COURSES OF STUDY

M.Sc. in BOTANY

(Effective from the Academic Session, 2024-2026)

Under Choice Based Credit System (CBCS)

BERHAMPUR UNIVERSITY
BHANJA BIHAR
BERHAMPUR – 760 007 (GANJAM)
ODISHA

2024

A Brief Profile of the Department

The Department of Botany was established in 1969 and founded by the late Prof. Harihar Pattnaik, a renowned algologist. Since its inception, the department has grown appreciably not only in terms of student and faculty strength, but also in the introduction of new courses, specializations, and broadening research activities. The Government agencies fund the department through research grants from CSIR, UGC, DBT, DAE, MoEF, and CC, the Government of India, OFSD, the S & T Department, and the Government of Odisha.

Program Outcome: M.Sc. in Botany

M.Sc. in Botany is a two-year regular course, offered by the PG Department of Botany, Berhampur University. The present syllabus covers different components of theory and practical, as well as project work, field study, and seminar presentations, which will help the students to have in-depth knowledge of advanced Botany. During and after the completion of this course, students are expected to know Microbiology, different lower (Cryptogams) and higher plants (Phanerogams) diversity, their anatomy, physiology, biochemistry, biostatistics, reproductive biology, genetics, evolutionary history and Paleobotany, etc. The students can learn about the origin and history of different cultivated plants, their economic importance, utilization and conservation of natural resources, and different renewable and nonrenewable energy sources. The course curriculum is designed to introduce the students about sensory biology and stress physiology along with the hands on training on the theory and practical aspects of different instruments along with microbial and plant tissue culture. The course also encompasses an enriched knowledge of Ecology, environmental pollutions and different Environment laws. After completion of this course, students are expected to have practical knowledge on how to handle and operate basic instruments for their experimental purposes. They might have basic idea on experimental designing, project handling and writing their project reports, which may be beneficial for them in future and improve their capability to write notes and research articles for different scientific journals. The degree of M.Sc. Botany may open their path into academia/research career at national and international level as a scientist, as a teaching faculty or as a scholar or into different administrative positions.

Course Outcome

After successful completion of this course, students will be able to understand, the cell structures function of cells, the fundamental unit of life along with molecules present in cells, the concepts in prokaryotic, eukaryotic, and viral genetics, the central dogma of molecular biology (replication, transcription, and translation), the types of mutation, gene regulation and transposable element, the diversity of lower cryptogams (Algae, Fungi, Bacteria, and viruses), the collection and study of algae, fungi, bacteria from different natural sources, their identification up to generic level. After completion

of the course, the students will be familiar with various physiological aspects involved in plant development, the role of enzymes in it, and the mechanism of photosynthesis, respiration, nitrogen, and lipid metabolism. Identification of genus and species of locally available wild plants, preparation of botanical keys at the generic level by locating key characters, knowledge of at least 10 medicinal plant species, the study of at least 20 locally available families of flowering plants, secondary metabolites and its use in taxonomy, development of plant reproductive parts i.e. male, female gametophytes and fruits. Sterilization techniques for media as well as for explants and their culture, anther culture, pollen culture, micropropagation, embryo rescue technique, somaclonal variation, isolation of plant protoplasts and their fusion techniques, tissue culture of important horticultural and medicinal plants, etc. The students will also learn microbial isolation and pure culture techniques. The students will learn different aspects of Ecology, environmental problems, and their mitigation rules along with different Environmental laws.

Course Curriculum

The Post-Graduate (M.Sc.) curriculum in Botany is of two-year duration in a choice-based credit system (CBCS) and a total of 94 Credits and 2100 marks. The system of examination is of semester pattern. There will be four semesters each core/elective paper carries 4 credits and 100 marks. There are five core papers (four theory and one practical) in the first and second semesters and one add-on-vocational paper (non-credit) in the 2nd semester. In the third semester, there is one core theory paper, one practical paper, one elective paper (interdisciplinary theory paper open for the other department students), two elective theory papers, and one add-on-vocational paper (non-credit). In the fourth semester, there will be three core papers (One core theory paper, one Core Seminar & Field Study/ Industrial Visit/Scientific Visit paper, and one core dissertation/project work) and two elective theory papers**.** For the seminar Presentation, students have to present their seminar on subject-relevant to the topic of biological sciences and submit their Field Study/ Industrial Visit/Scientific Visit report**. The Field Study/ Industrial Visit/Scientific Visit report will be examined by the board of examiners consisting of faculty members of the department and one external member from outside. S**tudents have to do their project work on a particular problem related to Botany/Biosciences under the supervision of one of the faculty members of the Post Graduate Department of Botany or from any reputed Universities/Institutes/Organizations for their M.Sc. dissertation/thesis. All the theory papers have 30 marks for internal evaluation {**5 Marks (Assignment) + 5 Marks (Quiz/GD) + 20 marks (Subject)}** and 70 marks for the end-term examination.

Core Research Areas

The faculty members of the department work on all current topics in Botany, ranging from Algal Biotechnology, Pharmaceutical Microbiology, Ethnobotany, Biochemistry, Bioinformatics & Computational Biology, and Plant Molecular Biology, etc.

Semester: I/II/III/IV - Credit: 94; Core 16; Elective: 05; Value added course: 02; Add on: 01

Course Structure of M.Sc. in Botany							
Sem.	**Course No.**	**Paper Name**	**Credit**	**Type (Core/ Elective)**	**Mid* Term Marks)**	**End term Marks**	**Total (Marks)**
I	BOTA C101	Microbiology	4	Core	30	70	100
	BOTA C102	Lower Plant Diversity and Paleobotany	4	Core	30	70	100
	BOTA C103	Cell Biology and Evolution	4	Core	30	70	100
	BOTA C104	Genetics and Molecular Biology	4	Core	30	70	100
	BOTA C105	Indian Knowledge System and Botany	4	Core	30	70	100
	BOTA P106	Practical	6	Core	-		100
Total Credits/core/electives (26/06/00) Total marks: 600							
II	BOTA C201	Systematics of Angiosperms	4	Core	30	70	100
	BOTA C202	Plant Physiology and Metabolism	4	Core	30	70	100
	BOTA C203	Biochemistry and Biostatistics	4	Core	30	70	100
	BOTA C204	Ecology and Environment	4	Core	30	70	100
	BOTA P205	Practical	6	Core	-	-	100
	BOTA VAC206	Organic Farming	-	NC	-	-	Grade
Total Credits/core/electives (22/05/00) Total marks: 500							
III	BOTA C301	Plant Embryology and Anatomy	4	Core	30	70	100
	BOTA E302(A)	(A) Molecular Plant Pathology and Immunology	4	Elective	30	70	100
	Or BOTA E302(B)	(B) Natural Resources, Conservation and Utilization	4	Elective	30	70	100
	BOTA E303(A)	(A) Computational Biology and Bioinformatics	4	Elective	30	70	100
	Or BOTA E303(B)	(B) Environmental Biotechnology and Waste Management	4	Elective	30	70	100
	BOTA P304	Practical	6	Core	-	-	100
	BOTA CT300**	Inter-Disciplinary Elective#**	4	CBCT	30	70	100

	BOTA VAC305	Nursery and Horticulture Techniques	-	NC	-	-	Grade
Total Credits/core/electives (22/02/03) Total marks: 500							
IV	BOTA C401	Advanced Plant Biotechnology	4	Core	30	70	100
	BOTA E402 (A)	Microbial and Molecular Techniques	4	Elective	30	70	100
	BOTAE402 (B)	Molecular Stress Biology and Biotechnology of Cyanobacteria	4	Elective	30	70	100
	BOTAE403 (A)	Phytomedicine	4	Elective	30	70	100
	BOTAE403 (B)	Environmental Law	4	Elective	30	70	100
	BOTA C404	Field Study & Seminar	4	Core	-	100	100
	BOTA D405	Dissertation (Project Work)	**6**	Core	-	-	100
	BOTA AC406	Cultural Heritage of Ganjam	-	NC	-	-	Grade
Total Credits/core/electives (22/003/02) Total marks: 500							
		Total Credit: 84			**Total Marks: 2100**		

**** 5 Marks (Assignment) + 5 Marks (Quiz/GD) + 20 marks (Subject)= 30 Marks**

***CBCT (Inter Disciplinary Elective Papers)**

*** All PG Students are required to complete one SWAYAM-NPTEL Course (minimum 02 Credits) on or before completion of the 3rd Semester. The course to be opted by the students shall be finalized by the Departmental Nodal Officer and Course Coordinator of SWAYAM. The course credit shall be included in the 3rd Semester Grade sheet.**

(# Students have to choose one of the following courses except 'BOTA-CT-300')

BOTA-CT-300: Economic Botany (Offered by Dept. of Botany)

BIOT-CT-300: Biotechnology in Human Welfare (Offered by Dept. of Biotechnology)

ENVS-CT-300: Population and Environmental Issues (Offered by Dept. of Environment Studies)

MARB-CT-300: Environmental Impact Assessment and Management plans (Offered by Dept. of Marine Science)

ZOOL-CT-300: Conservation Biology (Offered by Dept. of Zoology)

Value-added course: BOTA- VAC-206; BOTA- VAC-305

Add On Course (AC): BOTA-AC-406: Cultural Heritage of South Odisha

Code Used: BOTA- Botany, C- Core, P- Practical, D- Dissertation, CT- Choice Based Credit Transfer), VAC- Value Added Course, AC- Add-on Course, NC- Non-Credit

*3rd-semester students can opt for two elective courses BOTA E302 (A) or (B), BOTA E303 (A) or (B) and one CBCT course offered by other departments. Other department students can opt for BOTA CT300.

** 4th-semester students can opt for two elective courses BOTA E403 (A) or (B), BOTA E404 (A) or (B))

(BOTA: Botany, C: Core, E: Elective; P: Practical, VAC: Value Added Course, AC: Add on course & D: Dissertation).

DETAILS OF SYLLABUS

SEMESTER: I

Semester: I Course No: BOTA C101
Course Name: Microbiology
Credits: 4 Core/Elective: Core

Course details

Chapter	Contents	Hours
Unit- I	**History and scope of Microbiology**, Microbial evolution, classification of microorganisms, five kingdom classification, three domain classification; modern approaches in microbial taxonomy, ribosomal RNA sequencing; Bergy's manual of bacterial classification, the role of bacteria and archaea in human health, medicine, agriculture, and industry.	**12**
Unit- II	**Bacteria and Archaea:** Cell structure; nutrition; reproduction; Bacterial genetics: conjugation, transduction, and transformation, sex-duction, mapping genes by interrupted mating; plasmid; episome; microbial growth & methods of microbial growth measurements; bacterial toxin. General features and pathogenicity of Mycoplasma, Rickettsia, and Spirochetes.	**12**
Unit- III	**Cyanobacteria:** Classification, cell structure, nutrition, reproduction, cellular differentiation, akinetes, and its function, heterocyst (heterocyte) and its function, cyanotoxin; the role of cyanobacteria in human health, medicine, agriculture, bioenergy, and industry. General Characteristics and Evolutionary Significance of Prochlorophyceae,	**12**
Unit- IV	**Virus:** General properties; structure, purification, cultivation, the principle of viral taxonomy, classification, one-step growth experiment, Phage and its life cycle, RNA phages, DNA viruses, RNA viruses; viroid and prions; structure, transmission, and replication of plant virus (TMV) and animal viruses (HIV); Economic importance of virus	**12**
Total		**48**

Referred Textbooks/materials/ research articles:

1. Microbiology by Prescott, L. M., Harley, J. P. and Klen, D. A, Tata McGraw-Hill, New York.
2. Microbiology by Pelczar, Jr., M. J., Chan E.C.S. and Krieg, N. R, Tata McGraw-Hill, New Delhi.
3. General Microbiology by Stanier, R.Y., Ingraham, J.L., Wheelis, M.L., and Painter, P.R. The McMillan Press Ltd.

4. Brook Biology of Microorganisms by Madigan, M.T., Martinko, J.M. and Parker, J. Prentice-Hall.
5. Microbial Genetics by Maloy, S.R., Cronan, J.E.Jr., and Friefelder, D. Jones and Bartlett Publishers.
6. Phycology by R.E. Lee, Cambridge University Press (for Cyanobacteria)

Semester: I Course No: BOTA C102
Course Name: Lower Plant Diversity and Paleobotany
Credits: 4 Core/Elective: Core

Course details

Chapter	Contents	Hours
Unit- I	**Algae:** Distribution (terrestrial, freshwater, marine); thallus organization; cell structure; criteria for classification of algae; pigments, reserve food, flagella, reproduction (vegetative, asexual, sexual). Salient features of Glaucophyta, Rhodophyta, Euglenophyta, Phaeophyta Bacillariophyta, Xanthophyta, Chlorophyta, and Charophyta; algal blooms and toxins; economic importance of algae; algae as biofertilizer, food, feed and uses in industry.	**12**
Unit- II	**Fungi:** General characters of fungi; recent trends in classification; phylogeny of fungi; cell ultra-structure, unicellular and multicellular organization; substrate relationship in fungi; nutrition, reproduction; heterothallism; heterokaryosis; parasexuality; general account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina; Economic importance of Fungi i.e. medicine, food, industry, and disease, General account of lichen, Mycorrhizae and their economic importance.	**12**
Unit- III	**Bryophyta:** Classification; theories of origin (algal and pteridophyte), Phylogenetic relationships among Bryophytes; distribution, morphology, structure, reproduction, and life history; general account of Marchantiales, Jungermaniales, Anthocerotales, Sphagnales, Funariales and Polytrichales; Ecological importance; Evolution of gametophytes and sporophytes in bryophytes. **Pteridophyta**: Morphology, anatomy and reproduction; classification; evolution of stele; heterospory and origin of seed habit. General account of Psilopsida, Lycopsida; Sphenopsida, and Pteropsida.	**12**
Unit- IV	**Gymnosperms:** General characteristic features of Gymnosperms, Classification of Gymnosperms and their distribution in India. General account of Cycadales, Coniferales, Ephedrales, and Gnetales. **Paleobotany:** Geological time scale, origin and geological evidences; evolutionary time scale (eras, periods and epochs). Types of fossils, processes of fossilization, role of fossils in evolution. Brief account of fossil Pteridophytes and Gymnosperms. Cycadeoidales, Pentoxylales, Medullosales and Glosspteriodales.	**12**
Total		**48**

Referred Text books:

1. Phycology by R.E. Lee, Cambrige University Press
2. Algae by L.E. Graham and L. W. Wilcox Prentice Hall
3. Introductory Phycology by Kumar, H. D. (1988), East-West Press, New Delhi.

4. Bryophyta by B.R. Vasista, S. Chand Publication
5. Bryophyta by N. S, Parihar, Central Book Depot, Allahabad.
6. Gymnosperms by Bhatnagar, S. P. and Moitra, A., New Age International, New Delhi.
7. Biology and Morphology of Pteridophytes by Parihar, N. S., Central Book Depot, Allahabad.
8. Gymnosperms: Structure and Evolution by Chamberlin, C. J., Dover Publications, New York.
9. Introductory Mycology by Alexopoulus, C. J., Mims, C. W. and Blackwel, M., John Wiley, New York.
10. An Introduction to Mycology by Mehrotra, R. S. and Aneja, R. S., New Age International, New Delhi.

Semester: I Course No: BOTA C103
Course Name: Cell Biology and Evolution
Credits: 4 Core/Elective: Core

Course details

Chapter	Contents	Hours
Unit- I	**Structural organization of the plant cell and their function:** Structure and functions of the cell wall, plasma membrane, ion carriers, channels and pumps, receptors, chloroplast, mitochondria, peroxisome, endoplasmic reticulum, ribosome, lysosome, vacuole, nuclear pore, and nucleolus. Cell shape and motility: cytoskeleton organization, role of microtubules and microfilaments in flagella and other moments.	**12**
Unit- II	**Cell cycle:** Mitosis, meiosis, DNA synthesis in cell cycle, regulation of cell cycle: role of cyclins and cyclin-dependent kinases; cytokinesis and cell plate formation; cell surface receptors, G-protein coupled receptors, signal transduction pathways, secondary messengers, regulation of signaling pathways.	**12**
Unit- III	**Structure and organization of eukaryotic chromosomes:** Chromatin - heterochromatin and euchromatin, special types of chromosomes, chromosome morphology, karyotype, chromosome banding, sex chromosomes, sex determination in plants, dosage compensation, B-chromosomes, Chromosome organization, DNA packing, Nucleosome, Nuclear DNA content, C-value paradox, satellite-DNA, cot-curve, unique and repetitive DNA, Junk DNA and ENCODE project, *In situ* hybridization concept and techniques, FISH and GISH.	**12**
Unit- IV	**Evolution:** Lamarckism; Darwinism-concepts of variation, adaptation, struggle, fitness, and natural selection. Neo-Darwinism, synthetic theory of evolution, genetic polymorphism, gene pool, gene frequency; Hardy-Weinberg Law, Origin of new genes and proteins; molecular evolution, epigenetics, and adaptive evolution.	**12**
Total		**48**

Referred Textbooks:

1. Cell Biology by De-Robertis Saunders, Singapore.
2. Reproduction in eukaryotic cells, Prescott DM, Academic Press.
3. Developmental Biology, Gilbert SF, Sinauer Assoc. Inc.
4. Cell in Development and Inheritance, Wilson EB, McMillan, New York.
5. Molecular Biology of Cells, Alberts B et al.
6. The Cell: A molecular approach by Cooper G. M., ASM Press, Washington, D. C., USA.
7. Essentials of Molecular Biology by Malacinski, G. M and Feidfelder, D Ed. Jones and Bartel, London.
8. Gene IX or X by Lewine, B. Person-Prentice Hall, London.

Semester: I, Course No: BOTA C104
Course Name: Genetics and Molecular Biology

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Genetics:** Mendelism and deviation of Mendelian ratios, epistasis, linkage and crossing over, sex-linked inheritance, three-point test cross and chromosome mapping, Extra chromosomal inheritance, mitochondrial and chloroplast genome.	**12**
Unit- II	**Cytogenetics:** Structural chromosome aberrations: duplication, deficiency, inversion, and translocations heterozygotes; Numerical chromosome aberrations: aneuploids: trisomics and monosomics; euploids: autopolyploids, allopolyploids, segmental allopolyploid, role polyploidy in speciation with reference to *Triticum* and *Brassica*.	**12**
Unit- III	**Molecular genetics:** Prokaryotic and eukaryotic DNA replication: DNA polymerases, replisome, replicon, primase, telomerase. RNA transcription: mRNA, tRNA, rRNA, siRNA, miRNA, RNAi, RNA polymerases, RNA-processing: RNA splicing, spliceosome, RNA editing. Deciphering genetic code. Protein translation, post-translational modifications, protein targeting. Regulation of gene expression in prokaryotes and eukaryotes; Fine structure of gene, cis-trans test.	**12**
Unit- IV	**Mutagenesis, DNA damage, and repair:** Spontaneous and induced mutations, physical and chemical mutagens, the molecular basis of mutations, transposable elements in prokaryotes and eukaryotes, mutations induced by transposons, site-directed mutagenesis, DNA damage, and repair mechanisms. Environmental mutagenesis and genetic toxicology	**12**
Total		**48**

Referred Text books:

1. Genetics: A Conceptual Approach by Pierce, B. A., W. H. Freeman, New York.
2. Principles of Genetics by Simmons, M.J., Snustad, D.P., Tamarin, R.H.
3. Molecular Biology of the Gene by J.D. Watson, N.H. Hopkins, J.W.Roberts, J.A. Steitz and A.M. Weiner, the Benjamin / Cummings Pub. Co. Inc., California.
4. Genomes by T.A. Brown.
5. Molecular Cell Biology by J. Darnell, H. Lodish and D. Baltimore, Scientific American Books Inc USA 1994.
6. Gene IX by Benjamin Lewin, Oxford University Press, U.K.
7. Molecular Biology of the Cell by B. Alberts, D. Bray, J. Lewis, M. Raff. K. Roberts, and J.D. Watson, Garland Publishing Inc., New York.
8. The Cell: A molecular approach by Cooper G. M., ASM Press, Washington, D. C., USA.

Semester: I, Course No: BOTA C105

Course Name: Indian Knowledge System and Botany

Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Microbiology in Indian Vedic Knowledge**: Sukshmjeevanu in Vedas (The concept of microbes by Rishi Kanva; discoveries of Rishi Kanva and his descendants Atri, Yamadagnni, and Agasti against microbial infection are in Atharvaveda).	**12**
Unit- II	**Indian Knowledge System on Concept of origin of life:** Ancient Science of India 10: Primary Concept on Origin of Life: Origin of Life-concept in Manusmriti	**12**
Unit- III	**Indian Knowledge System on Plant Morphology of Plants:** Description of plant morphology in *Samhita* - Charak (1st Century AD); Susruta (600 BC); Parasar (1st Century BC or AD); Study of plants in *Nighantu* Period in India (In *Rajanighantu,* In *Dhanvantarinighantu,* In *Nighantushesha,* In *Bhavprakashnighantu*); Indian Traditional Ayurvedic System of Medicine and Nutritional Supplementation:	**12**
Unit- IV	**Indian Knowledge System on medicinal plants before Theophrastu**s: Ancient Indian rishi's (Sages) knowledge of botany and medicinal plants since Vedic period: Study of plants in Vedic period (2500 BC to 600 BC) in India; study of plants in *Samhita* period (900 – 600 BC) in India (The *Charaka Samhita,* The *Sushruta Samhita*)	**12**
Total		**48**

References

1. Kuhad U, Goel G, Maurya, PK, Ramesh Kuhad C. 2021. Sukshmjeevanu in Vedas: The Forgotten Past of Microbiology in Indian Vedic Knowledge, Indian journal of Microbiology, 61: 108-110.
2. Padhy S 1999. Ancient Science of India 10: Primary Concept on Origin of Life-A Review, Anthropologist, 54(1-3): 1-6 (2023)
3. Balkrishna A, Mishra R.K, Srivastava A, Joshi B, Marde R and Prajapati UP. 2019. Ancient Indian rishi's (Sages) knowledge of botany and medicinal plants since Vedic period was much older than the period of Theophrastus, A case study-who was the actual father of botany? International Journal of Unani and Integrative Medicine 3(3): 40-44.
4. Pandey M. M., Rastogi S, and Rawat A. K. S. 2013. Indian Traditional Ayurvedic System of Medicine and Nutritional Supplementation. Evid Based Complement Alternate Med.: 376327.

Semester: I, Course No: BOTA P106
Course Name: Practical

Credits: 6 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Microbiology **Lower plant diversity** **Cell Biology** **Genetics and Molecular Biology**	1. Laboratory Protocol, general rules and regulations for laboratory safety. 2. Bacterial staining (simple staining, negative staining, Gram staining, and acid-fast staining, spore and capsule staining) 3. Microbial pure culture techniques (Streak plate methods, Pour plate methods); sub-culturing techniques. 4. Microscopic measurement of microorganisms (Micrometry). 5. Measurements of cultural characteristics of microorganisms. 6. Measurement of growth microorganisms (microbial cells counting, CFU counting, spectrophotometric/colorimetric analysis, etc.) 7. Collection, identification of cyanobacteria, micro and macroalgae, preparation of permanent slides of cyanobacteria, and microalgae. Preservation, and preparation of herbarium macroalgae. 8. Study of morphology and reproductive structures of fungi belonging to different classes through permanent microscopic preparations and preserved specimens. 9. Study of temporary & permanent preparation for microscope observation of external and internal features of the vegetative and reproductive structure of important genera of Bryophytes. 10. Study of temporary and permanent preparation of vegetative and reproductive structure of Pteridophytes. 11. Study of temporary and permanent preparation of vegetative and reproductive structure of Gymnosperms and Fossils. 12. Squashing techniques for the study of mitosis and meiosis in onion root tip and flower bud; Microscopic analysis of different stage cell division and microphotography. 13. Mitotic index of dividing cells of *Allium cepa* root tips. 14. Comparative karyotypic analysis of two species of a genus. 15. Isolation of plant DNA and quantification of extracted DNA by spectrophotometric method 16. Chromosome mapping through two and three point test cross	**100**
Total		**100**

Referred books/manual/Monographs

1. Microbiology A Laboratory Manual by Cappuccion, J.G., and Sherman, N., Addison Wesley
2. Microbiological Applications (A Laboratory Manual in General Microbiology) by Benson, H.J., W.C.B., Wim C. Brown Publishers
3. Practical Botany, Vol. 2 by S.C. Santra, NCBA publication
4. Handbook of Microbial Technology by Yadav, A.K. and Mowade, S.M.
5. Methods in Plant ecology by S.B. Chapman, Wile and son publications
6. Algal cuture techniques by Andersen
7. Manuals of Phycology by Smith

SEMESTER: II

Semester: II, Course No: BOTA C201
Course Name: Systematics of Angiosperms
Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Taxonomic Structure:** Taxonomic hierarchy; Concept of species, genus and family, Plant Nomenclature: Salient features of International Code of Nomenclature (ICN) for Algae, Fungi and Plants: priority, effective and valid publications and author citation. Type concept, Taxonomic Tools**:** Field and Herbarium techniques; Floras and Botanic Gardens, Computer and Taxonomy.	**12**
Unit- II	**Systems of Angiosperm Classification:** Artificial, natural and phylogenetic systems, relative merits and demerits of major systems of classification (Bentham and Hooker, Engler and Prantle, Hutchinson and Takthajan). Angiosperm Phylogeny groups (APG)	**12**
Unit- III	**Angiosperm Families:** Floral structure and phylogenetic relationship among the taxa under the following orders: Liliflorales, Scitaminae, Orchidales, Ranales, Rosales, Tubiflorae, Malvales, Asterales and Rubiales.	**12**
Unit- IV	**Taxonomic Evidence:** Morphology, anatomy, palynology, embryology, cytology, phytochemistry, and serology. Phylogenetic tree and Cladistics	**12**
Total		**48**

Referred Textbooks/articles:

1. Principles of Angiosperms Taxonomy by Davis, P. H. and Heywood, V. H., Robert E. Kreiger, New York.
2. Current Concepts in Plant Taxonomy by Heywood, V. H. and Moore, D. M., Academic press, London.
3. Principles and Methods Plant Biosystematics by Solbrig, O. T., MacMillan, London.
4. Plant taxonomy and Biosystematics by Stace, C. A., Edward Arnold, London.
5. Diversity and Classification of Flowering Plants by Takhtajan, A. L. Columbia University Press, NY.
6. Contemporary Plant Systematics by Woodland, D. W. Prentice-Hall, New Jersey, USA

Semester: II, Course No: BOTA C202
Course Name: Plant Physiology and Metabolism
Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Membrane transport and translocation of water and solutes:** Plant water relation, mechanism of water transport through xylem, phloem loading and uploading, passive and active solute transport, membrane transport proteins. **Photosynthesis:** Light harvesting complex, structure and chemistry, Photolysis of water and Hill Reaction, Photo-phosphorylation, CO_2-fixation, C_3 and C_4 and CAM pathways, photorespiration.	**12**
Unit- II	**Respiration:** Glycolysis, Fermentation, TCA cycle, pentose phosphate pathways, mitochondrial electron transport and ATP synthesis, alternate oxidase, Glyoxylate Cycle.	**12**

	Lipid metabolism: fatty acid biosynthesis, synthesis of membrane lipids, storage lipids and their catabolism.	
Unit- III	**Nitrogen metabolism:** Biological nitrogen fixation, a symbiotic and symbiotic nitrogen fixation, nodule formation, nod and *nif* genes, their regulation and function, mechanism of nitrate uptake and reduction, ammonium transport and assimilation. **Sensory Biology:** Structure, function, and mechanisms of action of phytochromes, cryptochromes and phototropins, stomatal physiology; **Phytohormones:** Plant growth regulators, structure and function, ethylene, abscisic acid, brassinosteroids, polyamines, jasmonic acid.	**12**
Unit- IV	**Stress Physiology:** Plant responses to biotic and abiotic stress, mechanisms of biotic and abiotic stress tolerance, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress. Oxidative metabolism: reactive oxygen species (ROS), antioxidants, antioxidant enzymes: catalase, peroxidases, superoxide dismutase, glutathione transferase, glutathione reductase, *Halliwell–Asada cycle*. Physiology of aging and senescence, influence of hormones and environmental factors on senescence. Programmed cell death.	**12**
Total		**50**

Referred Textbooks:

1. Plant Physiology by Taiz & Zeiger, Sinauer Publications
2. Biochemistry and Molecular Biology of Plants by Buchachnanan, B. B., Grissem, W. and Jones, R. L. J., American Society of Plant Physiologists, Rockville, USA.
3. Plant Physiology by Devlin, R. N. and Witham, F. H., CBS Publishers, Delhi.
4. Plant Physiology by Salisbury, F. B. and Ross, C. W., Wordsworth Publication California, USA

Semester: II, Course No: BOTA C203
Course Name: Biochemistry and Biostatistics
Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Basics of Biochemistry:** Structure of atoms, molecules, chemical bonds, stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding and hydrophobic interactions. Principle of biophysical chemistry and bioenergetics: pH, buffer, reaction kinetics, thermodynamics, colligative properties, couples reactions, group transfer, biological energy transfer.	**12**
Unit- II	**Biomolecules:** Composition, structure, and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Confirmation and stability of protein (Ramachandra plot, secondary, tertiary and quaternary structure; domains, motif, and fold). Confirmation and stability of nucleic acids (A-, B-, Z- DNA, RNA); phenols and terpenes.	**12**
Unit- III	**Plant enzymes and coenzymes:** Nomenclature and classification of enzymes and coenzymes: Distribution of enzymes in plant, structure and function of Isozymes. Enzyme kinetics, mechanism of enzyme action and its regulation. Factors affecting enzyme action. **Antioxidants**: Structure and functions of ascorbic acid, glutathione, tocopherol, carotenoids, etc.	**12**

Unit- IV	**Biostatistics:** Frequency distribution, cumulative and relative frequency. Measurement of central tendency and dispersion, mean, median and mode, mean deviations, variance and standard deviation, coefficient of variation, errors. Analysis of variance (ANOVA). Comparison of means: Students 't' test and paired 't' test. Chi-square (X2) test, 2 x 2 contingency table and association analysis as applied to biological experimental data. Simple correlation and linear regression analysis.	**12**
Total		**48**

Referred Text books:

1. Lehninger Principle of Biochemistry by Nelson and Cox
2. Advanced Biochemistry by Voet and Voet
3. Principle of Biochemistry by Stryer
4. Biochemistry by Mathews, C. K., Van Holde, K. E. and Ahern, K. G., Addison-Wesley Publishing Company, San Francisco, USA.
5. Genes VH, B. Lewin, Oxford University Press.
6. Proteins – Structure and Molecular Properties, TE Creighton, WH Freeman and Company.
7. Introduction to Protein Structure, C. Branden and J. Tooze, Garland Publishing, New
8. Fundamentals of Biostatistics by Veer Bala Rastogi
9. Fundamentals of Biostatistics by Bernard Roser

Semester: II Course No: BOTA C204
Course Name: Ecology and Environment
Credits: 4 Core/Elective: Core

Course details

	Contents	Hours
Unit- I	**Ecosystem organization & function:** Biotic and abiotic components, trophic level, food chain, food web, Aquatic ecosystems, Marine ecosystems, Wetland ecosystems, Grassland ecosystems, Forest ecosystems. Ecological adaptations, Energy flow in the ecosystem, primary production (methods of measurement), decomposition, energy dynamics, ecological efficiencies, concept of energy subsidy, universal energy flow, The Gaia hypothesis, Biogeochemical cycle.	**14**
Unit- II	**Population ecology:** Population interactions (population density, natality, mortality, population age structure, carrying capacity, Community ecology: Ecological communities and ecosystems, structural analysis of communities, inter- and intra-specific competitions, Mutualism and commensalism, predation, parasitism, amensalism, competition and coexistence, Habitat and ecological niche.	**12**
Unit- III	**Ecological regulation:** System studies, Chemical transformations, Biochemical transformations, ecological succession, Mechanism of ecological succession and characters of succession.	**10**
Unit- IV	**Environmental Pollution:** Concept of pollution, air pollution, water pollution, terrestrial/soil pollution, noise pollution, and radiation pollution. Source of pollutants: natural and anthropogenic pollutants; Global warming and climate change; Greenhouse gases (GHG), Ozone layer depletion, consequences of climate change: smog, acid rain etc. Environmental Pollution and Legislative solution: Pollution Control Board; natural and men made disasters and disaster management; Environmental	**14**

	education and awareness, environmental audit, environmental management, environmental crisis, environmental ethics.	
Total		**50**

Referred Textbooks:

1. Concepts of Ecology by Kormondy, E. J., Prentice-Hall India, New Delhi.
2. Fundamentals of Ecology by Odum, E. P. Saundas, Philadelphia, USA.
3. Ecology and Field Biology bySmith, R. L. Harper Collins, New York.
4. Ecology bySubrahmanyam, N. S. and Sambamurty, A. V. S. S. New Delhi

Semester: II Course No: BOTA P205
Course Name: Practical

Credits: 6 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Plant Systematics **Plant Physiology Biochemistry** **Ecology and Environment** **Biostatistics**	1. Description and identification of Angiosperms at family, genus, and species levels using Floras. 2. Herbarium techniques. 3. Determination of Transpiration and Absorption ratios. 4. Measurement of rate of photosynthesis 5. Preparation of Buffers. 6. Quantitative estimation of Protein (Lowry methods/Bradford Method), Sugars (Anthrone Methods), Lipids (Bligh and Dryer Method). 7. Quantitative estimation of Amino acids (Ninhydrine methods) 8. Spectrophotometric analysis of different enzymes (CAT, APX, GR, SOD) 9. Estimation of pigments (chlorophylls and carotenoids) from plant and algal materials. 10. Estimation Dissolved oxygen (DO) water samples by Winkler's method 11. Physico-chemical analysis of water and soil (pH, chloride, phosphate, nitrogen. potassium) 12. Determination of primary productivity of water samples. 13. Determination of minimum size and number of quadrants required for reliable estimates of biomass in grassland 14. Determination of frequency, density of a species of a grassland community. 15. Calculation of Important Value Index (IVI) of grassland ecosystem. 16. Measurement of Central Tendency 17. Measurement of dispersion 18. Students's T test 19. X^2 (chi-square) distribution	**100**
Total		**100**

Referred practical books/manuals

1. Biochemical Methods by Pingoud, Urbanke, Hoggett and Jeltsch, Willey-VCH

2. Experimental biochemistry bySwitze, R.L. and garrity, L.F., Freeman and Company, New York
3. Analytical Biochemistry and Separation Techniques by Palanivelu, P
4. Biochemical calculations, by Segel
5. Phytochemicals Techniques by N. Raaman
6. Phytochemicals methods by Harborne, J.G, Springer

Semester: II, Course No: BOTA VAC206
Add on Course Name: Organic Farming
Credits: NC **Non Credit**

Course details

Chapter	Contents	Hours
Unit- I	**Introduction to Organic Farming:** Introduction; Need of Organic Farming; Benefits of Organic Farming; Social aspects of Organic Farming; Market aspects of Organic Farming	**08**
Unit- II	**Organic Fertilizers:** Need of Organic Fertilizer; Benefits of Organic Fertilizer; Preparation of Organic Fertilizer; Demonstration & land preparation. Plant Nutrients: Name of plant Nutrients; Functions of Nutrients in plant growth and Development Sources of nutrients for Organic Agriculture: Organic Manure: Rural compost, City compost, Oil cakes, Animal wastes, Green Manure with Leguminous crops in crop rotation. In-situ incorporation of crop residues	**08**
Unit- III	**Biofertilizers and their method of use:** Need and Benefits of Microorganism, Management of Microorganism, mechanism of action in increasing soil fertility **Preparation of vermin compost:** Pit construction; Raw materials; Availability of specific species of earth worm; Method of preparation; Quality improvement of finished vermicompost	**08**
Unit- IV	**Plant Protection Measures:** Integrated pest & disease management techniques, Organic pesticides, bio-pesticides. Inorganic pesticides, disadvantages of their use. Seed, seedling and soil Treatment measures. Feasibility of complete dependence on organic sources.Good Harvesting Practices; Storage; Transportation; Supply Chain.	**08**
Total		**32**

Referred Textbooks:

1. Aasics of Organic Farming by Bansal and Mamta, CBS publication
2. A text book of Modern Organic Farming
3. Principles of Organic Farming: Textbook (By P. L. Maliwal)

SEMESTER: III

Semester: III, Course No: BOTA C301

Course Name: Plant Embryology and Anatomy

Credits: 4 **Core/Elective: Elective**

Chapter	Contents	Hours
Unit- I	**Male and female gametophyte:** Structure of anthers, microsporogenesis, role of tapetum, pollen development, and gene expression; male sterility, sperm dimorphism, and hybrid seed production, pollen germination, pollen tube growth and guidance, pollen storage, pollen allergy, pollen embryos. Female gametophyte**:** Ovule development, megasporogenesis; organization of the embryo sac, structure of the embryo sac cell.	**12**
Unit- II	**Pollination, Pollen-pistil interaction, and fertilization:** Floral characteristics, pollination mechanisms, and vectors, breeding system; commercial considerations, the structure of the pistil, pollen stigma interactions, sporophyte and gametophytic self-incompatibility (cytological, biochemical and molecular aspects), double fertilization, *in vitro* fertilization.	**12**
Unit- III	**Seed development and fruit ripening:** Endosperm development during early, maturation and desiccation stages, embryogenesis, ultra-structure; cell lineages during late embryo development; storage proteins of endosperm and embryo; polyembryony, apomixis; embryo culture, dynamics of fruit growth and ripening; Latent life-dormancy; Importance and types of dormancy, seed dormancy, overcoming seed dormancy, bud dormancy.	**12**
Unit- IV	**Plant Anatomy:** Tissue and tissue system; Meristematic tissue, distribution of mechanical tissues, apical meristem, Root-shoot transition, shoot-root development, leaf development and phyllotaxy, transition to flowering. Nature and need of secondary growth, Normal secondary growth in dicot stem, Anomalous secondary growth in dicot and monocot stem (adaptive and non-adaptive),	**12**
Total		**48**

Course details

Referred Text books:

1. Seed: physiology of Development and Germination by Bewley, J. D. and Black, M..Plenum, New York.
2. The Embryology of Angiosperms by Bhojwani, S. S. and Bhatnagar, S. P., Vikas Publishing House, New Delhi.
3. Molecular Embryology ofFlowering Plant by Raghavan, V. Cambridge University Press, Cambridge.
4. Developmental Biology of Flowering Plants by Raghavan, V., Springer-Verlag, New York.
5. Plant Anatomy by B.P. Pandey. S. Chand & Co. Ltd.
6. Anatomy of Angiosperms by B.K. Mishra and N. Dash, Kalyani Publishers.

Semester: III, Course No: BOTA E302(A)

Course Name: Molecular Plant Pathology and Immunology

Credits: 4 **Core/Elective: Elective**

Chapter	Contents	Hours
Unit- I	**Phytopathology:** Plant disease symptoms, modes of infection and dissemination; altered metabolism of plants under biotic and abiotic stresses; host-parasite relationship, disease triangle,disease cycle and stages of disease development, molecular mechanism of pathogenesis, recognition phenomenon, penetration and invasion.	**12**

Unit- II	**Host resistance:** Primary disease determinant; enzymes and toxins in relation to plant diseases; host defense mechanism, molecular mechanism of resistance; phytoalexins, PR proteins, antiviral proteins, SAR, HR and active oxygen radicals	**12**
Unit- III	**Immune system:** Innate and adaptive immune system Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cell epitopes, structure and function of antibody molecules, generation of antibody diversity, monoclonal antibodies, antibody engineering, antigen-antibody interactions	**12**
Unit- IV	**Immune response :**MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, humoral and cell-mediated immune responses, primary and secondary immune modulation, complement system.	**12**
Total		**48**

Course details

Referred Textbooks:

1. Plant Pathology by Mehrotra, R. S. and Aggarwal, A., Mc Graw Hill Education.
2. Kuby Immunology, 4th edition, R.A. Goldsby, Thomas J. Kindt, Barbara A. Osborne (Freeman).
3. Immunology, A Short Course, 4th Edition, Eli Benjamin, RichardCoico, Geoffrey
4. Sunshine (Wiley-Liss).
5. Fundamentals of Immunology, William Paul.
6. Ivan Roitt: Roitt's Essentials of Immunology

Semester: II, Course No: BOTA E302(B)
Course Name: Natural Resources and Utilization
Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Introduction to Natural Resources**: Concept of natural resources, types and classification. Factors causing resource accessibility, statistical distribution and function. Ecological, social and economic dimension of resource management.	**12**
Unit- II	**Natural resources and management:** Conservation of natural resources, Non-renewable energy resources, Alternative sources of energy, new concepts for alternative energy. Renewable energy resources: Water resources, soil resources, Soil conservation and management. Water resources and conservation: rain water harvesting, water shed management, uses of water, Forest as a renewable resource, deforestation, afforestation, conservation, social forestry, wild-life conservation	**12**
Unit- III	**World centre of primary diversity of domesticated plants:** Basic concepts, origin of agriculture and plant introduction. Origin, evolution, botany, cultivation and uses of (i) Food crops, (ii) fibre crops, (iii) medicinal and aromatic plants, and (iv) vegetable and oil-yielding crops with special reference to local plants. Plants, plant parts and plant products used in homeopathy medicines, Plants, plant parts and plant products used in ayurvedic medicines, Important timber-yielding plants, Important poisonous plants of India.	**14**

	Concept of phytogeography: Climate and Vegetation pattern of the World; Endemism, Floristic regions of India; vegetational pattern of India.	
Unit- IV	***In situ* conservation:** International efforts and Indian initiatives; protected areas in India – Sanctuaries, national parks, biosphere reserves, wetlands and mangroves for conservation of wild biodiversity. ***Ex situ* conservation:** Principles and practices; botanical gardens, field gene banks, seed banks, cryobanks, general account of the activities of Botanical Survey of India (BSI), National Bureau of Plant Genetic Resources (NBPGR). Principles of conservation; extinction; environmental status of plants based on IUCN (Now World Conservation Union). Salient features of Biodiversity Act and rules.	**12**
Total		**48**

Referred Textbooks:

1. An Advance Text book and Biodiversity: Principles and Practice by K.V. Krishnamurthy, Oxford & IBH publication, New Delhi.
2. Plants, Genes and Agriculture by Conway, G. and Barbier, E., Jones and Bartlett, Boston, USA.
3. Tropical Botanical Gardens Their role in Conservation and Development by Heywood, V. H. and Wyse Jackson, P. S., Academic press, San Diego, USA.
4. Understanding Biodiversity: Life sustainability and Equity by Kothari, A, Orient Longman, New York.
5. Biodiversity and its Conservation in India by Negi, S. S. Indus Publishing Company, New Delhi.
6. Evolution of Crop Plants by Simmonds, N. W., Longman, New York.

Semester: IV, Course No: BOTA E303(A)
Course Name: Bioinformatics and Biostatistics
Credits: 4 **Core/Elective: Elective**

Course details

Chapter	Contents	Hours
Unit- I	**Introductory Bioinformatics:** Introduction to Bioinformatics, Introduction to data structures and database concepts, Biological sequence analysis and information retrieval, pairwise and multiple sequence alignment: BLAST, FASTA, Phylogenetic analysis.	**12**
Unit- II	**Basics of Molecular Modelling:** Introduction to Molecular Modelling and its Applications. Biomolecular modeling problems: protein folding, protein misfolding. Basic concepts of quantum mechanics, *ab initio* structure prediction. Molecular mechanisms, energy calculations, Bond stretch, Angle bending, torsional terms, Electrostatic interaction- van der Waals interactions. Molecular modeling in drug discovery.	**12**
Unit- III	**Structure-Based Drug Designing:** Structure-based drug designing: 3D pharmacophores, molecular docking, De novo Ligand design, 3D database searching and virtual screening**,** Mechanism of drug absorption, distribution, metabolism, and excretion: ADME process; Drug toxicity evaluation, Pharmacokinetics.	**12**
Unit- IV	**Molecular Dynamics and Simulations:** Introduction to molecular dynamics and simulations; Monte Carlo simulation of biomolecules. Comparative modelling of protein: by homology modeling, validation of protein models – Ramachandran plot, threading, and ab initio modeling.	**12**
Total		**48**

Referred Textbooks:

1. Molecular Modelling: Principles & Applications. By Andrew R. Leach, Pearson (Prentice Hall) 2nd Edition 2001.
2. Bioinformatics: A practical guide to the analysis of genes and proteins. By AD Baxevanis and
BFF Ouellette (Wiley-Liss) 3 rd Edition 2005.
3. Guidebook on Molecular Modeling in Drug Design- N. Claude Cohen, 1996. Elsevier
4. Molecular Modeling Basics- Jan H. Jensen, 2010. CRC Press.
5. Computational Chemistry and Molecular Modeling, Principles and Applications- K. I. Ramachandran, G. Deepa, K. Namboori, 2008
6. Textbook of Drug Design and Discovery, 5th Edition- Kristian Stromgaard, Povl Krogsgaard-
Larsen, Ulf Madsen, 2016. CRC Press.

Semester: IV, Course No: BOTA E303(B)
Course Name: Environmental Biotechnology and Waste Management
Credits: 4 **Core/Elective: Elective**

Course details

Chapter	Contents	Hours
Unit- I	**Aquatic toxicity assessment:** concept of toxicity; mechanism of toxicant action; dose, effect and response; analysis of response curves; statistical doses of toxicants; Selection of test batteries, media, apparatus and facilities, liquid media and sediment toxicity assessment, microtox acute toxicity test.	**12**
Unit- II	**Bioaccumulation:** Concept and measurement, food chain and lipophilicity approach, quantitative structure activity relationship, kinetics of uptake and retention, factors affecting bioaccumulation. Bioaccumulation of metals: metal accumulation by flora and fauna; biosorption, phytofiltration, phytochelatin and phytoextraction; role of metalphores	**12**
Unit- III	**Biodegradation of organic pollutants:** Microbial processes for degradation; measurement of biodegradability; aerobic and anaerobic degradation of carbohydrates, proteins and lipids, aliphatic hydrocarbons, aromatic hydrocarbons, degradation of halogenated organics, co-metabolic degradation, degradative capacity of fungi	**12**
Unit- IV	**Fate of pesticides in the environment:** Fundamental reaction of pesticide metabolism; microbial transformation of pesticides-oxidations, decarboxylation, dealkylation, halogen reaction, aromatic ring cleavage, hydrolysis and nitrate reduction, waste management.	**12**
Total		**48**

Referred Textbooks:

1. Ecology and Field Biology by Smith, R. L. Harper Collins, New York.
2. Ecology by Subrahmanyam, N. S. and Sambamurty, A. V. S. S. New Delhi

Semester: III, Course No: BOTA CT300
Course Name: Economic Botany
Credits: 4 **Core/Elective: Interdisciplinary**

Course details

Chapter	Contents	Hours

Unit- I	Origin, history, domestication, botany, cultivation, production, and use of: Cereals (Wheat, rice, maize, sorghum, pearl millet, and minor millets) and Pulses.	**12**
Unit- II	Origin, distribution, cultivation, production, and utilization of economic plants of following groups such as Plant of agro-forestry importance: Teak, Sal Acacia, Sesbania, Neem, etc. Fibers: cotton, silk cotton, jute, sunn hemp. Oilseeds: Groundnut, sesame, castor, rape seed, mustard, sunflower, safflower, niger, oil palm, coconut and linseed.	**12**
Unit- III	Origin, distribution, classification, production and utilization of Fruits: mango, banana, citrus, guava, grapes and other Indigenous fruits; apple, plum, pear, peach, cashew nut, and walnut; Vegetables: tomato, brinjal, okra, cucumber, cole crops, gourds etc.	**12**
Unit- IV	**Important medicinal and aromatic plants**: Sarpagandha, Belladonna, Cinchona, Nux-Vomica, Vinca, Mentha and Glycirrhiza, Plantago etc.; Narcotics: Cannabis, Datura, Gloriosa, Pyrethrum and opium. Important Spices and condiments Ginger, Garlic, Cinnamon, Cardamom, Cumin, Foeniculum, etc.	**12**
Total		**48**

Referred Textbooks:

1. Economic Botany by B.P. Pandey. S. Chand & Co. Ltd.
2. Economic Botany: S. L. Kochhar, Cambridge University Press
3. Economic Botany- Principle & Practices: G.E. Wickens, Kluwer Academic Publishers
4. Economic Botany & Ethnobotany: AfrozAlam, Willey

Semester: III, Course No: BOTA P304
Course Name: Practical
Credits: 6 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Plant Embryology and Anatomy	1. Microscopic observation various microsporangium (T.S & L.S.), Microspore tetrad, Pollen structure 2. Pollen counting and viability; staining of pollen tube 3. Microscopic study of ovules (T.S. & L.S.), Ovaries (T.S. & L.S.), structure of embryo sac organisation, types of endosperm etc. 4. Microscopic observation of Primary and Secretory tissue systems, Ecological anatomy, wood anatomy, preparation of permanent slides. 5. 5.Colorimetry & Spectrophometry, Determination of Absorption maxima of Dyes and verification of Beer-lambert's Law. 6. Centrifugation 7. Pair wise and multiple sequence alignment by using EMBL-EBI and/or ClustalW2 tools. 8. Phylogenetic analysis of proteins and genes using PHYLIP and /or Phylogenetic analysis using parsimony (PAUP) or any other analytical tools. 9. Protein Structure visualization and Homology modelling of proteins through PyMol, VMD and Swiss-PDBV.	**100**

Bioinformatics **Natural Resources**	10. Docking of small molecules to protein binding sites by AutoDock-Vina and MGL Tools or protein-protein docking through online modes. 11. Protein structure predictions via online servers like I-TASSER, Phyre2, QUARK, PredictProtein. 12. Molecular Dynamics simulation of small protein and water complex by AMBER/GROMACS. 13. ELISA for quantitative detection of plant pathogen 14. Immunodiagnostics (demonstration using commercial kits). 15. Preparation of a short list of the ten most important sources of firewood and timber in the locality. Give their local names, scientific names, and families to which they belong. Mention their characters. 16. Study of biodiversity and important flora of Odisha and India through field trips.	
Total		**100**

Referred practical books/ manuals/monographs

1. A Practical Guide for Basic Bioinformatics and Biostatistics by Pallavi Pandey & Pooja Tiwari. Notion Press; First edition (2017), ISBN- 13: 978-1946822260.
2. Introductory Practical Biostatistics by Misra, B.N. and M.K. Misra
3. Practical Biochemistry: Principles and Techniques by Wilson and Walker
4. Plant reproduction by T. Pullaiahm, K. Lakshminarayana, B. Hanumanta Rao
5. Udbhida Sangraha (In Odia) by M.K. Misra
6. Flora of Odisha by Saxena, H.o & M. Brahmam

Semester: III, Course No: BOTA VAC305
Add on Course Name: Nursery and Horticulture Techniques
Credits: NC **Non Credit**

Course details

Chapter	Contents	Hours
Unit- I	**Introduction to Nursery:** Plant nursery: Definition, importance; Basic facilities for a nursery; layout and components of a good nursery. Nursery beds, types, their merits and demerits; precautions to be taken during preparation. Brief account of growing media; nursery tools and implements. Containers for plant nursery, Brief account of plant propagation structures.	**08**
Unit- II	**Introduction to Horticulture:** Horticulture: Definition, importance of horticulture in terms of economy, production, employment generation, environmental protection and human resource development. Fruit and vegetable zones of India and Odisha. Export scenario and scope for Horticulture in India. Classification of horticultural crops based on soil and climatic requirements	**08**
Unit- III	**Introduction to Vegetable crops:** Importance of vegetable cultivation in India and Odisha. Classification and Nutritive value of vegetables Importance, morphology and taxonomy, varieties, climate and soil, seeds and sowing, manuring,irrigation, intercultural operations, diseases and their control, harvesting and yield of following crops: Cultivation of (a) Brinjal(b) Tomato(c) Capsicum (d) Spinach (c) Coriander and (d) Mentha	**08**

Unit- IV	**Introduction to Fruit crops:** Importance of fruit growing in India and Odisha. Nutritive value of fruits. Origin, history, distribution, area and production, uses and composition, varieties, soil and climatic requirements, propagation, planting, training and pruning, manuring and fertilizer application, irrigation, intercropping, harvesting and yield, diseases and pests of the following tropical fruit crops: (a) Mango (b) Guava and (c) Papaya	**08**
Total		**32**

Referred Text books:

1. Nursery Management of Fruit Crops in India
2. Plant Propagation and Nursery Management

SEMESTER: IV

Semester: IV, Course No: BOTA C401
Course Name: Advanced Plant Biotechnology
Credits: 4 **Core/Elective: Core**

Course details

Chapter	Contents	Hours
Unit- I	**Plant nutrition, plant cell and tissue culture:** General introduction, history, scope, concept of cellular differentiation, totipotency. Plant micro and macronutrients, vitamins and growth hormones (auxins, gibberellins, cytokinins): physiological effects and mechanism of action, Media for plant tissue culture. Fundamental aspects of morphogenesis, micropropagation techniques, organogenesis somatic embryogenesis, androgenesis, gynogenesis and adaptive embryogenesis.	**12**
Unit- II	**Protoplasm culture:** Somatic hybridization, protoplast isolation, fusion and culture, hybrid selection and regeneration. Possibilities, achievements and limitations of protoplasm research. Applications of plant tissue culture: clonal propagation, artificial seed production of hybrids, somaclones, production of secondary metabolites/natural products, cryopreservation and germplasm storage.	**12**
Unit- III	**Plant genomics:** Introduction to plant genomics, functional genomics, transcriptomics and proteomics, comparative genomics, organelle genomes (Mitochondria and Chloroplast). Study of Genome: shotgun approach, clone contig approach, chromosome walking and jumping, c-DNA, genome and gene libraries. Analysis of genome: DNA fingerprinting techniques: RFLP, RAPD, AFLP, SSR, SNP, DNA microarray. Expressed sequence tags (ESTs).	**12**

Unit- IV	**Recombinant DNA, Transgenic and genome editing technologies:** Methods of R-DNA technology and genetic manipulation; restriction endonucleases, vectors: plasmid, cosmid, BAC, YAC, *Agrobacterium* - the natural genetic engineer of Ti and Ri plasmid, mechanism T-DNA transfer to plant; Insect-, pathogen- and herbicide-resistant plants, stress-tolerant plant; Genome and gene editing (CRISPR Cas-9) technologies for plant improvement. Regulatory, biosafety, and ethical issues relating to transgenic and gene-editing.	**12**
Total		**48**

Referred Textbooks:

1. Molecular Biotechnology: Principles and Applications of Recombinant DNA by Glick, B. R. and Pasternak, ASM Press, Washington, D. C., USA.
2. Plants from Test Tube: An Introduction to Micropropagation by Kyte, L. and Kleyn, J.3rd Ed. Timber press, Port land, USA.
3. Plant Cell and Tissue Culture Vol VI by Pollard, W. J. and Walker, Humana press Clifton, USA.
4. Gene Cloning and DNA Analysis by Brown T. A. Blackwell Science, London.
5. Biotechnology and Plant Genetic Resources by Callow, J. A., Ford-Lloyed, B. V. and Newbury, H. J., Conservation and Use, CAB International, Oxon UK
   Practical Applications of Plant Molecular Biology by Henry, R. J., Chapman & Hall, London, UK
   Proteomics in Functional Genomics by Jolles, O. and Jornvall, H. (eds). Birkhauser Verlag, Basel, Switzerland.

Semester: IV, Course No: BOTA E402 (A)
Course Name: Microbial and Molecular Bio-techniques
Credits: 4 **Core/Elective: Elective**

Course details

Chapter	Contents	Hours
Unit- I	**Techniques of microbial culture:** Preparation of solid and liquid media for algae, fungi and bacteria, pure culture isolation, maintenance and storage of microbes, culture characteristics, fixation and staining, cytophotometry and flow cytometry	**12**
Unit- II	**Chromatographic techniques:** Principles of chromatography (Adsorption and Partition chromatography), Planar chromatography (Paper and Thin-layer chromatography), Column chromatography (Gas chromatography, Gel exclusion/permeation chromatography, Ion exchange chromatography, Affinity chromatography, HPLC)	**12**
Unit- III	**Molecular Techniques**: Sequencing of Proteins and nucleic acids; Southern, Northern and Southern and Western blotting techniques; Methods for measuring nucleic acid and protein interactions. Polymerase chain reaction (PCR), RT-PCR.	**12**
Unit- IV	**Electrophoretic techniques:** General principles, support media, electrophoresis of proteins (SDS-PAGE, native gels, gradient gels, isoelectric focusing gels and two dimensional gels), electrophoresis of nucleic acids (Agarose, pulse-field and sequencing gels).	**12**
Total		**48**

Referred Text books:

1. Wilson, K. and Walker, J., (1994) Practical Biochemistry: Principles and Techniques 4th ed. Cambridge University Press.
2. Instrumental methods of analysis by Willard *et al*.
3. Practical Biochemistry: Principles and Techniques by Wilson and Walker

4. Principles and Techniques of Biochemistry and Molecular Biology by Wilson and Walker
5. Laboratory Manual of Biotechnology by S. K. Bhatnagar and DeepikaAbrol, S. Chand &Co.

IV, Course No: BOTA E402 (B)

Course Name: Molecular Stress Biology and Biotechnology of Cyanobacteria

Credits: 4 **Core/Elective: Elective**

Course details

Chapter	Contents	Hours
Unit- I	**Ecology of cyanobacteria:** Molecular ecology (a) Bioinformatics tools and databases (Cyanobase) (b) Model organisms e.g., *Synechocystis* sp. PCC 6803, *Anabaena* sp. PCC 7120 (c) environmental genomics, metagenomics and phylogeny of cyanobacteria across environmental gradients; Nutraceuticals: Cyanobacteria as source of antioxidants, biomolecules, metabolic engineering, metabolic tapping of *Spirulina platensis,* etc.as a model for desired nutraceuticals	**12**
Unit- II	**Cyanobacterial light-harvesting complex:** Phycobiliproteins, Carotenoids and xanthophylls, structure and regulation of light harvesting genes, light-harvesting proteins of cyanobacteria *vis a vis* light-harvesting complex of higher plants	**12**
Unit- III	**Cyanobacterial responses towards abiotic stresses:** Salinity, ultraviolet radiation, temperature, herbicides inhibiting PSI and PSII, desiccation and heavy metals; Signal transduction under abiotic stress (SOS pathway).	**12**
Unit- IV	**Gene mining from cyanobacteria:** Cyanobacteria as a source of stress-tolerant genes for the development of stress-tolerant crops using gene pyramiding technology**(b)** Targeted genetic modifications in cyanobacteria Cyanobacteria and green chemistry: Genetic engineering for the production of biofuels (biodiesel, hydrogen production), bioplastics, nanomaterials (nanotechnologies)	**12**
Total		**48**

Referred Textbooks/Suggested readings

1. **Bryant** DA (1995) The Molecular Biology of Cyanobacteria, Kluwer Academic Publisher, Berlin.
2. **Whitton** BA, **Potts** M (2000) Ecology of Cyanobacteria - Their diversity in Time and Space, Kluwer Academic Publishers, Berlin.
3. Chavvat F, Chavvat CC (2013) Advances in Botanical Research Vol 65 Genomics of Cyanobacteria, Elsevier.
4. Sarma TA (2012) Handbook of Cyanobacteria, 1st edition, CRC press, Boca Raton, USA.
5. Larkman WD, Douglass E,Raven JA, Photosynthesis in Algae, Kluwer Academic Publishers, Berlin.

Semester: IV, Course No: BOTA E403 (A)

Course Name: Phytomedicine

Credits: 4 **Core/Elective: Elective**

Course details

Chapter	Contents	Hours

Unit- I	**Importance of medicinal plants:** Relevance of herbal medicine as primary health care package; sources of information on medicinal plants; Organization of information in database (national and international); Causes for the decline and the current scenario in Indigenous systems of medicine; a comparative evaluation of accessibility and benefits of different systems of medicine	**12**
Unit- II	**Marine Drugs:** Introduction, Classification – antimicrobial, anti-inflammatory, antispasmodic, antiparasitic, anticancer, cardiovascular, insecticide, anticoagulants, marine toxins. Algae as potential source of therapeutic compunds	**12**
Unit- III	**Potentials of medicinal plants:** WHO and Indian Scenario; herbal medicine – a natural resource; commercial and medicinal uses of medicinal plants in India; Study of few commercial /raw drugs/ medicinal plants - *Usnea; Drynaria; Pinus; Vinca rosea; Rauwolfia serpentina; Withania somnifera; Coleus forskohlii; Emblica officinalis; Saraca asoca; Aloe vera; Glycyrrhiza glabra; Commiphora mukul, Boswelia serrata*	**12**
Unit- IV	**Poisonous plants: C**lassification; chemical constituents, symptoms, treatment and systematic description of some poisonous plants - *Papaver somnifera, Calotropis gigantea, Gloriosa superba, Digitalis purpurea, Datura metel, Strychnos nux-vomica* **Plant Allergens**: Types and classification; description, symptoms, chemical constituents, and treatment of the following allergic plants - *Parthenium hysterophorus, Urtica sp., Acacia sp., Eucalyptus globulus, Arachis hypogaea* and *Solanum*	**12**
Total		**48**

Referred Textbooks:

1. Phytomedicine edited by Rouf Ahmad Bhat, Khalid Hakeem, Moonisa Aslam Dervash
2. Phytomedicine edited by Parimelazhagan Thangaraj

Semester: IV, Course No: BOTA E403 (B)
Course Name: Environment Law
Credits: 4 **Core/Elective: Elective**

Course details

Chapter	Contents	Hours
Unit- I	**Introduction:** Meaning and Definition of Environment and Environment Pollution: Problem and prospects;- Ozone Depletion, Global Warning – Climatic Changes – Need for the preservation, conservation and protection of Environment – Environmental Pollution – Kinds, Causes and effects of Pollution	**12**
Unit- II	**Protection of Forest and Wildlife:** Indian Forest Act, 1927: Kinds of forest: Private, Reserved, Protected and Village Forests, The Forest (Conservation) Act, 1980; The Wild Life (Protection) Act, 1972: Authorities to be appointed and constituted under the Act, Hunting of Wild Animals, Protection of Specified Plants, Protected Area, Trade or Commerce in wild animals, animal articles and trophies; Its prohibition.	**12**
Unit- III	**International Law:** International Environmental Regime – Transactional Pollution – Customary International Law - Stockholm Declaration on Human Environment, 1972 – The role of UNEP for the Protection of Environment – Ramsar Convention 1971 – Bonn Convention (Migratory Birds) 1992 - Nairobi Declarations, 1982 - Rio, Conference on Environment and Development, 1992 (Earth Summit), Rio Declaration	**12**

Unit- IV	Convention on Biological Diversity, The Indian Biological Diversity Act 2002, v. Convention on Climate Change 1992 – Kyoto Protocol 1997, Johannesburg Convention 2002	**12**
Total		**48**

Referred Text books:

1. Environmental Law & Policy in India – Shyam Diwan, Armin Rosencranz
2. Environmental Law in India – P. Leelakrishnan
3. PILand Environmental Protection-Geetanjali Chandra
4. The Water (Prevention and Control of Pollution) Act, 1974
5. The Air (Prevention and Control of Pollution) Act, 1981
7. Richard L. Riversz, et al. (eds.) Environmental Law, the Economy and
8. Sustainable Development (2000), Cambridge.
9. S.K.Nanda, Environmental Law, 2007
10. Relevant Bare Acts/Notifications.
11. Paras Diwan: Studies on Environmental Cases.
12. Lal's Commentaries on Water and Air Pollution and Environment Protection Laws

Semester: III, Course No: BOTA C404
Course Name: Seminar and Field Study//Scientific Visit
Credits: 4 Core/Elective: Core

Seminar Presentation and Field Study:

The student seminar presentation carries 50 marks and the field study report also carries 50 marks. Students must present at least one seminar before the final Examination during the 4th semester. Students must submit a detailed field study/scientific visit/filed survey report. **The Seminar and report of the field study/scientific visit report will be examined by board examiners consisting of departmental faculties and one external examiner from outside duly approved by the authority**

Semester: IV, Course No: BOTA D405

Course Name: Dissertation
Credits: 06 Core/Elective: Core

DISSERTATION/PROJECT WORK

Students have to do their project work on a particular problem related to Botany/Biosciences under the supervision of one of the faculty members of the Post Graduate Department of Botany or from any reputed Universities/Institutes/Organizations duly approved by the Head of the Department for their M.Sc. dissertation/thesis. Students in advance may contact the respective researchers/scientists from around the country to carry out the work for the project much before the start of the 4th Semester (beginning/mid of the 3rd semester) to avail sufficient time for the planning and execution of the work. The dissertation carries 100 marks. The dissertation will be examined jointly by both internal (supervisor) and external examiners. The Dissertation work PowerPoint presentation (will be before the board of examiners consisting of the department faculty members and an external examiner from outside duly approved by the authority.

The dissertation must be certified with **Turnitin for Plagiarism/similarity index certificate, signed by the Internal (supervisor) and the candidate. The UGC-2019 plagiarism rules are recommended by Berhampur University 2019-2020 before acceptance of the M.Sc. dissertation for evaluation.**

Format of M.Sc. Dissertation:

1. Title Page
2. Declaration certificate from the Candidate
3. Certificate from the supervisor
4. Plagiarism certificate, signed by the supervisor and the candidate
5. Abstract/summary
6. Materials and Methods
7. Results
8. Discussion
9. Conclusion
10. References

Semester: IV, Course No: VAC
Course Name: Cultural Heritage of Ganjam
Credits: NC **Core/Elective: Non Credit**

Course details

Chapter	Contents	Hours
Unit- I	**Kabi Samrat Upendra Bhanja: Life and Literary works**	**08**
Unit- II	**Other Literatures of Ganjam**	**08**
Unit- III	**Cultural Heritage of Ganjam**	**08**
Unit- IV	**Folk Tradition of Ganjam**	**08**
Total		32

CBCT papers are interdisciplinary

Botany students can choose any of the under-mentioned courses offered by other departments of BU

Semester: III, Course No: BIOT CT-300

Course Name: Biotechnology in Human Welfare
Credits: 4 **Core/Elective: Interdisciplinary**

Chapter	Contents	Hours
Unit- I Basic Concepts of Biotechnology	Basic Concepts of Biotechnology and its Applications, Recombinant DNA technology; gene cloning, human genome project, Tools of Bioinformatics.	**10**
Unit- II Agricultural and Environmental Biotechnology:	Application in Breeding, Nitrogen fixation, Transfer of pest resistance genes to plants, Interaction between plants and microbes, Qualitative improvement of livestock. Crop plant genome project. Chlorinated and non-chlorinated organ pollutant degradation; degradation of hydrocarbons and agricultural wastes, stress management, development of biodegradable polymers	**10**

Unit- III Medical and Pharmaceutical Biotechnology	Development of therapeutic agents, recombinant live vaccines, gene therapy, Diagnostics; Principle of DNA fingerprinting, Stem cell Biology, Ethical issues in Biotechnology research	**10**
Unit- IV Industrial Biotechnology	Introduction to bioprocess technology. Range of bioprocess technology and its chronological development. Basic principle of fermentation technology. Types of microbial culture and its growth kinetics– Batch, Fed batch and Continuous culture.	**10**
Total		**40**

Referred Textbooks:

1. John E. Smith. Biotechnology (2009) 5th Edition, Cambridge University Press.
2. Ignacimuthu Biotechnology: An Introduction (2012) 2nd Edition, Narosa Publishing House Ltd., India

Semester: III, Course No: ENVS CT-300

Course Name: Population and Environmental Issues
Credits: 4 **Core/Elective: Interdisciplinary**

Chapter	Contents	Hours
Unit 1: Demographic Overview	Introduction, History of human population growth, The demographic transition: India and World; Projections of population growth, Effects of human population growth, Unsustainable lifestyle – increased consumerism	**12**
Unit-2: Energy Crisis	Energy Crisis: Background, Possible causes (Energy demand and consumption, Production capacity and dependence on imports); Ecologically friendly alternatives and Possible Measures	**12**
Unit-3: Environmental Contamination	Ambient Air pollution, Indoor air pollution, and Health Impacts, Surface water pollution, Groundwater pollution and Health Impacts Solid Waste Pollution and Sustainable Solid Waste Management; Hazardous waste pollution, Radioactive waste, Electronic waste and Biomedical waste	**12**
Unit-4: Ecological Footprints and Carrying Capacity	Ecological footprints: Concepts, perspectives, carbon footprint, water footprint, Overshoot of ecological footprint and biocapacity of planet Earth, Resources Depletion.	**12**
Total		**48**

Referred Text Books

1. Cunningham WP and Cunningham MA (2002). Principles of Environmental Science: Inquiry and Applications. McGrawHill Publications, New Delhi, 418 pp.
2. Johri R (2009). E-Waste: Implications, regulations, and management in India and current global best practices. TERI Press, New Delhi. 330 pp.
3. McKillop A and Newman S (2005). The Final Energy Crisis. Pluto Press, London. 325 pp.
4. Miller GT Jr. (1996). Living in The Environment: Principles, Connections, and Solutions. 9thEdition. Wadsworth Publishing Company, New York. 727 pp.
5. Park C (2001). The Environment: Principles and Applications. 2nd Edition, Routledge Publishers, London and New York, 598 pp.

Semester: III, Course No: MARB CT-300
Course Name: Environmental Impact Assessment and Management Plans
Credits: 4 **Core/Elective: Interdisciplinary/Elective**
CBCT

Units	Contents	Hours
Unit-1	Introduction to Environmental Impact Assessment. Environmental impact Statement and Environmental Management Plan. EIA notifications of Government of India from time to time. Guidelines for Environmental audit.	**20**
Unit-2	Environmental Impact Assessment (EIA) Methodologies. Generalized approach to impact Assessment. EIA processes, Scoping EIA methodologies, Procedure for reviewing Environmental impact analysis and statement. Environmental Management Plan and its monitoring, Evaluation of proposed actions.	**20**
Unit-3	Nexus between development and environment, Socio-economic impacts, Aid to decision making, Formulation of development actions, Sustainable development, categorization of projects under EIA, project planning and implementation, Impact prediction, Mitigation measures.	**20**
Unit-4	Introduction to. Selection of appropriate procedures, Restoration and rehabilitation technologies. Landuse policy for India. Urban planning for India. Rural planning and landuse pattern. Environmental priorities in India and sustainable development. CRZ notifications and Environmental Impact Assessment in coastal zone. Coastal zone management plans of India.	**20**
Total		**80**

Referred Text Books / References

1. W.P. Cunningham, 2010: Principles of Environmental Science.
2. Satsangi and A.Sharma 2015: Environmental Impact Assessment and Disaster Management.
3. R.R.Barthwal 2002: Environmental Impact Assessment.
4. R.Paliwal and L. Srivastava, 2014: Policy Intervention Analysis- Environmental Impact Assessment.
5. C.H.Ecceleston, 2004: Environmental Impact Assessment.
6. J. Hou, 2015: New Urbanism: The future City is Here.
7. James R. Craig, 2010: Earth Resources and the Environment.
8. J. Glassion, 2011: Introduction to Environmental Impact Assessment.
9. Glasson J., Therivel R., Chadwick A, (2005): Introduction to environmental impact assessment Taylor & Francis Group, London and NewYork.
10. Morris P., Therivel R., (2009): Methods of Environmental Impact Assessment 2009, 3rd edition, Routledge, Taylor & Francis Group, London and NewYork.
11. Morris P., Therivel R., (2001): Methods of Environmental Impact Assessment 2001, 2nd edition, Spon Press, Taylor & Francis Group, London and NewYork.
12. Eccleston C. H., (2011): Environmental Impact Assessment 2011, CRC Press, Taylor &Francis Group.

Semester: III, Course No: ZOOL CT-300
Course Name: Conservation Biology
Credits: 4 **Core/Elective: Interdisciplinary/Elective**
CBCT

Units	Contents	Hours
Unit-1 Basic Concepts	Biodiversity (genetic diversity, species diversity, ecosystem diversity) and its use, Causes of biodiversity losses, IUCN red list of threatened species, Invasive species, Alien species, Indicator species, Keystone species, Umbrella species, Flagship species, Charismatic species.	**16**
Unit-2 Measuring Biodiversity	Alpha, Beta and Gamma diversity , Species Richness(S), Evenness(E) , Simpson index(D), Shannon-Weiner Index (H'), idea on biodiversity calculator software.	**16**
Unit-3 International and National efforts for conserving biodiversity	National Act and International Act related to Biodiversity Conservation: Biological diversity Act 2002, National Biodiversity Authority, People Biodiversity Registrar, Convention on Biological diversity, Cartagena Protocol and Nagoya Protocol, Sustainable Development Goal and Biodiversity, Aichi Biodiversity Targets, CITES, WWF.	**16**
Unit-4 Conservation Measures and Molecular Phylogeny	In-situ conservation (Indian context) (Sanctuaries, National and Biosphere reserves) and Ex-situ conservation (Indian context) (Botanical gardens, zoos, cryopreservation, gene bank) NCBI data base, basic idea on phylogenetic tree, Construction and interpretation of molecular phylogeny tree based on COI and 16s rRNA gene sequences using MEGA and other tools.	**16**
Total		**64**

Referred Books and References:

1. Fundamental of Ecology: O.P Odum
2. Campbell Biology: Reece, Urry, Cain et al.
3. Evolutionary analysis: Herron and freeman
4. Convention of Biological diversity- https://www.cbd.int/
5. Aichi Biodiversity Targets- https://www.cbd.int/sp/targets/
6. IUCN-https://www.iucn.org/
7. CITES-https://cites.org/eng
8. https://sustainabledevelopment.un.org/topics/biodiversityandecosystems
9. https://bch.cbd.int/protocol/
10. https://www.cbd.int/abs/
11. https://wwf.panda.org/
12. http://moef.gov.in/
13. http://nbaindia.org/