UNIVERSITY OF KERALA

THIRUVANANTHAPURAM

M.Sc. Degree in Botany

(Specialization: Ethnobotany and Ethnopharmacology)

Course Structure & Syllabus

(w.e.f. 2020 Admissions)

October 2020

PG BOARD OF STUDIES IN BOTANY

UNIVERSITY OF KERALA
M.Sc. Degree in Botany (Ethnobotany and Ethnopharmacology)Course structure

Semester	Paper Code	Title of the Paper	Hours/ semester	Hours / week		ESA hours	Maximum Marks		
				L	P	3	CA	ESA	Total
I	BE 211	Ethnobotany and Ethno pharmacology and Indigenous/traditional knowledge	108	6	2	3	25	75	100
	BE 212	Histology, Microtechnique &Histochemistry, Biophysics, Biostatistics	108	6	3	3	25	75	100
	BE 213	Phycology, Mycology, Bryophytes and Pteridophytes	108	6	2	3	25	75	100
	BE 214	Practical I	126		7	4	25♦	75♦	Δ
	Total for Semester I		**450**	**18**	**7**	**13**	**75**	**225**	**300**
II	BE 221	Gymnosperms, Morphology and Angiosperm taxonomy	108	6	3	3	25	75	100
	BE 222	Pharmacognosy, Phytochemistry	108	6	2	3	25	75	100
	BE 223	Reproductive Biology, Plant Physiology, Biochemistry	108	6	2	3	25	75	100
		Practical I							100♦
	BE 224	Practical II	126		7	4	25	75	100
	BE 224	Submission I* (I A+1B)						25+25	50
	Total for Semester II		**450**	**18**	**7**	**13**	**100**	**350**	**550**
III	BE 231	Genetics, Cell and Molecular Biology, Immunology	108	6	2.5	3	25	75	100
	BE 232	Environmental Biology, Forest Botany, Plant Biotechnology, Evolution.	108	6	2.5	3	25	75	100
	BE 233	Microbiology, Plant pathology, Plant Breeding, Horticulture	108	6	2	3	25	75	100
	BE 234	Practical III	126		7	4	25♦♦	75♦♦	Δ Δ
	Total for Semester III		**450**	**18**	**7**	**13**	**75**	**225**	**300**
IV	BE241	Special Paper –Herbal technology, Bioinformatics and *in silico* drug designing	144	8	4	3	25	75	100
	BE 242	Special Paper –II Ethnopharmacology, Phytopharmaceutical Drug Development, IPR & Patents	144	8	3	3	25	75	100
		Practical III							100♦♦
	BE 243	Practical IV	126		7	4	25	75	100
	BE 244	Dissertation (Topics-Ethnobotany, Ethnopharmacology, Phytochemistry and Plant Diversity and conservation)	36	2				100	100
	BE 245	Submissions II**						50	50
	BE 246	Comprehensive Viva Voce					25	75	100
	Total for Semester IV		**450**	**18**	**7**	**10**	**100**	**450**	**650**
		Grand Total					**400**	**1400**	**1800**

Δ The S1 practical examination marks (25♦+75♦=100♦) will be awarded only during II semester practical Examinations.
Δ ΔThe S3 practical examination mark (25♦♦+75♦♦=100♦♦) will be awarded only during IV semester practical Examinations.
* Evaluation of the Submission 1(A) will be along with Practical I. Evaluation of the Submission 1(B) will be along with Practical II.
** The evaluation of the Submission II will be along with the Viva Voce at the end of 4th Semester. L-Lecture, P-practical, ESA-End Semester Assessment, CA-Continuous Assessment (Internal)

*Students may be assigned Dissertation topic in the First Semester itself so that they will be able to spend more time on dissertation work and submit the dissertation by the end of Fourth Semester

UNIVERSITY OF KERALA
M.Sc. Degree in Botany (Specialization in Ethnobotany and Ethnopharmacology)
SCHEDULE OF WORK LOAD

Semester	Paper code	Subject	Total hours		T Hours/ week	P Hours/ week
			T	P		
I	BE 211	Ethanobotany	45	18	2.5	1
		Ethanopharmacology	54	18	3	1
		Indigenous knowledge/Traditional knowledge	9	0	0.5	0
	BE 212	Histology	27	9	1.5	0.5
		Microtechnique & Histochemistry	27	27	1.5	1.5
		Biophysics	27	9	1.5	0.5
		Biostatistics	27	9	1.5	0.5
	BE 213	Phycology	36	9	2	0.5
		Mycology	18	9	1	0.5
		Bryophyte	18	9	1	0.5
		Pteridophytes	36	9	2	0.5
II	BE 221	Gymnosperms	27	9	1.5	0.5
		Morphology	9	0	0.5	0
		Angiosperm Taxonomy	72	45	4	2.5
	BE 222	Pharmacognosy	45	9	2.5	0.5
		Phytochemistry	63	27	3.5	1.5
	BE 223	Reproductive Biology	27	9	1.5	0.5
		Plant Physiology	54	18	3	1
		Biochemistry	27	9	1.5	0.5
III	BE 231	Genetics	45	18	2.5	1
		Cell and Molecular Biology	54	27	3	1.5
		Immunology	9	0	0.5	0
	BE 232	Environmental Biology	45	18	2.5	1
		Forest Botany	9	0	0.5	0
		Plant Biotechnology	36	27	2	1.5
		Evolution	18	0	1	0
	BE 233	Microbiology	27	18	1.5	1
		Plant pathology	18	0	1	0
		Plant Breeding	45	9	2.5	0.5
		Horticulture	18	9	1	0.5
IV	BE 241	Special Paper – I Herbal Technology, Bioinformatics approaches in Drug Design and Development	54	36	3	2
			90	36	5	2
	BE 242	Special paper – II Ethnopharmacology, Phytopharmaceutical Drug Development, IPR & patents	36	9	2	0.5
			81	36	4.5	2
			27	9	1.5	0.5
	BE 244	Dissertation	36	-	2	-

Elective Special papers

1. **BE 241**Herbal Technology, Bioinformatics approaches in Drug Design and Development
2. **BE 242** Ethnopharmacology, Phytopharmaceutical Development, IPR

(Both Elective special papers are compulsory)

Study Tour

Study tour in the 2nd and 4th semesters of the PG programme is compulsory.

2nd Semester: Minimum three one day field trips or 3 to 4 day study tour for flora awareness. 4th Semester: Visit to at least two regional and two national research institutions.

Industrial visit-

Five to 10 days of industrial training to gain experience in Phytopharmaceutical development. A report of industrial visit should be submitted

SUBMISSIONS

Submission I (Evaluation along with **2nd Semester Practical Examination)**

Submission 1 (A)

1. Ethnobotany– Herbarium of ten species of ethnobotanical importance 10 marks

2. Algae/Fungi/ Bryophytes/ Pteridophytes-Total fifteen species with minimum three from each group 15marks

Total = 25 marks

Submissions can be either as herbarium or as preserved specimens. Evaluation of the Submission 1(A) will be along with Practical I.

Submission I (B)

1. Herbarium of invasive species/Exotic species (5 numbers each) 10x1= 10 marks
2. Herbal drugs / products (5 numbers) 5x2= 10marks
3. Tour Report 5 marks

Total =25 marks

Evaluation of the Submission 1(B) will be along with Practical II.

Submission II (Evaluation along with **4th Semester Practical Examination)**

1. Detailed report of industrial visit and visit to any four National / Regional research institutions and the type of research works undertaken by the centers. 10marks

2. A model research proposal seeking fund to carry out research on a specific problem 20marks
3. Power Point presentation of the dissertation carried out by the student before the examiner 20marks

Total = 50 marks

The evaluation of the Submission II will be along with the Viva Voce at the end of 4th Semester.

Topic of the dissertation may be chosen from any area of botany and may be laboratory based, field based or both or computational, with emphasis on originality of approach.It may be started during2nd/3rdsemester and shall be completed by the end of the 4th semester. It should be duly signed by the research guide and the head of the Department and submitted for evaluation. The dissertation to be submitted should include:

- Introduction
- Objectives of the study
- Materials and methods
- Results and discussion
- Summary and conclusion
- References

Scheme for Practicals	Duration	CA	ESA	Total Marks
Practical I (BE 214) includes all the topics under papers BE 211, 212 & 213	4 hrs	25	75	100
Practical II (BE 224) includes all the topics under papers BE 221, 222 & 223	4 hrs	25	75	100
Practical III (BO 234) includes all the topics under papers BE 231, 232 & 233	4 hrs	25	75	100
Practical IV (BE 243) includes all the topics under papers BE 241 & 242	4 hrs	25	75	100

The practical examinations are conducted at the end of the Semester II and Semester IV. Practical I and II examinations will be conducted at the end of the Semester II and Practical III and IV examinations will be conducted at the end of the Semester IV. Certified records of practical works done and submissions, if any, should be submitted at the time of each practical examination.

Criteria for Continuous Assessment (CA)

Theory

Criteria	Marks
Attendance	>90 - 5 marks
	>85% - 4 marks
	>80% - 3 marks
	>75% - 2 marks
	75% - 1 marks
Test Papers (2)	5x2= 10 marks
Seminar	5 marks
Assignment	5 marks
Total	**25 marks**

Practical

Criteria	Marks
Attendance	5 marks
Good Lab Practice	10 marks
Model Practical	10 marks
Total	**25 marks**

SCHEME OF EXAINATION AND MARK DISTRIBUTION

Semester	Paper code	Paper	Hours/ Semester	ESA hours	Maximum marks		
					CA	ESA	Total
I	BE 211	Paper 1	108	3	25	75	100
	BE 212	Paper 2	108	3	25	75	100
	BE 213	Paper 3	108	3	25	75	100
	BE 214	* Practical I Score will be included in Semester II	126	4	25	75	100
	Total for Semester I		**450**	**13**	**100**	**300**	**400**
II	BE 221	Paper 1	108	3	25	75	100
	BE 222	Paper 2	108	3	25	75	100
	BE 223	Paper 3	108	3	25	75	100
	BE 224	Practical II	126	4	25	75	100
	Submission I					50	**50**
	Total for Semester II		**450**	**13**	**100**	**300**	**450**
III	BE 231	Paper 1	108	3	25	75	100
	BE 232	Paper 2	108	3	25	75	100
	BE 233	Paper 3	108	3	25	75	100
	BE 234	**Practical III Score will beincluded in Semester IV	126	4	25	75	100
	Total for Semester III		**450**	**13**	**100**	**300**	**400**
IV	BE 241	Special Paper I	144	3	25	75	100
	BE 242	Special Paper II	144	3	25	75	100
	BE 243	Practical IV	126	4	25	75	100
	BE 244	Dissertation	36			100	100
	BE 245	**Submission II**				50	**50**
	BE 246	Viva voce				100	100
	Total for Semester IV		**450**	**10**	**100**	**500**	**550**
Grand Total					**400**	**1400**	**1800**

Distribution of marks in each Semester Examination

Semester	Continuous Assessment		End Semester Assessment		Total marks
	Theory	Practical	Theory	Practical	
I	75	-	225	--	300
II	75	50 (25+25)	225	150 (75+75)	500
III	75	-	225	--	300
IV	50	50 (25+25)	150	150 (75+75)	400
	Dissertation				100
	Submissions				100
	Comprehensive Viva Voce				100
	Grand Total				**1800**

Distribution of Marks in Practical Examination

Practical Exam	**Examination**	**Record/Submission**	**Total Marks**
I	**55**	**Record – 10 submission – 10**	**75**
II	**55**	**Record – 10 Herbarium / Field note -10**	**75**
III	**65**	**Record – 10**	**75**
IV	**65**	**Record -10**	**75**

SEMESTER I

BE 211 ETHNOBOTANY, ETHNOPHAMACOLOGY AND INDIGENOUS/TRADITIONAL KNOWLEDGE

144 hrs (Theory: 108 hrs; Practical: 36 hrs)

Course Outcome:

- Appreciate the need to conserve floristic and cultural diversity of the region.
- Rescue and document Ethnobotanicals for sustainable use of plant resources.
- Understand the need for development of new drugs for safe and more rational use of herbal preparations.
- Recognition of intellectual property rights and its benefit to people and society who share their knowledge and wisdom.
- Develop laboratory skill in testing of herbal drugs and new commercial products.

Ethnobotany (Theory: 45 Hours)

Module I

Introduction, relevance, scope and status. Classification, International, National and Regional (Kerala State) Contributions (J.W.Harshberger, R.E.Schultes, E.K.Janakiammal, S.K.Jain, K.S.Manilal, V.V Sivarajan & P.Pushpangadan). Centres of Ethno botanical studies in India, AICRPE-All India Coordinated Research Project on Ethno biology, FRLHT- Foundation for the Revitalisation of Local Health Traditions. Contributions of AICRPE and FRLHT to ethno biology of India. Study in brief about Tribal/Folk communities of Kerala State focussing on Anthropology, Customs and Beliefs & Archaeological Ethnobotany. (Koraga, Kurichiya, Adiyan, Paniya, Cholanaikan, Kadar, Kurumba, Kuruman, Kani, Ulladan). Role of ethnomedicine and its scope in modern times. Role of Ethnobotany in conservation and sustainable development (18hrs)

Module II

Methods and techniques used in Ethnobotany-Field level activities for data collection- Approach, Documentation(Audio, Video recording, Photographs, Interview – Methods, Questionnaire, and Data sheet), Consent forms, Forest productivity check by analysing the log books of Forest, EDC, VSS etc), Authentication of plant species (Field Book, Herbarium) Field and Lab Procedures, Preparation of Data Sheet and Data Base. Peoples biodiversity Register (PBR).
Impact of Ethnobotany in herbal-medicine industry, land-use development, agriculture, forestry, betterment of rural livelihoods and education. Biodiversity and conservation of some useful medicinal

plants.Sharing of wealth concept with few examples from India. Plant used in ethno medicine- e.g.: *Trichopus zeylanicus, Ocimum sanctum, Aegle marmelos, Janakia arayalpatra, Phyllanthus niruri, Cissampelos pareira.* Preparation and their uses. (27hrs)

Ethnopharmacology (Theory: 54 Hours)

Module III

Introduction, scope and relevance. Brief account of Phytochemistry, pharmacodynamics and pharmacokinetics. Difference between herbal/botanicals and pharmaceutical medicine. Classification and sources of crude drugs. Quality, safety and efficacy of herbal medicines/ neutraceuticals. Role of ethnopharmacology in drug development. (12hrs)

Module IV

Basic definition and types of toxicology, Regulatory guidelines for conducting toxicity studies as per OECD, Alternative methods to animal toxicity testing. Biopiracy, Intellectual Property Rights(IPR). Ethnopharmacology and IPR issue. Integrated drug development programme, technology transfer and commercialization of Traditional medicine. (12hrs)

Module V

Biological screening of herbal drugs- introduction and need for phytopharmacological screening. *In vitro* Screening methods used for herbal drugs: Antimicrobial screening of herbal drugs, Screening for anticancer activity, Screening for antioxidant activity, Screening for antiurolytheticactivity . *In vivo* Screening methods used for herbal drugs: Screening for anti-inflammation and analgesic activity, Screening for antiulcer activity, Screening for antidiuretic activity, Screening for liver related disorders. Database on pharmaceutical uses of plants (30hrs)

Indigenous/Traditional Knowledge 9hrs (0.5hrs/wk)

Module VI

Plants used by ethnic groups as food, medicines (Ethnomedicine), beverages, fodder, fibre, resins, oils, fragrances and other uses. NWFP(Non Wood Forest Produces), animal products, minerals, artefacts, and rituals, used by Tribal and Folk Communities of Kerala. Traditional/indegenous knowledge and its importance. Ethnobotany and Ethnopharmacology as a tool to protect interests of ethnic groups and

rural development. (9 hrs)

Practicals: 36hrs (2hrs/wk)

Ethnobotany (18 hrs)

1. Field trip to tribal settlement to survey, document and frame hypothesis on people-plant relationship.
2. Review of a Peoples Biodiversity Register (PBR) in collaboration with BMC of a local self government.
3. Collection, processing and preservation of ethnobotanical specimens in the institutional repository.
4. Identify and document plant parts used in preparation of crude drugs/herbal formulations

Ethnopharmacology (18 hrs)

1. Patent Searching of herbal molecules.
2. Testing of Antimicrobial activity of herbal drug of by disc diffusion method.
3. Estimation of antioxidant activity of herbal drug.
4. Testing of cytotoxicity of herbal drug.
5. Determination of biochemical parameter in blood and tissue samples of liver function, lipid profile, kidney function , evaluation of anti oxidant enzymes , (SOD,CAT ,GSH) in liver tissue, evaluation of hematological parameters, histopathological studies **(optional)**

REFERENCES

1. Traditional plant medicines as sources of new drugs. P J Houghton in Pharmacognosy Trease and Evan's.16 Ed .2009
2. Cunningham, A. B. (2001). Applied Ethnobotany. Earthscan publishers Ltd. London & Sterling, VA, USA Cotton, C.M. (1996).
3. Ethnobotany-Principles and application. John Wiley& Sons Ltd., West Sussex, England
4. In vivo and in vitro assays Glimpses of ethnopharmacology 1994 Eds. P Pushpangadan ,V George and U.Nyman
5. Faulks, P.J. (1958). An introduction to Ethnobotany, Moredale Publ. London
6. Jain, S. K. (1981). Glimpses of Indian Ethnobotany. Oxford & IBH publishing Co. Pvt. Ltd., New Delhi
7. Jain, S. K. (1989). Methods and approaches in Ethnobotany. Society of Ethnobotanists, Lucknow

8. Jain, S. K. (1995). A manual of Ethnobotany. Scientific Publishers, Jodhpur
9. Jain, S. K., Mudgal, V., Banerjee, D. K., Guha, A., Pal, D. C. and Das, D. (1984). Bibliography of Ethnobotany. Botanical Survey of India, Howrah
10. Jain S.K.(1997). Contribution to Indian Ethnobotany, Sci. Publ. Jodhpur
11. Jose Boban K. (1998). Tribal Ethnomedicine: Continuity and change. APH publishing corporation 5, Ansari Road, Darya Ganj, New Delhi
12. Phytochemical Methods. Harborne JB. 1984 .Chapman and Hall , London
13. Mathur, P. R. G. (1977). Tribal situation in Kerala. Kerala Historical Society, Trivandrum
14. Shashi, S. S.(1995). Tribes of Kerala (Encyclopedia of Indian tribes Series-8). Ammol Publication Pvt. Ltd. Ansari Road, Daryagang, New Delhi
15. Snehalatha and Jain, S. K. (1998). Historical Archive in Ethnobotany. Institute of Ethnobotany, NBRI, Lucknow
16. Medical Pharmacology, Padmaja Udaykumar. Sixth Edition, CBS Publishers & Distributors Pvt Ltd.

BE 212. HISTOLOGY, MICROTECHNIQUE, HISTOCHEMISTRY, BIOPHYSICS AND BIOSTATISTICS

162 hrs (Theory: 108 hrs; Practical: 54hrs)

Course Outcome:

- Understand the anatomical features of plant parts and identify the anomalous growth
- Correlate the anatomical features to taxonomy
- Familiarize the techniques for the preservation and processing of tissues
- Apply practical experience in microtechnique and histochemistry in laboratories
- Familiarize the instruments used in biology and statistical applications in solving biological problems

Histology **Theory 27 hrs (1.5hrs/wk)**

Module I

1. Origin, structure and function of cambia and their derivatives. Seasonal variation in cambial activity (6 hrs)
2. Anomolous cambial activities in *Amaranthus, Mirabilis, Bougainvillea, Aristolochia.*(6 hrs)
3. Structure of wood TS, TLS and RLS - Soft wood, Hard wood, Sap wood, Heart wood. Role ofextractives in wood quality. Wood anatomy of the following wood yielding plants of Kerala: *Artocarpus integrifolia, Tectona grandis, Dalbergia latifolia, Ailanthus malabarica, Alstonia scholaris.* (7 hrs)
4. Nodal anatomy, root –stem transition (4 hrs)
5. Organization of shoot and root apex, shoot and root development (2 hrs)
6. Anatomy in relation to taxonomy (2 hrs)

Practical **9 hrs (½ hr/wk)**

1. Anomalous structures of the types mentioned in the syllabus.
2. Leaf anatomy: epidermal peels, stomatal study.
3. Nodal anatomy and root-stem transition.
4. Maceration of herbaceous and woody stems- separation of different cell types.

References

1. Cutler D.F., Ted Botha T. and Stevenson D.W. 2016. Plant Anatomy: An Applied Approach. John Wiley & Sons.
2. Clive K. 2016. Plant Anatomy, Morphology and Physiology. Syrawood Publishing House
3. Esau, K. 2006. The Anatomy of Seed Plants. 2nd Edition. John Wiley & Sons, New York.
4. Fahn, A. 1989. Plant Anatomy, Pergamon Press, Oxford, New York.
5. Eames, A. J. & Mac Daniels, L. H. 1979. An Introduction to Plant Anatomy. McGraw Hill NY
6. Cutler, E. G. 1978. Plant Anatomy (Vol. I, II.) Edward Arnold, London.
7. Chandurkar, P. J. 1966. Plant Anatomy. Oxford & IBH Publication Co. New Delhi.
8. Foster, A. S.1960. Practical Plant Anatomy. Van Nostrand & East West, New Delhi.
9. Metcalfe,C.R.&Chalk,L.1950.AnatomyoftheDicotyledonsandMonocots(Vol.I,II), Oxford University Press, London

Microtechnique and Histochemistry **27 hrs (1.5 hrs/wk)**

Module II

1. Scope of histochemistry and cytochemistry in Biology. (1hr)
2. Chemical fixation –reagents and fixatives, chemistry of fixation; Tissue dehydration – reagents, Infiltration and embedding; Sectioning and mounting (9 hrs)
3. Tissue processing technique for light microscope, hand and serial sections, squashes, smears and maceration (9 hrs)
4. Microtomy-Rotary, Sledge, Freezing, Cryostat and Ultratomes (6 hrs)
5. Classification and chemistry of biological stains. General and specific vital stains and flurochromes. (6 hrs)
6. Micrometry, camera lucida, photomicrography. (3 hrs)
7. Tissue processing techniques for electron microscopy. (2 hrs)

Module III

1. Detection and localization of primary metabolites- Carbohydrates (PARS reaction), Proteins (Coomassie brilliant blue staining), Lipids (Sudan Black method). Brief mention about other methods also. (4 hrs)
2. Detection and localization of secondary metabolites- alkaloids, terpenoids, phenolics. (3 hrs)
3. Enzyme histochemistry- General design and applications. (2 hrs)

Practical **27 hrs (1.5 hrs/wk)**

1. Preparation of double stained free hand sections and identification of the tissues with reasons (Normal or Anomalous secondary thickening).
2. Preparation of serial sections from the given block and identification of the tissues with histological reasoning.
3. Free hand sections showing localization of soluble components –Proteins, Sugars and Lipids.
4. Preparation of squashes and smears; Maceration of tissues for separating cell types
5. Measurement of microscopic objects (algal filaments, spore, pollen etc.)
6. Students are expected to get a thorough understanding on reagents and buffers for tissue processing.
7. Students should submit 10 permanent slides (2 serial, 4 hand sections, and 1 whole mount/sledge, 1squash, 1smear, 1 histochemical localization)

References

1. Yeung E.C.T., Stasolla C., Sumner M. J. & Huang B. Q. 2015. Plant Microtechniques and Protocols. Springer Nature
2. Prasad M. K. & Prasad M. K. 2000. Emkay Publications
3. Kierman, J.A.1999. Histological and Histochemical Methods. Butterworth Publ. London.
4. Ruzin, Z. E. 1999. Plant Microtechnique and Microscopy. Oxford Press, New York.
5. Harris, J. R. 1991. Electron Microscopy in Biology. Oxford University Press, New York.
6. Gahan, P.B. 1984. Plant Histochemistry and Cytochemistry. Academic Press, London.
7. Johanson, W. A.1984. Plant Microtechnique. McGraw Hill, New York.
8. Johanson, W. A. 1982. Botanical Histochemistry-Principles and Practice. Freeman Co.
9. John E. Sass. 1964. Botanical Microtechnique. Oxford & IBH Publishing Co. Calcutta.
10. Gary, P. 1964. Hand book of Basic Microtechnique. John Wiley & Sons, New York.
11. Pearse, A. G. E. 1960. Histochemistry. Vol. I & Vol. II, J&A. Churchill, London.
12. Johansen, D. A. 1940. Plant Microtechnique. Tata McGraw Hill Publishing Co. Ltd. New Delhi.

BIOPHYSICS **27 hrs(1.5 hrs/wk)**

Module IV

1. pH and buffer solutions.Hydrogen ion concentration and pH. Measurement of pH. Henderson and Haselbalch equation. Function of buffers in a biological system Importance of buffers in research. (3 hrs)
2. Principles and applications of light and electron microscopy, resolving power, depth of field. Bright field and dark field, phase contrast (negative and positive phase contrast), fluorescence, fluorescence resonance energy transfer (FRET), differential interference contrast (DIC) microscopy, scanning and transmission electron microscopy. different fixation and staining techniques for EM, freeze-etch and freeze- fracture methods for EM, atomic force microscopy (AFM). Flow cytometry, confocal microscopy- different types, FISH, GISH. (10 hrs)
3. Chromatography:Planarandcolumnchromatography,Adsorptionandpartitionchromatography, partition coefficient, Principle and applications of Gel filtration, Ion exchange and affinity chromatography, Thin layer chromatography (4 hrs)

Module V

1. Electrophoresis. Horizontal and vertical gel electrophoresis, PAGE, SDS- PAGE, DIGE (Differential gel electrophoresis), PFGE (Pulsed field gel electrophoresis), Immuno electrophoresis. Enzyme localization by electrophoresis. Zymogram and isozyme analysis. RIA, ELISA. Isoelectric focusing. (6 hrs)
2. Centrifugation. Basic principles of centrifugation, RCF (relative centrifugal force), sedimentation coefficient, Ultra centrifugation - Differential centrifugation, density gradient centrifugation (zonal and isopycnic). (3hrs)

Practical **9 hrs(0.5 hr/wk)**

a. Separation of pigments by column chromatography
b. Separation of amino acids by paper chromatography
c. Separation of alkaloids, phenols and pigments by TLC

References

1. Upadhyay,A.,Upadhyay,K.&Nath,N.2017.BiophysicalChemistry–Principlesandtechniques. Himalaya Publishing House.
2. Narayanan, P. 2000. Essentials of Biophysics. New Age International Publishers, NewDelhi.
3. Daniel, M. 1999. Basic Biophysics for Biologists. Agro Botanica, Bikaner.
4. Roy, R.N.1999. A Text Book of Biophysics. New Central Book Agency(P) Ltd.,Calcutta.
5. Hoppe, W. Lohmann, W. Markl, H. & Zieghr, H. Eds.1983. Biophysics. Springer Verlag, NewYork.
6. DavidFreifelder.1982.PhysicalBiochemistry-ApplicationtoBiochemistryandMolecular Biology. W. H. Freeman.
7. Slayter, F.M. 1970. Optical Methods in Biology. Wiley Inter Science.
8. Casey, E.J. 1962. Biophysics: Concepts and Mechanics**.** Chapman & Hall, Ltd., London.

Biostatistics **27 hrs (1.5 hrs/wk)**

Module VI

1. Sampling methods and errors (3 hrs)
2. Measures of central tendency- Arithmetic mean. Median and Mode (3hrs)
3. Measures of dispersion – range, quartile deviation, mean deviation, standard deviation,
4. Coefficient of variation. (4 hrs)
5. Probability – basic concepts, theorems of probability. (2 hrs)
6. Experimental designs – randomized block designs, split plot design, Latin square. (4 hrs)
7. Test of significance – t- test, chi square test. (4 hrs)
8. Correlation and regression analysis. (4hrs)
9. F-test, ANOVA (3 hrs)

Practical **9 hrs (0.5hrs/wk)**

1. Using the given data from plant science, calculate dispersion.
2. Find out chi square value of the given data.
3. Find out broad sense heritability of data from plant science.

4.Preparation of graphs using EXCEL or similar packages

References

1. Veer Bala Rastogi, 2015. Biostatistics. 3rd edition. Medtech.
2. Norman Bailey, T. J. 2012. Statistical methods in Biology. Cambridge University Press.
3. Khan, I. A. and Khanum, A. 2008. Fundamentals of Biostatistics, 3rdedition.
4. Richards, J. & Sunder Rao, P. S. S. 2006. An introduction to Biostatistics and research methods.
5. Dutta, N. 2002. Fundamentals of Biostatistics: Practical approach

BE 213. PHYCOLOGY, MYCOLOGY, BRYOPHYTES AND PTERIDOPHYTES

144 hrs (Theory: 108 hrs; Practical: 36 hrs)

Course Outcome

- Awareness about about geographical distribution, classification ,structure ,life history and phylogeny of Algae, Fungi Bryophytes and Pteridophytes .
- Understand ecological role of the plans and economically important products obtained from them and their uses.
- Familiarize the fossil members of these groups.

Phycology **36 hrs (2hrs/wk)**

Module I

1. Principles and modern trends in taxonomy of algae ; Contributions of Indian Algologists (2hrs)
2. Classification of Algae (Fritsch F. E. 1935; Lee R. E. 2018). Characteristic features of major Divisions. (4 hrs)
3. Thallus organization and its morphological variations; Evolutionary trends (3 hrs)

Module II

1. Cell structure – Prokaryotic, mesokaryotic and eukaryotic organizations. (3 hrs)
2. Structure, reproduction and life cycle of the following types: (20hrs)
   Scytonema , Hydrodictyon, Ulva, Pithophora, Draparnaldiopsis, Cephaleuros, Halimeda, Nitella, Padina, Turbinaria, Amphiroa, Gracilaria, Ceramium, Spirulina,.
3. Economic importance of Algae- Algae as biofuel. Algae as biofertilizers, as food, their uses in industry, water blooms and their ecological role. (4 hrs)

Practical **9hrs (0.5 hrs /wk)**

1. A record of algal types mentioned above – A study of their morphology and structure.
2. Field trips to be conducted for students to get familiarized with the local flora.

References

1. Lee, R. E. 2018. Phycology 5th Edition. Cambridge University Press, New Delhi.
2. Barsanti, L. & Gualtieri, P. 2014. Algae: Anatomy, Biochemistry, and Biotechnology, 2nd Edition. CRC Press.
3. Sharma, O. P. 2011. Text book of Algae. Tata McGraw Hill Publ. Comp. Ltd. New Delhi.
4. Bilgarmi, K. S & Saha, L. C. 2010. A Textbook of Algae. CBS Publishers, New Delhi.
5. Kumar, H. D. 1999. Introductory Phycology. East West Pvt. Ltd., New Delhi.
6. Vashishta, B. R. 1999. Algae. S. Chand & Company, New Delhi.
7. Bold, H. C. & Wynne, M. J. 1995. Introduction to Algae. Prentice Hall of India, New Delhi.
8. Kashyap, A. K. & Kumar, H. D. 1994. Recent advances in Phycology. Rastogy &Company.
9. Prescott, G. W. 1984. The Algae: A review. Lubrecht & Cramer Ltd.
10. Round, F. E. 1984.The Ecology of Algae. Cambridge University, Press, London.
11. Smith, G. M. 1976. Cryptogamic Botany Vol.1.Tata Mc Graw Hill Publ. Comp. Ltd. New Delhi.
12. Gangulee, H. C. & Kar, A. K. 1973. College Botany, Vol. I. New Central Book Agency Pvt. Ltd.
13. Fritsch F. E. 1935, 48. Structure and reproduction of algae. Cambridge University Press.

Mycology **18hrs (1hr/wk)**

Module III

1. Principles and modern trends of classification of Fungi - (Alexopoulos *et al.*1996; Kirk *et al.* 2001); Contributions of Indian Mycologists. (2 hrs)
2. Structure, reproduction and phylogeny of: Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes (4 hrs)
3. Thallus structure, reproduction and life cycle of the following types: *Phytophthora, Aspergillus, Polyporus, Lycoperdon, Ganoderma, Schizophyllum, Colletotrichum.* (8 hrs)
4. Economic importance of fungi with special reference to secondary metabolites; Fungi as biocontrol agent. Wild edible mushrooms (2hrs)
5. Classification, thallus structure, reproduction, ecological significance and Economic importance of Lichens. Thin Layer chromatography and micro crystallography for the identification of lichen chemicals. Thallus structure, reproduction and life cycle of the following types: *Parmelia*. (2 hrs)

Practical **9hrs (½hr/wk)**

1. Study of the morphology and reproductive structures of the types mentioned in the syllabus.

References

1. Sharma , O. P. 2017. Fungi and Allied Microbes. McGraw Hill Education
2. Dube, H. C. 2013. An Introduction to Fungi. 4th Edition. Scientific Publishers, India.
3. Kirk, P., Cannon P.F., Minter D.W. & Stalpers J. A. 2008. Ainsworth & Bisby's Dictionary of Fungi. 10th Edition. CAB International, Oxon UK.
4. Alexopoulose, C. J., Mims, C.W. & Blackwell, M. 2007. Introductory Mycology. 4thEdn. John Wiley & Sons, New York.
5. Sharma,O.P.2007.Text book of Fungi. Tata Mc Graw Hill, Publishing Co.Ltd. New Delhi.
6. Sumbali, G. 2005.The Fungi. Narosa Publishing House, New Delhi.
7. Sharma, P. D. 2004.The Fungi for University students. Rastogi Publications, Meerut.
8. Kirk, P. M., Cannon, P. F., David, J. C. &Stalpers, J. A. 2001. Ainsworth & Bisby's Dictionary of the Fungi, 9th Edition. CABI Publishing.
9. Chopra, G.L.1998. A text book of Fungi. S. Nagin & Co. Meerut.
10. Srivastava, J. P. 1998. Introduction to Fungi. Central Book Depot, Allahabad.
11. Elizabeth Moore-Landeeker.1996.Fundamentals of Fungi. Prentice Hall, New Jersey.
12. Mehrothra, R.S. & Aneja, K. R. 1990. An Introduction to Mycology. Wiley Eastern Ltd. New Delhi.
13. Hudson, H. J. 1986. Fungal Biology. Edward Arnold, London.
14. Moore,D.,CasseltonL.A.WoodD.A.&J.C.Frankland1986.DevelopmentalBiologyof higher fungi. Cambridge University Press
15. Hale, M. E.1983. Biology of Lichens. Edward Arnold, London.
16. Bessy, E. A. 1979. Morphology and Taxonomy of Fungi. Vikas Publishing House, New Delhi.
17. Ainsworth,G.C.,Sparrow,K.E.&Sussman,A.S.1973.TheFungi.AcademicPress,New York.
18. Burnett, J. H. 1968. Fundamentals of Mycology. Edward Arnold Ltd. London
19. Awasthi, D.D. 2000. Lichenology in Indian Subcontinent - A Supplement to 'A Handbook of Lichens' . Pages : iv, 124, ISBN-10 : 81-211-0187-5
20. Awasthi, D.D. 2007. A Compendium of the Macrolichens from India, Nepal, and Sri Lanka Pages : viii, 580, ISBN-13 : 978-81-211-0600-9.

BRYOPHYTA **18 hrs (1hr/wk)**

Module IV

1. General characters; Contributions of Indian Bryologists. (1hr)
2. A general account of morphological and anatomical features, reproduction, life history and phylogeny of: Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Polytrichales.(6 hrs)
3. Life cycle study of the following types:(8 hrs)
   Lunularia, Targionia, Reboulia, Porella, Sphagnum, Polytrichum.
4. Origin and evolution of Bryophytes (2 hrs)
5. Economic importance of Bryophytes, Bryophytes as indicators of water and air pollution. (1hr)

Practical **9 hrs (½ hr/wk)**

Morphological and anatomical studies of the types mentioned in the syllabus.

References

1. Botanical Survey of India. 2016. Liverworts and Hornworts of India – An annotated checklist.
2. Vanderpoorten A. & Goffinet B. 2009. Introduction to Bryophytes. Cambridge Publishers.
3. Shaw, J. & Goffinet, B. 2000. Bryophyte Biology, Cambridge University Press.
4. Rashid, A. 1998. An introduction to bryophyte. Vikas Publishing House, New Delhi.
5. Chopra, R.N. 1998. Topics in Bryology. Allied Printers, New Delhi.
6. Chopra, R.N. & Kumara, P. K. 1988. Biology of Bryophytes. Wiley East, New Delhi.
7. Prem Puri.1981. Bryophytes: Morphology, Growth and differentiation. Atma Ram and Sons,New Delhi.
8. Parihar, N.S. 1980. An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
9. Smith, G. M. 1976. Cryptogamic Botany Vol. II. Tata McGraw Hill. Publishing Co. Ltd. New Delhi.
10. Cavers, F. 1976. The interrelationship of Bryophyta. S. R. Technic House, Asok Rajpath, Patna.
11. Watson, E.V. 1968.The structure and life of Bryophytes. Cambridge University, London.

Pteridophyta **36 hrs (2hrs/wk)**

Module V

1. General characters, classification (Bierhost, 1971) and life cycle of Pteridophytes; Contributions of Indian Pteridologists. (2 hrs)
2. Comparative morphology, structure, ecology and phylogeny of the following groups: Psilopsida, Lycopsida, Sphenopsida, Pteropsida. (7hrs)
2. Structure, reproduction and life cycle of the following types: (18hrs) *Isoetes, LycopodiumAngiopteris, Ceratopteris, Blechnum, LygodiumAdiantum, Acrostichum, Azolla.*

Module VI

3. Telome theory-basis, elementary proves- origin of sporophylls in Lycopsida, Sphenopsida and Pteropsida- origin of root- merits and demerits of telome theory; Evolutionary trends in the gametophytes of Pteridophytes. (5 hrs)
5. Conservation of Pteridophytes: Pteridophytes as ecological indicators. (2 hrs)
6. Principles of Paleobotany, Fossil pteridophytes: *Zygopteris* (2 hrs)

Practicals **9hrs (0.5 hrs/wk)**

1. Structural details of the vegetative and reproductive parts of the types mentioned in the syllabus.
2. Identification of fossil types mentioned above.

References

1. Sharma, O. P. 2017. Text book of Pteridophyta. McGraw Hill Education.
2. Sundara Rajan, S. 1999. Introduction to Pteridophyta. New Age Publications, New Delhi.
3. Rashid, A.1999. Pteridophyta. Vikas Publishing House, New Delhi.
4. Sporne, K. R. 1986. Morphology of Pteridophytes. Hutchinson University Library, London.
5. Stewart, W. N. 1983. Paleobotany and Evolution of Plants. Cambridge University Press, London.
6. Eames, E. J. 1983. Morphology of Vascular Plants. Standard University Press.
7. Parihar, N. S. 1980. An Introduction to Embryophyta Vol. II. Pteridophyta. Central Book Depot, Allahabad.
8. Smith, G. M. 1976. Cryptogamic Botany Vol. II. Tata McGraw Hill, Publ. Co. Ltd. D elhi.
9. Shukla, A. C. & Misra, S. P. 1975. Essentials of Paleobotany. Vikas Publ. House ND
10. Bierhost, D.W. 1971. Morphology of vascular plants. Macmillan, London.
11. Scott, D. H.1962. Studies in Fossil Botany. Hafner Publishing Co. NewYork.

12. Arnold, C. A. 1947.An Introduction to Paleobotany. McGraw Hill, NewYork.

SEMESTER II

BE 221 GYMNOSPERMS, ANGIOSPERM MORPHOLOGY AND TAXONOMY

(Theory 108 hrs; Practical 54 hrs)

Course Outcome:

- Awareness in identifying characters, classification and lifecyle of Gymnosperms
- Understand the concepts and principles related to morphology and Plant taxonomy
- Acquire the skill in plant identification and herbaria preparation
- Develop an attitude in conserving plants for sustainable development

Gymnosperms **27 hrs (1.5 hrs/wk)**

Module 1

1. General characters, affinities, distribution and classification (Sporne, 1965; Christenhurz and Bing, 2016). Economic importance of Gymnosperms. (4hrs)

2. Structural details of vegetative and reproductive parts, phylogeny and inter relationships of the following orders : Cycadofilicales, Pentoxylales, Cycadales, Ginkgoales, Coniferales, Gnetales.(14 hrs)

Module II

1.Structure, reproduction and life cycle of the following types:

Zamia, Araucaria, Podocarpus, Ephedra (9 hrs)

Practical **9 hrs (½ hr/wk)**

1. Anatomy of stem (TS, RLS, TLS), leaf and reproductive structures of the types mentioned in the syllabus.

References

1. Christenhurz M.J.M. Reveal, J.L. Farjon, A. Gardner, M. F &. Mill, R.R. M. and Chase M.W..(2011)
2. A new classification and linear sequence of extant gymnosperms. Phytotaxa 19: 55-70. Magnolia Press
3. Chamberlain, C. J. 2000. Gymnosperms. CBS Publishers, New Delhi.
4. Biswas, C. & Johri, B. M. 1999. The Gymnosperms. Narosa Publishing House, New Delhi.
5. Vashishta, P.C. 1999. Gymnosperms, S. Chand & Company, New Delhi.

6. Bhatnagar, S. P. & Moitra, A. 1997. Gymnosperms. New Age Publications, New Delhi.
7. Sharma, O. P. 1997. Gymnosperms, Pragati Prakasan, Meerut.
8. Sporne, K. R. 1986. Morphology of Gymnosperms, Hutchinson University Library, London.
9. Ramanujan, C. G. K. 1976. Indian Gymnosperms in time and space. Today and Tomorrows printers and publishers, New Delhi.
10. Chamberlain, C. J. 1955. Gymnosperms-structure and evolution. Dover Publications, Inc. New York.
11. Coulter, J. M. & Chamberlain, C. J. 1964.Morphology of Gymnosperm. Central Book Depot.

Angiosperm Morphology **9 hrs (0.5 hr/wk)**

Module III

1. Origin of Angiosperms (1hr)
2. The concept of primitive angiosperm flower. Origin and evolution of flower (2hrs)
3. Origin and evolution of structure and morphology of stamens (2 hrs)
4. Origin and evolution of carpels: different types- concept of foliar origin of carpels; types of ovary; evolution of placentation types- inferior ovary- foliar and axial concepts. (2hrs)
5. Role of floral anatomy in interpreting the origin and evolution of flower and floral parts (2 hrs)

References:

1. Eames, EJ. Morphology of Angiospe1ms. Mc Graw Hills Book Co. New York
2. Barnard, C. The interpretation of Angiosperm flower. Aust. J Sci.24:64'72. 1961.
3. Manilal, KS. Vascularization of corolla in Compositae. Jlndian Bot. Soc.59; 189-196
4. Meeuse, AD. J Some fundamental principles of interpretive floral morphology. Int.l Sci. Publ. Hissar. 1974. 5. Melville, R New theory of Angiosperm flower. Nature 188: 14-18. 1960.
5. Puri, V. Inferior ovary. Phytomorpholgy2:122.1952.

Taxonomy of Angiosperms **72 hrs (4 hrs/wk)**

Module IV

1. Principles of taxonomy as applied to the systematic and classification of plant kingdom - species concept, taxonomic structure. (1hr)
2. Classification – brief study of Artificial (Linnaeus), Natural (Benthem and Hooker) and Phylogenetic

(Bessey and Takhtajan) systems. (2 hrs)

3. Detailed study of modern system of classification – Angiosperm Phylogeny Group (APG) classification system. (2 hrs)
4. Plant nomenclature: Brief history on the origin and development of nomenclature; Contents and major provisions of latest International Code of Nomenclature for algae, fungi, and plants (ICN) - Author citation, Typification and different kinds of types, Effective and valid publication of names, Principle of priority and its limitations, Conservation of names, Names of hybrids. Definition of nomenclature terms- autonym, homonym, basionym, tautonym and nomen nudum. A very brief account on International Code of Nomenclature of Cultivated Plants (ICNCP).

(5 hrs)

Module V

1. History and development of taxonomy in India. Classification of taxonomical literature, general indices, floras, icons, monographs, reviews and journals (3hrs)
2. Herbarium – definition, steps involved in the development of herbarium, utility of herbarium and their maintenance, general account of National and regional herbaria with special reference to Central National Herbaria, Calcutta (CAL) and Madras Herbarium (MH), Botanical Survey of India, Botanical gardens and importance of botanical garden in taxonomic studies, important National and International Botanical gardens, Royal Botanical Garden, Kew, Indian Botanical Garden, Calcutta, National Botanical Garden, Lucknow and Tropical Botanical Garden, Trivandrum. Botanical survey of India

(6 hrs)

3. Construction of taxonomic keys (indented and bracketed) and the utilization. (2 hrs)
4. Biosystematics- Turners concept and categories (2 hrs)
5. Modern concepts and trends in plant taxonomy. Elementary treatment of i. Cytotaxonomy, ii. Chemotaxonomy, iii. Numerical taxonomy (taximetrics), iv. Molecular taxonomy, v.Phylogenetic systematics-Basic principles (5 hrs)

Module VI

1. Study of the following angiosperm families giving importance to morphological peculiarities if any (Special emphasis should be given on morphological and phylogenetic interrelationships, recent revisions and rearrangements between and within the families, and its critical analysis): (45 hrs)

Ranunculaceae Magnoliaceae Capparidaceae Polygalaceae

Caryophyllaceae	Portulacaceae	Dipterocarpaceae	Malvaceae
Rhamnaceae	Vitaceae	Sapindaceae	Leguminosae
Combretaceae	Rhizophoraceae	Myrtaceae	Melastomaceae
Passifloraceae	Cucurbitaceae	Apiaceae	Rubiaceae
Asteraceae	Sapotacae	Oleaceae	Asclepiadaceae
Boraginaceae	Solanaceae	Scrophulariaceae	Acanthaceae
Verbenaceae	Lamiaceae	Amaranthaceae	Aristolochiaceae
Piperaceae	Lauraceae	Loranthaceae	Euphorbiaceae
Urticaceae	Causuarinaceae	Orchidaceae	Scitaminae
Amaryllidaceae	Liliaceae	Arecaceae	Araceae
Cyperaceae	Poaceae.		

Practicals **45hrs (2.5 hr/wk)**

1. Study of representative members of all the prescribed families as evidenced by record of practical work (to be submitted during the practical examination).
3. Identification of fresh specimens using flora and other supportive documents like monographs.
4. Visit to a recognized herbaria (The report of the same should be submitted separately).
5. Field work for familiarizing the local flora under the supervision of teachers, and documentation of the proceedings.
6. Study tour of minimum three days should be conducted to biodiversity rich zones of Western Ghats, for familiarizing the floristic wealth (The report of the same should be submitted for valuation).
7. Preparation of dichotomous key (minimum 5 keys).
8. A minimum of 10 abbreviations of authors' names to be presented in the record.
9. Expansion of 10 floral formulas.
10. Exercises in nomenclatural citations and solving nomenclatural problems (At least 10).
11. A minimum of 40 herbarium specimens giving representation of minimum of 40 families to be submitted for valuation.

References:

1. Singh, G. 1999. Plant Systematics: Theory and Practice, Oxford IBH.
2. Sivarajan, V. V. 1999. Principles of Plant Taxonomy, Oxford and IBH Publishing Co.
3. Judd, W.S., Campbell, C. S., Kellog, E. A. & Stevens P. F. 1999. Plant Systematics. Sinauer Associates, Inc., Massachusetts, USA.
4. Sivarajan, V. V. 1991. An introduction to Principles of Taxonomy, London.
5. Ambasta, S. P. 1986.The Useful Plants of India, Publication and Infm. Directorate, CSIR, New Delhi.
6. Stace, C. 1985. Plant Taxonomy and Biosystematics, London.

7. Arora, P. K. & Nayar, E. K. 1984. Wild relatives of Crops plants in India, NBPGR Sci. Monograph No. 7.

12.Gibbs, R. D. 1975. Chemotaxonomy of Flowering Plants. In The quarterly review of Biology, 50: 3

13.Takhtajan, A. L. 1969. Flowering plants. Origin and Dispersal. Oliver and Boyed.

14.Rendle, A. B. 1967. Classification of Flowering Plants, Cambridge University Press.

15.Lawrence, G. H. M. 1964. Taxonomy of Vascular Plants, Macmillan Co. New York.

16.Davis, P. H. & Heywood. 1963. Principles of Angiosperm Taxonomy, Oliver-Boyd.

17.Hutchinson, J. 1959. Families of Flowering Plants, Cambridge University Press.

18.Lawrence, G. H. M. 1955. An Introduction to Plant Taxonomy, Central Book Depot.

19.Gamble, J. S. 1935. Flora of Presidency of Madras, London.

20. Hooker, J. D. 1879. Flora of British India. Reeve &Co., London.

BE 222 PHARMACOGNOSY AND PHYTOCHEMISTRY

Theory 108 hrs; Practicals 36 hours

Course Outcome:

- Awareness about types of drugs and systems of medicine
- Analyze the purity and strength of crude drugs
- Identify the sources of drugs
- Apply the Identification and separation techniques to evaluate the medicinally important metabolites

PHARMACOGNOSY **45 hrs (2.5 hrs/wk)**

Module I **(9 hrs)**

Introduction to Pharmacognosy:

1. Definition, history, scope and objectives, development and applications of Pharmacognosy.
2. Sources of Drugs – Plants, Animals, Minerals. Drug description.
3. Organized drugs and unorganized drugs (All parts of plant origin; starch; dried latex, dried juices, dried extracts, gums and mucilages, calcium oxalate crystals, oleoresins, gum-resins, fixed oils, fats and waxes).
4. Systems of Medicine: Classical / Codified (Ayurveda, Unani, Siddha, Homoeo- AYUSH), Oral/ Non-codified (Tribal, Folk, Traditional); Modern (Allopathy).
5. Ethnomedicine, ethnopharmacognosy, ethnotaxonomy.
6. Pharmacopoeia - importance

Module II **(18 hrs)**

Identity, purity and strength of the drug

1. Classification of Crude drugs: Morphological, Taxonomical, Chemical and Pharmacological. Need for classification of drugs.

Methodology for identity: Macroscopy (taxonomic, morphological, organoleptic);microscopy (including histochemical); powder studies and chemical assay; detection of foreign matter.

2. Quality control of crude drugs
   a) Cultivation of medicinal plants including good cultivation practice, good collection practice, good processing and good storage practice and good manufacturing practices, Processing of plant drugs, purification of raw drugs, factors causing drug contamination.
   b) Market study of crude drugs including adulterants and substitutes using standard procedures.
   c) Single drug standardisation in Ayurveda, Siddha and Unani. Preparation of monographs.

d) Forensic pharmacognosy; narcotic drugs; toxic drugs, high value medicinal plants (of RET category).

Module III **(18hrs)**

Analytical Pharmacognosy

1. Introduction to phytochemical screening to detect secondary metabolites.
2. Introduction to biological testing of herbal drugs (analgesics, anti-inflammatory and antioxidant agents).
3. Source and uses of selected drugs: Composition, source plants, therapeutic uses and commercial applications of: **Alkaloids:** Periwinkle, Rauvolfia, Belladonna, Opium, Sida; **Non Protein Amino Acid**: Mucuna; **Phenylpropanoids and Flavonoids:** Coffee, Tea, Ruta; **Steroids, Cardiac Glycosides &Triterpenoids**: Liquorice, Dioscorea, Digitalis; **Volatile oils**: Mentha, Clove, Ginger, Cinnamon, Fennel, Coriander; **Tannins:** Catechu, Red Sander; **Resins:** Guggul, Asafoetida, Myrrh, Colophony; **Glycosides:** Senna, Aloe, Bitter Almond.

Suggested References:

1. Abdul Khader, S.2014. A Textbook of Medicinal Botany. Shamsudeen Publishers, New Eswari Nagar, Pallavaram, Chennai-43
2. Anonymous. 1978. The Ayurvedic Formulary of India. Govt. of India, New Delhi
3. Anonymous. 1999. The Ayurvedic Pharmacopoeia of India. Vol. I (1 & 2). Ministry of Health and Family Welfare, Govt. India, New Delhi.
4. Chauhan, M.G. and Pillai, A.P.G. 2005. Microscopic Profile of Powdered Drugs Used in Indian Systems of Medicine. Institute of Ayurvedic Medicinal Plant Sciences, Jamnagar.
5. Daljithsimha, K. 1974. Unani Dravyaguna Darshana. Ayurvedic and Tibbi Academy, Lucknow
6. ICMR. 2003. Quality Standards of Indian Medicinal Plants (Vol.1). Indian Council of Medical Research, New Delhi
7. Iyengar M.A. Anatomy of Crude Drugs
8. Jackson, B.P. and Snowdon, D.W. 1992. Atlas of Microscopy of Medicinal Plants, Culinary herbs and Spices. CBS Pub., New Delhi 26 of 32
9. KameswaraRao, C. 2000. Database of Medicinal Plants. KSCST, Bangalore
10. NarayanaAiyer, K. and Kolammal. M. 1963. Pharmacognosy of Ayurvedic Drugs (12 vol.). University of Kerala, Thiruvananthapuram
11. Sivarajan, V.V. and Indira, Balachandran. 1994. Ayurvedic Drugs and their Plant Sources. Oxford & IBH Pub. Co. Pvt. Ltd. New Delhi
12. Trease, G.E. and Evans, W.C. 1983. Pharmacognosy (12th ed.). BaillièreTindall, London

13. Vaidya, B. 1982. Some Controversial Drugs in Indian Medicine. ChaukambikaOrientalia, Varanasi
14. Wallis, T.E. 1997. Text Book of Pharmacognosy (5th ed) CBS Publishers & Distributors, Delhi

PHYTOCHEMISTRY (63 hrs)

Module IV Introduction to Phytochemistry (18 hrs)

Historical background of Natural Product Chemistry and the development of Phytochemistry. Important phytochemicals their sources and potential utilities. Phytochemicals as drugs, cosmetics, food additives, flavours, nutraceuticals, biofuels.

Biosynthesis of Phytochemicals: Evolution of Phytochemicals. Primary metabolism and secondary metabolism. Major biosynthetic pathways: Mevalonic acid pathway, Shikimic acid pathway and Polyketide pathway. Biosyntheis of alkaloids. Role of enzymes in biosynthesis of phytochemicals.

Classification of Phytochemicals: Major class of primary metabolites. Major class of secondary metabolites. Classification of terpenoids, flavonoids and alkaloids. Phytochemical screening, profiling, high throughput screening and dereplication studies.

Extraction Techniques: Different extraction techniques. Solvent extraction, criteria for selection of solvents, polarity index of solvents. Hydro distillation, steam distillation, crystallization, sublimation, maceration, percolation, enfluerage, expression, sonication, microwave assisted extraction, solid phase micro extraction and super critical fluid extraction.

Module V: Separation Techniques (9hrs)

Principles of chromatography: Adsorption, partition, size exclusion, affinity, ion exchange. Different types of chromatography: Column Chromatography (CC), Thin Layer Chromatography (TLC), High Performance Thin Layer Chromatography (HPTLC), Paper Chromatography (PC), High Performance Liquid Chromatography (HPLC), Flash Column Chromatography (FCC), Gas Liquid Chromatography (GLC), Circular Counter Current Chromatography (CCC). Stationary phases and mobile phases in chromatography. Normal Phase and Reverse Phase chromatography. Convergence chromatography. Chiral chromatography,

Spectroscopic Techniques (27hrs)

Conventional structure elucidation methods. Introduction to spectroscopy. Theory, laws, and instrumentation associated with various spectroscopic techniques.

Ultraviolet and visible spectrophotometry (UV-Vis): Beer Lambert's law, applications. Infrared Spectroscopy (IR): Sampling technique, modes of molecular vibrations, Factors affecting vibrational frequencies, absorption of common functional groups.Raman Spectroscopy, Atomic Absorption Spectroscopy (AAS), Flame Emission Spectroscopy/ Atomic Emission Spectroscopy (AES), Nuclear Magnetic Resonance spectroscopy (NMR): ^{1}H and ^{13}C NMR spectroscopy. Chemical shift, spin-spin coupling, coupling constant. Introduction to 2D NMR methods - DEPT, NOE, HOMO and HETEROCOSY. Applications of NMR to simple structural problems.,Mass Spectrometry (MS): Different Ionization methods: EI, CI, FAB, MALDI, ESI and APCI. Different detection methods: Magnetic Field Deflection, Quadrapole, Ion trap, Time of Flight (ToF). Structural information obtained from MS, molecular ion peak, base peak, mass resolution. X-ray Crystallography: Unit cell, lattice, basic crystal systems, Braggs Law. Different X-ray diffraction methods., Thermal Analyses Techniques: Differential Scanning Calorimetry (DSC), Thermo Gravimetric analysis (TGA)

Hyphenated Analytical Techniques

Introduction to hyphenated analytical techniques in phytochemistry. Hyphenation of extraction and separation techniques. Hyphenation of separation and characterization techniques. GC-FID, GC-MS, GC-EAD, HPLC-UV, LC-MS, LC-MS-MS, LC-NMR, LC-SPE-NMR, LC-UPCC.

Module VI: Application of Phytochemistry in Chemotaxonomy, Chemical ecology, Chemogenomics and Metabolomics (9hrs)

Significance of chemotaxonomy. Secondary metabolic profiling of plants and chemotaxonomy. Statistical analysis in chemotaxonomy. Chemotaxonomy and phylogeny. Role of phytochemicals in pollination, insect attraction/repellence. Chemogenomics and metabolomics with the help of phytochemical profiling.

PRACTICALS

PHARMACOGNOSY 9hrs (0.5 hrs/wk)

1. Analysis of crude drugs by morphological and anatomical characterization selected drugs including histochemistry.
2. Determination of leaf constants such as stomatal index, stomatal number, vein-islet number, vein-termination number and palisade ratio.
3. Determination of size and structure of starch grains, crystals, sclereids.
4. Powder drug analysis - fluorescence and reaction with chemical reagents.
6. Determination of Ash value
7. Determination of extractive values of crude drugs
8. Determination of purity, moisture content , extraneous matter
9. Determination of swelling index and foaming of powdered drugs

PHYTOCHEMISTRY **27 hrs (1.5 hrs/wk)**

Extraction Techniques

Soxhlet extraction: *Curcuma longa* rhizome powder, *Piper nigrum* fruits powder.

Hydrodistillation:*Syzygium aromaticum, Cymbopogon fluxiousus, Cinnamomum malabatram*

Class tests for phytochemicals

Terpenoids/Steroids: Lieberman-Burchard test

Flavonoids: Shinodas test

Coumarins: Borntragers test

Alkaloids: Mayers test, Dragendorfs test, Wagners test

Chromatographic Techniques

Paper chromatography: PC of sugars in nectar

Thin Layer chromatography: TLC separation of curcuminoids from Curcuma longa rhizome extract. Comparison of market sample and authentic rhizome samples.

Preparative Thin Layer chromatography (PTLC): Isolation of trimyristicin from *Myristica fragrance* fruits

Column chromatography: Column chromatographic separation of chlorophyll pigments from green leaves extract. Column chromatographic separation of eugenol from clove oil.

Estimation Techniques

Estimation of phenolics, flavonoids, curcumin, piperin

Spectral Interpretation

Analysis of recorded UV-Vis., IR, NMR and mass spectra of some simple phytochemicals such as carvone, citral, menthol, luteolin, kaempferol, nicotine, caffeine and glycyrrhizin.

References

1 Atta-ur-Rahman, T.I., Le Quesne, Philip W. (eds.) (1988) Natural Product Chemistry, Springer, Germany.

2 Chatwal G. R. (Reprint 2005, edition 1996) Organic Chemistry of Natural Products. Vol. I and Vol. II. Himalaya Publishing House, Mumbai.

3 Cseke L. J., Kirakosyan A., Kaufman P. B., Warber S. L., Duke J. A. and Brielmann H. L. (eds.) (2006) Natural Products from Plants. 2nd edn. CRC Press, Boca Raton.

4 Dewick P M. (2009) Medicinal Natural Products (A Biosynthetic Approach), John Wiley & Sons Ltd., England.

5 Harborne J. B. Phytochemical Methods. (1973) Chapman and Hall, London

6 Harborne J. B., Baxter H., and Moss P. G. (1999) Phytochemical Dictionary. Handbook of Bioactive Compounds from Plants, Taylor and Francis Ltd, UK.
7 Ikan R. (1969) Natural Products a Laboratory Guide, Academic press, Cambridge.
8 Kalsi P. S. (2016) Spectroscopy of Organic Compounds, Wiley Estern Ltd., Delhi.
9 Kaufman P. B., Natural Products from Plants, CRC Press, New York.
10 Kemp, W. (1991) Organic Spectroscopy. 3rdedn. Palgrave, New York.
11 Mann J., Davidson R. S., Hobbs J. B., Banthorpe D. V. and Harborne J. B. (eds.). (1994) Natural Products: Their Chemistry and Biological Significance. Longman Scientific and Technical, Harlow, England.
12 Markham K. R., (1982) Techniques of Flavonoid Identification, Academic Press, London.
13 Methods in Plant Chemistry and Economic Botany. (1991) Mammen Daniel, Kalyani Publishers, New Delhi.
14 Paech, K. and Tracey, M. V. Modern Methods of Plant Analysis, Vol. I-VII Springer, Germany.
15 Panda H. (2012) The Complete Technology Book on Herbal Perfumes & Cosmetics, NIIR Project Consultancy Services, Delhi.
16 Phytochemical Techniques. (2006) Raaman N. New India Publishing Agency, New Delhi.
17 Sadasivam S. and Manikkam A. (1991) Biochemical Methods for Agricultural Sciences. TNAU, Coimbatore.
18 Silverstein R. M. and Webster F. X. (2014) Spectroscopic Identification of Organic Compounds, 7th edn, Wiley, India.
19 Torssel, K. B. G. (1997) Natural Product Chemistry. A Mechanistic, Biosynthetic and Ecological Approach. Swedish Pharmaceutical Society, Stockholm
20 Wagner H., Bladt S. and Zgainski E. M. (1984) Plant Drug analysis. A Thin Layer Chromatography Atlas. Springer Verlag, Berlin

BE 223 REPRODUCTIVE BIOLOGY, PLANT PHYSIOLOGY AND BIOCHEMISTRY

Theory 108 hrs; Practicals 36 hrs)

Course Outcomes

- Understand methods of reproduction and apply it for breeding varieties
- Understand physiology and biochemistry of metabolic processes
- Identify and evaluate various metabolites involved in growth and reproduction of plants

Reproductive Biology **27 hrs (1.5 hrs/wk)**

Module I

1. Asexual reproduction: Vegetative apomixis. Adventive embryony. Non recurrent apomixis, diplospory, apospory, parthenogenesis, androgenesis, automixis, semigamy, agamic complex. (4 hrs)
2. Sexual reproduction: Microsporogenesis - male gameteophyte - pollen fertility and sterility. Pollen storage. Pollen viabilityand germination. (3 hrs)
3. Megasporogenesis-embryosacs-development and types. (2 hrs)

Module II

1. Pollination biology - primary and secondary attractants of pollination - ultra structural and histochemical details of style and stigma - significance of pollen-pistil interactions. (3 hrs)
2. Fertilization-barriers to fertilization- intra ovarian pollination and *in vitro* fertilization – embryo rescue. (4 hrs)
3. Embryo, endosperm and seed development. Polyembryony, Parthenocarpy. (4 hrs)
4. Androgenesis and gynogenesis. (2 hrs)
5. Application of Palynology in taxonomy (2 hrs)
6. Economic importance of pollen, Pollen allergy - Pollen analysis of honey – role of apiaries in crop improvement. (2 hrs)

Practical 9 hrs (½ hr/wk)

1. Pollen germination: *in vitro* and *in vivo* viability tests.
2. Study of pollen types using acetolysed and non-acetolysed pollen.
3. Developmental stages of anther, ovule, embryo and endosperm.

References

1. Bhojwani, S.S & Bhatnagar, S.P. 2000. The Embryology of Angiosperms, Vikas Publishing House Pvt. Ltd. New Delhi.
2. Pandey, S.N. & Chadha, A. 2000. Embryology. Vikas Publishing House Pvt. Ltd. New Delhi.
3. Pandey, A.K. 1997. Introduction to Embryology of Angiosperms. CBS Publishers and Distributors, New Delhi.
4. Johri, B.M. 1984. Embryology of Angiosperms. Springer Verlag. Berlin.
5. Maheswari, P. 1980. Recent Advances in the Embryology of Angiosperms.

Plant Physiology **54 hrs (3 hrs/week)**

Module III

1. Photosynthesis: Efficiency and turn over. Light harvesting complexes. Photosystem I and II - Structure and function. Mechanism of electron transport. Water oxidizing clock. Rubisco Structure and function. Photo inhibition. Phytochromes. CO2 fixation: C3, C4 and CAM pathways. Energetics of CO_2 fixation. (10 hrs)
2. Photorespiration and glycolate metabolism. Mechanism of photorespiration in C3 and C4 plants. Factors regulating photorespiration. (6 hrs)

Module IV

1. Respiration. Anaerobic, aerobic. Glycolysis, TCA cycle, ETS and ATP synthesis, transporters involved in exchange of substrate of products, Pentose phosphate pathway. (10 hrs)
2. Transport of metabolites – Xylem and Phloem sap translocation. (3 hrs)
3. Photoregulation and growth responses. Plant morphogenesis. Physiology of flowering, fruit ripening, senescence and abscission. (4 hrs)
4. Biological clock and circadian rhythm. (3 hrs)
5. Seed metabolism, glyoxylate cycle in fatty seeds during germination. (4 hrs)
6. Nitrogen metabolism. Nitrate and ammonium assimilation. Symbiotic and non symbiotic. Role of leg hemoglobin. (4 hrs)
7. Physiological response of plants to stresses like drought, heat and cold. Salt tolerance in plants. (5 hrs)
8. Role of phytoalexins. Defense mechanism. Phenyl propanoid pathway in plants. (3 hrs) Allelopathy – Plant derived compounds.
9. Plant hormones – Physiological effects and mechanism of action. (2 hrs)

Practical 18 hrs (1 hr/wk)

1. Extraction and estimation of total proteins by TCA precipitation and Lowry'smethod.
2. Isolation of chloroplast from fresh leaves and estimation of chlorophyll proteins.

3. Chlorophyll survey of five plants. Quantification, absorption spectra of chlorophyll and carotenoids using different solvents.
4. Hill activity by DCPIP/ ferricyanide reduction.
5. Extraction and estimation of total phenols.
6. Physiological identification of CAM in plant species.

REFERENCES

1. Taiz, L. & Zeiger, E. 2010. Plant Physiology. 5th Edition. Sinauer Associates Inc., Publishers.
2. Öpik, H., Rolfe S.A. & Willis A. J. 2005. The Physiology of Flowering Plants. 4th Edition. Cambridge University Press.
3. Hopkins, W. G. 2002. Introduction to Plant Physiology. John Wiley & Sons. Inc. New York.
4. Salisbury, F.B. & Ross. C. 2000. Plant physiology. John Wiley & Sons, New Delhi.
5. Jain, J.L. 2000. Fundamentals of Biochemistry. S. Chand & Co. New Delhi.
6. Hall, D.O. & Rao, K.K. 1999. Photosynthesis. Cambridge University Press.
7. Noggle, G. R. & Fritz, G. J. 1999. Introductory Plant Physiology. Prentice hall, London.
8. Devlin, R. M. & Witham, F. H. 1997. Plant Physiology. CBS Publishers and Distributors, Delhi.
9. Brett, C.T. &Waldron, K.K. 1996. Physiology and Biochemistry of Plant Cell Walls, Chapman and Hall London.
10. Dennis, D. T. & Trurpin, D. H. (Eds.) 1993. Plant Physiology, Biochemistry and Molecular Biology. Longmann Scientific and Technical, Singapore.
11. Daphne. J. Osborne, Micheal. & Jackson, B. 1989. Cell Separation in Plants Physiology, Biochemistry and Molecular Biology. Springer – Verlag. Berlin.
12. Conn, E.E., Stumpf, P.K. Bruening G. & Doi R.Y.1987. Biochemistry. John Wiley and Sons.
13. Fitter, A.H. & Hay R.K.M. 1987. Environmental Physiology of Plants. Academic Press.
14. Wilkins, M.B. (Ed.) 1984. Advanced Plant Physiology, Pitman Publishing Co. New York.
15. Strafford, G.A. 1979. Essentials of Plant Physiology. Heinemann Publishing Co. New York.
16. Hess, D. 1975. Plant physiology. Narosa Publishing House, New Delhi.
17. Hatch, M.D. Osmond, C. B. & Slatyer, R. O. 1971. Photosynthesis and Photorespiration.

BIOCHEMISTRY 27 hrs (1.5 hr/wk)

Module V

1. Structure, function and metabolism of carbohydrates – Synthesis of starch, cellulose and sucrose. Interconversion of hexoses and pentoses. (5 hrs)
2. Structure, function and metabolism of lipids: Biosynthesis of fatty acids. Biosynthesis of Triacyl glycerol, diacyl glycerol, monoacyl glycerol. Gluconeogenesis. Membrane lipids. Lipid oxidation. (7 hrs)
3. Proteins and amino acids: Structure and classification of amino acids. Biosynthesis of amino acids. Classification of protein based on structure, function and localizationsites. Primary, secondary, tertiary and quaternary structure. Protein domains. Ramachandran plot. Purification of proteins. (6 hrs)

Module VI

1. Enzymes: IUB system of classification and nomenclature. Distribution of plant enzymes. Soluble and membrane bound enzymes. Co enzymes, substrate specificity, regulation of enzyme activity, Inhibitors, allosteric enzymes. Isozymes. Ribozymes. Abzymes. Enzyme kinetics. the Michaelis–Menten equation, Lineweaver-Burk plot, Km and Vmax. (6 hrs)
2. Biosynthesis of purines and pyrimidines. Metabolism of nucleotides. (3 hrs)

Practical 9 hrs (0.5 hrs/wk)

1. Preparation of standard solutions of BSA, Glucose, Catechol.
2. Extraction and estimation of soluble proteins by Bradford method.
3. Estimation of reducing sugars.
4. Isolation, assay and determination of specific activity of plant enzymes of germination, growth and fruit ripening, viz. amylase, protease, peroxidase and polyphenol oxidase.

References

1. Becker, W. M., Hardin & Bertoni G. 2018. Becker's World of the Cell. Pearson Education Ltd.
2. Nelson D. L. & Cox, M. M. 2017. Lehninger Principles of Biochemistry. 7th Edition. W H Freeman & Co.
3. Appling D. R., Anthony-Cahill S.J. & Mathews, C.K. 2016. Biochemistry. Concepts and Connections. Pearson Education Limited.
4. Berg, J. M., Tymozko. J. L. & Stryer, L. 2015. Biochemistry, 8th Edition. W. H. Freeman and Company.
5. Voet, D., Pratt C.W. & Voet, J. G. 2008. Principle of Biochemistry, 4rd Edition. John Wiley Sons Inc.
6. Jain, J.L. 2000. Fundamentals of Biochemistry. S. Chand & Co. New Delhi.
7. Hames, B.D., Hooper, N.M., & Houghton, J.D1999. Instant notes in Biochemistry. Viva books Pvt. Ltd. New Delhi.
8. Harborne, J.B. 1999. Plant Biochemistry. Chapmann & Hall, New Delhi.
9. Campbell, M.K. 1999. Biochemistry. Saunders College Publishing, New York.
10. Fisher J. & Arnold J.1999. Instant Notes in Chemistry for Biologists. Viva Books Pvt. Ltd. New Delhi.
11. Goodwin, T. W. & Mercer, E. I. 1996. Introduction to plant Biochemistry. CBS Publishers and Distributors, New Delhi.
12. Satyanarayana, U. 1999. Biochemistry. Books and Allied (P) Ltd. Calcutta.

13. Plummer, D.T. 1996. An Introduction to Practical Biochemistry. McGraw Hill.
14. Dennis, D. T. & Trurpin, D. H. (Eds.) 1993. Plant Physiology. Biochemistry and Molecular Biology. Longmann Scientific and Technical, Singapore.
15. Wilson, K. & Goulding, K. H. 1992. Biologists Guide to Principles and Techniques of Practical Biochemistry. Cambridge University Press.
16. Conn, E.E., Stumpf, P.K. Bruening G. & Doi R.Y.1987. Biochemistry. John Wiley and Sons. New Delhi.

SEMESTER III

BE 231 GENETICS, CELL AND MOLECULAR BIOLOGY, IMMUNOLOGY

Course outcomes:

- Awareness about Molecular Biology and Immunology and various techniques in Molecular Biology
- Apply the practical skill in isolation of DNA, RNA and Protein genetic studies
- Understand gene action, gene regulation and synthesis

Classical Genetics 18 hrs (1hr/wk)

Module I

1. Mendelian principles–Brief account and critical evaluation. (2hrs)
2. Linkage, recombination and linkage maps – Bateson's concept of coupling and repulsion. Morgan's concept of linkage, linear arrangement of genes, linkage groups, complete and partial linkage, recombination linkage maps, three point test crosses, interference, coefficient of coincidence and negative interference.
   (3 hrs)
3. Microbial Genetics – Genetic recombination in viruses – lysogenic and lytic cycles in bacteriophages. Retro viruses, reverse transcriptase, onco viruses, and oncogenes. Bacterial recombination - transformation experiment of Griffith, Avery *et al.* Conjugation – F+, F- and Hfr F- conjugations. Conjugation mapping – F – duction (sexduction).Transduction-generalized and specialized. Recombination in fungi (tetrad analysis in *Neurospora*), Complementation tests. (4 hrs)

Module II

1. Biochemical Genetics –Inborn errors of metabolism- Major types of metabolic errors in man: Phenylketonuria, Alkaptonuria, Albinism, Tyrosinosis, Goitrous cretinism. (2 hrs)
2. Gene concept – Allele, Multiple alleles, pseudoallele, polygenes. Factor concept of Mendel, Presence absence theory of Bateson. Gene-Enzyme relationship, One gene - One enzyme hypothesis. Benzer's concepts of cistron, muton and recon. Brief description of the following types of genes- smart genes (luxury genes), housekeeping genes, Barbara Mc Clintock's transposons, overlapping genes, split genes, homeotic genes, pseudogenes, orphan genes, selfish genes, gene cluster, gene families**.** (4 hrs)

Module III

1. Population genetics – Systems of mating and their genetic effects. Hardy Weinberg law and its applications. Factors affecting gene frequencies – mutation, migration, selection, genetic drift, genetic polymorphism and selection, founder effect, genetic load. (3 hrs)

Molecular Genetics (27hrs)

Module IV

1. DNA as the genetic material, DNA constancy, C - Value paradox, structure of B-DNA and Z-DNA. (2hrs)
2. DNA replication – Stage, unit and mode of replication. Semi conservative mode of replication. Messelson – Stahl experiment. System of replication –, enzymes and protein factors. Replisome. Okazaki fragments. DNA polymerases of prokaryotes and eukaryotes, topoisomerases, gyrases, ligases and nucleases. (6 hrs)
3. DNA damage and repair- Photoreactivation repair, excision repair, recombinational repair, SOS repair. Genetic diseases caused by defects of DNA repair system – Blooms syndrome, Xeroderma pigmentosum, Retinoblastoma. (2 hrs)

Module V

1. Mutation – Types of mutations, methods of detection (CIB method, attached X method). Molecular mechanism of spontaneous and induced mutations, site directed mutagenesis. Environmental mutagenesis and toxicity testing, high radiation belts of Kerala. Mutagenic effects of food additives and drugs. Ames test. (3 hrs)
2. Genetic code –Features of the genetic code and its exceptions. (2 hrs)
3. Protein synthesis - Central dogma, Transcription, organization of transcriptional units. Prokaryotic and eukaryotic RNA polymerases and their function. RNA processing and translation. (2 hrs)

Module VI

1. Gene Regulation –Gene Regulation in Prokaryotes – Operon concept, positive and negative control attenuation, anti-termination. Gene Regulation in Eukaryotes – Heterochromatinisation and DNA methylation- DNA methylases,. Transcriptional regulation – signal transduction - upstream and downstream. Regulatory sequences and transacting factors, activators and enhancers. Post transcriptional regulation – RNA processing – split genes, hn RNA, introns and

exons, capping, polyadenylation, splicing, snRNAs and spliceosomes. Post transcriptional silencing, MicroRNAs, RNA inhibition. Translational regulation and Post Translational regulation - Cleavage and processing of proteins. Genetic imprinting. (8 hrs)

2. Gene synthesis – Khorana's artificial synthesis of the gene for alanine transfer RNA and tyrosine transfer RNA of yeast. (2 hrs)

Practical 27 hrs (1.5 hr/wk)

1. Work out problems in linkage, chromosome mapping, molecular genetics and population genetics.

References

1. Krebs, J. E., Goldstein, E. S. & Kilpatrick, S. T. 2018. LEWIN'S GENES XII. Jones & Bartlett Learning.
2. Janet, I. & Wallace, M. 2017. KARP'S Cell and Molecular Biology. John Wiley & Sons, Inc.
3. Lodish, H., Berk, A., Kaiser, C. A. & Krieger, M. 2012 Molecular Cell Biology. 7th Edition, W. H. Freeman, NY, USA.
4. Alberts, B., Bray, D., Hopkin, K. & Johnson, A. D. 2009. Essential Cell Biology. 3rd Edition, Garland Science, NY, USA.
5. Watson, J.D., Baker T.A., Bell S.P., Gann A., Levine M. & Losick R. 2014. Molecular biology of the gene. 7th Edition. Cold Spring Harbor Laboratory, Tania, MIT
6. Snustad, P. D. & Simmons, M. J. 2012. Principles of genetics 6th Edition. John Wiley & Sons, Inc.
7. Benjamin A. Pierce. 2012. Genetics. A Conceptual Approach 4th Edition. W. H. Freeman and Company.
8. Klug, W. S., Cummings, M. R., Spencer, C. A. & Palladino. M. A. 2012. Concepts of genetics. Pearson Education, Inc.
9. Hartwell, L. H., Hood, L., Goldberg, M. L., Reynolds, A. E. & Silver, L. M. 2011. The McGraw Hill Companies, Inc.
10. Russell, P. J. 2010. Genetics: A molecular approach. 3rd Edition. Pearson Education, Inc.
11. Strickberger, M. W. 2008. Genetics 3rd Edition. Pearson Education India.
12. Weaver, R. F. 2008. Molecular Biology. 5th Edition. McGraw-Hill, New York.
13. Brown, T.A. 2006. Genomes. 3 Garland Science.
14. Tamarin, R. 2001. Principles of Genetics 7th Edition. McGraw Hill Education.
15. Goodenough, U. Genetics. 1984. Holt Saunders, New York.
16. Sinnot, E. W. Dunn, L. C. & Dobzhansky, T. 1958. Principles of Genetics. McGraw Hill, New Delhi.

CELL AND MOLECULAR BIOLOGY 54 hrs; (3 hrs/week)

Module I

1. Introduction to cell biology – Cellular organization; Prokaryotic and Eukaryotic cells. Cytoskeleton; Its role in cell organization and mobility. (3 hrs)
2. Structure and organization of nucleus, nucleolus (NOR). Nuclear-Cytoplasmic transport (Nuclear localization signals, NPC Proteins, Nuclear import and export receptors). (3 hrs)

3. Chromosomes – Structure and organization of chromatin, packaging of DNA into chromosomes. Organization and role of centromere and telomere (centromeric and telomeric sequences). (4 hrs)
4. Structural and Numerical variations in chromosomes –Structural: Deletions, Duplications, Inversions and translocations. Meiotic behaviour of structural variants. Numerical: Euploids and aneuploids. Meiotic behaviour of numerical variants. Evolutionary significance of chromosomal variations. (4 hrs)

Module II

5. Cell cycle and its regulation - Stages of cell cycle (Mitosis and Meiosis). Spindle formation and its disintegration, mechanism of chromosome movement and separation during anaphase, Role of cohesins and condensins, Role of motor proteins. Cell cycle and its control mechanisms (Check points); Role of cyclins and cyclin dependent kinases, cdk activating kinase (CAK), cdk inhibitory proteins (CKIs). (6 hrs)
6. Apoptosis –Mechanism of programmed cell death; Extrinsic and intrinsic pathways, Inhibitors of apoptosis. Mechanism of aging. (4 hrs)
7. Cell differentiation – Stem cells, Cell potency, Molecular mechanism of cell differentiation (Brief account), Transcriptional control, Translational control. (3 hrs)

MOLECULAR BIOLOGY 27 hrs

Module III

Basics in Molecular Biology

1. The RNA World. Molecular Clock. (1 hr)
2. DNA Topology- Twist and Writhe. Supercoiling. (1 hr)
3. Proteins involved in DNA Replication, Telomere and Telomerase. (1 hr)
4. Protein Folding. Role of Molecular Chaperones. (1 hr)
5. Isolation and purification of RNA, DNA (genomic and plasmid), different separation methods. (2 hrs)
6. Molecular cloning of DNA. Cutting and joining DNA Molecules, Restriction endonucleases. Cloning vectors-features. Plasmids, Cosmids, Bacteriophage vectors, Phagemids, Yeast artificial chromosome (YAC), Bacterial artificial chromosome (BAC) and P1 phage vectors. (3 hrs)

Module IV

Techniques in Molecular Biology

1. Polymerase chain reaction (PCR) Procedure and Components. Types of PCR i) inverse PCR.

ii) Rapid amplification of cDNA ends (RACE) iii) Real-time quantitative PCR. PCR applications (4 hrs)

2. Generation of genomic and cDNA libraries. (2 hrs)
3. Restriction digestion and ligation; Restriction mapping. (2 hrs)
4. Sequencing genes and short stretches of DNA including Sanger dideoxy sequencing andNext Generation Sequencing (NGS brief account only). (3 hrs)

Module V

1. Protein sequencing methods, detection of post translation modification of proteins. Foot Printing Assay. (1hr)
2. Molecular markers - RFLP, RAPD and AFLP techniques. (2 hrs)
3. Blotting techniques Sothern, Western, Northern and Dot Blot. Labelling of Nucleic acids. (2 hrs)
4. New Trends in Gene modification:- CRISPER/Cas System (2 hrs)

Practical (27 hrs 1.5 hrs/wk)

1. Meiosis - *Rhoeo, Chlorophytum, Crotalaria, Datura* (at least one should be recorded).
2. Mitosis – Metaphase and Anaphase
3. Isolation and purification of genomic DNA.
4. Demonstration of electrophoresis – Horizontal and Vertical.
5. Isolation of total RNA (Demonstration only).

References

1. Clark, D. P. Pazdernik, N.J. & Mc Gehee M.R. (2019) Molecular Biology 3rd Edition Elsevier Inc.
2. Becker, W. M. Hardin, J. & Bertoni G. 2018. Becker's World of the Cell. Pearson Education Ltd.
3. Krebs, J. E., Goldstein, E. S. & Kilpatrick, S. T. 2018. LEWIN'S GENES XII. Jones & Bartlett Learning.
4. Janet, I. & Wallace, M. 2017. KARP'S Cell and Molecular Biology. John Wiley & Sons,
5. Sen, S., Kar, D. K. & Johri, B. M. 2005. Cytology & Genetics. Alpha Science International Ltd.
6. De Robertis & De Robertis. 1998. Cell and Molecular Biology. B.I. Waverly Pvt. Ltd. New Delhi.
7. Strickberger, M. W. 1985. Genetics. Macmillan India, New Delhi.
8. Jurgen Schulz-Scaffer, 1985. Cytogenetics- Plants Animals and Humans. Springer Verlag, Berlin

9. Lodish, H., Berk, A., Kaiser, C. A. & Krieger, M. 2012 Molecular Cell Biology. 7th Edition, W. H. Freeman, NY, USA.
10. Alberts, B., Bray, D., Hopkin, K. & Johnson, A. D. 2009. Essential Cell Biology. 3rd Edition, Garland Science, NY, USA.
11. Watson, J.D., Baker T.A., Bell S.P., Gann A., Levine M. & Losick R. 2014. Molecular biology of the gene. 7th Edition. Cold Spring Harbor Laboratory, Tania, MIT
12. Cooper, G. M. & Hausman R. E. 2013. The Cell – A Molecular Approach. Sinauer Associates
13. Jones, R. L. 2012. The Molecular Life of Plants. Wiley-Blackwell.
14. Weaver, R. F. 2008. Molecular Biology. 5th Edition. McGraw-Hill New York.
15. Primrose S. B. & Twyman, R.M. 2006. Principles of Gene Manipulation and Genomics. Blackwell Publishing.

IMMUNOLOGY **9 hrs (0.5hr/wk)**

Module VI

1. Immunity-mechanism; Innate and adaptive immune system: cells and molecules involved in innate and adaptive immunity. (1 hr)
2. Antigens, antigenicity and immunogenicity. B and T cell epitopes. (2 hrs)
3. Structure and function of antibody molecules, generation of antibody molecules,
4. generation of antibody diversity. (2 hrs)
5. Antigen antibody interactions, MHC molecules, antigen processing and presentation,
6. Activation and differentiation of B and T cell, B&T cell receptors. (2 hrs)
7. Humoral and cell mediated immune responses, primary and secondary immune
8. Complement system, Toll like receptors cell mediated effector functions. (2 hrs)

References

1. Abbas A.K., Lichtman A. H. H. & Pillai, S. 2018. Cellular and Molecular Immunology, Elsevier, Inc.USA.
2. Madigan M. T., Bender K.S., Buckley D.H., Sattley, W.M. & Stahl D.A. 2017 Brock Biology ofMicroorganisms. Pearson Education, Inc.
3. Gupta, S. K. 2014. Essentials of Immunology. Arya Publications.
4. Pommerville, J. C. 2011. Alcamo's fundamentals of microbiology, 9th Edition.
5. Male, D., Brostoff, J., Roth, D. B. and Roitt, I. 2006. Immunology, 7th Edition. Elsevier Limited.
6. Black, J. G. 1999. Microbiology –Principles and Explorations, Prentice Hall, London.

BE 232 ENVIRONMENTAL BIOLOGY, FOREST BOTANY, PLANT BIOTECHNOOGY AND HORTICULTURE

Theory 108 hrs; Practicals 45 hrs

Course Outcomes:

- Understand the concepts on ecosystem and environment
- Understand the causes and effects of pollution and climate change
- Awareness about the significance of genetic resources and its conservation
- Understand and apply methods of gene transfer techniques and production of improved varieties

ENVIRONMENTAL BIOLOGY 45hrs (2.5 hrs/wk)

Module I

1. Introduction Ecology, levels of organization and habitat- interaction between environment and biota. Ecological niches, Concept of habitat and niche; niche width and overlap; resource partitioning; character displacement. (4 hrs)
2. Ecosystem: Structure and function; Concepts and dynamics of Ecosystems: Types – Freshwater, marine and terrestrial. Components of ecosystem, Productivity, energy flow and mineral cycling- application of Law of thermodynamics, food chain, food web, ecological pyramids. Biogeochemical cycles. Development and evolution of ecosystems. Ecosystem management; structure and function of some Indian ecosystems: Grassland, terrestrial, forest, and aquatic (fresh water, marine, estuarine). (10 hrs)
3. 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. (3hrs)
4. Nature of communities; community structure and attributes; edge effect and ecotone; Methods to study community structure (4 hrs)
5. Species interactions - types of interactions, inter specific competition, herbivory, carnivory, symbiosis. (2 hrs)
6. Ecological concepts of species: Autecological level (genecology), Synecological level (Ecosystem level). Ecads (Ecophenes), Ecotypes, Ecospecies. (2 hrs)
7. Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.

(2 hrs)

Phytogeography

Module II

1. Major terrestrial biomes. theory of island biogeography; Deserts (dry and cold) Tundra, Grassland, Savannah, Temperate forests, Tropical rain forests, Mangrove; biogeographical zones of India (3 hrs)
2. Factors of plant distribution. Theories concerning present and past distributions-continental drift, glaciations, existence of land bridges and their effect on plant distribution. Phytogeographic regions of the world (Vegetational belts). Soil, climate, flora, and vegetational types of India. (6 hrs)
3. Disaster management, Global environmental problems- ozone depletion, greenhouse effect, global warming, acid rain, nuclear hazards – Climate change, Eutrophication. (4hrs)
4. Environmental pollution; global environmental change; biodiversity-status, major drivers of biodiversity change; biodiversity management approaches. Current environmental issues in India, Environmental education and awareness. Green Protocol. (5 hrs)

Practical 18 hrs (2 hrs/wk)

1. To find out the dissolved oxygen content in the given water sample (pond, lake, well etc).
2. To find out the primary production in the given water sample using light and dark bottle method.
3. Estimation of carbonate and bicarbonate content in water samples.
4. Estimation of total organic carbon content in the given soil sample

References

1. Sharma, P. D. 2004. Environmental Biology, Himalaya Publications.
2. Trivedi, R. K. & Goel, P.K. 2003. Introduction to Air pollution, Techno-Science Publication.
3. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001. Environmental Encyclopedia, Jaico Publ. House, Mumbai.
4. Chapman J. & Reiss M. 2000. Environmental Biology. Cambridge University Press.
5. Agarwal, K.C. 2001. Environmental Biology, Nidi Publ. Ltd. Bikaner.
6. Jadhav, H & Bhosale, V.M. 1995. Environmental Protection and Laws. Himalaya Pub. House, Delhi.
7. Brunner, R.C. 1989. Hazardous Waste Incineration, McGraw Hill Inc.
8. Odum, F. E. 1971. Fundamentals of Ecology. W.B. Saunders and Company.

9. Schatz, G.E. 1996. Malagasy / Indo-Australo-Malesian Phytogeographic Connections. http://www.mobot.org/MOBOT/Madagasc/biomad1.html
10. Bharucha, F. R. 1984. A Text Book of Plant Geography of India. Oxford University Press.
11. Puri, G.S. 1983. Indian Forest Ecology, Vol. I, II. Oxford, New Delhi.
12. Ronald Good. 1964. The Geography of Flowering Plants. Longmans.
13. The International Biogeography Society http://www.biogeography.org/
14. Tree of Life. URL: http://tolweb.org/tree/phylogeny.html
15. Huismann, O. & de By R. A. (Editors) 2009. Principles of geographic system- An introductory text book. ITC, The Netherlands.

Forest Botany **(9 hrs; ½ hr/Wk)**

Module III

1. Forests- definition, study of various forests of the world and India. (1 hr)
2. Forest products – Major and minor with reference to Kerala. (2 hrs)
3. Influence of forest on environment. (2 hrs)
4. Consequence of deforestation and industrialization. (2 hrs)
5. Sustainable use of bioresources. (2 hrs)

References

1. Shanmughavel, P. 2014. Forest Botany, Pointer Publishers.
2. Bor, N.L. 2008. A Manual of Indian Forest Botany International Book Distributors.
3. Puri, G. S. 1989. Indian Forest Ecology, Vol. II, Oxford & IBH Co. Pvt. Ltd.
4. Agarwal, V. P. 1985. Forest in India, Oxford & IBH.
5. Champion, G. H. & Seth, K. A. 1968. A Revised Survey of Forest types of India. **C.**

PLANT BIOTECHNOLOGY **36 hrs (2hrs/wk)**

Module IV

1. Scope and impact of biotechnology - an overview. Plant tissue culture techniques: Culture media and culture conditions, hormonal regulation of growth and differentiation, micropropagation; shoot tip, nodal segment, meristem cultures: callus culture, callus mediated organogenesis, cell suspension culture. (8 hrs)
2. Somatic embryogenesis. Artificial seeds. Applications. Protoplast culture, Somatic hybridization and its impact on plant breeding. Use of protoplasts in genetic transformations. (3 hrs)
3. Somaclonal and Gametoclonal variations. Genetic basis. Applications (2 hrs)

4. Haploid production: anther and ovule culture. Applications. (1hrs)
5. Production of secondary metabolites. Cell immobilization. Bioreactor technology. Cryopreservation (3 hrs)

Module V

1. Genetic engineering: Methods and applications. Applications of gene cloning techniques in plants. Genetically modified organisms and foods (GMO/GMF) (3 hrs)
2. Methods of gene transfer in plants. *Agrobacterium* and CaMV mediated gene transfer; direct gene transfer using PEG, microinjection, electroporation, microprojectile (biolistics) method, liposome mediated DNA delivery, Transposons as vectors. (6 hrs)
3. Application of Plant Biotechnology: - Transgenic plants -Traits for improved crop production, Herbicide Resistance, Vaccines from Plants, Genetic Pesticides, Pathogen resistance. Molecular farming of antibodies in plants and Enhanced Nutrition. Technique and Controversy of Terminator Gene Technology. Genome Editing. (6 hrs)
4. Plant Promoters Use of Different Promoters in Transgenic Plant Development: Current Challenges and Future Perspectives (2 hrs)
5. Plant artificial chromosome technology (1hrs)

Practical 27 hrs (1.5 hrs/wk)

1. Preparation of culture medium (MS, N&N, SH, B_5), sterilization and inoculation.
2. Shoot multiplication, Callus culture and organogenesis of important crops/medicinal plants/ornamentals.
2. Isolation and estimation of genomic DNA.
3. Demonstration of Agarose gel electrophoresis.
4. Encapsulation of seeds/embryos in calcium alginate.
5. Students have to submit a record of the above.

References

1. Nathan Mitchell (Ed) 2020 Plant Biotechnology: Principles And Applications. Syrawood Publishing House
2. Thieman, W. J. & Palladino, M. A. 2013. Introduction to biotechnology. 3rd Edition Pearson Education, Inc..

3. Chawla, H.S. 2008. Introduction to Plant Biotechnology. 3rd Edition. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
4. Ratledge, C. & Kristiansen, B. 2006. Basic Biotechnology. 3rd Edition. Cambridge University Press.
5. Crueger, W. & Crueger, A. 2000. Biotechnology - A Text book of Industrial Microbiology.
6. Trivedi, P.C. (Ed.) 2000. Plant Biotechnology - Recent Advances. Panima Publishing Co. New Delhi.
7. Brown, T.A. 1999. Genomes. John Wiley & Sons. New York.
8. Griffiths *el al*., 1999. Modern Genetic Analysis. W.H. Freeman & Co. New York.
9. Gupta, P.K. 1999. Elements of Biotechnology. Rastogi Publications, Meerut.
10. Gamborg, O.L & Phillips, G.C. 1998. Plant Cell, Tissue Organ Culture. 1998. Narosa Publishing House, NewDelhi.
11. Mertins, T. R. & Hammorsmith, R. L. 1998. Genetics a Laboratory Investigation.
12. Backer, J. M. Caldwell G.A. & Zachgo E.A. 1996. Biotechnology- A Laboratory Course. AcademicPress, New York.
13. Dixon, R.A. & Gonzales, R. A. (Eds.) 1994. Plant Cell Culture - A Practical Approach. Oxford University Press, New York.
14. Pamela Peters. 1993. Biotechnology-A Guide to Genetic Engineering. Wim.C Brown Publishers, USA.
15. Old R.W. & Primrose. S.B. 1991. An Introduction to Genetic Engineering. Blackwell Scientific Publications, Oxford, London.
16. Brown, C.M., Campbell, I. & Priest, F.G. 1990. Introduction to Biotechnology. Blackwell Scientific Publications, Oxford, London.
17. Primrose, S.B. 1989. Modern Biotechnology. Blackwell Scientific Publications, Oxford, London.
18. Brown, C. M. 1987. Introduction to Biotechnology. Blackwell Scientific Publications, Oxford, London.
19. Thorpe, T.A. 1981. Plant Tissue Culture Academic Press, London.

EVOLUTION 18 hrs (1 hr / Wk)

Module VI

1. Origin and evolution of life. (2 hrs)
2. Concepts and theories of evolution. Classical and synthetic theories of evolution. (4 hrs)
3. Forces and mechanism of evolution. (3 hrs)
4. Speciation. (3 hrs)

5. Isolation mechanism. (2 hrs)
6. Evolution above species level. (2 hrs)
7. Molecular evolution. (2 hrs)

References:

1. Herron, J. C., Freeman, S.m Hodin, J., Miner, B. & Sidor, C. 2014. Evolutionary Analysis. 5th Edition. Pearson Education, Inc.
2. Shapiro, J. A. 2011. Evolution- A view from the 21st Century. Publishing as FT Press Science.
3. Sproule, A. 1998. Charles Darwin: Scientist who have Changed the World. Orient Longman, New Delhi.
4. Strickberger, M. W. 1996. Evolution, Jones and Bartlett Publishers, New York.
5. Briggs, D. & Walters, S. M. 1984. Plant Variation and Evolution, Cambridge University Press, London
6. Calow P. 1983. Evolutionary principles, Blackie & Son Limitted.
7. Wooley, P. 1983. Molecular theory of evolution, Springer-Verlag, Berlin.
8. Echrlich, P. R. & Holm, R. H. 1974. Process of evolution, Oxford &IBH, New Delhi.
9. Savage, J. M. 1969. Evolution, Oxford &IBH, New Delhi.

BE 233 MICROBIOLOGY, PLANT PATHOLOGY, PLANT BREEDING AND HORTICULTURE

Theory 108 hrs; **Practicals 45 hrs**

Course Outcomes:

- Understand types of microbes and its economic importance
- Generate basic knowledge in plant breeding, and horticulture
- Understand different breeding methods and develop practical skills in plant breeding
- Identify the microbial diseases in plants and apply the control measures

Microbiology **27 hrs (1.5 hrs/wk)**

Module I

1. Brief history of microbiology. Experiments of Pasteur and Tyndall, Koch's postulates. Methods of sterilization. (2 hrs)
2. Bacteria - Classification based on Bergey's Manual. Significance of 16 S RNA in Bacterial identification. (2 hrs)
3. Major groups of microorganisms and their characteristics -prions, viroids, viruses, bacteria, archaebacteria, mollicutes, actinomycetes, cyanobacteria, viable but nonculturable (VBNC) bacteria Morphology, and ultrastructure of typical bacterium. (6 hrs)

Module II

1. Plant microbe interactions –Bacterial and fungal endophytes. Isolation of endophytes (2 hrs)
2. Products of Endophytes- Phytohormones (Auxin, Cytokinin, Gibberellin, abscisic acid, ethylene, Siderophores) Secondary metabolites. (3 hrs)
3. Growth and nutrition of microorganisms. Growth characteristics. Continuous culture devices - Chemostat. (3 hrs)
4. Extremophiles – Acidophilic, Alkalophilic, Thermophilic and halophilic bacteria. (2 hrs)
5. Microbes in Agriculture: Rhizosphere, Nitrogen fixation, Mycorrhiza**,** Cyanobacteria (4 hrs)
6. Industrial Microbiology: Microbial fermentation-Major industrial products from microbes:
7. Beverages, Antibiotics, Secondary metabolites, Recombinant products (3 hrs)

Practical 18 hrs (1 hr/ wk)

1. Practical involving preparation of media, principles of isolation, pure culturing aspects and maintenance of culture.
2. Differential staining– Gram staining of pure cultures of *Bacillus/Lactobacillus/Rhizobium/Escherichia coli.*

3. Demonstration of bacterial motility by hanging drop method.
4. Isolation of *Rhizobium* from root nodule of legumes.
5. Test for coliforms in contaminated water.
6. Isolation of pure bacterial culture by streak plate method.

References

1. Tortora, G.J., Funke, B.R. & Case, C.L. 2019. Microbiology an Introduction. 13th Edition. PearsonEducation, Inc.
2. Madigan M.T., Bender K.S, Buckley DH, Sattley WM & Stahl DA. (2019) Brock Biology of Microorganisms 15th Edition. Pearson Education, Inc.
3. Talaro, K. P. & Chess, B. 2018. Foundations in microbiology. 10th Edition. Pearson Education, Inc.
4. Cowan, M.K. & Smith H. 2018. Microbiology: A Systems Approach. 5th Edn. Mc Graw Hill Edn.
5. Joanne M. Willey Linda M. Sherwood & Christopher J. Woolverton (2017) Prescott's Microbiology, Tenth Edition Hill Education.
6. Pommerville, J. C. 2017. Alcamo's Fundamentals of Microbiology, 11th Edition. Jones & BartlettLearning.
7. Iwasa, J. & Marshall, W. 2017. KARP'S Cell and Molecular Biology. John Wiley & Sons, Inc.
8. Bauman, R. W. 2015. Microbiology: with diseases by body system 4th Edn. Pearson Educn, Inc.
9. Sharma, P. D. 2010. Microbiology. Narosa publishers, New Delhi.
10. Dubey, R. C. & Maheswari, D.K. 2010. A Text book of Microbiology, S. Chand & Company,New Delhi.
11. Rangaswami G and Bagyaraj D.J. 2004. Agricultural Microbiology. Prentice-Hall of India Pvt. Ltd.
12. Atlas, M. & Bartha, R. 2000. Microbial Ecology, Longmann, New York.
13. Black, J. G. 1999. Microbiology – Principles and Explorations, Prentice Hall, London.
14. Casida, L. E. 1997. Industrial microbiology. New Age Publishers, New Delhi.
15. Pelczar, M. J., Chan, E. C. S. & Kreig, N. R. 1993. Microbiology-concepts andapplications. McGraw Hill, Inc. New York.
16. Stainer, R.Y. *Stanier R.Y., Ingraham J.L., Wheelis M.L. and Painter P.R.* 1990. The microbial world.Prentice Hall of India, New Delhi.

Plant Pathology **18 hrs (1 hr/wk)**

Module III

1. History of Plant pathology, General principles and concepts of host-parasiteinteraction. (2 hrs)
2. Defence mechanisms - Systemic Acquired Resistance and Induced Systemic Resistance, major signalling pathways of plant defence mechanism. (4 hrs)
3. Epidemiology and quarantine. (1 hr)
4. Principles and methods of plant disease control: Fungicides and pesticides, natural pesticides, sanitation, disease resistance. Biological control: biocontrol agents,bio- inoculants, natural enemies, bio-traps. (2 hrs)
5. Study of the following plant diseases with reference to symptoms, causal organism, disease cycle and control measures. (9 hrs)
    i. Paddy - Brown spot and Sheath Blight
    ii. Ginger Soft rot
    iii. Rubber - Powdery mildew
    iv. Cardamom Mosaic disease
    v. Tea - Red rust
    vi. Sugarcane - Red rot
    vii. Ladies finger - Yellow vein mosaic
    viii. Pepper - Quick wilt
    ix. Bacterial wilt - Tomato

Practical

A record of all diseases mentioned in the syllabus.

References

1. Agrios, G.N. 2005. Plant Pathology 5th Edition. Academic Press, New Delhi.
2. Sharma, P. D 2005. Plant pathology. Narosa Publishing House, New Delhi.
3. Rangaswamy, G. & Mahadevan, A. 2002. Diseases of crop plants in India. Prentice Hall of India, New Delhi.
4. Singh, R. S. 2000. Introduction to the principles of plant pathology. Oxford IBH, New Delhi.
5. Mehrotra, R. S. 2000. Plant pathology. Tata McGraw Hill, Publishing Co. Ltd. New Delhi.
6. Marshall, H. 1999. Diseases of plants. Anmol Publications Pvt. Ltd., New Delhi.
7. Swarup 1999. Plant diseases. Anmol Publications Pvt. Ltd. New Delhi.
8. Bilgrami, K. S. & H. C. Dube.1990. A text book of modern plant pathology. Vikas Publishing House, New Delhi.
9. Butler, E. J. & Jones, S. G. 1949. Plant pathology. Macmillan & Co. Ltd. London.
10. Chatterjee, P. B. 1997. Plant protection techniques. Bharati Bhavan, Patna.
11. Chattopadhayay, S.B. 1991. Principles and procedures of plant protection Oxford&IBH, Delhi.

12. Manners, J.G.1982. Principles of Plant pathology. Cambridge University Press, London.
13. Mundkur, B. B.1982. Text book of Plant diseases. Macmillan India Ltd., New Delhi.
14. Pathak, V. N., Khatri, N. K. & Pathak, M. 1996. Fundamentals of Plant pathology. Agrobotanical publishers, India, Bikaner.

Plant Breeding (45 hrs; 2.5 hrs/wk)

Module IV

1. Definition, Objectives. Importance of floral biology in plant breeding. (2 hrs)
2. Methods of crop improvement i. Plant Introduction: Definition, types and procedure. Sources of germplasm. Centres of genetic diversity. Concepts of de Candolle and Vavilov. Primary, secondary and microcenters. Genetic erosion. Preservation and utilization of germplasm. Gene banks. NBPGR. International exchange of germplasm. (4 hrs)
3. Selection: Principles, genetic basis and methods: Mass selection, pure line selection, clonal selection. (5 hrs)
4. Hybridization: Objectives. Procedure. Major achievements. Problems and causes of failure of hybridization. Handling of hybrids - Bulk method and pedigree method of selection. Distant hybridization - Role of interspecific and intergeneric hybridization in crop improvement (6 hrs)

Module V

1. Genetics of incompatibility and sterility. Role in crop improvement Types of male sterility: Gametic and zygotic sterility. Somatoplastic sterility. Cytoplasmic and genetic sterility. Methods to overcome incompatibility: (4 hrs)
2. Backcross breeding: Theory and procedure. (4 hrs)
3. Inbreeding: inbreeding consequences. Heterosis- Definition. Genetic and physiologic basis. Application in plant breeding. Steps in the production of single cross, double cross, three way cross, synthetic cross, multilines. Ideotype breeding: Concept, Achievements: (Wheat – Asana, Donald. Rice – Super Rice). (6 hrs)
4. Polyploidy breeding: induction of autopolyploidy and allopolyploidy. Achievements. (3 hrs) Mutation breeding: Principles, objectives, procedure. Induction of mutations: Physical and chemical mutagens - Recurrent irradiation, Split dose irradiation, Combination treatment. Achievements. (5 hrs)
5. Resistance breeding: Principles. Methodology. Basis of resistance: structural biochemical, physiological and genetic. Vertical and Horizontal resistance. (4 hrs)
6. Seed production and certification. (2 hrs)

7. Centres of crop breeding: International and National (with special reference toKerala) (2 hrs)

Practical 9 hrs (½ hr/Wk)

1. Emasculation; preparation of the inflorescence for crossing.
2. Estimation of pollen sterility and fertility percentage.
3. Pollen germination: *in vitro* and *in vivo* viability tests
4. Study of pollen types using acetolysed and non-acetolysed pollens
5. Developmental stages of anther, ovule, embryo and endosperm.

References

1. Chopra, V. L. 2012. Plant Breeding Theory & Practice Oxford & Ibh Publishing Co Pvt Ltd
2. Ghahal, G. S. & Gosal, S. S. 2002. Principles and Procedures of Plant Breeding. Narosa Publishing House.
3. Singh, B. D. 1996. Plant Breeding: Principles and Methods. Kalyani Publications.
4. Allard, R. W. 1995. Principles of Plant Breeding. John Wiley and Sons, Inc.
5. Sharma, J. R. 1994. Principles and Practices of Plant Breeding. Tata McGraw-Hill Publishers
6. Company Ltd.
7. Hayward, M. D., Bosemark, N.O. & Romagosa, T. 1993 (Eds.) Plant Breeding. Principles and Prospects. Springer.

Horticulture 18 hrs (1 hr/wk)

Module VI

1. Concept and Scope – Familiarization of famous gardens in the world and in India. (1hr)
2. Tools and Implements. (1 hr)
3. Plant growing structures – Greenhouse, Glasshouse andMist chamber. (1 hr)
4. Plant propagation: Seed propagation and vegetative propagation- natural and artificial.
5. Artificial methods of vegetative propagation: Cuttage, layerage, graftage, budding, micropropagation. (2 hrs)
6. Cultural practices – Thinning, training, trimming and pruning. (2 hrs)
7. Fertilizers: NPK, biofertilizers, green manure, compost, vermicompost. (2 hrs)
8. Outdoor horticulture: Components and designs of gardens. Types of gardens: (3hrs)
9. Vegetable/ medicinal/ floral. (2) Home gardens, public gardens, vertical gardens, roof gardens. Lawns and landscapes. (2 hrs)

10. Commercial horticulture: Nurseries, Orchards, Floriculture: Production of cut flowers. Floral decorations (Brief account only). Indoor plants. (2 hrs)
11. Arboriculture: Pruning, bracing, feeding and transplanting. Bonsai: Principles and procedure. (2 hrs)

Practical 9 hrs (½ hr/wk)

1. Budding – 'T' Budding and Patch Budding.
2. Layering – Any two methods.
3. Grafting – Any two methods.
4. Designing of gardens and Methods of Landscaping
5. Familiarization of tools and implements used in Horticulture.
6. Maintain 5 medicinal plants of ethnobotanical significance in the department.

References

1. Gupta, S. N. 2018, Handbook of Horticulture, 1st Edition, Jain Brothers.
2. Shry, C. & Reiley. 2016. Introductory Horticulture; 9th Edition. Cengage Learning.
3. Singh, J. 2014. Fundamentals of Horticulture, Kalyani Publishers.

SEMESTER IV

SPECIAL PAPER 1

BE 241 HERBAL TECHNOLOGY, BIOINFORMATICS APPROACHES IN DRUG DESIGN AND DEVELOPMENT

THEORY144 hrs PRACTICAL 72 hrs

Course Outcome

- Understand branches of Herbal Technology such as Medicinal plants, Natural dyes, Biopesticides, Biofertilizers and Biofuel.
- Students would acquire knowledge of Herbal Technology and Neutraceutical therapy.
- Comprehend the role of metabolomics and microbial diversity around plants in deciding the quality of herbal drug product.
- Develop knowledge on the use of Herbal technology in Cosmetics and laws pertaining to herbal technology
- Understand biological databases, Pharmacogenomics and Sequence Analysis.
- Acquire knowledge of molecular viewing of macromolecules and prediction and analysis of protein structure.
- Understand Molecular Designing and development of Drugs (Computer Aided Drug Design) and identify the steps for designing new drugs, target lead molecule identification and validation.

HERBAL TECHNOLOGY (54 hrs)

Module I

Introduction and scope of Herbal Technology -Plants for Human welfare. Utilisation of Different categories of Plants: Medicinal plants, Natural Dyes, Biopesticides, Biofertilizers and Biofuel.

(9 hrs)

Module II

Herbal Drug Technology. Herbs as raw materials, Herbal-Drug and Herb-Food Interactions General introduction to interaction and classification. Action and side effects of active principles of Selected Herbs: eg. Curcumin, Pepper, Garlic, Ginseng , Artimisinin, Taxol, Camptothecin.

(9 hrs)

Module III

Herbal Plant extraction and Formulation - single plant and poly herbal formulations, Quality control. Herbal Cosmetics: Biological membranes, Inter facial Phenomena: Liquid-Liquid interface, , Liquid-Solid interface, detergency and water repellence. **(9 hrs)**

Module VI

Plants of Indian Traditional Medicine, Reverse Pharmacology, Activity Guided Fractionation and Characterization. Herbal technology for the marketing of herbal drug. Model herbal products, IPR protection, CBD, Equitable Benefit Sharing, Example- Jeevani - Herbal drug from Kerala with global acceptance. **(9 hrs)**

Module V

Nutraceuticals: Biological Effects of Nutraceuticals. Nutraceuticals related to neural, cardiovascular diseases and renal disorders. Nutraceuticals for health promotion, immune-boosting, protection.Metabolomics (brief account) and role of soil micro flora in herbal medicine Quality. **(9 hrs)**

Module VI

Regulatory measures adapted for the release of herbal product to industries, Efficacy, toxicity and allergenicity, Preclinical analysis and Clinical trials, Biotechnological interventions. Good Manufacturing Practices, Global acceptance of Herbal products , Quality Control, Repurposing of herbal products for controlling Epidemics and Pandemic, Ethical Issues **(9 hrs)**

Practicals 36 hrs (2 hrs/wk)

1. Preparation of Herbal Extracts. Evaluation of different preparative methods - Profiling functional group variation
2. Active principle identification of Herbal products through chromatography.
3. Anti-inflammatory Activity, Antioxidant activity, Cyclooxygenase inhibitory assay, Lipoxygenase Inhibitory Assay
4. Test for Steroids, Anthraquinones, Alkaloids and Flavonoids

References:

1. M. Daniel (2008) Herbal Technology: Concepts and Scope. Satish Serial Publishing House
2. Magazine R (2019) DRUGS AND COSMETICS FORMULATIONS. ISBN-13 : 978-8123919942. CBS Publisher : India
3. Ramesh Gupta (Ed) (2016) Nutraceuticals: Efficacy, Safety and Toxicity. Academic Press.
4. Agarwal S.S. and Paridhavi M. (2012) Herbal Drug Technology 2nd Edition Orient Blackswan Publisher. ISBN: 9788173717871,

BIOINFORMATICS APPROACHES IN DRUG DESIGNING AND DEVELOPMENT

A. INTRODUCTION TO BIOINFORMATICS Theory 90 hrs

Module I **(12 hrs)**

Introduction to Bioinformatics, Types of Biological databases, Nucleotide & Protein sequence database , Applications of Bioinformatics. Pharmacogenomics: Overview, present status, Pharmacogenomics and Personalized medicine

Module II **(18 hrs)**

Sequence Analysis – Global Alignment, pairwise analysis, Scoring Matrices (an introduction), Multiple Sequence Analysis. Molecular Phylogeny – Gene and Species tree. Molecular evolution and Kimura'stheory, Definition and description, various types of Phylogenetic Trees, Terminology in Phylogenetic tree. Cladogram and Phylogram, Steps in constructing a tree, Significance of Molecular Phylogeny.

B. DRUG DESIGN AND DEVELOPMENT

Module III

Introduction to Drug Design and Discovery: Drug discovery process, Role of Bioinformatics in drug design.Protein Structure Prediction – Secondary Structure prediction (Chou Fasman method) and Tertiary structure prediction (Comparative modelling, Abinitio prediction, Homology modeling). Structural Bioinformatics – Molecular Structure viewing tool –Rasmol. **(12 hrs)**

Module IV

Insilco Drug design Parameters of Molecular Docking. Target identification and validation, lead optimization and validation, Structure-based drug design and ligand based drug design.**(18 hrs)**

Module V

Molecular Recognition, Biostructure-Based Drug Design. Targets for Drug Development Receptors: Structure, Function; Ion Channels Histamine Receptors. **(18 hrs)**

Module VI

Drug design for Neglected Diseases; Infections caused by Helminthic parasites and Protozoan Parasites. Natural Products in Drug Discovery Natural Products as Lead Structures.**(12 hrs)**

Practicals **36 hrs** (2 hrs/wk)

1. Molecular docking (using either Free or commercial Software).

2. Screening of plant based lead molecules against plausible target proteins involved in disease development.
3. Blast search with Protein Sequence and Nucleic Acid Sequence
4. Phylogenetic tree creation with CLUSTAL X, W and MUSCLE
5. Creation of phylogentic trees for the selected families of angiosperms

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References

1. O'Donnell J.J., Somberg J., Idemyor V. andO'Donnell J.T. (2019) Drug Discovery and Development, Third Edition. CRC Press
2. Mukhopadhya C.S., Choudhary R.K., Iquebal, M.A (2018) Basic Applied Bioinformatics John Wiley & Sons, Inc.
3. David Edwards (Ed) (2016) Plant Bioinformatics Methods and Protocols Second Edition. Springer Science&Business Media New York
4. Lesk, A.M. (2002).” Introduction to Bioinformatics”, 1st Edition, Oxford University Press, Oxford, UK. Jin Xiong (2007) Essential Bioinformatics, Cambridge University Press India, Pvt LTD
5. Larsen P.K., Liljefors T. and Madsen U (2002) Textbook of Drug Design and Discovery. Taylor and Francis New York
6. Mount, D.W. (2001).” Bioinformatics – Sequence and GenomeAnalysis”, 1st Edition, Cold Spring Harbor Laboratory Press, New York, USA.

Special Paper II

BE 242 II Ethnopharmacology, Phytopharmaceutical product Development , IPR & Patents

Theory144 hrs Practical 54 hrs

Course Outcome:

- Appreciate ethnopharmacology as an integrative science of social and biocultural components.
- Practice scientific method in documenting Indigenous/traditional knowledge for future use.
- Understand the need for the development of new herbal drugs
- Develop laboratory skills in the scientific testing of herbal drugs and new commercial products for safe and rational use.
- Have an in-depth understanding of the ethical and commercial implications of drug development from medicinal plants**.**

Ethnopharmacology: (36 hrs)

Module I

Importance of traditional/ Indigenous knowledge in pharmacology and drug development. Role of anthropology, medical science, and chemical science in Ethnopharmacology. Ethnopharmacology as an interdisciplinary science with contributions from historians of science, clinicians, agronomists, biochemists, and researchers in veterinary medicine. Importance of credible plant identification in ethnopharmacology. Principles of management of human diseases and remedies in modern medicine. Drug resistance, neglected tropical disease and remerging diseases. Categories of general drugs. The laws, regulations, policies and procedures of the country to protect safety of consumenrs. Review of traditional/indigenous therapeutic uses of plants used by ethnic and cultural groups of Kerala, their contexts of use, preparation, dosage, route of administration. Ethnopharmacology of algae, fungi, Lichen, bryophytes, Pteridophytes. Review of higher plants used as medicines in India. Need for the preservation of biodiversity and indigenous knowledge.

Phytopharmaceutical Drug Development (81 hrs)

Module II

Forms of phytopharmaceuticals drugs: Essential oils, Liquid extracts, tinctures, herbal tea, concentrated soft and dry extracts and Pure pharmaceutical drug. Standardization of phytopharmaceuticals to ensure efficacy, safety, toxicity and shelf life. Use of correct botanical raw material (correct plant and plant part) and the quantity. Intrinsic toxicity, External toxicity, Banned

drugs, Herb -drug interaction, Shelf life determination.

Cultivation of medicinal plants including good cultivation practice(pesticide free conditions), good collection practice, good processing and good storage practice and good manufacturing practices, Processing of plant drugs, purification of raw drugs using phytochemical techniques.

Standard operating procedures (SOPs) and Good practices in production of Phytopharmaceuticals - The Drug Manufacturing Unit, GMP Requirements Based on WHO. Guidelines for Ayurvedic Pharmaceutical Industries by AYUSH, Scope, Requirements, Premises, Ancillary areas, Storage areas, Weighing areas, Production areas, Quality control areas. Prevention of cross-contamination and bacterial contamination during production, Finished products, Rejected, recovered, reprocessed and reworked materials, Reference samples and standards. Good practices in quality control, Stability studies, Qualification and validation. Hygiene of Workers, Health, Clothing, Sanitation and Medical Services. Labels, Packaging materials, Bar-coding. (36 Hrs)

Module III

Biological testing of herbal drugs (analgesics, anti-inflammatory and antioxidant agents). Evidence for clinical efficacy, evaluation of side effect and toxicity . Use of Bioinformatics tools in drug development. Regulatory guidelines for herbal medicine and pharmaceutical product development, Storage and distribution-General study of the drugs and Cosmetic Act and related rules. Schedules relating to Ayurvedic drugs –Schedule E (1),Schedule T. Medicinal and Toilet preparations (Excise duties) Act 1955 and rules1956. Factories Act1948. Drug dependence, misuse and abuse. Medico legal analysis with special references to Narcotic drugs and psychotropic substances Act1985. Advertisement of Drugs and Cosmetics – Prohibited and exempted advertisements. Drugs and Magic remedies (objectionable advertisements) Act 1955. (18 hrs)

Module IV

Herbal product development: Methodologies, Challenges, and Issues. Traditional herbal products and phytopharmaceuticals. Successful development of natural health products, dietary food supplements and nutraceutical products . Phases of clinical trials, Development of innovative combinations and formulations. Evidence based evaluation techniques. Herbal monographs in Indian Pharmacopoeia and Monographs by the Indian Council of Medical Research. (15 hrs)

Module V

Organisations involved in drug standardisation in India, ASU drugs and phytopharmaceuticals. Market study of crude drugs including adulterants and substitutes using standard procedures. a .Pilot scale production b .Scaling up of herbal products c .lndustrial production

Challenges from lab to market. Indian Herbal product market and the overseas market, product diversification and Industries related to Herbal products in India. (12 hrs)

Intellectual Property Rights and Patents (27hrs)

Module VI

IPR Brief history,Types of Intellectual Properties , Role of undisclosed informationd .Rationale of patents, Rationale of licences, Management of IPR in pharmaceutical Industry, Special aspects of drug patent specification.

Practicals 54 hrs (3hrs/wk)

(Ethnopharmacology 9 hrs/wk; Phytopharmaceutical Drug Development 36 hrs; IPR & patents 9hrs)

1. Study on the effect of particle size on dissolution/ compatibility/flow properties.
2. Testing of drug degradation compounds using TLC.
3. Dissolution of drugs in different pH media for comparison of performance.
4. Analysis of different herbal formulations like tablets, pills, asavas, aristhas, powders, etc.
5. Methods for analysis of raw materials and single herbal drugs.
6. Methodology to study toxicity of herbal drugs
7. Preparation of e-PBR in collaboration with BMC of local self government.
8. List out trade names, combinations, banned drugs, newly introduced and out dated drugs, drug tragedies.
9. Industrial visits (3Nos) and 5-10 day herbal industry training and report.

References

1. Dharti And Vidhi Kirti (2020) Concise Course In Industrial Pharmacy, S Vikas And Company.
2. Jai Malik (2018) Pharmacognosy and Phytochemistry, paiging publishers
3. Chiragkumar J. Gohil (2018) Fundamentals of Pharmacy, IP Innovative Publication Pvt. Ltd.
4. Herbalism, Phytochemistry and Ethnopharmacology(2011).Apple Academic Press ,Florida ,. Amritpal Singh. CRC Press, Taylor & Francis Group
5. Brahmankar Jaiswal (2015) Biopharmacuitics And Pharmacokinetics - A Treatise, Vallabhaprakashan publishers
6. Amritpal Singh (2017), Regulatory and Pharmacological Basis of Ayurvedic Formulations, CRC Press.
7. An overview and implication in pharmaceutical industry technology and research. 2011.Publishing Kluwer
8. Indian Pharmacopoeia 2010. Volume-I, II & III, Indian Pharmacopoeia Commission. New Delhi.
9. Banker, Rhodes. (2009) Modern pharmaceutics. Vol 121, 4th Ed. New York: Marcel Dekker Inc
10. B. S. Kuchekar (2008) Pharmaceutical Jurisprudence Pragati Books Pvt. Ltd.
11. Herbert. (2005) Pharmaceutical dosage form- Tablets, Vol 1,2,3, 2nd Ed. New York: Marcel Dekker Inc
12. Guarino RA. (2002) New drug approval process. Vol 100. New York: Marcel Dekker Inc.Bernd Markert (1996) Instrumental Element and Multi-Element Analysis of Plant Samples: Methods and Applications, Wiley Publishers