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 2019 - Incorporating Outcome Based Education (OBE) with effect from 2020 Admission onwards - Implemented - Subject to ratification of Academic Council - Orders Issued.

G & A - IV - J

U.O.No. 5455/2021/Admn Dated, Calicut University.P.O, 21.05.2021

Read:-1. U.O.No. 8959/2019/Admn Dated, 07.07.2019

2. E-mail dated 07.04.2021 from the Chairperson, BoS, Plant Science
3. Remarks of the Dean, Faculty of Science, dated 08d.05.2021
4. Orders of the Vice Chancellor in the file of even no., dated 16.05.2021

ORDER

1. The Scheme and Syllabus of M.Sc Applied Plant Science Programme, in accordance with CCSS UG Regulations 2019, was implemented in the University with effect from 2019 Admission onwards, vide paper read (1) above.
2. Vide paper read (2) above, the Chairperson, Board of Studies, Plant Science (Single Board) forwarded the scheme and syllabus of M.Sc Applied Plant Science Programme, incorporating Outcome Based Education (OBE) in the existing syllabus, in accordance with CCSS PG Regulations 2019, with effect from 2020 Admission onwards, after circulating among the members of the Board, as per Clause (34) of Chapter 3 of Calicut University First Statutes (CUFS)1976.
3. The scheme and syllabus of M.Sc Applied Plant Science Programme, incorporating Outcome Based Education (OBE), 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, incorporating Outcome Based Education (OBE) in the existing syllabus, in accordance with CCSS PG Regulations 2019, is therefore implemented, with effect from 2020 Admission onwards, subject to ratification by the Academic Council.
5. Orders are issued accordingly.
6. U.O.No. 8959/2019/Admn Dated, 07.07.2019 stands modified to this extent. (modified syllabus appended).

Arsad M

Assistant Registrar

To

1. The Head, Dept. of Botany

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

Forwarded / By Order

Section Officer

M.Sc. Course in Applied Plant Science (CCSS)

(Effective from 2019 Admissions)
(OBE implementation 2020 onwards)

Program Objectives (PEOs)	
The **M. Sc. Applied Plans Science** program defines various achievements that graduates are expected to attain after graduation	
PO1	The courses have been 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 programme 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 MSc Applied Plant Science program, the students are expected to	
PSO1	To have knowledge about the classification of plants from cryptogams to phanerograms. Identification of the plants in the field. Study of biodiversity in relation to habitat and correlate with climate change, land and forest degradation. To apply plant science in agriculture through study of plant pathogens, enhancing crop productivity, improvements of crops. The knowledge in paleobotany will help to trace the evolution of plants.
PSO2	Morphogenesis, taxonomy, anatomy and embryology are taught with the intention of to have knowledge on the external and internal characters of plants, which will help them in identification and classification of plants, which have practical application in biochemical and pharmaceutical aspects
PSO3	Knowledge related to fundamental of biostatistics, bioinformatics tools and biophysical principles are imparted, which will help them for the analysis of relevant biological situations and for developing intellectual skills on biological data and databases.
PSO4	They will acquire skills to identify the local, medicinal, rare, endangered, endemic plants and exotic plants in their original habitats, therapeutic values and their cultivation practices, which will be help them to formulate ways and

	means for effective conservation and future use of these plants. Understand the role of plants in sustaining life and the interrelationship between human beings and nature, their importance in sustainable development and the importance of biodiversity conservation so as to develop conservation strategies.
PSO5	Will help them to elucidate the molecular and functional adaptations in plants in response to both biotic and abiotic stresses. Identifying genes responsible for stress tolerance and genetic engineering of plants for enhanced stress tolerance will also be possible.

Program Outcomes (POs)	
On successful completion of the M. Sc. MSc Applied Plant Science program	
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	Biotechnological innovations by applying modern, appropriate techniques in the field of Plant Molecular Biology and Plant Biotechnology.
PO3	Understand the issues of environmental aspects and sustainable development.
PO4	Improved production of plant based medicines, food and other plant products for the advancement of man's holistic development and welfare.
PO5	Students can acquire knowledge on basic scientific phenomena, fundamental, principles and applications of various statistical tools relevant to different biological situations.
PO6	Enhancement of their ability to execute their ideas, knowledge and concepts in multidisciplinary ways

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

Semester	Course No.	Name of the course	Credit for the course	Marks		
				Internal (20%)	External (80%)	Total
1	BOT1C01	Viruses, Bacteria, Algae & Bryophytes (Theory)	3	20	80	100
	BOT1C02	Viruses, Bacteria, Algae & Bryophytes (Practical)	1	10	40	50
	BOT1C03	Fungi and Plant Diseases (Theory)	3	20	80	100
	BOT1C04	Fungi and Plant Diseases (Practical)	1	10	40	50
	BOT1C05	Pteridophytes & Gymnosperms (Theory)	3	20	80	100
	BOT1C06	Pteridophytes & Gymnosperms (Practical)	1	10	40	50
	BOT1C07	Anatomy of Angiosperms & Microtechnique (Theory)	3	20	80	100
	BOT1C08	Anatomy of Angiosperms & Microtechnique (Practical)	1	10	40	50
	BOT1A01	The Process of Research (Theory)	2	-	-	-
2	BOT2C09	Plant Physiology (Theory)	3	20	80	100
	BOT2C10	Plant Physiology (Practical)	1	10	40	50
	BOT2C11	Biochemistry, Biophysics & Immunology (Theory)	3	20	80	100
	BOT2C12	Biochemistry, Biophysics & Immunology (Practical)	1	10	40	50
	BOT2C13	Plant Morphogenesis, Embryogenesis & Plant Biotechnology (Theory)	3	20	80	100
	BOT2C14	Plant Morphogenesis, Embryogenesis & Plant Biotechnology (Practical)	1	10	40	50
	BOT2C15	Environmental Biology (Theory)	3	20	80	100

	BOT2C16	Environmental Biology (Practical)	1	10	40	50
	BOT2A02	Biotechniques and Instrumentation (Practical)	2	-	-	-
3	BOT3C17	Angiosperm Taxonomy and Phytogeography (Theory)	3	20	80	100
	BOT3C18	Angiosperm Taxonomy and Phytogeography (Practical)	1	10	40	50
	BOT3C19	Genetics, Plant Breeding, & Biostatistics (Theory)	3	20	80	100
	BOT3C20	Genetics, Plant Breeding, & Biostatistics (Practical)	1	10	40	50
	BOT3C21	Cell Biology & Molecular Biology (Theory)	3	20	80	100
	BOT3C22	Cell Biology & Molecular Biology (Practical)	1	10	40	50
	BOT3C23	Genetic Engineering & Bioinformatics (Theory)	3	20	80	100
	BOT3C24	Genetic Engineering & Bioinformatics (Practical)	1	10	40	50
4	BOT.4 *	Elective 1*	4	20	80	100
	BOT.4 *	Elective 2*	4	20	80	100
	BOT.4 *	Elective 3*	4	20	80	100
	BOT.4 *	Elective 4*	4	20	80	100
	BOT4P01	Dissertation	8	--	200 (160 + 40 for viva)	200
Grand Total						2400

*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 Cell Biology (Theory); Credit: 4
8) BOT4E08 Molecular Biology (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

There shall be provision for additions or deletions of elective papers to be offered, if necessary, in the ensuing years of admission subject to approval by departmental council and other bodies concerned. There shall be four elective (theory) papers in the 4thsemester. There shall be no practical examination in the 4th semester in lieu of whicheach student has to submit a dissertation in one of the areas of elective papers chosen by him/her.

Eligibility

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 of any other University recognised by this University.

Examiners

There shall be one internal examiner and one external examiner for all the courses (including dissertation) in each semester. The internal examiners of each semester shall be the teachers who actually imparted instruction in that particular semester. The external examiners shall be selected from a panel of external examiners approved by the Departmental Council for each semester.

Record of Practical Work

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

Dissertation

Topic of dissertation may be chosen from an area of one of the elective papers opted in the 4th semester.

Evaluation (Internal & External) 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 2019) is to be followed for internal and external evaluation and grading.

Plan of Question Papers for External Examinations

Theory:

Core & Elective Papers:

Part A: Two essay-type question of 10 marks out of three questions
(2x10 = 20 marks).

Part B: Eight short answer questions of 5 marks each out of ten questions
(8x5 = 40 marks).

Part C: Ten short answer questions of 2 marks each out of twelve questions
(10x2 = 20 marks).

Practicals:

The Board of Examiners for practical examinations of I to III 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-30 marks; records/submission-10 marks.

Duration of examinations

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

The Department Council will decide the evaluation criteria for the Ability Enhancement Course (BOT1A01-The Process of Research-Theory) and the Professional Competency Course (BOT2A02-Biotechniques and Instrumentation-Practical).

Syllabi of Core and Elective Courses

Core Courses

1st Semester

BOT1C01 Viruses, Bacteria, Algae and Bryophytes (Theory)
Credit: 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. 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; growth : growth kinetics, bacterial cell cycle; nutritional types of bacteria; modes of genetic exchange - transformation, transduction and conjugation.

2. Applied aspects: major industrial products from bacteria (Amino acids, Biopolymers, and recombinant products), waste water treatment, biodegradation, bioremediation, bioaugmentation and biofuels.

3. Association with vascular plants: symbiotic nitrogen fixation- *Rhizobium*, stem-nodulating

rhizobia, actinorhizae, *Agrobacterium*.

4. General account on actinomycetes, mycoplasmas, chlamydiae, spirochaetes, Rickettsia and Deinococcus-Thermus.

Viruses

1. Classification, 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 lyticcycles); viruses and cancers;

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 suppliments,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.
5. Applied aspects: biofuel production, food supplements, pharmaceutical industries, algal blooms, commercial cultivation of algae.
6. 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. General account of the anatomy, reproduction and life history of Marchantiales, Jungermanniales, Polytrichales and Anthocerotales.
3. Applied bryology: ecological uses, household uses, medicinal uses (herbal medicines, transgenic products), decorative bryophytes, aquarium bryophytes, heavy metal detection and clean up, erosion control, horticultural uses (soil conditioning, air layering, potculture, container gardens and hanging baskets), bioindicators of pollution.
4. Fossil bryophytes : a general account

References:

Madigan, M. T. et al. 2008. Brock Biology of Microorganisms. Benjamin Cummings
Prescott, L. M. et al. 2005. Microbiology. McGraw Hill
Singleton, P. 2004. Bacteria in Biology, Biotechnology and Medicine. Wiley.
Beck, J. V. et al. 1968. Laboratory Manual for General Microbiology. Burgess Pub. Co.

Pollack, R. A. et al. 2004. Laboratory Exercises in Microbiology. Wiley.
Chapman, V. J. 1941. An Introduction to the Study of Algae. Cambridge University Press.
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.
Irvine, D. E. & D. M. John. 1984. Systematics of the Green Algae. Academic Press.
Stevensen, J. *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.
Smith, G. M. 1978. Manual of Phycology. The Ronald Press Company.
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. 1972. Algal Biofertilizers and Rice Cultivation. Today and Tomorrow's publishers.
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.
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.
Schofield, W. B. 2001. Introduction to Bryology. The Blackburn Press.
Nair, M. C. et al. 2005. Bryophytes of Wayanad, Western Ghats. MNHS, Calicut.

BOT1C02. Viruses, Bacteria, Algae and Bryophytes (Practical)
Credit: 1
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.
5. Demonstration of bacterial motility by hanging drop method.
6. Isolation of *Rhizobium* from root nodules of legumes.

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 7 herbarium sheets).
2. Field collection and study of the types mentioned below and their classification up to generic level.

Chlorophyta: *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:
Asterella, Cyathodium, Riccia, Anthoceros, Bryum, Pogonatum, Targionia, Porella, Marchantia, Plagiochasm, Lunularia, Conocephalum.

References:

Madigan, M. T. et al. 2008. Brock Biology of Microorganisms. Benjamin Cummings
Prescott, L. M. et al. 2005. Microbiology. McGraw Hill
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Prescott, G. W.1969. The Algae. A Review. Thomas Nelson and Sons Ltd.
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Venkataraman, G. S. 1972. Algal Biofertilizers and Rice Cultivation. Today and Tomorrow's publishers.
Venkataraman, G. S., Goyal, S. K., Kaushik B. D., and Roychaudhary, P. 1974. Algae form and function. Today and Tomorrow's printers.
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Glime, J. M. & Saxena, D.1991. Uses of Bryophytes. Today and Tomorrows Printers & Publishers.
Schofield, W. B. 2001. Introduction to Bryology. The Blackburn Press.
Nair, M. C. et al. 2005. Bryophytes of Wayanad, Western Ghats. MNHS, Calicut.

BOT1C03 Fungi and Plant Diseases (Theory)
Credit: 3

Course Objectives:		
The main objectives of this course are to: 1. To acquire knowledge on diverse groups of fungi 2. To gain knowledge on the classification, structural organization and reproduction of Fungi. 3. To obtain knowledge on the life cycle patterns of fungi and their significance. 4. To obtain knowledge in the principles and methods of plant pathology and to learn the symptoms and control 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 forms	K1
2	Understand the diversity in habits, habitats and organization of fungi.	K2
3	Inherit knowledge on the exploitation of useful products from fungi for the betterment of human welfare	K3
4	Apply their acquired knowledge to know better about diseases of crop plants of Kerala, their causative organisms and their control measures.	K4
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

1. An overview of true fungi and fungal analogues (straminipilan 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; 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.
2. Updated phylum-level classification of true fungi by Tedersoo et al. 2018; current taxonomic concepts regarding straminipilan fungi and protistan fungi. 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,

conidomata, conidia and conidium ontogeny, other asexual propagules, teleomorph-anamorph connections.

6. Lichens: thallus structure, nutrition, reproduction, mutualistic interaction, ecological and economic significance.

7. Importance of the plant diseases; concept of plant disease; 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 pathogenic fungi, bacteria, mycoplasmas, nematodes and phanerogams; plant disease management; 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.

Kavanagh, K. 2017. Fungi, Biology and Applications 3rd edition. Wiley.

Kirk, P. M. et al. 2008. Dictionary of the Fungi, 10th Edition. CABI.

Nash, T. H. 2008. Lichen Biology 2nd edition. Cambridge University Press.

Rangaswami G. 1999. Diseases of Crop Plants of India, 4th ed. Prentice Hall of India.

Webster, J. and Weber, R. 2007. Introduction to Fungi. Cambridge University Press.

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.

BOT1C04 Fungi and Plant Diseases (Practical)

Credit: 1

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, cassava mosaic.
6. Isolation of pure culture of a fungal plant pathogen from a diseased plant.

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BOT1C05 Pteridophytes and Gymnosperms (Theory)
Credit: 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** - Undestand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

1. Introduction: A brief account of the origin and general characteristics.
2. DNA barcoding in Pteridophytes. The Pteridophyte Phylogeny Group (PPG 1).
3. Classification: An outline of recent system of classification of Pteridophytes.
4. Habitat diversity with special reference to South Indian Pteridophytes and their conservation. Endemic and endangered pteridophytes of South India.
5. Stelar organization, 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 speciations: Pteridophytes with low and high chromosome number; polyploidy in Pteridophytes; intergeneric and interspecific hybridity.
9. Ecological and economic significance of Pteridophytes.
10. A brief account on the diversity, distribution, habitat, external and internal morphology and mechanism of reproduction of sporophytes, gametophytic generation, sexuality and embryogeny of the following orders: a). Rhyniales; b). Psilotales; c). Lepidodendrales; d). Lycopodiales; e). Isoetales; f). Sphenophyllales; g). Cladoxylales; h). Marattiales; i). Ophioglossales; j). Osmundales; k). Salviniales; l). Filicales.

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.

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BOT1C06 Pteridophytes and Gymnosperms (Practical)
Credit: 1

Pteridophytes:

1. Study of morphology and anatomy of vegetative and reproductive organs of the following genera: *Psilotum, Lycopodium, Isoetes, Angiopteris, Ophioglossum, Osmunda, Salvinia, Azolla, Lygodium, Acrostichum, Gleichenia, Pteris, Adiantum* and *Asplenium.*

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.

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BOT1C07 Anatomy of Angiosperms & Microtechnique (Theory)
Credit: 3

Course Objectives:		
The main objectives of this course are to: 1. To classify meristems and to identify their structures, functions and roles 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 and the mechanism of water uptake by the plants. 4. To have firsthand information on various aspects of microtechnique, and its application in forensic science especially to identify plant fragments.		
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. Can help in the identification of adulterants in raw drugs used in pharmaceutical industry. Can utilize the expertise in forensic investigations.	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. To develop expertise in determining the quality of wood, and the age of the tree by examining the wood samples.	K3
4	To state the types of growth and to compare their structure and functions and processes of flower development.	K4
K1 - Remember; **K2** - Undestand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

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, vascular differentiation, development of aerenchyma, development of laticifers.
3. Vascular cambium structure and function; unusual features of structure and development in stems and roots: primary peripheral thickening meristem; anomalous stem and root structure.
4. Cambium in wound healing and grafting, cork-cambium, origin and function.
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. Root: development, structural organization of root apical meristem, developmental activities, developmental zones, longitudinal files of cells, quiescent centre concept and promeristem concept. T- division.
7. Leaf: development, structural diversity, anatomy of C3 and C4 plants. Ecological leaf anatomy, sun and shade leaves, xeromorphic leaves, succulent leaves, halophytic leaves and hydromorphic leaves.
8. 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 blocks and 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, insoluble carbohydrates & lipids. Enzyme histochemistry – General account.
8. Vital staining: Principle, procedure, and applications.

References:

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BOT1C08 Anatomy of Angiosperms & Microtechnique (Practical)
Credit: 1

Anatomy:

1. Anomalous secondary growth: *Dracaena, Bignonia, Amaranthus, Nyctanthes, Mirabilis, Bougainvillea* and beetroot.
2. Leaf anatomy: C3 and C4 plants, succulents, xeromorphic leaves, halophytes and hydrophytes.
3. Stomata: types, stomatal index.

Microtechnique:

1. 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 sectionsshould be submitted for evaluation.

References:

Beck, C. B. (2005). An Introduction to Plant structure and Development. Cambridge University Press.
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Ability Enhancement Course (AEC)
BOT1A01 The Process of Research (Theory)
Credit 2

1. The primary principles that define the scientific method: Empiricism, Determinism, Parsimony, Testability. The difference between 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; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, textbooks, current contents, Biological Abstracts: Web resources, E-journals, E-books, Search engines, Scirus, Google Scholar, Wiki- Databases, ScienceDirect, SciFinder, Scopus. The Internet and the World Wide Web. Internet resources for biosciences. Finding and citing published information. Reference management software.
3. 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.
4. Ethics in research: Ethical Guidelines for animal subjects. Ethics in reporting research: data errors and plagiarism. Checking documents for plagiarism.
5. Safety in the laboratory: General Safety and lab-safety procedures, Chemical, electrical and UV safety, safe handling of toxic and hazardous chemicals, storage and disposal of chemicals.
6. An overview of Intellectual property protection (IPP) and Intellectual property rights (IPR).

References

1. Wayne C. Booth et al. 2016. The Craft of Research, Fourth Edition. University of Chicago Press.
2. 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.
3. Anonymous. 2019. The Chicago Manual of Style. University of Chicago Press.
4. Barbara Gastel & Robert Day. 2016. How to Write and Publish a Scientific Paper, 8th Edition. Greenwood.
5. Mildred L. Patten & Michelle Newhart. 2017. Understanding Research Methods 10th Edition. Routledge.
6. Christopher M. Gillen. 2007. Reading Primary Literature: A Practical Guide to Evaluating Research Articles in Biology. Pearson.
7. E. Bright Wilson Jr. 1991. An Introduction to Scientific Research. Dover Publications.
8.W. C. Booth et al. 2016. The Craft of Research, Fourth Edition. University of Chicago Press.
9. Victoria E. McMillan 1997.Writing Papers in the Biological Sciences, Bedford Books, Boston.
10. Harrison W. Ambrose & Katharine Peckham Ambrose 1987. A Handbook of Biological Investigation, 4th edition, Hunter Textbooks Inc, Winston-Salem.
11. H.G. Gauch 2012. Scientific Method in Brief. Cambridge University Press.
12. N. M. Glazunov 2012. Foundations of Scientific Research. National Aviation University.

2nd Semester

BOT2C09 Plant Physiology (Theory)
Credit: 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 indepth 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; **K6** - Create		

1. Water and plant cells: Water in plant's life, properties. 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 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. Passive and active transport. Transport proteins: carriers, Michaelis-Menten Kinetics. Channels: Voltage dependent K+ channels, voltage gated channels, Calcium channels, vacuolar malate channels. ATPase activity and electrogenic pumps. Patch clamp studies. Application of Nernst equation. 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 photoassimilates- export. Starch and sucrose synthesis. Allocation and partitioning: Phloem loading and unloading. Concept of osmotically generated pressure flow. Importance of plasmodermata 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, differentiation and development: Analysis of plant growth: production of cells, growth velocity profile. Cytological and biochemical events. Differentiation: secondary cell wall formations, multinet growth hypothesis of cell wall. 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. Classification of seeds, 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, morphogenesis in cultured tissues; 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.

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 photophysiology, effect on stem elongation, gene expression, stomatal opening, proton pumps, phototropism, role of carotenoids.

12. Senescence and programmed cell death: Apoptosis and necrosis. Programmed cell death 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. 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.

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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.
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BOT2C10 Plant Physiology (Practical)
Credit: 1

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. Analysis of Phosphorus in plant tissues.
5. Separation of plant pigments by paper chromatography/ thin layer chromatography and absorption spectra of pigments separated.
6. Quantitative estimation of chlorophyll content using spectrophotometry.
7. Measurement of Photosynthesis - Hill Reaction
8. Measurement of Light Intensity and Light Transmission Ratio.
9. Measurement of growth rate using various parameters
10. Demonstration of Amylase activity and gibberellic acid effect in germinating cereal seeds.

11. Regulation of Seedling Growth by Plant Hormones
12. Protein estimation by dye binding method.
13. Estimation of proline in plant tissues under various abiotic stresses.
14. Determination of peroxidase activity in plant tissues affected by biotic/abiotic stresses
15. 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.

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BOT2C11 Biochemistry, Biophysics and Immunology (Theory)
Credit: 3

Course Objectives:		
The main objectives of this course are to: 1. Biochemical organization of cell and different types of macromolecules, their structure and function. 2. The student is able to understand different metabolic pathways 3. Practical exercises are designed to make the student relate the theoretical aspects to enzymes, their nomenclature, kinetics and functions 4. To student known the application and acquire laboratory skills biological significance of co-enzymes and minerals. 5. To acquire knowledge in the area of various biophysical techniques.		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Explain basic metabolic pathways of plants and formation of metabolites through various biosynthetic pathways in plants	K1
2	Utilization of radioactive isotopes in the investigation of biosynthetic pathways	K2
3	Acquire knowledge on immunological techniques	K3
4	Apply current biochemical and biophysical techniques to plan and carry out their experiments.	K4
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Biochemistry:

1. pH and buffers – properties of water, acids, bases and buffers, Henderson-Hasselbalch equation, pH, pKa, Kw, proton hopping, buffers in living system, common buffers.
2. Carbohydrate: introduction to mono-, di-, oligo- and polysaccharides, linear and ring structures, homo- and heteroglycans, major reactions of reducing and non-reducing sugars, 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.
3. Amino acids and proteins: amino acids – classification, properties, optical activity, unusual amino acids, ninhydrin reaction; biosynthesis and breakdown of 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.
4. Enzymology – structure, function and classification of enzymes, coenzymes, substrate specificity, regulation of enzyme activity, active sites, inhibitors, allosteric enzymes, kinetics, negative and positive co-operativity, multienzyme, isoenzymes, ribozyme, abzyme, detailed study of FAS and Rubisco, penicillin and magic bullet, suicidal inactivators, enzyme in curing Trypanosomiasis.
5. Lipids – classification, brief account on compound and derived lipids with examples, classification of fatty acids, biosynthesis of fatty acids (microbes, plants and animals), alpha, beta and omega oxidation of fatty acids, omega fatty acid and functional food, trans-fatty acids and their dangers, detailed study of coconut oil.
6. Nucleic acid: biosythesis and break down of purines and pyrimidines. Brief account on the types and conformation of DNA and RNA.

7. Vitamins and hormones: classification, structure, function and source of vitamins, vitamins as coenzymes, phytohormones – classification, structure, function and biosynthesis.

Biophysics:

1. Energy metabolisms - concept of free energy, entropy, enthalpy, chemical equilibria, principles of thermodynamics, thermodynamics of phosphate compounds, thermodynamics of life; thermodynamics, kinetics and mechanisms of membrane transport, energy rich bonds, redox reactions, synthesis of ATP, substrate level-, oxidative- and photo-phosphorylations.
2. Instrumentation, principles and functioning of: colorimetry and spectrophotometry, centrifugation, ultracentrifugation, electrophoresis, isoelectric focusing, chromatography (TLC, gel filtration, iron exchange, affinity, GC, GC-MS, HPLC, FPLC), NMR, X-ray crystallography, MRI, tools in nanotechnology (Atomic Force Microscopy, Scanning Tunneling Microscope, Scanning Probe Microscope), Fluorescent Microscopy, Flow-cytometry, liquid scintillation.
3. Radio isotopes, radioactive decay, radiations and their applications in biology.

Immunology:

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, applications of immunological techniques – ELISA, immunodiffusion, immunoelectrophoresis. Monoclonal and polyclonal antibodies, HAT medium.

References:

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Nelson, D. L. & Cox, M. M. 2008. Lehninger Principles of Biochemistry (4th Edn). W.H. Freeman and Co.

Pandey, A., Webb, C., Soccol, C. & Larnche, C. 2007. Enzyme Technology. Springer.

Rao, C. V. 2005. Immunology: A Text Book. Narosa Publishing House.

Sambrook, J. & Russel, D.W. 2008. Molecular Cloning – A laboratory manual (5th Edn). Cold Springer Harbor Laboratory Press.

Upadhay, A., Upadhay, K. & Nath, N. 2008. Biophysical Chemistry – Principles and Techniques. Himalaya Publishing House.

BOT2C12 Biochemistry, Biophysics and Immunology (Practical)
Credit: 1

1. Detection of non-reducing sugar in the presence of reducing sugar.
2. Quantitative estimation of reducing sugar from plant tissue by any suitable method.
3. Extraction and estimation of starch from plant tissue by a suitable method.
4. Colorimetric estimation of protein by Biuret method.
5. Colorimetric estimation of protein by Lowry et al. method.
6. Measurement of amylase/invertase/protease from any suitable plant/microbial source using suitable 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:

Alberghina, C. 2000. Protein Engineering in Industrial Biotechnology. Harwood Academic Publications.

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Upadhay, A., Upadhay, K. & Nath, N. 2008. Biophysical Chemistry – Principles and Techniques. Himalaya Publishing House.

BOT2C13 Plant Morphogenesis, Embryogenesis & Plant Biotechnology (Theory)
Credit: 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 asceptic 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; **K5** - Evaluate; **K6** - Create		

Plant Morphogenesis:

Basic concepts of plant morphogenesis. Totipotency, symmetry, polarity, differentiation, pattern formation. Factors influencing morphogenesis. Organisation of shoot and root apical meristem and the molecular basis of their development. Leaf development. Floral meristems and floral development in *Arabidopsis* and *Antirrhinum*.

Embryogenesis:

Microsporogenesis, pollen morphology, microgametogenesis, pollen-pistil interaction, female gametophyte in angiosperms, fertilization, endosperm, embryo, polyembryony, apomixis.

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:

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Maheswari, P. An introduction to Embryology of Angiosperms, McGraw Hill.

BOT2C14 Plant Morphogenesis, Embryogenesis & Plant Biotechnology (Practical)
Credit: 1

Acetolysis of pollen grains and study of pollen morphology.
Dissecting out embryos of different stages; types of embryogeny
Preparation of stock solutions: different media -
Preparation of solid and liquid media.
Inoculation technique: Culture of different explants.
Introduction of callus and organogenesis.
Anther, ovary, embryo culture; Meristem culture.
Cryopreservation
Production of synseed.
In vitro fertilization

References:

Bhojwani, S.S. and Razdan, M.K. 1983. Plant Tissue culture: Theory and Practice. Elsevier.
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BOT2C15 Environmental Biology (Theory)
Credit: 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	K2

	inter relationships	
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
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 groundwater sources, 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; levels of species diversity and its measurement; edges and ecotones.
Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.
Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones 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 and management.

References

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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 the Physical Environment, Rutledge.
Primack R.B. (2002), Essentials of Conservation Biology (3rd Edition), Sinauer Associates, Sunderland, SA
Saxena H. M. (2006) Environmental Studies, Rawat Publications
ShilpaShyam, H. N.Verma, S. K.Bhargava (2006), Air Pollution and its impact on plant Growth, 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.

BOT2C16 Environmental Biology (Practical)
Credit: 1

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 watersamples (pH, conductivity, turbidity, hardness, chloride, dissolved oxygen, free carbon dioxide, Biological Oxygen Demand,microorganismsetc.) using standard methods.
4. Determination of selectedair 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 analysisof vegetation using species-area curve method.
6. Determination of frequency (including heterogeneity), density and abundance ofspecies in a given area using quadrat method.
7. Determination of the Importance Value Index (IVI) of plant species in a communityby 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.

Professional Competency Course
BOT2A02-Biotechniques and Instrumentation (Practical)
Credit 2

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.

3rd Semester

BOT3C17 Angiosperm Taxonomy and Phytogeography (Theory)
Credit: 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	Can utilize the informations fromherbarium resources, and knowledge on botanical gardens in future studies, and in plant based industries.	K2
3	Can have an 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	Help to understand terms and concepts related to Phylogenetic Systematics	K4
5	To gain practical knowledge on identification of plant species using taxonomic literature and to understand local flora.	K5
K1 - Remember; **K2** - Undestand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

1. Taxonomy: 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. Taxonomic structure, taxonomic hierarchy, taxonomic categories – supraspecific and infraspecific categories; Concept of species, genus and family.
5. Modern trends in Plant Taxonomy: Biosystematics, Numerical Taxonomy: Phenetics and Cladistics; Cladistic methodology; methods of Molecular Taxonomy.
6. Molecular Phylogeny principles and procedure, classification of tree building methods: Maximum Likelihood and Bayesian analysis.Cladogram analysis. Brief account of DNA barcoding in plants.
7. Taxonomic characters: Concept of character, character variations and their taxonomic implications.
8. Plant description terminologies; method of describing a plant species using morphological characters.

9. General account on the sources of taxonomic characters: Morphology, Anatomy, Embryology, Cytology, Palynology, Phytochemistry.
10. 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.
11. Problems in Evolutionary taxonomy: Concept of primitive and advanced characters/groups, monophyly and polyphyly, parallelism and convergence, homology and analogy.
12. Practical identification of plants: Different kinds of Identification keys, Construction of dichotomous keys – Indented and bracketed keys.
13. Various kinds of Taxomonic literature: Floras, Revisions, Manuals, Monographs, Periodicals and Journals.
14. Methods of plant exploration; Management of Herbaria; Major Herbaria in India and the World; Role of Herbaria in taxonomy.
15. History of botanical studies in India; Hortus Malabaricus and its relevance to taxonomic studies; major centers of taxonomic and floristic studies in India; organization and functions of Botanical Survey of India (BSI).
16. Botanical Gardens: Role of taxonomy in biodiversity conservation.

Phytogeography:
Introduction to Biogeography. Aims and major approaches to the study of Phytogeography. Descriptive Phytogeopgraphy: Types of plant distribution: Continuous distribution; cosmopolitan, circumpolar, circumboreal or circum-austral, and pantropical; Discontinuous distribution; Theory of land-bridge, theory of continental drift, theory of polar oscillations or Shifting of poles, glaciations. Centers of origin and diversity of plants; Methods of dispersal, migrations and isolation; Theories on the distribution of plants: theory of age and area, theory of tolerance. Factors influencing plant distribution;. Floristic regions of the world: Vegetation Zones in relation to latitudes and altitudes; a brief account of the phytogeographical regions of India (recent classification by BSI); Endemics: Neoendemics and relics.

References:
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.
Davis, P. H. & Heywood, V. H. 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.
Hutchinson, J. 1959. The Families of Flowering plants. Oxford.
Mc Neill, J. et al. 2006. International Code of Botanical Nomenclature (ICBN) (Vienna Code). A.R.G. GautnerVerlag K.G.
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.
Kitching, I. J.et al. 1998. Cladistics – the theory and practice of Parsimony Analysis. Oxford University Press.
Manilal K. S. 1980. Botany and History of Hortus Malabaricus. Oxford & IBH Pub. Co.
Naqshi, A. R. 1993. An introduction to Botanical Nomenclature. Scientific Publishers.
Radford, E. A. 1986. Fundamentals of Plant Systematics. Harper & Row Publishers.
Simpson, M. G. 2006. Plant Systematics. Elsevier.
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.
Stace, C. A. 1989. Plant Taxonomy and Biosystematics. Edward Arnold.
http://www.iapt-taxon.org/nomen/main.php
Avise, J. C. (2000). Phylogeography. The History and Formation of Species. Harvard University Press.
Brown, J. H. & M. V. Lomolino (1998). Biogeography. 2nd Edition. Sinauer Associates, Inc.
Cox, C. B., Healey, I. N. & Moore, P. D. (1976). Biogeography. An Ecological and Evolutionary Approach. 2nd Edition. Blackwell Scientific Publications.
MacDonald, G. (2003). Biogeography: Introduction to Space, Time and Life. John Wiley & Sons, Inc.
Simmons, I. G. (1979). Biogeography: Natural and Cultural. Edward Arnold Ltd.
Whittaker, R. H. (Ed.) (1973). Ordination and Classification of Communities. In R. Tüxen (Ed. in Chief), Handbook of Vegetation Science. Part V. Dr. W. Junk b.v. Publishers.

BOT3C18 Angiosperm Taxonomy and Phytogeography (Practical)
Credit: 1

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, under the guidance and supervision of a teacher, 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 forty, well preserved, correctly identified and labeled herbarium specimens along with the field book and report for 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. Interpretation of maps, dendrograms, Landsat images pertaining to the vegetation distribution, continental drift.

References:

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.
Davis, P. H. & Heywood, V. H. 1973. Principles of Angiosperm Taxonomy. Robert R Krieger Publishing Co.
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Harris J. G. & M. W. Harris. 2007. Plant Identification Terminology. Spring Lake Publishing.
Hutchinson, J. 1959. The Families of Flowering plants. Oxford.
Mc Neill, J. et al. 2006. International Code of Botanical Nomenclature (ICBN) (Vienna Code). A.R.G. GautnerVerlag K.G.
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Kitching, I. J.et al. 1998. Cladistics – the theory and practice of Parsimony Analysis. Oxford University Press.
Naqshi, A. R. 1993. An introduction to Botanical Nomenclature. Scientific Publishers.
Radford, E. A. 1986. Fundamentals of Plant Systematics. Harper & Row Publishers.
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Avise, J. C. (2000). Phylogeography. The History and Formation of Species. Harvard University Press.
Brown, J. H. & M. V. Lomolino (1998). Biogeography. 2nd Edition. Sinauer Associates, Inc.
Cox, C. B., Healey, I. N. & Moore, P. D. (1976).Biogeography.An Ecological and Evolutionary Approach.2nd Edition. Blackwell Scientific Publications.
MacDonald, G. (2003). Biogeography: Introduction to Space, Time and Life. John Wiley & Sons, Inc.
Simmons, I. G. (1979). Biogeography: Natural and Cultural. Edward Arnold Ltd.
Whittaker, R. H. (Ed.) (1973). Ordination and Classification of Communities. In R. Tüxen (Ed. in Chief), Handbook of Vegetation Science. Part V. Dr. W. Junk b.v. Publishers.

BOT3C19 Genetics, Plant Breeding, and Biostatistics (Theory)
Credit: 3

Course Objectives:		
The main objectives of this course are to: 1. Apply quantitative problem-solving skills to genetics problems and issues. 2. Describe the chromosome theory, molecular genetics and quantitative and evolutionary genetics. 3. To learn Plant breeding methods and role of molecular markers in plant breeding		
4. To acquire a comprehensive understanding of the statistical tools for analysis in genetics and plant breeding techniques.		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Students will demonstrate an understanding of Mendelian and molecular genetics, cell structure, cell physiology, and molecular processes of cells. Understanding of the principles of evolution.	K1
2	To understanding the role of genetic technologies in industries related to biotechnology, pharmaceuticals, energy, and other fields. Understanding the role of genetic mechanisms in evolution. Understanding the different methods of plant breeding for the improvement of crop	K2
3	The ability to recognize the experimental rationale of genetic studies as they are described in peer-reviewed research articles and grant proposals.	K3
4	Students will demonstrate the ability to work effectively with computational, mathematical, and statistical approaches to acquire, analyze, and model experimental datasets. The ability to evaluate conclusions that are based on genetic data.	K4
5	Communication skills required in the discipline including oral presentations of research data, published research articles, grant proposals, and poster presentations at conferences	K5
6	They become well versed in summarizing and organizing the collected data as well as the logical presentation and analysis of the same	K6
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

Genetics:

1. Mendelism- Mendelian factors- segregation of mendelian factors- dominance, codominance and incomplete dominance of mendelian factors.
2. Independent assortment- interaction of genes- multiple allelism.

3. Linkage and joint segregation- Linkage analysis- mapping of genes- linkage and recombination in eukaryotes and prokaryotes- Mapping by different methods.
4. Quantitative genetics- Multiple factors- continuous variation- continuous and threshold traits- QTL- Heritability- transgressive variation.
5. Plasmagenes- cytoplasmic inheritance- chloroplast genes and mitochondrial genes- maternal inheritance- informosomes- Applications of extranuclear inheritance.
6. Genetics of sex determination- sex linkage- sex linked, sex influenced and sex limited characters- sex linked lethal mutations.
7. Genetics of photosynthesis
8. Genetics of Nitrogen fixation
9. Biometrical genetics- probability and genetics- prediction of genetic behaviour- statistical tools in genetic analysis.
10. Genetics of prokaryotes- genetic organization of bacteria and viruses- bacterial mutants- transformation, conjugation and transduction.
11. Developmental genetics- genetic control of development in plants- genetic control of cell lineages.
12. Behavioural genetics- general account
13. Applied genetics- Eugenics, euphenics and euthenics. Immunogenetics.
14. Regulation of gene action in prokaryotes and eukaryotes.
15. Genetic structure of populations and its change - Hardy–Weinberg equilibrium – Sewall Wright effect - changes in genetic structure, causes and consequences – speciation and evolution.

Plant Breeding:

1. Introduction- Objectives of plant breeding- History-Biological foundations of plant breeding- conventional techniques- advanced techniques- special methods.
2. Biological foundations of Plant breeding- Role of heredity and environment in character expression- Systems of reproduction in plants- Mating systems in sexually reproduced plants.
3. 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.
4. Plant propagation- sexual, pseudosexual and asexual methods- special methods of plant propagation- micropropagation.
5. Conventional methods of plant breeding- plant domestication, plant introduction, selection and hybridization.
6. Modern methods of plant breeding- mutation breeding, polyploidy breeding and distant hybridization. Biotechnological approaches in plant breeding.
7. 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- 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 curtosis.
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:

Sambamurthy A. V. S. S. Genetics. Narosa Publishing House.
Brooker R. J. Genetics: Analysis and Principles. Addison Wesley Longman Inc.
Hedrick P. W. Genetics of Populations. Jones and Bartlett Publishers.
Griffiths A. J. F., Gelbbart W. M., Lewontin R. C., Miller J. H. Modern Genetic Analysis. WH Freeman & Company.
Dabholkar A. R. Elements of Biometrical Genetics. Concept Publishing Company.
Frankel O. H. and Bennet E. Genetic Resources in Plants. Blackwell.
Hotter P. Text Book of Genetics. Ivy Publishing House.
Satpathy G. C. Genetics. Kalpaz Publications.
Sadhu M. K. Plant Propagation. New Age International Publishers.
Allard R. W. - Principles of Plant Breeding. John Wiley & Sons.
Jain H. K. and Kharkwal M. C. Plant Breeding. Narosa Publishing House.
Chahal G. S. and Gosal S. S. Principles and Procedures of Plant Breeding. Narosa Publishing House.
Mohanan K.V. Essentials of Plant Breeding. PHI Learning Private Limited, New Delhi.
Roy D. Plant Breeding. Narosa Publishing House.
Hayward M. D., Bosemark N. O. and Romagosa I. Plant Breeding- Principles and Prospects. Chapman and Hall.
Gupta S.K. Plant Breeding. Agrobios.
Khan M. A. Plant Breeding. Biotech Books.
Sharma J. R. Plant Breeding. Tata McGraw Hill.
Joshi R. M. Biosafety and Bioethics. Isha Books.
Pagano M. and Gauvreau K. Principles of Biostatistics. Duxbury.
Sharma J. R. Statistical and Biometrical Techniques in Plant Breeding. New Age International Publishers.
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.
Jasra P. K. Biostatistics. Krishna Prakashan Media (P) Ltd.
Radhakrishnan V.V., Hrideek T.K., Raghu A.V. and Chandramohanan K.T. Crops of Kerala - An overview. Gregor Mendel Foundation, Calicut University, Kerala.
Phundan Singh. Essentials of Plant Breeding. Kalyani Publishers, New Delhi.

BOT3C20 Genetics, Plant Breeding and Biostatistics (Practical)
Credit: 1

Genetics:

1. Problems based on independent assortment, gene interaction 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:

Kowles R. Solving Problems in Genetics. Springer.
Sambamurthy A. V. S. S. Genetics. Narosa Publishing House.
Brooker R. J. Genetics: Analysis and Principles. Addison Wesley Longman Inc.
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Frankel O. H. and Bennet E. Genetic Resources in Plants. Blackwell.
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Sadhu M. K. Plant Propagation. New Age International Publishers.
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Roy D. Plant Breeding. Narosa Publishing House.
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Gupta S.K. Plant Breeding. Agrobios.
Khan M. A. Plant Breeding. Biotech Books.
Sharma J. R. Plant Breeding. Tata McGraw Hill.
Joshi R. M. Biosafety and Bioethics. Isha Books.
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Sharma J. R. Statistical and biometrical techniques in Plant Breeding. New Age International Publishers.
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Rangaswamy R. A Text Book of Agricultural Statistics. New Age International Publishers.
Jasra P. K. Biostatistics. Krishna Prakashan Media (P) Ltd.

BOT3C21 Cell Biology & Molecular Biology (Theory)
Credit: 3

Course Objectives:

The main objectives of this course are to:

1. To understand the structures and functions of cell junctions and other sub-cellular components of prokaryotic and eukaryotic cells, especially cell barriers, junctional complexes, organelles, nucleus and sub-nuclear components.
2. To understand how these cellular components and sub-cellular structures are formed, and how they generate and utilize energy in cells.To study the underlying mechanism of cell cycle, mitotic and meiotic cell divisions.
3. Students can learn about human disorders due to malfunctioning of cell membrane, cell junctions, organelles and nucleus.
4. To understand the molecular structure of DNA and RNA & associated mechanisms viz., DNA replication, gene expression, gene regulation, mutation, DNA repair and recombination.
5. Students will apply their knowledge of cell and molecular biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes, or alterations of genetic material and cell function brought about by mutation.

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 cell biology and basic concept of molecular biology, structure of extra-cellular components and intra-cellular organelles and advanced molecular mechanisms.	K1
2	To understand the structure and function of basic components of prokaryotic and eukaryotic cells, especially its membrane organization and organelles	K2
3	To introduce to rapid contemporary changes witnessed in plant molecular biology.	K3
4	Basic organization of genetic material and the realms of events associated with replication, gene expression, DNA repair and recombination will be examined	K4
5	The subject provides knowledge about different mechanisms of cell and molecular biology.	K5
6	Students will gain knowledge about the basic and fundamental organization of life and genetic material and their applications.	K6

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

1. Cell Junctions & Barriers - Ultra structure & functions: plasmodesma, tight, gap, adherens & other junctions, cell junction signalling; cell envelops - bacterial, archaeal, fungal and plant cell walls, S-layer, cytorrhysis, hectian strands, membrane nanotubes, cell membrane, membrane fluidity, potential & transport, intracellular & extracellular receptors, porosomes, ABC & SLC transporters; cell membrane & junction disorders

2. Cell Organelles - Ultra structure & functions: mitochondria, plastids, GERL complex: mitochondrial import, export, chondrome, ATP synthase, chaperones & chaperonins, kinetoplast, mitochondrial heterosis; plastid - types, photosynthetic domains, chloroplast import, plastome & transplastomics, CAB binding proteins, statoliths, stromules, chlorosomes, phycobilisomes & chromatophores; mitochondrial & plastid engineering; cell vacuoles, endocytosis & exocytosis, endosomes, exosomes, mitosomes, ejectosomes,

cellular trafficking, microvesicles; prokaryotic organelles

3. Microbodies – Structure & functions: glyoxisomes, peroxisomes, hydrogenosomes, oxalosomes, glycosomes, nif & senescence microbodies, Weibel-Palade body; ribosomes, biogenesis, types (prokaryotic, eukaryotic, cytoplasmic, organellar), structure, components & active sites, ribosomal dimers, polysomes, RRF, ribosomopathies, ribosome profiling, shunting & inactivators; proteasome; melanosome, tannosome.

4. Nucleus - Ultra structure & functions: nuclear membrane, pore complex, nucleoporins & transport; eu-, hetero-, pro- & anti-chromatin, CAF, centric heterochromatin, chromatin structure remodelling (RSC) complex, salt-and-pepper chromatin; nucleolus, perinucleolar compartment (PNC) & Cajal body; nuclear matrix, lamina & dot (PML body), paraspeckle, clastosomes, condensin, cohesin, prokaryotic and eukaryotic SMCs, transition nuclear proteins; nuclear envelopathies & laminopathies

5. Chromosomes - Ultra structure & organization: cytogenetic notation, karyotype, kinetochore, centromere proteins, satellites, SAT chromosomes, chromomeres, telomere & aging, telomerase, chromosome knobs, core, scaffold, coiling & compaction; nucleosome, histone modifying enzymes, HIstome, non-histone & HMG proteins, MCM proteins; special types - polytene, lamp brush, B-, micro-, mini-, mega-, neocentric & holocentric & parasitic chromosomes; giant & lampbrush-type chromosomes in plants

6. Cytoskeleton & cell cycle - 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, mitosis & meiosis, mechanisms, cyclins & CDKs, cyclosomes, cell cycle inhibitors, synaptonemal complex, centrosome & cancer, undulipodium, human cytoskeletal defects, ciliopathy; prokaryotic cytoskeleton, cytoskeletal drugs

7. DNA, molecular structure & associated mechanisms - types of DNA (super helical-circular, nicked-circular, linear, satellite, selfish), forms of DNA - A, B, C, D, E, H, Z, RL helix & triple helix; organellar DNA (ct DNA & mt DNA), si DNA; DNA bending & binding, G-quadruplex, DBD & DNA binding proteins; DNA replication – types, events & enzymology of replication, replisome, concurrent, simultaneous & bidirectional replication, rolling circle model & θ replication; DNA synthesis In Vitro.

8. RNA, gene expression & regulation - RNA genomes, transcription in prokaryotes & eukaryotes, RNA processing, splicing & spliceosomes, introns, intron homing, exons, exon shuffling, RNA editing; structure of RNA - rRNA, mRNA, tRNA (clover leaf model & 'L'- shaped tertiary model), tmRNA, snRNA, snoRNA, hnRNA, miRNA,piRNA, siRNA, tasiRNA, shRNA & stRNA; genetic code & exceptional codons; protein synthesis & inhibitors; prokaryotic & eukaryotic gene regulation, metabolite & amino acid operons, coordinate gene regulation, trans-splicing, fusion transcript

9. Mutation & DNA repair - somatic & germinal mutations, spontaneous & induced mutations, error-prone replication/repair mutation, direct and indirect DNA damage, environmental mutagens, molecular basis of mutation, homeobox, trinucleotide repeat expansion, DNA repair mechanisms (light-dependant-, excision-, mismatch-, post replication- & SOS-repair), senescence & apoptosis, DNA repair-deficiency disorders

10. 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, site-specific recombination, gene conversion, hetero-duplexes & recombinational probes; V(D)J/somatic, Cre-Lox & FLP-FRT recombination

References:

1. 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.

2. Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz, Graham T. Johnson 2017. Cell Biology. Elsevier, Amsterdam.
3. Gerald Karp 2016. Cell and Molecular Biology: Concepts and Experiments. 8th Edition, Wiley, NJ, USA.
4. Harvey Lodish, Arnold Berk, Chris A. Kaiser and Monty Krieger 2016.Molecular Cell Biology. 8th Edition, W. H. Freeman, NY, USA.
5. Leland Hartwell, Michael L. Goldberg, Janice A. Fischer 2015. Genetics: from genes to genomes. McGraw-Hill Education, New York, NY
6. 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.
7. Jeff Hardin, Gregory Paul Bertoni & Lewis J. Kleinsmith 2011. Becker's World of the Cell. 8th Edition, Benjamin Cummings, San Francisco, California, USA.
8. Stephen R. Bolsover, Elizabeth A. Shephard, Hugh A. White & Jeremy S. Hyams 2011. Cell Biology: A Short Course Wiley-Blackwell, NJ, USA.
9. Barbara A. Somervill 2011. Plant Cells and Life Processes. Raintree Publishers, Brunel Road, Houndmills, UK.
10. Brad Fitzpatrick 2011. Cells: The Building Block of Life – Plant Cells. Chelsea House Publishers, New York, USA.

BOT3C22 Cell Biology & Molecular Biology (Practical)
Credit: 1

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

References:

Celis, J. E. 1994. Cell Biology: A Laboratory Hand Book. Vol. 1-3 Academic press, Inc.
Barch, M. J. et al. 1997. The AGT Cytogenetics Laboratory Manual (3rd edn), Lippencott-Raven Publishers.

Jahier, J. 1996. Techniques of Plant Cytogenetics.Oxford & IBH Publishing Co. Pvt. Ltd.
Singh R. J. 1997. Plant Cytogenetics. CRC Press.
Sharma, A. K. & Sharma A. 1990. Chromosome Techniques – Theory & Practice. Butterworths & Co.
Rickwood, D. & Harris, J. R. 1996. Essential Techniques: Cell Biology. Promega.
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.
Bonifacino, J. S. 2003. Short Protocols in Cell Biology. John Wiley & Sons Inc.
Lloyd, R. V. 2004. Morphology Methods: Cell and Molecular Biology Techniques. Humana Press.

BOT3C23 Genetic Engineering & Bioinformatics (Theory)
Credit: 3

Course Objectives:

The main objectives of this course are to:

1. To provide the knowledge on bioinformatics and its applications and to familiarise students with nucleotide and protein databses and how to evaluate the sequences for homology
2. To understand and develop phylogenetic tree construction using various tools and prediction of neceotide sequencesto develop primers for pcr reaction, the computational biology of sequencing and gene mining and visaulisation 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 , seconday structure prediction etc.	K3
4	To explain how genetic engineering involves the use of recombinant DNA technology for crop improvement and to identify the molecular markers for selection of superior genotypes. Execute appropriate algorithms to identify the similarities and dissimilarities in biological samples.	K4
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

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

Genetic Engineering

1. Molecular Techniques: DNA markers & DNA probes, DNA Sequencing methods (Maxam & Gilbert, Sanger *et al*., capillary), RNA Sequencing, Sequanator, *In situ*

hybridisation (DIRVISH & FISH), PRINS, colony hybridisation, dot & slot blots; blotting (Southern, Northern, Western, South-Western & North-Western), RFLP, RAPD,

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. Human genome project.

2. 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, gene library; comparison of cloning vectors.

3. Gene transfer in prokaryotes and eukaryotes: Recombinant viral method; DNA-mediated gene transfer; protoplast fusion, micro-cell fusion; metaphase chromosome transfer; liposome mediated gene transfer; microinjection & electroporation; biolistics & organelle engineering.

5. Transgenesis in plants: Somaclones; plant cell - bacterium hybrids; biociders; biological control; pathogen resistance; herbicide resistance; stress resistance; homozygous cultivars; enrichment of storage proteins; 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, 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. Hidden Markov Models (HMMs), and threading methods. 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

INSILICO 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, Calculation of Molecular Properties using Energy Calculations (no derivation). Conceptual numericals.

References:

Genetic Engineering

1. Lewin B (2009). Genes IX. Humana Press.

2. Flynne WG (2008). Biotechnology and Bioengineering. Nova Science Publishers
3. Lipps, G. (2008). Plasmids: Current Research and Future Trends. Caister Academic Press.
4. Torr, J. D. (2006). Genetic Engineering-Current Controversies. Greenhaven Press.
5. Engdahl, S. (2006). Genetic Engineering-Contemporary Issues. Greenhaven Press, San Diego, USA.
6. Magnien, E. & De Nettancourt, D. (1985). Genetic Engineering of Plants and Micro-Organisms Important for Agriculture. Springer Verlag.
7. Fox, M. W. (2000). Beyond Evolution: The Genetically Altered Future of Plants, Animals, the Earth ... and Humans. Lyons Press.
8. Ho, R. J. Y. & Gibaldi, M. (2003) Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs. Wiley-VCH.

Bioinformatics

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

BOT3C24 Genetic Engineering & Bioinformatics (Practical)
Credit: 1

A. 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.

B. Bioinformatics

1. Exercises on Windows, Linux, UNIX, Networking, Internet search & Graphics.

2. Usage of Software for identification - Accessing existing databases on the World-wide Web; Software for identification of species;
3. Usage of softwares to elucidate structure of biomolecules, docking of molecules & molecular designing/modelling; Analytical software related to Genomics and proteomics.
4. Usage of similarity, homology and alignment softwares; Software of Microarray analysis – design, processing and analysis.

References:

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

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

4th Semester

Elective Courses

BOT4E01 Theoretical Aspects of Angiosperm Taxonomy (Theory)
Credit: 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 and their 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.
Mc Neill, J. et al. 2006. International Code of Botanical Nomenclature (ICBN) (Vienna Code). A.R.G. Gautner Verlag K.G.
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 Publishing House.
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.

BOT4E02 Applied Aspects of Angiosperm Taxonomy (Theory)
Credit: 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 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: Aquatic Plants, 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 KBD, IPNI, Digitizing herbaria.

5. International Code of Nomenclature for Algae, Fungi and Plants (ICN): Articles governing Effective and Valid Publication; Priority of names; Typificafion - Lectotypification, Neotypification, Epitypification; Rejection and retention of names; Conservation of names; Alternative names; Basic rules of species names; Common technical terms in nomenclatural citations- basionyms, Synonyms, Autonyms, Tautonyms, Homonyms.

6. Procedure involved in the recognition and publication of new plant species.

7. Preparation of taxonomic research articles for publication: format and major components of the article. Publication ethics.
8. Preparation of Floras, Monographs and Revisions; common format of nomenclatural citations.
9. Major sources of general Taxonomic references: Index Kewensis, Index Londinensis, 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 the building, 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.

Dahlgren, R. H. T., Clifford, & P. F. Yeo. 1985. The Families of Monocotyledons. Springer-Verlag.

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. & Moore, D.M. 1984. The Current concepts in Plant Taxonomy. Academic Press.

Hutchinson, J. 1959. The Families of Flowering Plants. Oxford.

Mc Neill, J. et al. 2006. International Code of Botanical Nomenclature (ICBN) (Vienna Code). A.R.G. Gautner Verlag K.G.

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.

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Nair, P.K.K. 1971. Pollen Morphology of Angiosperms. Vikas Publications.
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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.

BOT4E03 Fungal Biology and Technology (Theory)
Credit: 4

Course Objectives:		
The main objectives of this course are to: 1. To study the various aspects of the biology of fungi 2. To have an insight on fungal genetics 3. To obtain knowledge on 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	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,enzyme induction 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.

3. Fungal genetics: Heterokaryosis, sexual compatibility and mating types, parasexuality, vegetative incompatibility.
4. Fungal spores: diversity, passive and active mechanisms of spore discharge, spore dispersal.
5. 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.
6. Fungi in pathological relations of agricultural importance: fungi as parasites of plants, fungi as parasites and predators of nematodes, fungi as parasites of arthropods, biological control utilising fungi.
7. Fungi of medical interest: mycoses, mycotoxins, and mycetism.
8. Fungi as mutualistic symbionts: lichens, mycorrhizae, endophytes, fungi as insect symbionts, anaerobic chytrids in herbivores.
9. 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; fungi and production of alcoholic beverages: wine, beer, distilled spirits; 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:

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Kavanagh, K. (ed.) 2005. Fungi – Biology and Applications. 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.

BOT4E04 Fungal Systematics (Theory)
Credit: 4

Course Objectives:		
The main objectives of this course are to: 1. To gain knowledge on diverse groups of fungi including true fungi and fungal analogues 2. To know the current status of systematics of true fungi 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	K4

	of fungi	
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 fungalculture 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.
11. Updated classification of true fungi by Tedersoo et al. 2018; current taxonomic concepts regarding straminipilan fungi and protistan fungi.

References:

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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.
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BOT4E05 General Bryology (Theory)
Credit: 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. Fossil bryophytes; fossil Hepaticopsida, fossil Bryopsida, Naiadita.
7. Morphological and Anatomical studies on: Marchantiales (*Asterella, Reboulia, Marchantia, Dumortiera, Targionia, Cyathodium*); Ricciales {*Riccia*); Fossombroniales (*Fossombronia*); Metzgeriales (*Pallavicinia, Riccardia, Metzgeria*); Jungermanniales (*Jungermania*); Porellales (*Porella, Frullania*); Polytrichales (*Pogonatum*); Bryales (*Bryum*); Dicranales (*Garckea, Campylopus, Octoblepharum*); Funariales (*Funaria*); Pottiales (*Hyophila*)
8. Reproduction: Vegetative, Sexual; alternation of generations.

References:

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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.

BOT4E06 Applied Bryology (Theory)
Credit: 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 in Southern India, and other parts of the world.	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; **K6** - Create		

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, chemical constituents and physiological ecology,
6. Bryological Research Centres of the world; major Herbaria.
7. Bryological literature and resources;- lndex 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:

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.

BOT4E07 Cell Biology (Theory)
Credit: 4

Course Objectives:

The main objectives of this course are to:

6. The students can understand the various techniques used in Cell Biology for the detailed analysis of cell and cell organelles.
7. They can learn about the organization of biomembranes and the various signaling pathways within the cell.
8. 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.
9. To learn the various aspects of karyomorphology along with the different structural and numerical mutations in chromosomes.
10. To understand what is cancer, the different types, various carcinogens, the genes involved and the cancer gene therapy.

11. The students will get indepth 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
6	Creative knowledge of the students will be enhanced by inculcating recent cytogenetic characterization techniques	K6
K1 - Remember; **K2** - Undestand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

1. Techniques to study cell: differential centrifugation, cell-sorters, Dynabeads, hemo- & flow cytometers, Coulter counter, cell tracking, cell-culture, cell bank, cell-disruption,cell-fractionation, cell-incubator; microscopes -digital, interference, reflection, super- resolution & TIRF microscopy, cytophotometry, micro-densitometry; biophotonics, single-cell analysis& cytomics

2. Biomembranes & cell signaling: organization of biomembranes, podosomes, invadopodia, synaptosome, acrosome, argosome, melanosome; paracytophagy, membrane channels, signal transduction across membranes, biological crosstalk,SRP; channel-linked, enzyme-linked & GPC receptors, messengers, & plant signals, vesicular transport; protein sorting, signal peptide, protein translocation & secretory pathway

3. Phases & checkpoints of cell cycle: cell cycle proteins- cyclins, CDKs, CDK inhibitors, INK4a/ARF, cip/kip, p53, p63 & p73, CAS, E2F, MPF, Wee, Culin; cyclosome, cell cycle regulation, Programmed cell death, apoptosis in plants; Anoikis, Pseudoapoptosis, paraptosis, pyroptosis & Parthanatos;cellular growth & growth retardation, Klerokinesis; chemical effects on microtubule dynamics & cell cycle defects

4. Karyotype & karyomorphometry: common stains used for cytological studies, flurochromes,Diff-Quik and Pap stain,chromosomal nomenclature, karyomorphometrical techniques & centromeric indices, centromere protein A, B, C1, C2, E, F, H, I, J, K, M, N, O, P, Q & T; chromosomal polymorphism & banding, types & techniques - H, G, C, T, N, R, Pr, Q & F banding; International System for Human Cytogenetic Nomenclature (ISCN)

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, aneuploidogens; human genetic variation, haplotype, human numerical syndromes

6 Structural variations in chromosomes: chromosome diminution, translocation heterozygotes, Renner complex (α- & β complex), breakage-fusion-bridge cycle; genetic

consequences of cytotoxicity, cytotoxic agents; genetic time bombs & genetic sterilization; human structural syndromes, Ph chromosome, fragile sites, hot spots& cold spots; prenatal diagnosis – amniocentesis, chorionic biopsy & umbilical sampling; dbCRID

7. Radiation cytology: isotopes, radioactive labels, radioactive tracers & applications, biological, physiological & chromosomal effects of radiations, radiation chimeras, radiation hazards, nuclear and radiation accidents, radiation hazard assessment, radiation assessment detector, molecular imaging of radioactive material, radiation protection, safety guidelines; acute radiation syndrome, nuclear medicine & radiation therapy; radioactive waste disposal & nuclear reprocessing

8. Cytology of cancer: benign & malignant tumours, metastasis, transformation & differentiation; precancerous condition & paraneoplastic syndrome; cancers (adenoma, carcinoma, lymphoma, sarcoma, melanoma, blastoma, papilloma & leukemia), interaction with normal cells, chromosome rearrangements & cancer, double minute, genetic tumors, chemical carcinogenesis & teratogenesis, carcinogens & teratogens, tumor suppressor genes, oncogenes, oncovirus & cancer bacteria, radiation & DNA repairin carcinogenesis & cancer gene therapy.

9. Cytogenetic characterization techniques: image cytometry, magnetic-activated cell sorting, electrophoretic karyotyping,cytological markers, cytological maps, chromosome combing, FISH, Q-FISH, GISH & CISH, chromosome painting, whole chromosome painting probe, Harlequin staining, digital karyotyping& spectral karyotyping (SKY); array-comparative genomic hybridization, SNP array& virtual karyotyping, DECIPHER

10. Advances in cell biology: chromosome engineering, chromosome uptake, chromosome library, centromere activation, centromere mapping in eukaryotes, time- lapse microscopy & micro-cinematography; stem cells, stem cell markers, current progress in embryonic stem cells, plant stem cells & applications, cell therapy; biomarkers & artificial cell; synthetic membrane & membrane technology; High throughput cell biology, cellomics.

References

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Thomas D. Pollard , William C. Earnshaw, Jennifer Lippincott-Schwartz and Graham T. Johnson 2017. Cell Biology, Second edition. Philadelphia, PA Saunders/Elsevier

Agatha Wilson 2017. Essential Plant Cell Biology, Syrawood Publishing House, USA.

Gloria Doran 2016. Molecular Cell Biology, Syrawood Publishing House, USA.

George Plopper 2016. Principles of Cell Biology. Jones & Bartlett, Burlington, USA.

Ron Milo and Rob Phillips 2015. Cell Biology by the Numbers. 1st Edition, CRC Press, USA.

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Lynne Cassimeris, George Plopper & Viswanath R. Lingappa 2010. Lewin's Cells. 2nd Edition, Jones & Bartlett, Burlington, USA.

William V. Dashek and Marcia Harrison 2010. Plant Cell Biology. Science Publishers, New Hampshire, USA.

BOT4E08 Molecular Biology (Theory)
Credit: 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** - Undestand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create		

1. Molecular structure of chromosomes - centromere (point & regional), monopolin, telomere & mega-telomere, telomerase & telomestatin, telomere-binding proteins, nucleosomes, chromatosome, DNA packaging & packing ratio, chromosomal proteins, DNA sequences (highly repetitive, moderately repetitive & unique sequences); micro DNA, cDNA, gDNA, msDNA; chromosome conformation capture
2. Nucleic acids - structure & biosynthesis; nuclear, organellar (cpDNA, mtDNA) & cloning vector (phagemid, plasmid, lambda phage, cosmid, fosmid, PAC, BAC, YAC, HAC) DNA, DNA & RNA genomes, C-value, C-value paradox, different classes of DNA & their reassociation kinetics & Cot-values; nucleic acid analogs (XNA, GNA, TNA, HNA, LNA, PNA, Morpholino),bridged nucleic acid, nucleolin
3. DNA replication - enzymology of initiation, synthesis & termination, multiple replicons, pulse chase analysis, cpDNA-, mtDNA- & plasmid-DNA replication, CNV, VNTR, Y-STR, tandem exon duplication, segmental duplication, big gene, oscillating gene & pseudogene, nucleosome duplication, chromosome termini replication, DNA re-replication, duplication syndrome & DNA replication disorders

4. Gene expression - prokaryotic & eukaryotic gene expression, reporter genes, GUS reporter, promoters, enhancers, transcription factors, Transcriptional bursting, polycistronic messengers, structure of eukaryotic mRNA, rRNA & tRNA, RNA-binding proteins; protein sorting & targeting; gene expression/regulation disorders; other types of RNA (pre-mRNA/hnRNA, tmRNA, miRNA, siRNA, piRNA, snRNA, snoRNA, gRNA, shRNA, stRNA, ta-siRNA, sgRNA, sutherland RNA); ribonomics

5. Repair & recombination of genes - role of rec. A in repair & recombination of DNA, base excision repair, 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,molecular models of recombination in prokaryotes & eukaryotes, meiotic recombination checkpoint, homologous recombination & gene silencing; TILLING

6. Mobile genetic elements - 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- & Alu elements, LINEs, SINEs & L1 elements; TEs & mutation, TEs & evolution, transposon tagging, TEs & transgenesis; repeatome, trinucleotide repeat disorders

7. Gene regulation: bacterial gene control, eukaryotic gene control, epigenetic regulation , transcriptional &post-transcriptional regulation (sequestration, alternative splicing, miRNA), translational &post-translational regulation (reversible, irreversible), regulatory sequences in eukaryotic protein coding genes, transcription activators & repressors, operon concept, different types, regulons, modulon, stimulon, constitutive mutants, bacterial & eukaryotic transpositions.

8. Nucleic acid characterization techniques: extraction of DNA & RNA, detection of repeated DNA sequences, DNA renaturation kinetics, restriction mapping, DNA profiling & footprinting, ribotyping, chromosome walking & jumping; genetic disease diagnosis, DNA amplification, DNA miroarray, whole genome sequencing, SHOM & FAIRE-Seq, protein sequencing, sequanator; exon connection, reverse genetics &recombinase-mediated cassette exchange, RNA interference; HGT, gene theft & gene diagnostics, Human Variome Project, nucleic acid analogs & probes

9. Genetically modified products – GMOs, GMCs & GM foods, anti-sense therapeutics, genoceuticals, fusion biopharmaceuticals, biopharming, protein engineering, metabolite engineering & nif-engineering, novel antibiotics & phytovaccines, antiviral compounds, artificial sweetners, biocosmetics & biopesticides; biosteel & genetically modified bioplastics; detection of GMOs, GMO controversies; biowarfare

10. Techniques for genetic improvement: cloning of organellar genes, site directed & signature-tagged mutagenesis, gene knockout & knock-in, gene editing, gene therapy & enhancement, synthetic lethality &rescue, gene transfer techniques, organelle sequence transfer, sperm-mediated gene transfer, bioluminescence, sperm typing, cisgenesis & transgenesis, antisense technology; lipidomics & metabolomics

References:

Roger L. Lundblad and Fiona Macdonald 2018. Handbook of Biochemistry and Molecular Biology. 5th Edition, CRC Press, Taylor & Francis Group, USA.

James D. Watson, A. Baker Tania, P. Bell Stephen, Gann Alexander, Levine Michael and Losick Richard2017. Molecular Biology of the Gene. 7th Edition, Benjamin Cummings, San Francisco, California, USA.
Jocelyn E.Krebse, Elliott S. Goldstein and Stephen T. Kilpatrick Lewins 2017. GENES XII 12th Edition, Jones and Bartlette Learning, Burlington, USA.
Alison Snape, Despo Papachristodoulou, William H. Elliott and Daphne C. Elliott 2014. Biochemistry and Molecular Biology, Oxford University Press, UK.
David P. Clark and Nanette J. Pazdernik 2013. Molecular Biology, Academic Press, USA.
Russell Jones, Helen Ougham, Howard Thomas & Susan Waaland, 2012. The Molecular Life of Plants. Wiley-Blackwell, NJ, USA.
Lizabeth A. Allison 2012. Fundamental Molecular Biology. 2nd Edition, Wiley-Blackwell, NJ, USA.
David P. Clark & Nanette J. Pazdernik 2012. Molecular Biology. 2nd Edition, Academic Cell, Massachusetts, USA.
Michael M. Cox, Jennifer Doudna & Michael O'Donnell 2011. Molecular Biology: Principles and Practice. W. H. Freeman, NY, USA.
Robert F. Weaver 2011. Molecular Biology 5th Edition,McGraw-Hill, NY, USA.

BOT4E09 Ecological Aspects of Plant Functions
Credit: 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	
5. To know about various plant defense mechanisms	
6. To get deeper knowledge on ecosystem and biomass productivity	
Expected Course Outcome	
1. Will help tp recognize plant water interaction	K1
2. Will help to find out new 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
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 micro organisms 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 micorrhizal 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 carotinoids 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.

7. Ecological biochemistry: allelopathy and defense mechanism, defense against herbivores, qualitative and quantitative defense compounds, mode of mechanism for plants 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.

8. 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.

8. 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.

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MadhavaRao, K.V., Raghavendra, A.S. and Janardhan Reddy, K. 2006. Physiology and Molecular Biology of Stress Tolerance in Plants.Springer.

BOT4E10 Physiology of Plants under Stress
Credit: 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 the various stresses on plant	
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 plant to overcome it	
5. To obtain a thorough knowledge on various priming techniques	
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 osmolites 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 ethyleneproduction 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. Competition and other biotic influences: Mycorrhiza and herbivory.

References:

Shaw, A.J. 1990. Heavy Metal Tolerance in Plants: Evolutionary Aspects.CRC Press.
Chakraborty, U. and Chakraborty B. 2005. Stress Biology. Narosa Publishing House.
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. and Strzalka, K. 2002. Physiology and Biochemistry of Heavy Metal Detoxification and Tolerance in Plants.Kluwer Academic Publishers.

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Prasad, M.N.V. 2004. Heavy Metal Stress in Plants: From Biomolecules to Ecosystems. IInd Ed. Springer-Verlag.
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.
Jisha, K. C., Vijayakumari, K., &Puthur, J. T. (2013). Seed priming for abiotic stress tolerance: an overview. Acta Physiologiae Plantarum, 35(5), 1381-1396.
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BOT4E11 Basic Environmental Science
Credit: 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 locallevels- 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.

Reference:

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.
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Smith, R.L. and Smith, T.M. 1998. Elements of Ecology (4th Edition). The Benjamin Cummings Publishing Co.
Cunningham, W.P. and Saigo, B.W. 1999. Environmental Science (5th Edition) McGraw Hill.
Chapman, J.L. and Reiss, M.J. 1992. Ecology-Principle and Application, Cambridge University Press.
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.

BOT4E12 Applied Environmental Science
Credit: 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; **K6** - Create

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 (Radio active) 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, Bioflocculation
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:

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.
Mackenzie, A. ball, A.S. and Virdee, S.R. 2002. Ecology (2nd Edition). Viva Books Ltd.
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Chapman, J.L. and Reiss, M.J. 1992. Ecology-Principle and Application, Cambridge University Press.
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.

BOT4E13 Principles of Ethnobotany
Credit: 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.

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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.
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Ranfrew, Jane. 1973. Paleoethnobotany. Columbia University Press.

BOT4E14 Applied Ethnobotany
Credit: 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 practical 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, Plant identification. 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 of income; Protecting local resources.
7. Commercialization and conservation: Sustainable development - Economic growth and resource 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 of herbaria. Bull. Bot.Surv. India19:256-261.
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Ranfrew, Jane. 1973. Paleoethnobotany. Columbia University Press.

BOT4E15 Plant Tissue Culture

Credit: 4

Course Objectives:		
The main objectives of this course are to: 1. Understand the basic methods used in plant tissue culture 2. Develop and utilise 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 variousmethods	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	Can use these technique to mass propagater the plants and can use to for	K5

	agriculture and afforestation programes	
K1 - Remember; **K2** - Undestand; **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 regulators; growth retardants; undefined supplements; explants; sterilization; Inoculation; subculturing, etc.
3. 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.
4. Organogenesis- different types; factors effecting; problems related to micropropagation of woody (Medicinal) plants. Different stages of micropropagation, Somaclonal variation and its importance with special reference to medicinal and aromatic plants.
5. Somatic embryogenesis: direct and indirect; Factors effecting; embryo maturation; application. Synseeds and its significance.
6. Production of Pathogen free plants: Different methods; Meristem culture and its importance in commercialization especially of Medicinal and Aromatic plants.
7. Protoplast: Isolation and culture methods; Factors effecting; Somatic hybridization: Different types; Fusion methods. Application with special reference to Medicinal and Aromatic plants.
8. Haploids: Different types: Androgenesis and gynogenesis, Advantages; Significance in crop improvement with special emphasis on Medicinal and Aromatic plants.
9. Ovary, ovule, endosperm and embryo culture; importance. *In vitro* fertilization (recent advances) and its significance.
10. Secondary metabolites: Different classes; methods of production- factors effecting yield. Biotransformation; Different types with examples. Immobilization: Different approaches: Advantages.
11. Tissue culture in lndia with special reference to Kerala. Exploitation of medicinal plants of Kerala by Tissue culture.
12. 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.
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 Publishing Co. Pvt. Ltd.

BOT4E16 Plant Biotechnology
Credit: 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 variious agents 3. Understand the methods used for developing environment adaptive quality palnts 4. Understrand the environmental risks due to transenic technology		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	To understand the basic concepts of heterologous geen transfe	K1
2	Understand the mechanismof different types of gene construction and development of transgenic plants for human welfare	K2
3	Apply the technique of transgenics for developing important prodcuts like growth factors, hormones etc in plants	K3
4	Analyze the pros and cons of transgenic technology with reference to the new prodcuts released for human consumption	K4
K1 - Remember; **K2** - Undestand; **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, Parasite resistance.
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, alkaloides 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. Biorisks 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. Bioflocculation. Biosensors. Biochips. Biofertilizers-significance. Biological Nitrogen Fixation- nif genes- structure, transfer prospects. Nitrogenase biochemistry, function.

References:

Purohit SS. Biotechnology: Fundamentals and application. Agrobios.
Philipose PM. Experimental Biotechnology. Dominant Publishers & Distributors.
Razdan MK. Introduction to Plant Tissue culture. Oxford and IBH Publishing Co. Pvt.
Chawla HS. Laboratory manual for Plant Biotechnology. Oxford WH Freeman & Co.

Sambrook J & Russel DW. Molecular Cloning. Cold Springer Harbor Lab Press.
Sudhir M. Plant Biotechnology. Dominant Publishers & Distributors.
Smith RH. Plant Tissue Culture: Techniques and Experiments. Academic Press.
Slater A, Scott N, Fowler M. Plant Biotechnology: The Genetic manipulation of Plants. Oxford University Press.
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.

BOT4E17 Basic Pteridology
Credit: 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 Souther 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 advancedmorphological 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-heterospory and 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
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.
Hameed, C.A., Rajesh, K.P. and Madhusoodanan, P.V. 2003. Filmy Ferns of South India. Penta Book Publishers & Distributors.

BOT4E18 Applied Pteridology
Credit: 4

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.

   Psilopsida – Psilotales.
   Lycopsida – Lycopodiales, selaginellales, Isoetales
   Sphenopsida – Equisetales
   Filicopsida – Ophioglossales, Marattiales, Osmundales,
   Schizaeales, Cyatheales, Gleicheniales, Marsileales, Salviniales

6. Contribution by Indian Pteridologists – S.S. Bir, B. K. Nayar, Fr. V.S. Manickam, and A. Abraham.
7. Applied Pteridology – horticulture – Food – Medicinal – Biofertilizer – Weeds (aquatic and terrestrial) – Ecological Indicators – Pollution amelioration.
8. 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
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.
Hameed, C.A., Rajesh, K.P. and Madhusoodanan, P.V. 2003. Filmy Ferns of South India. Penta Book Publishers & Distributors.

BOT4E19 Biology and Taxonomy of algae and Cyanobacteria (Theory)
Credit: 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 thatwill also acquire ability to contribute in a multidisciplinary research team.	K5

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

1. Diversity of algae.
2. Comparative analysis of various algal classifications – G.M. Smith; G.E. Paenfus; G.W. Prescot; F.E. Fritsch; V.J. Chapman; C. van den Hoek et al.
3. History of Phycology: Prior to 1800; early 19th century; late 19th century; foundation of modern systematics, Modern trends in algal classification. Classifiation according to van den Hoek et al.1995
4. Brief account of recent developments in molecular phylogenetics and DNA barcoding of algae.
5. Algal habitats – distribution, symbiosis and parasitism. Algae as ecological indicators.
6. Algal literature; Monographs; Revisions; Floras, *etc*.
7. Describing, illustrating, naming and publishing algal taxa.
8. Reproduction and evolution of algae – Chlorophyceae, Phaeophyceae and Rhodophyceae.
9. General account on structure, reproduction and relationships of chlorophyta Dinophyta, Chrysophyta and Bacillariophyta and Rhodophyta
10. Cyanobacteria: pioneers of planet earth- Role in oxygenation of the primitive earth's atmosphere.

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

References:

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

BOT4E20 Applied Aspects of Algae and Cyanobacteria
Credit: 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 ascpects about these microrganism

3. Laboratory training is also included so that the students will acquire the skills and to implement theit 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's medium)
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:

1.Desikachary, T.V. 1959. Cyanophyta. Indian Council of Agricultural Research.
2.Venkataraman, G.S. 1972. Algal Biofertilizers and rice cultivation. Today and Tomorrow's Printers & Publishers.
3. Venkataraman, G. S., Goyal, S. K., Kaushik, B.D. & Roychaudhary, P. 1974. Algae,

form and function. Today and Tomorrow's Printers & Publishers.
4. Kannaiyan,S., Kumar, K. & Govindarajan, K. 2004. Biofertilizers technology, Scientific publishers
5. Anand, N. 1989. Hand book of blue – green algae. Bishen Singh and Mahendrapal Singh, Dehradun.
6. Subramanian, G., Kaushik, B.D., Venkataraman, G.S.1996.Cyanobacterial biotechnology.Oxford and IBH publ. co.
7. Sandhu, S.S.2013. Biofertilizer technology.Black print publishers, New Delhi.
8.Ashwani.K. Rai.1997. Cyanobacterial nitrogen metabolism and envirtonmental biotechnology.Narosa publishinh house.
9. Sivakumar P.K., Joe, M.M., Sukesh, K. 2010. An introduction to Industrial micrology. S. Chand and co.
10. Arun k. Sharma. 2002.Biofertilizers for sustainable agriculture. Agrobios Publishers
11.Vijayaraghavan, M.R. & Bhatia, B. 1997. Red algae: Structure, ultrastructure and reproduction. APH Publishing corporation
12. Van Den Hock, D.G. Mann and Jahus, H.M. Algae: An introduction to Phycology. Cambridge University press.
13. Round, F. E. 1975. The Biology of Algae. Edward Arnold.

BOT4E21 Genetics and Crop Improvement I
Credit: 4

Course Objectives:		
The main objectives of this course are to: 1. To understand the floral biology and breeding methods for different crops. 2. To obtain a 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. Comprehensive understanding on the crop management strategies of various crops of commercial significance		
Expected Course Outcomes:		
On the successful completion of the course, student 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. Students will be able to apply the knowledge on genetic resources for conducting plant breeding experiments.	K3
4	Will become able to analyze the problems and difficulties associated with crop improvement in specific crops.	K4
5	Will become able to evaluate the superior traits of economic significance among different accessions of a particular crop	K5
6	Able to 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.
3. Thrust areas of crop research and major bottle necks in R & D activities in the case of the above crops.

References:

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

BOT4E22 Genetics and Crop Improvement II

Credit: 4

Course Objectives:		
The main objectives of this course are to: 1. To obtain a comprehensive knowledge on the conventional and advanced crop improvement techniques. 2. To gain an insight on patenting life forms and Intellectual property rights. 3. To become an ambassador for sustainable agricultural practices by understanding the merits and demerits of different farming practices.		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Knowledge on Centres of origin & diversity for major crop plants	K1
2	Comprehensive knowledge on different measures of conservation for crop genetic diversity; Understand the procedures for seed production and certification	K2
3	Apply the knowledge on conventional and modern methods of breeding techniques on different crop plants	K3
4		K4
5	Students will become able to evaluate the pros and cons of GM food; able to evaluate the usefulness of measures taken for ensuring biosafety	K5

6		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. Systems of reproduction and mating systems in crop plants
3. Conventional methods of plant breeding- plant domestication, introduction, selection and hybridization.
4. Modern methods of plant breeding- Mutation breeding, polyploidy breeding, distant hybridization and biotechnological approaches in crop improvement.
5. Resistance breeding- breeding for pest, disease and stress resistance.
6. Genetics of photosynthesis
7. Genetics of nitrogen fixation
8. Patenting of life forms- IPR, farmers' rights and plant breeders' rights.
9. Production of improved seeds- seed certification- procedure of variety release.
10. Farming systems- intensive, organic, integrated- merits and demerits- sustainable agriculture.
11. Genetically modified crops- major achievements- merits and demerits- biosafety.

References:

Dabholkar A.R. Elements of Biometrical Genetics. Concept Publishing Company.
Frankel O.H. and Bennet E. Genetic Resources in Plants. Black Well.
Sadhu M.K. Plant Propagation. New AZge International Publishers.
Allard R.W. - Principles of Plant Breeding. John Wiley & Sons.
Jain H.K. and Kharkwal M.C. Plant Breeding. Narosa Publishing House.
Chahal G.S. and Gosal S.S. Principles and Procedures of Plant Breeding. Narosa Publishing House.
Roy D. Plant Breeding. Narosa Publishing House.
Mohanan K.V. Essentials of Plant Breeding. PHI Learning Private Limited, New Delhi.
Hayward M.D., Bosemark N.O. and Romagosa I. Plant Breeding- Principles and prospects. Chapman and Hall.
Gupta S.K. Plant Breeding. Agrobios India.
Khan M.A. Plant Breeding. Biotech Books.
Sharma J.R. Plant Breeding. Tata-McGraw Hill.
Joshi R.M. Biosafety and Bioethics. Isha Books.
Pagano M. and Gauvreau K. Principles of Biostatistics. Duxbury.
Sharma J.R. Statistical and biometrical techniques in Plant Breeding. New Age International Publishers.
Panse V.G. and Sukhatme, P.V. Statistical methods for Agricultural Workers. ICAR.
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