungal cell wall.
8. Explain the commercial importance of fungal enzymes.
9. Illustrate the applications of gene cloning in fungi.
10.Write an account on mycoses seen in human beings.
11.Give a brief account on radiotrophic fungi and radiosynthesis.
12. Describe the role of fungi in pathological relations of agricultural importance **(8 x 4 = 32 marks)**

Part C

*Answer any **ten** questions. Each answer should not exceed three sentences.*

13. Recall ambrosia fungi.
14. List the 3 main phases of fungal activity during composting process.
15. Give an account on dry rot of wood.
16. Define mating types in fungi.
17. Differentiate between vesicles and arbuscles in VAM.
18. Explain the role of mycorrhiza in mineral nutrition.
19. Differentiate between upstream and downstream processes in industrial fermentation.
20. Explain catabolite repression with reference to fungi.
21. Examine termite-*Termitomyces* relationship.
22. Illustrate the benefits derived by both the rumen chytrids and the ruminants by their association.
23. Provide a short note on aflatoxins.
24. Explain heterokaryosis.

(10 x 1 = 10 marks)

FOURTH SEMESTER M. Sc. DEGREE EXAMINATION

(CCSS-OBE)

Applied Plant Science

BOT4E04: Fungal systematics

Time: Three Hours **Maximum: 50 marks**

Part A

*Answer any **one** question. Each answer should not exceed 500 words.*

1. Prepare an essay on the magnitude, significance, and conservation of fungal diversity.

2. Give a detailed account of the taxonomic ranks used in fungal classification.

(1 x 8 = 8 marks)

Part B

*Answer any **eight** questions. Each answer should not exceed 250 words.*

3.Give an account of intraspecific taxonomic categories recognized in fungi.
4. Describe the major changes in the Melbourne Code that affected fungal nomenclature.
5. Illustrate the concepts of anamorph, teleomorph and holomorph with examples
6. Point out the steps in publishing a new fungal species.
7. Provide the various methods of preservation of fungal cultures.
8. Describe the concept of priority in botanical nomenclature.
9. Discuss the significance of morphology of basidium in the classification of basidiomycetes.
10. Explain the basic principles of numerical taxonomy.
11. Give a brief account on DNA barcoding in fungi.
12. Explain current taxonomic concepts regarding straminipilan and protistan fungi.

(8 x 4 = 32 marks)

Part C

*Answer any **ten** questions. Each answer should not exceed three sentences.*

13. Write a note on teratological forms
14. Prescribe the names and locations of 3 major fungal culture collections of the world.
15. Differentiate between phyletic and phenetic classifications.
16. Differentiate between biological species concept and phylogenetic species concept.
17. Differentiate between topotype and typotype.
18. Differentiate between phylogram and phenogram.
19. Distinguish between effective publication and valid publication.
20. Describe the use of ultrastuctural characters in fungal taxonomy with an example.
21. Cite an instance where cell wall chemistry is taxonomically useful.
22. Define ‘domains’ in biological classification.
23. Differentiate between species trees and gene trees.
24. Examine an instance where septal ultrastructure is taxonomically useful.

(10 x 1 = 10 marks)

FOURTH SEMESTER P.G. DEGREE EXAMINATION
(CCSS-OBE)
APPLIED PLANT SCIENCE
BOT4E 09 ECOLOGICAL ASPECTS OF PLANT FUNCTIONS

Time: 3 hours **Maximum Marks: 50**

Part A

Answer any one question. Answer not exceeding 500 words

3. Give a detailed account on allelopathy and modes of defense mechanisms.
4. Explain the regulation of electron transfer via cytochrome and alternative pathways and their ecological functions.

(1x8=8 marks)

Part B

*Answer any **eight** questions. Each answer not exceeding 250 words.*

3. Explain the effect of irradiance and CO_2 on leaf conductance.
4. Is transpiration a necessary evil? Comment your answer with suitable reasons.
5. Comment on post illumination CO_2 assimilation and sunfleck utilization efficiency.
6. Explain the effect of environment on the production secondary metabolites in plants.
7. Give an account on legume-rhizobium association.
8. What are the strategies adopted by plants to evade photoinhibition?
9. Compare the physiological and anatomical differences between sun and shade leaves.
10. Give an account on mycorrhizal association.
11. Write an account on net carbon balance of ecosystems.
12. Elaborate the water storage in leaves of aquatic angiosperms.

(8x4=32 marks)

Part C

*Answer any **ten** questions. Each answer not more than 3 sentences*

13. Mention the role of carotenoids and xanthophylls in photosynthesis.
14. What is endosymbiosis? Give an example.
15. Effect of soil nutrient supply on photosynthesis.
16. Chloroplast movement in response to changes in irradiation.

17. Bioenergy crops and applications.
18. Light response curve of sun and shade leaves.
19. Explain chemical defense in plants.
20. Describe NOD genes.
21. Explain boundary layer conductance.
22. Explain actinomycetes.
23. Mention winter water relations.
24. Describe ATP production in isolated mitochondria.

(10x1=10 marks)

FOURTH SEMESTER M. Sc. DEGREE EXAMINATION

(CCSS-OBE)

APPLIED PLANT SCIENCE

BOT4E15 PLANT TISSUE CULTURE

Time: Three Hours **Maximum: 50 Marks**

Part A

*Answer any **one** question in not more than 500 words.*

1. Explain somatic embryogenesis. Discuss its applications with reference to conservation of plant genetic resources

2. Explain the application of plant secondary metabolite in pharmaceutical development with special reference to threatened plants.

(1x8=8 Marks)

PART B

*Answer any **eight** questions in not more than 250 words.*

3. Explain how miniprotoplasts and cytoplasts are developed with its application
4. Discuss the role of doubled haploids in agricultural productivity
5. Critically analyze the role of cryopreservation in plant germplasm conservation
6. Describe the role of plant growth regulators in micropropagation
7. Critically evaluate different sterilization procedures used in plant tissue culture
8. Describe the critical factors affecting the hardening of tissue culture raised plants
9. Callus mediated plants show genetic instability. Suggest reasons
10. Somaclonal variations are rarely inherited in F2 generation. Critically comment
11. Enumerate the role of elicitors in secondary metabolite production
12. Differentiate between conventional and tissue culture-based mass propagation of plants

(8x4=32 Marks)

PART –C

*Answer any **ten** questions in not more than three sentences.*

13. Define caulogenesis
14. What is vitrification
15. Explain the role of mesoinositol in plant tissue culture
16. What are doubled haploids. Give examples
17. Explain the advantage of using a liquid medium for plant tissue culture
18. What is the role of PVS in plant conservation?
19. Differentiate between growth regulators and growth retardants
20. Explain acclimatization
21. Discuss bulbosum method of developing specific hybrids
22. Enumerate the adjuvants used in plant tissue culture
23. List the role of Calcium in plant tissue culture
24. Describe TTC test for viability

(1x10=10 Marks)

FOURTH SEMESTER M. Sc. DEGREE EXAMINATION

(CCSS-OBE)

APPLIED PLANT SCIENCE

BOT4E16 PLANT BIOTECHNOLOGY

Time: Three Hours **Maximum : 50 marks**

PART A

*Answer any **one** question in not more than 500 words.*

1. Discuss the bio risks of transgenic plants with special emphasis on plant quarantine
2. Enumerate the various strategies adopted for biofortification of food materials

(1x8=8 marks)

PART B

*Answer any **eight** questions in not more than 250 words.*

3. Describe eukaryotic transcription
4. What are TFBs. Explain their role in prokaryotic gene expression
5. Explain knockout plants
6. How does the quantity of agropine influence the crown-gall formation in plants
7. How the boll-worm of cotton can be controlled by using bacterial toxins?
8. Discuss terminator technology from a farmer's point of view
9. How the nutritional quality in plants can be enhanced using transgenic technology
10. Explain the role of *nif* genes in agriculture production
11. Explain how plastic accumulation can be reduced using biotechnological approaches
12. Plants are reservoirs of medicinally important substances. Enumerate with examples.

(8x4=32 marks)

PART C

*Answer any **ten** questions in not more than three sentences*

13. Explain biofortification
14. Discuss plant promoters

15. What is bioaugmentation
16. Explain microinjection
17. What are biochips
18. Discuss anaerobic fermentation in environmental biotechnology
19. Explain the role of introns in eukaryotic transcription
20. Enumerate the procedures for patenting a new technology
21. Describe the technique used in flower color change in plants
22. Is potato based edible vaccine is safe for consumption. Comment
23. Is coat protein expressed Papaya are safe to eat? Comment.
24. What is MAS **(10x1=10 marks)**

FOURTH SEMESTER M.Sc. DEGREE EXAMINATION
(CCSS-OBE)
APPLIED PLANT SCIENCE
BOT4E19-BIOLOGY AND TAXONOMY OF ALGAE AND CYANOBACTERIA

Time : 3 Hours **Maximum : 50 Marks**

Part A

*Answer any **one** of the following. Each answer should not exceed 500 words*

1. Compare the classification of algae by G.W. Presscot and G. M. Smith
2. Give an account on structure and different types of reproduction in cyanobacteria

(1 x 8= 8 marks)

Part B

*Answer any **eight** of the following. Each answer not to exceed 250 words*

3. Give a note on taxonomic monograph and floras
4. Enumerate the contributions of Indian cyanobacteriologists.
5. Describe the different types of reproduction in Chlorophyta
6. Discuss the pigment constitution in cyanobacteria
7. Write an account on nitrogen fixation in cyanobacteria
8. Discuss the importance of algal bloom
9.Compare the pigment constitution of Pheophyta and Rhodophyta
10.Discuss the monospore formation in red algae
11. Discuss the economic importance of brown algae
12. Enumerate the events occur during auxospore formation in diatoms

(8 x 4 =32 marks)

Part C

*Answer any **ten** of the following. Each answer should not exceed 3 sentences.*

13. Draw a labelled diagram of heterocyst
14. Describe tetrasporophyte
15. Explain the enzyme and the genes involved in nitrogen fixation
16. Write a short note on diatomaceous earth
17. Write a short note on algal symbiosis

18.Explain the cyanobacterial – Azolla association
19. Explain parasitism in algae
20. Give a short note on medicinal uses of algae
21. Discuss DNA barcoding in cyanobacteria
22. Write a note on preservation of cyanobacterial cultures
23.Write a note on akinete
24. List some media used in the culturing of cyanobacteria

(10 x 1= 10 marks)

FOURTH SEMESTER P.G. DEGREE EXAMINATION

(CCSS-OBE)

APPLIED PLANT SCIENCE

BOT 4E 21-GENETICS AND CROP IMPROVEMENT-1

(2022 Admissions)

Time: Three Hours **Maximum: 50 Marks**

Part A

Answer any **one** *question. Each answer should not exceed 500 words.*

1. Elaborate on the origin, variability and floral biology of rice.
2. Evaluate the impact of CGIAR in boosting International agricultural research. Add a note on the major activities of any one of the Institutes under CGIAR.

(1 x 8 = 8 marks)

Part B

Answer any **eight** *questions. Each answer should not exceed 250 words.*

3. Demonstrate the origin of cultivated wheat.
4. Outline the major activities of any two crop research institutes under ICAR.
5. Differentiate the floral biology of coffee and cardamom.
6. Summarize the role of commodity boards in the production and export of tea and coffee.
7. Explore the major crop management strategies followed in vanilla.
8. Discuss the major thrust areas of research in plantation crops.
9. Examine the major breeding techniques adopted for crop improvement in maize.
10. 'ICAR has played a crucial role in agriculture development in India'. Justify the statement.
11. Identify the suitable propagation techniques which can be adopted for crop improvement in cocoa.
12. Characterize the major types of tea based on fermentation level.

(8 x 4 = 32 marks)

Part C

Answer any **ten** *questions. Each answer should not exceed 3 sentences.*

13. Name the cultivated species of oil palm.
14. Name the Headquarters of CIMMYT.
15. Expose the advantages of GM varieties of rice citing suitable examples.
16. Identify the ICAR research institute which is solely dedicated for the improvement

of tropical tuber crops. Enumerate any five of its mandatory crops.

17. Cite any two examples for improved varieties of cocoa.
18. Define panicle. Cite an example for a panicle bearing crop.
19. Differentiate the terms *ear* and *tassel*.
20. State the botanical names, family and botany of useful parts of any two cereal crops.
21. Illustrate the floral biology of turmeric.
22. Cite any two examples for indigenous ginger varieties.
23. Point out the major bottlenecks in coffee breeding.
24. Design a suitable breeding method for the crop improvement in vanilla.

(10 x 1 = 10 marks)

FOURTH SEMESTER P.G. DEGREE EXAMINATION

(CCSS-OBE)

APPLIED PLANT SCIENCE

BOT 4E 22 - GENETICS AND CROP IMPROVEMENT-II (2022 Admissions)

Time: Three Hours **Maximum: 50 Marks**

Part A

Answer any **one** *question. Each answer should not exceed 500 words.*

1. Elaborate the stages involved in breeding for disease resistance. Differentiate vertical and horizontal disease resistances.
2. Characterize the genetic diversity present in the spectrum of different categories of crop genetic resources. Add a note on the significance of its conservation.

(1 x 8 = 8 marks)

Part B

Answer any **eight** *questions. Each answer should not exceed 250 words.*

3. Define sustainable agriculture. Summarize its goals and objectives.
4. Point out the different classes of quality seeds. Characterize the different stages of seed certification procedure.
5. Identify the rights ensured for farmers as evidenced by Protection of Plant Varieties and Farmers' Rights Act.
6. Illustrate the different classes of genes involved in photosynthesis of higher plants.
7. Demonstrate the role of allopolyploidy in crop improvement.
8. Elucidate the process of plant domestication.
9. Evaluate the various steps involved in the release of a new variety.
10. Review on the centres of origin of cultivated crops.
11. Examine the achievements in mutation breeding citing suitable examples.
12. Define plant introduction. Differentiate primary and secondary introduction citing suitable examples.

(8 x 4 = 32 marks)

Part C

Answer any ***ten*** *questions. Each answer should not exceed 3 sentences.*

13. Define Gene Bank. Name the world's first gene bank that is powered entirely by solar energy.
14. Differentiate between cleistogamy and chasmogamy.
15. Define male sterility. Enumerate the different types of male sterility.
16. Differentiate interspecific and intergeneric hybridization citing suitable examples.
17. Indicate the role of colchicine in plant breeding. Identify its natural source.
18. Summarize the advantages of Integrated Farming System.
19. Define Intellectual Property. Distinguish between copyright and trademark.
20. Discriminate between drought tolerance and drought resistance.
21. Point out the role of MAHYCO in Indian Agriculture.
22. Differentiate between mass selection and pureline selection.
23. Enumerate the morphological and physiological traits associated with drought resistance in crop plants.
24. Cite two common examples each for self-pollinating and cross- pollinating crops.

(10 x 1 = 10 marks)