ST. MARY'S COLLEGE (AUTONOMOUS)

Re-accredited with A+ Grade by NAAC

Thoothukudi – 628001, Tamil Nadu

(Affiliated to Manonmaniam Sundaranar University)

Syllabus

M.Sc. Botany

School of Biological Sciences

Outcome Based Curriculum

(w.e.f. 2021)

Preamble

The Department of Botany offers an enriched learning environment in Plant Science. The Botany programme provides basic training in Plant Biology, Ecology, Physiology, Marine Botany, Mycology, Plant Diseases and Biotechnology. The department has excellent laboratory and research facilities to augment research in the fields of botany. Besides, students develop transferable skills, critical and lateral thinking, analytic and interpretive skills and communicating skills. It has great scope for higher education in diverse branches of botany. The programme opens avenues for multiple job opportunities as Soil and Plant Scientist, Biophysicist, Biochemist, Biological Technician, Environmental Scientist, Mycologist, Plant Breeders, Horticulturist and Entrepreneur in plant products and herbal medicine.

Vision:

Developing academically, professionally and ethically empowered human resources.

Mission:

To provide an academic ambience that strengthens critical thinking, scientific inquiry and problem solving in the frontier areas of plant biology.

Programme Outcome

PO. No.	At the end of the M.Sc. Program, students will be able to
PO-1	obtain in-depth and detailed functional knowledge of the fundamental theoretical concepts and experimental methods in Science
PO-2	understand their subject areas more clearly and develop skills to critically reflect upon the theory they learn.
PO-3	adopt the scientific methods and hypothesis testing in designing and execution of experiments.
PO-4	think critically, work independently and focus in research oriented activities.
PO- 5	inculcate an ability to engage in life-long learning to improve professional competency.
PO-6	Realize the impact of science and technologies on human welfare.
PO-7	apply their professional ability for entrepreneurship and self employment.
PO-8	commit themselves to professional ethics and social responsibility.

Programme Specific Outcome:

PSO No.	At the end of the M.Sc. Botany Program, students will be able to	PO matched
PSO-1	understand the structural and the reproductive biology of diversified group of plants to relate their origin, evolution and phylogenetic relationship between them	PO-1, PO-2
PSO-2	analyse the interconnectedness of life on the earth through energy flow and nutrient cycling that knowledge, enable to know the potentiality of natural resources and need of its conservation.	PO-6
PSO-3	acquire cognizant on functioning of organisms at biochemical and molecular level that can be able to infer the biological adaptation, development and their behaviour in the environment	PO-6, PO-8
PSO-4	receive extensive hands on training in lab skills, field techniques, sample preparations, statistical analysis and problem solving across the spectrum of botany	PO-4, PO-7
PSO-5	acquire knowledge of marine ecosystem and its functions in time and space relating their economical and environmental services on earth	PO-1, PO-6
PSO-6	design experimental methods, formulate hypothesis, techniques adapted, data analysis that create biological inquiry, communication ability and entrepreneurship.	PO-3, PO-7
PSO-7	get awareness on environmental protection and social responsibility with a science enriched with biodiversity conservation, climate change implications and scientific ethics	PO-2, PO-7, PO-8
PSO-8	learn the microbes and their role in environment /industries that will demonstrate microbes as the model system for human wellbeing	PO-1, PO-5

Course Structure (w.e.f 2021) – PG Botany

Semester – I

Subject	Course Code	Course Title	Contact Hours / Week	Credits	Max. Marks		
					CIA	ESE	Total
Core I	21PBOC11	Plant Diversity I (Algae, Bryophyte Fungi, Lichen)	6	4	40	60	100
Core II	21PBOC12	Plant Microbe Interaction	6	4	40	60	100
Core III	21PBOC13	Bioinstrumentation and Research Methods	5	4	40	60	100
Core IV	21PBOC14	Phytochemistry and Pharmacognosy	5	4	40	60	100
Core Practical I	21PBOCR1	21PBOC11,21PBOC12	4	2	40	60	100
Core Practical II	21PBOCR2	21PBOC13,21PBOC14	4	2	40	60	100
			30	**20**			

Semester – II

Subject	Course Code	Course Title	Contact Hours / Week	Credits	Max. Marks		
					CIA	ESE	Total
Core V	21PBOC21	Plant Diversity II (Pteridophytes, Gymnosperms and Paleobotany)	5	4	40	60	100
Core VI	21PBOC22	Marine Botany	5	4	40	60	100
Core VII	21PBOC23	Developmental Botany	5	4	40	60	100
Core VIII	21PBOC24	Genetics and Bioinformatics	4	4	40	60	100
Field Project/ Mini project	21PBFW21			3	40	60	100
Core Practical III	21PBOCR3	21PBOC21, 21PBOC22	4	2	40	60	100
Core Practical IV	21PBOCR4	21PBOC23, 21PBOC24	4	2	40	60	100
			30	**23+2**			

Semester – III

Subject	Course Code	Course Title	Contact Hours / Week	Credits	Max. Marks		
					CIA	ESE	Total
Core IX	21PBOC31	Biochemistry and Biophysics	6	4	40	60	100
Core X	21PBOC32	Taxonomy of Angiosperms	6	4	40	60	100
Core XI	21PBOC33	Molecular Biology and Genetic Engineering	5	4	40	60	100
Core XII	21PBOC34	Ecology and Conservation Biology	5	4	40	60	100
Core Practical V	21PBOCR5	21PBOC31,21PBOC32	4	2	40	60	100
Core Practical VI	21PBOCR6	21PBOC33,21PBOC34	4	2	40	60	100
Self-Study Course/ MOOC	21PBOSS1/ 21PBOM31	Forest Botany		+2			
			30	**20+2**			

Semester – IV

Subject	Course Code	Course Title	Contact Hours / Week	Credits	Max. Marks		
					CIA	ESE	Total
Core XIII	21PBOC41	Plant Physiology	6	5	40	60	100
Core XIV	21PBOC42	Horticulture and Seed Technology	4	4	40	60	100
Core XV	21PBOC43	Plant Biotechnology	4	4	40	60	100
Core Practical VII	21PBOCR7	21PBOC41	2	2	40	60	100
Core Practical VIII	21PBOCR8	21PBOC42, 21PBOC43	4	2	40	60	100
Core Elective	21PBOE41 21PBOE42	Entrepreneurship Botany/ Nanobiotechnology	4	4	40	60	100
Project	21PBOP41	Project	6	6		100	100
			30	**27**			

SEMESTER I			
Core I	**Plant Diversity I (Algae, Bryophyte, Fungi and Lichen)**		
Course Code:21PBOC11	**Hrs/week: 6**	**Hrs/Semester: 90**	**Credit: 4**

Objectives:

- To have a comprehensive idea on cryptogams.
- To understand the taxonomy, characteristics and uniqueness of primitive plants and theircharacteristics.
- To have a broad knowledge on economic importance and ecological significance of lowerplants.

Course Outcomes

CO. NO	Upon completion of this course, students will beable to	PSO addressed	CL
CO-1	recall the distinguishing features of algae, bryophytes, fungi and lichens and appreciate their uniqueness	1, 2	An
CO-2	understand the status of cryptogams in evolutionof advanced plant groups	1, 2	Cr
CO-3	understand the basic skills and techniques in micropreparation and formulate methods to identify different plant groups	1, 6	Ap
CO-4	apply the practical knowledge to identify a particular group from a mixed group in the laboratory and in the field	6	Ap
CO-5	know the adaptive features of cryptogams to theirhabitats	1, 2	Un
CO-6	analyse the phylogenetic relationship between thedifferent groups	1, 2	Ap
CO-7	evaluate the economic and ecological significance of lichen	1, 2	Re
CO-8	critically think on the origin and evolution of Bryophyte	1, 2	Un

SEMESTER I			
Core I	**Plant Diversity I (Algae, Bryophyte, Fungi and Lichen)**		
Course Code: 21PBOC11	**Hrs/week: 6**	**Hrs/Semester: 90**	**Credit: 4**

UNIT I: Algae: Classification of algae by F.E.Fritsh (1945), Parker (1982). Contribution of Indian Phycologists: M.O.P. Iyengar, T.V. Desikachary and V.K. Krishnamurthy.

Coastal line of India: South East coast of India, West coast of India.

General characteristics and life cycle pattern of algae. Special structural features of the algal cell – nucleus, centrosomes, flagella, eye spots, contractile vacuoles, chloroplast, pyrenoid and reserve foods. Phylogenetic relationships with other plant groups. Economic importance of algae.

UNIT II: General characteristics, ecological, morphological and interrelationships of Chlorophyceae, Xanthophyceae, Bacillariophyceae, Dinophyceae, Phaeophyceae, Rhodophyceae and Myxophyceae. Fossil algae.

UNIT III: Bryophyta: Classfication of Bryophytes by Rothmaler (1951). Origin of Bryophytes. General characteristics. Morphological, anatomical structure, vegetative, sexual reproduction and alternation of generation and interrelationship of Marchantiales, Jungermaniales, Anthocerotales, Sphagnales and Polytrichales. Spore dispersal mechanism in bryophytes. Economic and ecological importance of Bryophytes.

UNIT IV: Fungi: Classification of Fungi by Alexopoulos and Mims (1979). General characteristics. Diversity of somatic, reproductive and fruiting structures of Myxomycetes, Zygomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes. Heterothallism, Heterokaryosis and Parasexuality in fungi. Economic importance of Fungi.

UNIT V: Lichens: A general account of lichens. Classification of lichens based on habitat, morphological features, internal structure, nature of fungal components. Occurrence and interrelationship of phycobionts and mycobionts, structure and reproduction in Ascolichens, Basiodiolichens and Deuterolichens. Lichens as indicators of Pollution, Economic importance of Lichens.

Books for Reference:

Algae

1. Bilgrami K.S and Sinha L.B *A Text Book of Algae*. New Delhi: CBS Publication and distributors, 2004.
2. Fritsch F.E *The structure and reproduction of algae*.Vol.I & II. UK: Cambridge

UniversityPress, 1972.

3. Kamat, N.D *Topics in Algae*. Aurangabad: Saikripa Prakasam, 1982.
4. Robert Edward Lee *Phycology*. UK: Cambridge University Press, 2008.
5. South G.R and Whittick *Introduction to phycology*. London: Blank well Scientific Publications,1987.
6. Chapman V.J and Chapman D.J *The Algae.* London: The Macmillan Press Ltd., andBasingstoke, 1975.

Bryophyta

1. Cavers F *Inter relationship of the Bryophyta*. London: Dawsons of Pall Mall. 1964.
2. Peter George *Hand Book of Bryophyta.* New Delhi: Rajat Publications , 2010.
3. Rashid A *An introduction to Bryophyta*. New Delhi: Vikas Publishing House Pvt. Ltd. 1999.
4. Watson E.V *Structure and life of Bryophytes*. London: Hutchinson University Library,1971.
5. Alain Vanderpoorten and Bernard Goffinet *Introduction to bryophytes,* UK: CambridgeUniversity Press, 2009.

Fungi

1. Alexopoulos and Mim's *Introductory Mycology*, Hyderbad: Wiley Eastern Ltd. 1983.
2. Johri R.M Sneh Lata and Kavita Tyagi *Text Book of Fungi*. New Delhi: Dominant Publishers and Distributors Pvt. Ltd. 2010.
3. Smith G.M *Cryptogamic Botany* Vol.I New York : McGraw Hill Book Company, 1988.

Lichen

1. Ahmadjian, V and Mason E. Hale M.E *The Lichens.* New York: Academic Press, 1973.

Practical: Hrs/Week - 2

- **Algae:** Micropreparation of *Nostoc, Oscillatoria, Coleochaete, Caulerpa, Codium, Valoniopsis, Enteromorpha, Ulva, Padina, Turbinaria, Hypnea, Gracilaria*.

  Collection, identification and preservation of fresh water and Marine algae. Preparation of algal herbaria
- **Bryophyta:** *Targionia, Reboulia, Plagiochasma, Pallavicinia, Anthoceros, Sphagnum,Polytrichum*.
- **Fungi:** *Pilobolus, Peziza, Xylaria, Polyporus, Agaricus*
  Observation and study of fungi under natural habitat.
- **Lichens:** *Usnea, Parmelia*

Field visit: No of days: 4 (Collection of Algae, Bryophytes, Fungi and Lichens)

Submission - Record Note Book

Bottle specimens/herbarium specimens (any five)

Laboratory Manuals for Reference:

1. Ashok M Bendre and Ashok Kumar *A Text Book of Practical Botany – Volume I.*Meerut: Rastogi Publications, 2009.
2. Srivastava H.N *Practical Botany Volume I,* Jalandhar: Pradeep Publications, 1987.

SEMESTER I			
Core II	**Plant Microbe Interaction**		
Course Code: 21PBOC12	**Hrs/week: 6**	**Hrs/Semester: 90**	**Credits: 4**

Objectives:

- To provide information on the growth and morphology of microbes
- To familiarize the interaction of plants with microbes
- To understand the basic principles related to plant diseases.

Course Outcomes

CO. No	Upon completion of this course, students will be able to:	PSO addressed	CL
CO-1	perform the techniques of isolation, characterization and measure the growth of bacteria	4	Re
CO-2	differentiate the mode of action of antibiotics	1	An
CO-3	outline the stages of disease pyramids and disease cycle.	2	Un
CO-4	know about the enzymes involved in plant diseases	1	Re
CO-5	understand the basic principles related to plant diseases.	2	Ap
CO-6	purify, detect and identify the plant viruses.	3	Re
CO-7	understand the general symptoms of bacterial disease, viral diseases and fungal disease	1	Un
CO-8	provide tools to design innovative, sustainable and tailored control methods to prevent plant diseases or to reduce theirimpacts	6	Cr

SEMESTER I			
Core II	**Plant Microbe Interaction**		
Course Code: 21PBOC12	**Hrs/week: 6**	**Hrs/Semester: 90**	**Credits: 4**

UNIT I: Early development of microbiology, contributions of Leeuwenhoek, Robert Koch, Edward Jenner, Alexander Flemming and Louis Pasteur. Isolation of pure culture and measurement of growth of bacteria. Purification and quantitative assay of plant viruses. Antimicrobial components: mode of action of penicillin, streptomycin and sulfonamides.

UNIT II: Introduction: Components of disease (disease pyramid); causes of disease; classification of diseases; stages in the development of disease (disease cycle); Enzymes in plant diseases-pectic enzymes, macerating enzymes and cellulolytic enzymes. Dissemination of plant pathogens, Integrated disease management.

UNIT III: Characteristic features of plant pathogenic bacteria, general symptoms of \bacterial diseases, Survival and spread of bacterial plant pathogens, control of bacterial disease. Symptoms, morphology of the causal organism, disease cycle and disease management of the following: Angular leaf spot of cotton, Citrus canker and Tundu disease of wheat.

UNIT IV: General characteristic of plant pathogenic fungi, survival, dissemination and spread, general symptoms, control of fungal diseases. Symptoms, morphology of the causal organism, disease cycle and disease management of the following: Wilt of cotton, Downy mildew of grapes and Ergot of rye.

UNIT V: General characteristic of plant viruses, translocation and distributions of viruses of plants, symptoms caused by plant viruses, Purification, detection and identification of plant viruses, control of plant viruses. Symptoms, morphology of the causal organism, disease cycle and disease management of the following: Bunchy top of banana, leaf curl of papaya and Yellow vein mosaic of bhindi.

Books for Reference:

1. Agrios G.N. *Plant Pathology*. London : Academic Press, 1997.
2. Caldwell D.R. *Microbial Physiology and Metabolism.* United states: Wm.C Brown publishers, 20 05.
3. Dubey R.C and Maheshwari D.K. *A text book of microbiology.* New Delhi:

S.Chand and company,2003.
4. Kumar H. D and Swati Kumar. *Modern concepts of Microbiology*. New Delhi: Vikas Publications, 2008.
5. Mehrotra R.S and Agarwal A. *Plant Pathology*. New Delhi: Tata McGraw Hill Publishing Company, 2003.
6. Pelczar H. and Reid R. *Microbiology* – Concepts and Applications. New Delhi:Tata Mc Graw Hill Publishing company Pvt.Ltd., 1998.
7. Pelzar M. J, C h a n E.C.S and Noel. R *Microbiology*, New Delhi: Tata Mc Graw Hill Publishing company Pvt.Ltd., 2010 .
8. Prasad T. V.S. *Soil Microbiology,* New Delhi: Dominant Publishers and distributors, 2011.
9. Prescott L.M, Harley J.P and Klein D.A *Microbiology*. London:Mc Graw hill, 2002.
10. Sharma P.D. *Plant Pathology*. NewDelhi: Narosa Publishing House Pvt. Ltd., 2006.

Practical: Hrs/week: 2

- Record of brief life history of scientist related to microbiology
- Methods of sterilization of glasswares
- Preparation of media
- Serial dilution technique
- Pure culture technique
- Effect of antibiotics on the growth of bacteria. Determination of MIC
- Micropreparation/ study of infected specimen prescribed in the syllabus
- Angular leaf spot of cotton
- Citrus canker
- Tundu disease of wheat
- Bunchy top of banana
- Leaf curl of papaya
- Yellow vein mosaic of bhindi.
- Wilt of cotton
- Downy mildew of grapes
- Ergot of rye

Submission - Record Note Book

Laboratory Manuals for Reference:

1. Lakshmanan M, Kunthala Jeyaraman, Jeyaraman and Gnanam, *Laboratory experiments in microbiology and molecular biology,* Higginbothams Pvt. Ltd., 1971.

2. Sharma P.D. *Plant Pathology*, NewDelhi: Narosa Publishing House Pvt. Ltd., 2006.

Semester I			
Core III	**Bioinstrumentation and Research Methods**		
Course Code: 21PBOC13	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credits: 4**

Objectives:

- To familiarize in collection of data and analysis of data for scientific solution
- To know the basic tools in research and to facilitate the students to undergo basic andapplication-oriented research
- To infuse the practical knowledge of using various scientific instruments to perform researchwork.
- To motivate the students to do research.
- To make them analyze the biological data.

Course Outcomes

CO.No	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	know microscope as the basic tool for biological research.	6	Ap
CO-2	acquaint with different tools and techniques essential for research work	6	Cr
CO-3	understand the fundamentals of statistics and statistical analysis	4	Un
CO-4	do statistical analysis and communicate the results of statistical analyses accurately and effectively	4	Ap
CO-5	know and explain the importance of internet in research and gather reference materials	6	Un
CO-6	examine the basic framework of research process and able to learn how to address research problem and what is to be done to solve it.	6	An
CO-7	communicate the research findings to the scientific forums	6	Cr
CO-8	develop an understanding of the ethical dimensions of conducting applied research	7	An

Semester I			
Core III	**Bioinstrumentation and Research Methods**		
Course Code: 21PBOC13	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credits: 4**

UNIT I: Microscopy: Principles, working mechanism and applications of Simple, Compound, Phase- Contrast microscopes, Electron microscopy (SEM). Principles and operations: pH meter, Electrical conductivity meters. Centrifugation: working principle and applications -differential and density gradient centrifugations; types: clinical/ low-speed, high speed, micro and analytical ultracentrifuges.

UNIT II: Chromatography: Principles, working mechanism and applications- Paper, Thin Layer, HPTLC, Column, HPLC and GC-MS. Spectrophotometry: Principles, working mechanism and applications -UV- visible, AAS, FTIR, MALDI.

UNIT III: Electrophoresis - principles, electrophoretic mobility, factors affecting electrophoresis, isoelectric focusing, types - vertical and horizontal. Agarose and polyacrylamide gel electrophoresis, detection and recovery of electrophorogram, gel documentation systems. Tracer techniques – Autoradiography, XRD.

UNIT IV: Biostatistics: Practice of statistical methods in biological research. Descriptive statistics: Measures of Central Tendency - Mean, Median and Mode. Measures of Dispersion- Standard deviation, coefficient of variation and standard error. Simple correlation and linear regression analysis. Inferential Statistics: Tests of statistical significance - Chi-square, t-tests and Analysis of Variance (ANOVA- one way &two-way).

UNIT V: Types of research, scientific research: hypothesis, experimentation, theory. Preparation of Research Article – Layout of a Research Paper, review article, online publications, thesis writing, Citation, referencing and bibliography, editorial process and proof-reading symbols. Journals in Botany-predatory, peer-reviewed, online journal, SCI journals, Web of science journals. Impact factor of Journals, Ethical issues related to publishing. Citation, google scholar, i-10, H index. Plagiarism and Self-Plagiarism. Oral presentation of research papers in conference.

Books for Reference

1. Guruamni N. *Research Methodology for Biological Sciences*, Chennai: MJP Publishers, 2006.
2. Gurumani N. *Scientific thesis writing and paper presentation*. Chennai: MJP Publishers, 2010.

3. Boyer R F. *Modern Experimental Biochemistry.* America: 3rd edn. Prentice Hall Publ, 2000.
4. Kothari C.R. *Research Methodology – Methods and techniques*, New Delhi: New age International (P) Ltd., Publishers, 2004.
5. Veerakumari L. *Bioinstrumentation*, Chennai: M.J.P. Publishers, 2015.
6. Gurumani N. *An Introduction to Biostatistics*, Chennai: 2nd edition M.J.P. Publishers, 2005.
7. Satguru Prasad. *Fundamentals of Biostatistics*, New Delhi:4th edition Emkay Publications, 2003.
8. Veera Bala Rastogi. *Fundamentals of Biostatistics*, Chennai: 2nd edition Ane Books Pvt. Ltd., 2009.

Practical: Hrs/week: 2

- Preparation of Molar, Normal, ppm, percentage and buffer solutions.
- Thin layer chromatographic separation of amino acids
- Separation of protein by PAGE
- Separation of DNA by AGE
- Digital photographic display of anatomical samples/ microscopic samples.
- Estimation of Na and K using flame photometer
- Demonstration-AAS, Fluorimeter and FTIR
- Data analysis with statistical package (SPSS& Excel) - mean, median, mode, standarddeviation, standard error student t-test, ANOVA
- Preparation of bibliography using reference tool (Zotero)
- Calculation of citation Index
- Determination of Impact Factor of Author, Article and Journal.

Books for Reference

1. Jayaraman J. *Laboratory manual in biochemistry*, New Delhi:Wiley Eastern Ltd.,1985.
2. Palanisamy S and Manoharan M. *Statistical methods for biologists*, Palani: II Edition Palani paramount publishers, 1994.
3. Ponmurugan P and Gangathara Prabhu B. *Biotechniques*. Chennai: MJP publishers, 2012.

Semester I			
Core IV	**Phytochemistry and Pharmacognosy**		
Course Code: 21PBOC14	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credits: 4**

Objectives:

- Exploring the plant resources as pharmaceuticals and nutraceuticals.
- To acquire knowledge on identification, extraction and utilization of phytochemicalconstituents through teaching and training.

Course Outcomes:

CO. No.	Upon completion of this course, students will be able to	PSO's addressed	CL
CO-1	confirm the promising role of the phytoconstituents as cytotoxicity and substantiate them for the treatment of fatal diseases	8	Re
CO-2	understand the importance of secondary metabolites and relate them in treating the ailments	6	Un
CO-3	identify and categorize medicinal potential of herbs based on their chemical constituents and therapeutic applications	1	Un
CO-4	associate the medicinal compounds with their natural resources	2	An
CO-5	analyse of qualitative and quantitative medicinal compounds in herbal drug preparation.	2	An
CO-6	extract essential oils from natural resources and utilize them effectively as pharamaceuticals and cosmeticals	7,8	Av
CO-7	evaluate the purity of the drugs and able to detect adulterations and substitutions	2,4	Ev
CO-8	screen and elucidate various pharmacologically important phytoconstituents to ascertain its medical quality	5	Ev

Semester I			
Core IV	**Phytochemistry and Pharmacognosy**		
Course Code:21PBOC14	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credits: 4**

UNIT I: Phytochemistry, Histochemistry, Biosynthetic pathway for secondary metabolites. Secondary metabolites - definition, classification, preliminary phytochemical screening. Glycosides: Definition, properties, classification, natural sources, pharmacological and toxicological effects of glycosides. Terpenoids- β-Sitosterol, Glycyrrhizin. Phenolics - Coumarins and Tannins. Steroids and alkaloids.

UNIT II: Flavonoids: Definition, properties, classification, natural sources and therapeutic applications offlavonoids. Medicinal uses of resins.

UNIT III: Extraction methods – Maceration, infusion, percolation, Decoction, soxlet extraction, supercritical fluid extraction, distillation, Counter-current Extraction, and cold extraction. Volatile oils - source, constituents, properties, extraction and utilization of Lemon grass oil, Vetiver oil, Clove oil and Eucalyptus oil. Intellectual property rights and trade of medicinal plants.

UNIT IV: Pharmacognosy: Definition, scope and applications of herbal medicine. Classification (morphological, therapeutic, chemical. and chemotaxonomic classifications): Collection and processing of crude drugs - adulteration of crude drugs. Pharmacognostical standards, synergy and polyvalent action of secondary metabolites.

UNIT V: Evaluation of crude drugs – Physico-chemical, organoleptic analysis. Botanical name, family, useful part, chemical constituents, adulterants and uses of the following drug Glycosides – Senna, Aloe, Digitalis, Liquorice; Terpenoids – Coriander, Fennel, Cinnamom; Alkaloids – Datura, Vinca, Pepper; Lipids - Castor, Neem, Sesame oil.

Books for Reference:

1. Agarwal S.S. and Paridhavi M. *Crude Drug Technology*, Hyderabad: Universities Press, 2007.
2. Evens W.C. *Pharmacognosy Medicinal and Aromatic Crops,* Singapore:Harcourt Brace and company Asian Pvt. Ltd., Universities press, 1987.
3. Farooqui A.A and B.S.Sreeramu B.S. *Cultivation of medicinal and aromatic crops,*Pune: Universities press, 2001.
4. Gurdeep Chatwal. *Organic Chemistry of Natural Products,* Mumbai: Himalaya Publishing house,1983.

5. Kokate C.K. Purohit A.P. and Gokhale S.R, *Pharmacognosy,* Pune: Nirali Prakshan Publishing House Ltd., 2004.
6. Tewari K.S, Vishogi N.K and Mehrotra S.N. *Text Book of Organic Chemistry* , Uttaarpradesh: VikasPublishing House Ltd., 1998.
7. Trivedi P.C. *Medicinal Plant conservation and utilization*, Jaipur: Aavishkar publishers,2004.
8. Trivedi P.C and Sharma N.K. *Ethomedicinal Plants,* Jaipur: Pointer Publishers , 2004
9. Wallis. *Text Book of Pharmacognosy,* New Delhi: CBS Publishers, 2003.
10. Yohanarasimban S.N. *Medicinal plants of India,* Jodhpur: 2004.

Practical: Hrs/Week: 2

- Morphology, histology and Powder characteristics, extraction and detection of Cinnamon,Clove, Fennel and Coriander.
- Isolation and detection of active principles:Caffeine from Tea dust
  Sennosides from Senna
  Curcumin from Turmeric
- Analysis of crude drugs by chemical tests for the detection of Glycosides - Senna, *Aloe*, Liquorice
  Terpenoids – Coriander, Fennel, Cinnamom
  Alkaloids – *Datura, Vinca*, Pepper
  Lipids - Castor, Neem, Sesame, Groundnut oil
  Resin – Ginger, Asafoetida.
  Volatile oil – Lemon and clove
- Distillation of Volatile oils and detection of phytoconstituents by TLS Jasmine and *Eucalyptus*

Books for Reference:

1. Kokate K.C and Gokhale S.B. Practical Pharmacognosy, Pune: 2008.
2. Chauhan M.G. and Pillai A.P.G, Microscopic Profile of Powdered Drugs Used in Indian Systems of Medicine. Jamnagar: *Institute of Ayurvedic Medicinal Plant Sciences,* 2005.

SEMESTER II			
Core V	**Plant Diversity II (Pteridophytes, Gymnosperms and Paleobotany)**		
Course Code: 21PBOC21	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credit: 4**

Objectives:

- To have a comprehensive idea on vascular cryptogams and phanerogams.
- To get an idea on the past history of biosphere and evolution of seed plants.
- To understand the taxonomy, characteristics and uniqueness of vascular plants.

Course Outcomes:

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	appreciate the uniqueness and distinguish between diverse groups of Pteridophytes and Gymnosperms using their characteristic features	1, 2	An
CO-2	discuss different life cycle patterns in different groups	1, 2	Cr
CO-3	know the basic skills and techniques in micropreparation and formulate methods to identify different groups	1, 6	Ap
CO-4	know the evolutionary significance of Pteridophyte	1, 2	Un
CO-5	infer pteridophytes are pioneer in the evolution of seedhabit	1, 2	Re
CO-6	compare and contrast the origin and evolution of steles,foliage, seed and seedless plants.	1, 2	An
CO-7	compare and contrast the seed and seedless plants.	1, 2	Ev
CO-8	review critically the biology, ecology of fossils andmethods of fossilization.	1, 7	Un

SEMESTER II			
Core V	**Plant Diversity II (Pteridophytes, Gymnosperms and Paleobotany)**		
Course Code: 21PBOC21	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credit: 4**

UNIT I: **Pteriodophytes:** Classification of pteridophytes (PPG) by Erics (2016 (upto order level). Origin and evolution of pteridophytes. General characteristics. Telome concept. Stelar evolution in pteridophytes. Heterospory and seed habit. Theories and modifications of alternation of generations. Life cycle pattern in homosporous and heterosporous pteridophytes. Distribution of pteridophytes in India

UNIT II: Morphological, anatomical structure, asexual and sexual reproduction of Psilotales, Lycopodiales, Selaginellales,Isoetales, Equisetales, Ophioglossles and Polypodiales. Aposory, Apogamy, Vivipary, Parthenogenesis. Economic importance of pteridophytes.

UNIT III: **Gymnosperms:** Classification of gymnosperms by Christenhusz *et al.* (2011) (Upto family level). General characteristics. Distribution of gymnosperms in India. Morphological, anatomical structure and reproduction of Cycadaceae, Ginkgoaceae, Welwitschiaceae, Gnetaceae and Ephedraceae,

UNIT IV: Morphological, anatomical structure and reproduction of Araucariaceae, Podocarpaceae and Cupressaceae. Affinities of gymnosperms with angiosperms and pteridophytes. Economic importance of gymnosperms.

UNIT V: **Paleobotany:** Geological time scale – fossilization and fossil types: compressions, incrustation, casts, molds, petrifactions, coal balls and compactions. General characters of fossil pteridophytes: *Horneophyton, Sphenophyllum* and *Calamites*. Fossil gymnosperms: *Williamsonia* and *Cordaites*. Indian Paleobotanists: Birbal Sahni, D.D. Pant, M. Ramanujam, Osmani.

Books for Reference:

Pteridophytes:

1. Bower, F.D. *Primitive land plants*. Vol. I & 2. Jaipur : Arihant Publishers. 1988.

2. Pandey S.N., Trivedi P.S., Misra S.P. *A text Book of Botany* Vol. II. New Delhi: Vikas Publishing House Pvt. Ltd., 2006.
3. Parihar, N.S. *An introduction to Embryophyta, Pteridophyta.* Allahabad: Central Book Depot Publications in Botany. 1967.
4. Rashid, A. *An introduction to Pteridophyta*. New Delhi: Vani Educational Books. 1985.
5. Sundara Rajan S. *Introduction to Pteridophyta*. New Delhi : New Age International Publishers. 2009.

Gymnosperms:

1. Chamberlain, C.J. *Gymnosperms.Structure and evolution*. New Delhi: CBS Publishers &Distributors, 1986
2. Johri R.M., Sneh Lata and Kavita Tyagi. *Text Book of Gymnosperms*. New Delhi : Wisdom Press. 2010.
3. Sporne, K.R. *The Morphology of Gymnosperms*. New Delhi: B.I. Publications Pvt. Ltd., 1974.

Practical: Hrs/Week – 2

Pteridophytes:

- *Selaginella* – Habit, Section: T.S. of stem, rhizophore, L.S. of cone
- *Isoetes* - Habit, Section: T.S. of leaf
  Permanent slide: L.S. of male and female cone
- *Equisetum* - Habit, Section: T.S. of internode
  Permanent slide: L.S. of cone
- *Lygodium* – Habit, Section: T.S. of rachis
  Permanent slide: T.S. of pinnule
- *Osmunda* – Habit, Section: T.S. of rachis
  Permanent slide: L.S. of cone
- *Pteris* – Habit, Section: T.S. of rachis and pinnule
- *Adiantum*- Habit, Section: T.S. of rachis and sori
- *Salvinia* – Habit, Section: T.S. of stolon
  Permanent slide: L.S. of cone

Gymnosperms:

- *Cycas* – Twig, Section: T.S. of corolloid root, rachis and leaflet
  Permanent slide: L.S. of microsporophyll, male cone (entire), female cone (entire)
- *Gnetum* – Twig, T.S. of stem and leaf
  Permananent slides: L.S. of male and female cone, wood showing anomalous secondary thickening and seed (entire).
- *Araucaria* – Twig, Section: T. S. of stem

Permanent slide: L.S. of cone

- *Podocarpus* – Twig, Section: T.S, of stem, leaf
  Permanent slide: L.S. of cone
- *Cupressus*: Twig, Section: T. s. of stem
  Permanent slide: L.S. of male cone and female cone

Fossils:

Pteridophytes:

- *Sphenophyllum*
- *Calamites*

Gymnosperms

- *Williamsonia*
- *Cordaites*

Field study: No. of days 3 (Pteridophytes and Gymnosperms: Western Ghats)

Submission - Record Note Book

Lab manuals for Reference:

1. Ashok M. Bendre and Ashok Kumar. *A Text Book of Practical Botany*Volume1. Meerut : Rastogi Publications. 2009.
2. Srivastava H. N, *Practical Botany* Volume I, Jalandhar : Pradeep Publications, 1987.

SEMESTER II			
Core VI	**Marine Botany**		
Course Code: 21PBOC22	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credits: 4**

Objectives:

- To give elaborate account on marine environment and its role in controlling the Earth'sclimate.
- To understand the different types of marine habitats and the adaptation of life there in.
- To understand the role of marine products and their socio economic and environmental significance

Course Outcomes:

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	analyze how marine organism adapt to their dynamic environment	5	Un
CO-2	recall how natural events and human activities affect coastal habitats	7	Re
CO-3	critically analyze and evaluate pollution issues, their sources and the influences humans have with the dynamic marine environment	7	An
CO-4	achieve practical skills in processing, preserving and culturing marine plants	6	Ev
CO-5	evaluate the uses of marine resources and realize the role of phytoplankton and bacteria in the economy of the ocean	5	Ap
CO-6	able to signify the characteristic feature of coral reefs and their role in biodiversity conservation	1	An
CO-7	able to identify and understand the role of mangroves in coastal protection and their adaptation to its hostile environment	5	Ap
CO-8	explain the ecological relationship between organisms and their environment	2	An

SEMESTER II			
Core VI	**Marine Botany**		
Course Code: 21PBOC22	**Hrs/week:5**	**Hrs/Semester: 75**	**Credits: 4**

UNIT I: Classification of marine habitat - ecology of pelagic, benthic and sublittoral zones, deep sea, sandy muddy and rocky shore. Characteristics of marine habitat – tides and chlorinity, upwelling, plate tectonics, tsunami, green house effect, carbon pump. Ocean and regulation of climate on earth.

UNIT II: Marine biodiversity –phytoplankton - characteristics, measuring and sampling. Marine bacteria, marine fungi, seaweeds and sea grasses. Threats and conservation of seaweeds and sea grasses. Nutrient cycling: carbon, nitrogen, sulphur and phosphorus.

UNIT III: Marine products - traditional uses; human food and agriculture. Marine colloids and hydrocolloids - Agar - agar, algin, alginates, carrageenan, diatomite, marine lipids, flavanoids, and carotenoids. Marine pharmacology –identification of bioactive compounds in marine organisms – mangroves, seaweeds, and sea grasses.

UNIT IV: Culture of micro algae –laboratory culture, preservation and maintenance of culture and mass culture. Commercial cultivation of seaweeds. Marine pollution –thermal pollution, oil pollution, heavy metal pollution, radioactive pollution and industrial pollution. Algal blooms. Global climate changes: impact on specific diversity and productivity, ocean as carbon sink, effect on coral bleaching. Biological rhythms.

UNIT V: Mangroves and salt marshes: geographical distribution, habit, adaptations, and trophic interactions. Present status and stresses on the mangroves with special reference to Sunderbans. Regeneration of mangroves. Coral reefs – ecology, species interaction, economic importance and conservation.

Books for Reference:

1. Cliton Jand Dawes. *Marine Botany.* New York: A wiley – Intersciences publication John Wiley andsons, 1981.
2. Dring M J. *The Biology of Marine plants.*London: Edward Arnold, 1982.
3. Kumudranjan Naskar and Rathindranath. *Ecology and Biodiversity of Indian mangroves. Vol. I & II,* Delhi: Daya publishing House, 1999.
4. Michael P. *Ecological methods for field and laboratory investigations*, Uttar Pradesh: Tata McGraw – Hill publishing Company Limited, 1986.
5. Sinha P.C. *Marine pollution,* New Delhi: Anmol publications Pvt. Ltd., 1998.

6. Tait R.V. *Elements of Ecology*, London: Butter worths, 1978.
7. Warren. *Biology and water pollution* control, London: W.B.Saunders Company, 1971.

Practicals: Hrs/Week: 2

- Determination of acidity
- Estimation of alkalinity
- Estimation of Salinity
- Collection and identification of phytoplankton.
- Determination of total hardness
- Estimation of nitrate (Spectrophotometry)
- Estimation of Phosphate (Spectrophotometry)
- Heavy metal analysis from mangrove sediments

Specimens / photographs / charts

- Plankton net
- Seaweeds
- Sea grasses
- Mangroves
- Alginates
- Carrageenan

Books for Reference

1. Murugesan A.G and Rajakumari. *Environmental Science and Biotechnology and Biotechnology Theory and Techniques, Chennai:* MJP Publishers, 2005.

SEMESTER II			
Core VII - Developmental Botany			
Course Code: 21PBOC23	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credit: 4**

Objectives

- To study the vegetative and reproductive development of seed-bearing plants
- This course is aimed at understanding the structural organization of tissues, organs and theirdevelopmental events controlled by environmental cues and genetic factors

Course Outcome

CO. No	Upon completion of this course ,students will be ableto	PSO addressed	CL
CO-1	understand the overview of essential aspects of development, organization and life cycle of seed bearing plants	3	Un
CO-2	know how embryo arises and the nature of signals that guide complex patterns of growth and differentiation in the embryo	4	Un
CO-3	explore and illustrate how the molecular and genetic approaches provide an insight into the mechanism that translate cues into organized pattern growth and development	4	Re, Un
CO-4	understand cell differentiation, organ development and network of gene signals that control developmental sequences	3	Un
CO-5	role of shoot and root apical meristem in vegetative growth and development	3	Re, Un
CO-6	know the biochemical and physiological changes associated with the development of sex organs, fertilization events and fruit development	4	Un,Ap
CO-7	know how the intrinsic programmes of development coupled to external influences such as nutrient levels, energy inputs and environmental signals.	4	Un
CO-8	acquire hands on training experience related to the course.	4	Re

SEMESTER II			
Core VII	**Developmental Botany**		
Course Code: 21PBOC23	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credit: 4**

UNIT I: **Embryogenesis:** Basic concept of development. Polarity and cell linages. Principle of determinants in plant embryogenesis – axis and pattern formation – apical, basal and radial; Cell plasticity - Meristem and indeterminate growth; Types of meristem – Root apical meristem (RAM) – quiescent center - development of lateral root and root hair formation - position dependent signaling process- hormonal control and maintenance of RAM; Shoot apical meristem (SAM)- organization and activities of SAM, role of gene and transcription factors; vegetative organization, tissue differentiation, leaf initiation and differentiation, Genetic approaches on SAM.

UNIT II: **Seed germination and Seedling establishment**: Seed structure, seed dormancy- breaking of seed dormancy; Seed germination – phases, mobilization of stored resource, seedling growth – growth curve- response to environmental cues- trophism – gravitrophism, phototrophism, thigmotrophism – role of auxin distribution in trophism; phototrophism- photomorphogenesis- shoot differentiation- vascular tissue differentiation; root growth and differentiation – emergence of lateral growth and biochemical and physiological considerations.

UNIT III: **Vegetative growth and organogenesis**: Leaf initiation and determination of phyllotaxy, differentiation of epidermal tissues and appendages, mesophyll tissues; venation pattern, role of hormones; primary root system and shoot system architecture; secondary growth in stem and root- secondary tissue and cambial activity- vascular cambium and cork cambium- abnormal secondary growth.

UNIT IV: **Floral development:** Floral evocation and development of floral parts - Floral meristem, floral organ development – gene control mechanism, homeotic gene control organ identity, competency and determination in floral evocation. Integrating environmental cues – photoperiodism – monitoring day length, circardian ryhythm, vernalization- promoting flowering with cold- temperature control; physiological and molecular control of floral organ development and hormone signals in floral evocation –, gender expression in flowers, genetic control of floral symmetry.

UNIT V: **Developmental biology of floral organs:** Anther differentiation – tapetal behavior, microsporogenesis, pollen development and maturation. Male gametogenesis- pollen germination; megasporogenesis – development of female gametophyte- organization of embryo sac- gene regulation on megagametogenesis- pollen pistil interaction self incompatibility – causes – morphological, cyto genetical reasons – fertilization- development of seed and fruit formation.

Books for Reference:

1. Leyser O and Day S *Mechanisms in plant development*. France: Black Well Publishing Company, 2009.
2. Howell S.H *Molecular genetics of plant development*. NY: Cambridge UniversityPress, 1998.
3. Taiz L and Zeiger E *Plant Physiology and development*. USA: Sinauer Associates.Sixth Edition. 2010.
4. Ragavan V *Developmental Biology of flowering plants.* NY:Springer. 2000.
5. Ragavan V *Experimental Embryogenesis in Vascular plants*. London: Academic Press Inc., 1976.
6. Shivana K.R and Joshi B.M *The angiosperm pollen structure and function*. Singapore: John Wiley & Sons, 1985.
7. Benjamin H Willier and Jane M Oppenheimer *Foundations of Experimental Embryology.* New Delhi. Prentice of India Private Limited, 1968.

Practical: Hrs/week: 2

- Micropreparation of shoot apex/root apex/flower buds/ anther/ ovary/ epidermal appendages formicrotomy
- Directionality of pollen tube growth: protein extraction and protein gel electrophoresis
- Pollen viability test
- Pollen germination test
- Hand sectioning of anther and ovary
- Dissecting embryo and endosperm

Books for Reference

1. Chawla H.S *Introduction to Plant Biotechnology*. New Delhi: Oxford & IBH publishing company Pvt.,Ltd., 2009.

SEMESTER – II			
Core VIII	**Genetics and Bioinformatics**		
Course Code:21PBOC24	**Hrs/Week: 4**	**Hrs/Sem: 60**	**Credits: 4**

Objectives:

- To develop an overall understanding on the concepts in genetics and their implications Gain skill on common Bioinformatics tools use in Biology
- To understand Mendel's and T. H. Morgan's theories, on inheritance and their applications
- To practice chromosome mapping, pedigree analysis and basic problems in population genetics
- To comprehend chromosomal aberrations and its implications
- To get trained on Bioinformatics tools used in DNA/RNA/protein sequence analysis
- To get trained on protein structure/visualization and phylogenetic software

Course Outcomes:

CO. No.	Upon completion of this course, students will be able to	PSO addressed	C L
CO-1	predict the possible outcome in a parental cross of known genes	4	Ap
CO-2	associate the physical basis of heredity and the mode of inheritance of a character	2	Un
CO-3	predict the unknown phenotype and genotype in a partially known pedigree	4	Ap
CO-4	map a gene and measure the distance between two genes	4	Ap
CO-5	understand various chromosomal aberrations and various chromosome banding techniques	1,2	An, Un
CO-6	comprehend the operations in population genetics	2	Un
CO-7	predict gene of unknown sequences, similarity between sequences, protein structure, phylogenetic relationships between large groups using genomic data	1, 4	An, Ap
CO-8	learn barcoding techniques and sequence submission	1,2	An, Un

SEMESTER – II			
Core VIII	**Genetics and Bioinformatics**		
Course Code: 21PBOC24	**Hrs/Week: 4**	**Hrs/Sem: 60**	**Credits: 4**

UNIT I: A brief account on Mendelian Principles. Sex linked inheritance. Formulating and testing genetic hypotheses: Chi-square test and probability theory in genetics. Pedigree analysis. Genetic counselling. Chromosome basis of inheritance. Linked genes, recombination and crossovers: Classical experiments in *Drosophila*. Chromosome mapping: two point and three point test cross, gene order and distance calculation. Somatic tests to assigning genes to chromosomes. Genetic recombination and gene mapping in eukaryotes e.g. *Neurospora*.

UNIT II: Chemical composition and packaging of eukaryotic chromosomes. Concept of gene. C-Value paradox, Cot-value and its significance. Chromosome structure in eukaryotes: Chemical composition of eukaryotic chromosomes, the three levels of DNA packaging, Ultra structure of centromere and telomere. Repeated nucleotide sequences, satellite DNA.Structural aberrations in chromosomes: Haploidy, Anueploidy, Polyploidy, and their types, cytological study and identification of autopolyploids and allopolyploids, Genetic consequences of ploidy alteration: Evolution of hexaploid wheat. Structural alteration in chromosome: Deletion, Duplication, Inversion & Translocation, hetrozygote. Chromosomal aberreation related syndromes. Chromosome banding: Q-band, G-band, R-band, C-band, *in situ* hybridization: GISH, FISH, Molecular maps.

UNIT III: Population genetics: History, Gene frequencies and Genotype frequencies, Gene pool. Systems of Mating: Random mating and Hardy-Weinberg Principle, Application of Hardy-Weinberg principles: Test for Random mating, Test for sex-linked trait, Test for carrier gene frequency, Test for mode of inheritance, Test for multiple gene. Non-random mating, Positive non-random mating, Negative non random mating.

UNIT IV: NCBI, DDBJ, EMBL. Submitting sequence: Sesquin. Sequence structure and mapping data bases. Comparing nucleotide and amino acid sequence: BLAST, Multiple sequence alignment: CLUSTALW, CLUSTAL omega. Protein databases: UniProtKB/Swiss-Prot, PIR, PDB, SCOP & CATH, ProDom, PFAM. Protein visualization tools: Swiss PDB Viewer, Pymol. Expasy proteomic tools: AA Compident and Peptide Mass. Motif and patterns PROSITE, BLOCKS, CADD, Introduction to software: JPred, 3DPSSM, Modeller, ITASSER, Procheck**.**

UNIT V: The terminology of phylogenetics- Trees, Root, branches, Node, Leaf, Clade; lineage sorting, orthology, paralogy, xenology; "basal" lineages, crown vs. stem groups, Phylogram *vs*. cladogram. Multiple sequence alignment & Tree building software - ClustalW, Mega, Phylip, Phylodraw, Phyml, RaxML, Treeview.

Books for Reference

1. Benjamin Lewin, *Genes VII.* New Jersey: Pearson Prentice Hall, 2004.
2. David Preifelder. *Molecular Biology*. New Delhi : Narosa publishing House, 2006.
3. Dnyansagar, V. R.. *Cytology and Genetics*. Tata Mc Graw – Hill Publishing Company limited, 1986.
4. Robert H. Tamarin.. Principles of Genetics. New Delhi : Tata Mc. Graw - Hill publishing company Ltd, 2006.
5. Rastogi S.. C., Mendiratta N., and Rastogi, P. *Bioinformatics: Methods And Applications:(Genomics, Proteomics and Drug Discovery)*. New Delhi: PHI Learning Pvt. Ltd., 2013.
6. Sathyanarayana,U. *Biotechnology*. Kolkatha: Book and Allied (P). Ltd., 2006.
7. Singh B.D. *Genetics.* New Delhi: Kalyani Publishers, 2017.
8. Snustad D.P. and Simmons M. J. *Principles of Genetics*. New Jersey: Wiley Asia Student Edition. Wileyand Sons, Inc., 2012
9. Verma P.S. and Agarwal V.K. *Genetics.* New Delhi: S. Chand and Co., 1991
10. Vijendra Das L. D. *Genetics and plant breeding*. New Delhi: New age International (P) limited Publishers, 2005.

Practicals: Hrs/Week: 2

- Problems coming under Mendelian pattern of inheritance
- Problems using chi-square, probability theory and pedigree
- Countable slides for the metaphase anaphase spread to be prepared each for mitosis and meiosis,and submit at the end of the semester.
- Karyotyping
- Chromosome structural aberration – Translocation in *Tradescantia spathacea* (Rhoeo)
- General genetic tests for genetic toxicity
- Test for gene mutations in bacteria –Bacterial reverse mutation Test
- Chromosomal aberrations due to the effect of mutagens – EMS/2,4 – D/acridine orange in *Allium cepa*
- Sequence analysis using BLAST
- Multiple sequence alignment using CLUSTAL W and CLUSTALX
- Protein structure prediction – PDB, JPred, Modeller
- Create Phylogenetic tree using minimum three of the tools mentioned in the syllabus

Books for Reference:

1. Bendre Kumar. *A Text book of Practical Botany, Volume I & II (7th Edition).* Merrut: RastogiPublications, 2014.
2. Proudlock R. *Genetic Toxicology Testing A Laboratory Manual.* USA: Academic Press, CA, 2016.

SEMESTER III			
Core IX	**Biochemistry and Biophysics**		
Course Code: 21PBOC31	**Hrs/week: 6**	**Hrs/Semester: 90**	**Credits:4**

Objectives:

- To provide updated knowledge of plant's molecular, macro molecular and supra molecular architecture and how they determine the function of plant life.
- To enhance transferable skills such as conduction of quantitative estimation of biomolecule and give mathematical reasoning to interpret the data of the same.
- Familiarise and applies the concept of other branches of sciences that span plant biology such as chemistry, physics and mathematics.

Course Outcomes:

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	study the polymeric biomolecules and their monomeric building blocks	1,2	Re
CO-2	illustrate that living organisms and biological system interact via molecular connection	1,3	Re
CO-3	able to realise the importance of structural configuration and atomic rearrangement of macromolecule with respect to their functions	1,6	Re
CO-4	detect the source of vitamins and their chemistry and distinguish their symptoms specific to their deficiency	2,4	Re
CO-5	outline enzyme groups and know the nomenclature that be able to explain the specificity of enzyme's role and mode of action	2,3	An
CO-6	set up and operate variety of experiments to analyse data accompanied by problem solving and recording.	3,4	Ap
CO-7	draw electromagnetic spectrum and understand the properties of light to relate biological applications.	2,7	Ap
CO-8	explain that energy is needed by plant and that is transformed in biochemical system as governed by the laws of thermodynamics	3,7	Cr

SEMESTER III			
Core IX	**Biochemistry and Biophysics**		
Course Code: 21PBOC31	**Hrs/week: 6**	**Hrs/Semester: 90**	**Credits:4**

UNIT I: **Biomolecules: Carbohydrates** - Classification, Structure of monosaccharides (glucose, galactose, fructose and mannose), disaccharides (trehalose, sucrose, maltose and cellobiose), polysaccharides (starch, cellulose, glycogen, chitin). Properties of carbohydrates. **Amino acids:** Structure and classification based on R - group. **Protein:** Structural organisation of protein (primary, secondary (keratin), tertiary (myoglobin) and quaternary structure (hemoglobin)), bonds involved in protein structure. Properties of protein.

UNIT II: **Metabolism**: Introduction to metabolism. **Metabolism of carbohydrate**: Gluconeogenesis, metabolism of glycogen, galactose and fructose. **Metabolism of aromatic amino acids**: Biosynthesis and degradation of phenylalanine, tyrosine and tryptophan. Intermediatory metabolism. Commercial polypeptides – ACTH, Thymosin.

UNIT III: **Lipids:** Classification, structure and properties of simple lipids (triglyceride and wax), compound lipids (phospholipids and glycolipids) and derived lipids (steroids - cholesterol, terpines). **Metabolism of lipids:** Biosynthesis and degradation of fatty acid and cholesterol. **Vitamins:** Biochemical functions of vitamin A, B_{12}, C, D.

UNIT IV: **Enzymes** –nomenclature IUPAC 1974. Isozymes, Allozymes. Principles of catalysis, enzyme action, active site,activation energy, enzyme kinetics (invertase). Cofactors and inhibitors. Coenzymes NADP, FAD, FMN and coenzyme A. Factors affecting enzyme activity.

UNIT V: **Biophysics**: Dual nature of light, electromagnetic spectrum, phosphorescence, fluorescence and bioluminescence. Laws of thermodynamics, concept of enthalpy, entropy and free energy. Redox couple, redox potential, coupled reactions, oxidative phosphorylation. High energy compound - ATP.

Books for Reference:

1. Bhutani S.P. *Chemistry of Biomolecules*. New Delhi: Ane Books Pvt. Ltd., 2009.
2. Conn E. E. and Stumpf P. K. *Outlines of Biochemistry*. New York: John Wiley and Sons, Inc., 1987.
3. Cox M.M. and Nelson D. L. *Principles of Biochemistry*. India: Replika Press Pvt. Ltd., 5th edition, 2008.
4. David Rawn. *Biochemistry*. New Delhi: Panima Publications, 2004.
5. Ferrier D. R. *Biochemistry*. New Delhi: Wolters Kluwer (India) Pvt. Ltd., 6th edition, 2014.
6. Gupta S.N. *Biochemistry*. Meerut, India: Rastogi Publications, 2011.
7. Lehninger A. L. *Principles of Biochemistry*. Delhi: CBS publishers and Distributors, 1987.
8. Nagini, S. *Text Book of Biochemistry*. Chennai, India: Scitech Publications Pvt. Ltd., 2nd edition, 2007.
9. Salil Bose. *Elements of Biophysics*. Madurai: Jothi Books, 1982.
10. Sathyanarayana, U and Chakrapani U. *Biochemistry*. Kolkata: Arunabha Sen, Books and Allied (P) Ltd. 3rd edition, 2006.

Practical

Hrs/Week: 2

- Estimation of total carbohydrates.
- Titration of amino acid (glycine)
- Estimation of free amino acid from plant tissues (Ninhydrin method)
- Estimation of total soluble protein from plant tissues (Barfoed's test)
- Separation of amino acids (ascending paper chromatography).
- Separation of photosynthetic pigments (column chromatography).
- Absorption spectrum of chlorophyll
- Study of enzyme kinetics and determination of Km value.
- Saponification value of two vegetable oils.
- Enzyme assay- Protease
- Chem sketch/morvin sketch for compound structure prediction
- Pass online analysis
- Submission - Record Note Book

Laboratory Manual for Reference:

1. Jayaraman. J. *Laboratory manual in Biochemistry.* New Delhi: New Age International Publishers, 2011.

SEMESTER III			
Core X	**Taxonomy of Angiosperms**		
Course Code:21PBOC32	**Hrs/week:6**	**Hrs/Semester: 90**	**Credit:4**

Objectives:

- To acquire knowledge on different systems of classification and to have an insight on modern trends in classification of Angiosperms.
- To provide practical understanding of floristic feature of angiosperm that enable to identify plants up to species level in the field / forest inventory
- Infer the significance of taxonomy in understanding the evolutionary relationship between plants and to involve in research practices.

Course Outcomes:

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	understand the rules of botanical nomenclature and taxonomical hierarchy that enable to organize the plant based on the hierarchical system	1	Ap
CO-2	apply scientific literature for identifying and grouping of underrepresented plants in the taxonomic literature	4	Re
CO-3	to outline different systems of classification and recall the contribution of taxonomist/naturalist in plant systematics	6	Un
CO-4	compare the traditional and modern system of classification and report its merits and demerits.	1	Ap
CO-5	realize the importance of taxonomical literature (flora, monograph, botanical gardens, herbarium and government organization) and utilize them for plant identification and conservation.	1	Un
CO-6	apply effectively the traditional and modern tool (Keys, interactive keys, e-flora, digital herbarium) to develop skill in plant identification	4	Un
CO-7	recognize how the role of cytology, embryology , phytochemistry and molecular biology of plants help to authenticate the identity of plants	7	Ap
CO-8	gain hands on working experience in describing the floristic feature of the plants of specified families and make sketches of that.	1	An

SEMESTER III			
Core X	**Taxonomy of Angiosperms**		
Course Code:21PBOC32	**Hrs/week:6**	**Hrs/Semester: 90**	**Credit:4**

UNIT I: Definition, objectives and brief history of plant taxonomy. Botanical Nomenclature: need for scientific names, polynomial and binomial nomenclature. ICBN: principles, Rules and Recommendations, the rank of taxa (family, genus, species, infra-specific taxa), type method, typification, author citation, publication, effective and valid publication, retention, rejection of names and principle of priority. Phylocode: principles, rules and advantages. Taxonomic hierarchy: Ranks in the hierarchical system (order, family, genus, species and intra specific)

UNIT II: Classification: Relative merits and demerits of major systems of classifications: Linnaeus, Bentham and Hooker's and Angiosperm Phylogeny Group (IV). Current trends in Biosystematics: Phenetics: principles of taximetrics. Cladistics: phylogenetic terms and phylogenetic diagrams. Numerical taxonomy: construction of taxonomic groups, applications, merits and demerits.

UNIT III: Tools of taxonomy: Floras, monographs, revisions, websites. Herbarium and botanical gardens: their role in teaching, research and conservation, important herbaria and botanic gardens of the World. Dichotomous keys: guidelines for constructing dichotomous keys (indentedand bracketed key), interactive keys (computer aided). Digital herbaria: e- flora. Taxonomic evidences: anatomy, cytology, embryology and chemosystematics based on the phytochemicals (phenols, alkaloids, flavonoids and terpenoids). Molecular systematics (DNA bar coding).

UNIT IV: Vegetative and floral characters of the following families: Ranunculaceae, Capparidaceae, Tiliaceae, Meliaceae, Rhamnaceae, Sapindaceae, Fabaceae, Combretaceae, Asteraceae, Sapotaceae.

UNIT V: Vegetative and floral characters of the following families: Solanaceae, Boraginaceae, Convoluvaceae, Scrophulariaceae, Bignoniaceae, Verbenaceae, Nyctaginaceae, Orchidaceae, Commelinaceae and Cyperaceae.

Books for Reference:

1. Davis P.H. and Heywood V.M. Principles of Angiosperm Taxonomy. London: Olive & Byod, 1983.
2. Gurcharan Singh. Plant Systematics. New Delhi: Oxford & IBH Publishing Company, 2004.
3. Gurcharan Singh. Plant Systematics. New Delhi: Oxford & IBH Publishing Company, 2012.
4. Lawrence G.H.M. Taxonomy of Vascular Plants. New Delhi: Oxford & IBH Publishing Company, 1951.
5. Naik V.N. Taxonomy of Angiosperms. New Delhi: Tata Mc Graw Hill Publishing Co., 1984.
6. Pandey S. N., Misra S.P. Taxonomy of Angiosperms. New Delhi: Ane Books India, 2008.
7. Sharma O.P. Plant Taxonomy. New Delhi: Tata Mc Graw Hill Publishing Co Ltd., 1993.
8. Singh G. Plant Systematics – Theory and Practice. New Delhi: Oxford & IBH, 1999.
9. Mathur R.C. Systematic Botany Angiosperms. Agra: Agra Book Store, 1972.

Practical:

Hrs/Week-2

- Study of wild taxa representing different families and identification to species level.
- Construction of taxonomic keys (dichotomous).
- Field trips within and around the campus; compilation of field notes and preparation of herbarium sheets.
- Identification of plants using floras.

Submission - Record note book, five herbarium sheets, photography of five dissected flowers and field note book

Taxonomic Manual for Reference:

1. Gample J.S. Flora of the Presidency of Madras – Vol I & II, Reprint. Authority of Secretary of state for India in Council, 1956.

SEMESTER - III			
Core XI	**Molecular Biology and Genetic Engineering**		
Course Code: 21PBOC33	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credits: 4**

Objectives:

- To furnish broad insight on chemical nature of hereditary material (DNA), organization of chromosome at different phases of cell cycle, basic rules, governing its replication and to examine genes have the code to life.
- To apply the understanding of DNA and adopt molecular techniques to manipulate gene to get the desired output.
- To educate the students in strategizing research methodologies employing genetic engineering techniques.

Course Outcomes:

CO.No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	know the chemistry of genetic material and details of its replication at molecular level	1	Un
CO-2	pronounce how errors during replication are repaired	6	An
CO-3	infer complexity of gene expression in eukaryotes over prokaryotes	2	Un
CO-4	explain gene regulation mechanisms at various levels by which they can learn how it controls growth and development of an organism	4	Cr
CO-5	Understand the principles of genetic engineering and basic steps of gene cloning	2	Un
CO-6	advocate the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering	1	Un
CO-7	grasp different types of gene transfer methods employed in gene cloning process	2	Cr
CO-8	practice the advanced techniques in genetic engineering, investigate the different strategies of recombinant DNA technology and resolve the problems encountered	3	Ap

SEMESTER - III			
Core XI	**Molecular Biology and Genetic Engineering**		
Course Code: 21PBOC33	**Hrs/week: 5**	**Hrs/Semester: 75**	**Credits: 4**

UNIT I: **Replication of DNA:** Molecular mechanism of DNA replication in prokaryotes (activation, initiation synthesis of new strands of DNA, termination and helix formation) and eukaryotes (replication of the ends of eukaryotic chromosomes, telomerase enzyme), Enzymology of DNA replication (DNA polymerase enzymes in prokaryotes and eukaryotes and DNA ligase enzymes), replication models (theta replication of DNA, rolling circle model and D-loop model). **DNA repair:** necessity of DNA repair, mistakes in DNA (types), Biochemical mechanism of DNA repair (mismatch repair and repair of thymidine dimers).

UNIT II: **Gene expression:** Definition of gene, types of genes, functions of genes, transcription and processing of RNA in prokaryotes and eukaryotes, genetic code, translation in prokaryotes (initiation, elongation, termination) and eukaryotes (initiation, elongation, termination and polypeptide folding), post translational processing of protein (protein folding).

UNIT III: **Regulation of gene expression:** Gene regulation in prokaryotes: Coordinated gene regulation, strategies of gene regulation, mechanism of gene regulation at transcriptional level induction (*lac* operon – structure, functioning) and repression (*trp* operon – structure). **Gene regulation in eukaryotes:** genome level (presence of multigene families, gene alteration, gene arrangement), transcription level (acetylation of histones, euchromatin remodeling complexes, methylation of nucleotides, control elements, transcription factors, mediators, insulator, regulatory proteins, hormones and chromosome level), post-transcriptional level (post-transcriptional control by choice of splice site, polyproteins, regulation of gene expression by RNA, control on transport of RNA, control at translation of RNA, mRNA degradation control, protein folding level and protein degradation control).

UNIT IV: **Genetic Engineering:** Discovery, denaturation and renaturation of DNA, artificial synthesis of gene, restriction enzymes – types, target sites, DNA cleavage styles (sticky and blunt end style). Biological tools for recombinant DNA technology (enzymes, linkers, foreign DNA and cloning vectors). Vectors – cloning and expression vector, plasmid vectors – types, characteristics (pBR322 and pUC8), bacteriophage vectors (lambda phage and M13 vectors), cosmid vectors (pJB8), phagemid vectors (pBluescript), artificial chromosome vectors (BAC and YAC), shuttle vectors, fosmid vectors.

UNIT V: **Techniques used in Genetic Engineering:** Generation of DNA fragments (DNA cleavage by restriction enzymes, Southern blotting technique, Northern blotting and Western blotting). Artificial synthesis

of gene (Chemical assembly of oligonucleotides, enzymatic assembly of oligonucleotides and complementary DNA synthesis). Joining of foreign DNA fragment to a cloning vector (sticky, blunt end ligation and homopolymer tailing method). Introduction of recombinant DNA into host cell (transformation, transduction, electroporation, liposomes, microinjection and microprojectile). Selection and screening of transformed cells (reporter genes, elimination of non-transformed cells, identification of clones having rDNA, selection, formation and expression of cloned genes). Genetic engineering and human welfare.

Books for Reference:

1. Veer Bala Rastogi. *Principles of Molecular Biology*. India: MEDTECH. 2016.
2. Brown T.A. *Gene cloning and DNA analysis, An Introduction.* Manchester: John Wiley & Sons. 2010.
3. Primrose S.B and Twyman R. *Principles of gene manipulation and genomics*.Wiley. 7th edition 2006.
4. Verma P.S. and Agarwal V.K. Genetic Engineering. New Delhi: S. Chand & Company. 2010.
5. Benjamin Lewin. *Genes VII.* Burlington: Pearson Prentice Hall. 2004.
6. Channarayappa. *Molecular Biology. Principles and Principles and Practices.* India: Universities Press Pvt. Ltd., 2006.
7. Nicholl D.S.T. *An Introduction of genetic engineering*. UK: Cambridge University press. 2001.
8. Robert H. Tamarin. *Principles of Genetics*. New Delhi: Tata Mc. Graw-Hill publishing company Ltd., 2006.
9. Sathyanarayana U. *Biotechnology.* Kolkatha: Book sand Allied (P). Ltd., 2006.
10. Glick B.R, Pasternak J.J and Patten C.L. *Molecular Biotechnology: principles and applications of recombinant DNA*. Washington: ASM Press. 4th edition 2010.

Practicals

Hrs/ week - 2

- Estimation of DNA by diphenylamine method.
- Estimation of RNA by Orcinol method.
- Isolation of bacterial genomic DNA.
- Isolation of genomic DNA from plant tissue.
- Separation of DNA fragments using AGE.

- Digestion of DNA with restriction enzymes.
- Vecscreen software to detect foreign DNA.
- Protein translation using p BLAST.

Laboratory Manual for Reference:

1. William D. Stansfield, Jame S. Colome and Raul J. Cano. *Theory and Problems Molecular and cell biology*. Schaum's outline series, 1st edition McGraw-Hill. 2019.

SEMESTER - III			
Core XII Ecology and Conservation Biology			
Course Code: 21PBOC34	**Hrs / Week:5**	**Hrs / Semester: 75**	**Credits:4**

Objectives:

- To explore the natural capital asset, ecosystem services provided by the biodiversity and their biogeochemical intersection that shape the environment.
- To realize the current ecological threat associated with biodiversity and learn about global / national level action taken to address the issues of biodiversity.
- To understand the characteristics of community, community dynamics and development of community forest.

Course Outcomes:

CO. No	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	reveal the range of plant diversity in terms of structure, function and their environmental relationships.	5	Un
CO-2	describe the climatic and edaphic factors and ecological succession	5	Un
CO-3	categorize the plants based on adaptation	3	An
CO-4	address the global environment crisis and the strategies applicable for environmental problem mitigation	7	Ev
CO-5	learn the global level environmental summit organized that focused for sustainable future	7	Cr
CO-6	know the importance of remote sensing in finding the current status of global health	7	Cr
CO-7	recognize the causes of environmental problems	7	Un
CO-8	manage and conserve the biological resources	7	Cr

SEMESTER - III			
Core XII	**Ecology and Conservation Biology**		
Course Code: 21PBOC34	**Hrs / Week:5**	**Hrs / Semester: 75**	**Credits:4**

UNIT I: Plant and the environment: climatic factors - air, water and temperature; Edaphic factors - types based on texture and colour. Components of soil- soil air, soil water, pH, mineral matter, organic matter, soil profile - soil organisms - reclamation of soil erosions and conservation. Biotic Factors, positive and negative interactions. Structure and function of major ecosystems - terrestrial (Grassland, forest and desert) aquatic (pond).

UNIT II: Population structure and dynamics: Basic concepts - characteristics of population, size and density, dispersion, age structure, natality, mortality, biotic potential and life table. Population dynamics - theory of population growth, Plant population dynamics, Regulation of population growth, Evolution among population and population interaction. Ecological succession - Causes of succession, Kinds of succession and process of succession. Climax concept – mono climax and poly climax theories. Adaptation of plants- hydrophytes and xerophytes

UNIT III: Environmental Management Plan (EMP), ecological indicators. Bioremediation – *in situ* and *ex situ* bioremediation: Bioremediation of - hydrocarbon, dyes, heavy metals and xenobiotics. Bio- augmentation – principles and use of enzymes. Bio-filtration – biofilters, microorganisms used and mechanism. Bioleaching - microorganisms used, leaching process, examples of bioleaching. Ecology in national affairs- carbon trading, carbon sequestration, blue carbon, climate conference, convention and summit.

UNIT IV: Conservation of biodiversity *In situ* conservation – National park, wild life sanctuaries and Biosphere reserve, afforestation, social forestry, agro forestry. *Ex situ* conservation - field gene bank, seed bank, pollen bank, tissue culture, DNA bank and cryopreservation methods. Species based approaches, Social approaches- sacred groves and sthalaviriksha. Green movements – Chipko movement and Silent valley movement.

UNIT V: Organizations associated with biodiversity management, IUCN, WWF, UNEP, NBPGR, ICAR, WHF. Biodiversity legislations – GATT, TRIPS, CITES, Wild life preservation Act (1972), Rio Summit – Agenda- 21, Convention on biological Diversity, Biodiversity**,** Act (2002). Role of indigenous people in conservation. Biopiracy, sustainable development and management of biodiversity.

Text Books:

1. Sharma, P.D. *Elements of ecology*. Meerut: Rastogi Publications. 1999.
2. Shukla, R.S. and Chandal, S.S. *Plant Ecology*. New Delhi: S. Chandal and Co.1991.

Books for Reference:

1. Asthana and Meera Asthana. *Environmental problems and solutions.* New Delhi: S.Chand and Co. Ltd., 2001.
2. Balasubramania, D., Bryee C.F.,Dharmalingam, K., Green J. and Jeyaraman K. *Concepts in Biotechnology*. Universities Press.2005.
3. Dash M. C. *Fundamentals of ecology*. New Delhi: Tata McGraw Hill publishing Co. Ltd.2001.
4. Murugesan, A.G. and Rajakumari *Environmental Science and Biotechnology, theory and Techniques.* Chennai: M.J.P. Publishers, 2005.
5. Sharma, P.D. *Elements of ecology*. Meerut: Rastogi Publications. 1999.
6. Trivedi P.R, Sharma, P.L. and Sundarshan, K. N..*Natural environment and Constitution of India.* New Delhi: Efficient offset printers. 1994.
7. Tyller Miller G. *Environment Science.* Singapore: Thompson Brooks / Cole. 2004.
8. Varshney C. K. *Water pollution and management*. Noida: S.P. Printers.1989.

Practical Hrs/week: 2

- Determination of soil pH (at least 3 types of soil)
- Determination of soil texture.
- Determination of soil moisture.
- Determination of soil bulk density.
- Determination of soil porosity.
- Determination of soil organic matter content.

- Estimation of calcium.
- Estimation of magnesium.
- Estimation of sodium.
- Estimation of potassium.
- Estimation of nitrogen.
- Adaptation of plants- hydrophytes, xerophytes and halophytes,
- India map showing grass land, forest and desert.
- India map showing hotspots
- India map showing Biosphere reserves.
- Endangered / Endemic plants lists and photos (any2).

Scientific visits: Visit to any nearby place to observe the ecosystem their communities and their succession.

Submission - Record note book.

Book for Reference:

1. Murugesan A.G. and Rajakumari *Environmental Science and Biotechnology Theory and Techniques.* Chennai: MJP Publishers.2005.

SEMESTER - III	
Self Study	**Forest Botany**
Course Code: 21PBOSS1	**Credit: + 2**

Objectives:

- To understand the need of conservation of forest ecosystem.
- To gain knowledge in areas of forest ecosystems and management strategies.
- To know the significance of forests and their products.

Course Outcomes:

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	explain the need for conservation of forest ecosystem	1,2	Un
CO-2	discuss the role and objectives of social forestry	2,6,8	Ap, Un
CO-3	justify forest as a balanced ecosystem.	2,3,5	Re
CO-4	describe the principles and methods of various irrigation systems in water management in the forest.	1,2	Un
CO-5	develop knowledge, skills, understanding and competence in areas of forest ecosystems management	2,4,6	Un, An
CO-6	understand the role of agroforestry in the cultivation of new tree species	3,4,6	Un
CO-7	know about energy plantations under social forestry	1,2,8	Un, An
CO-8	identify wood based on physical, chemical and anatomical characteristics.	3,4,7	Un, Re

SEMESTER III	
Self Study	**Forest Botany**
Course Code: 21PBOSS1	**Credit: +2**

UNIT I: Water - a vital resource, India's water budget. Ground water, rain water, Forest nursery - Water management and manuring - organic manure - compost. Principles and methods of irrigation - sprinkler, drip, pitcher and irrigation systems.

UNIT II: Scope of forestry, Definition of forest, forest as balanced ecosystem. Forest management - objectives, management of flora - choice of species, salvage - cutting, pruning and coppicing.

UNIT III: Social forestry - objectives, Role of social forestry in cottage industry; Agro forestry - techniques and implementation. Energy plantations under social forestry programme - Recreation forestry.

UNIT IV: Conservation of forests, Forest conservation act 1980. Role of exotics in forestry. Minor forest products. Important forest based industries- Pulp and paper.

UNIT V: Nature and properties of wood: physical, chemical and mechanical. Anatomy of wood, Durability of wood. Defects and abnormalities of wood, wood seasoning and preservation; Defects due to seasoning and machining

Books for Reference:

1. Anandan Kumaravelan R. *Environmental Science and Engineering*. India: Seitech publication Pvt. Ltd., 2005.
2. Buce J. Zobel, Gerrit Van wyk and Fcr Stahl. *Growing exotic forests*. New York: Wiley inter science publication John wileys sons.1987.
3. Kasturi Reddy. *Biodiversity and land conservation*. Delhi: Pacific publication N-187, Shivaji Chowk. Sadat pur Extension 110 094, 2010.
4. Rana. S. V. S. *Essentials of Ecology and Environmental Science.* IV edition PHI learning Private Ltd., New Delhi 110011, 2009.
5. Rao. M. K.*Environment and climate change.* New Delhi: Manglam Publications. 2011.
6. Shukla R.S, Chandel P.S. *A text book of plant ecology*. New Delhi: S. Chand and Company Ltd., Ram Nagar. 2006.
7. Trivedi. P. R Trivedi, Gurdeep Raj. *Environmental Ecology*. New Delhi: Akas deep publishing house. 2002.
8. Tyler Miller. G. *Environmental Science*. Singapore: Thomson Brooks/cole. 2004.

SEMESTER - IV			
Core: XIII	**Plant Physiology**		
Course Code: 21PBOC41	**Hrs/week: 6**	**Hrs/Semester : 90**	**Credits: 5**

Objectives:

- To make them understand the organized complexity of the life process in plants.
- To investigate how the physical process and chemical connection determine plant's function and to layout practical skills in conducting a physiological experiment.
- To comprehend how the environmental cues sensitize chemical signals to regulate a lot of physiological functions.

Course Outcomes:

CO.No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	understand the effect of the soil-plant-water continuum (SPWC) and assess the need of mineral nutrients and symptoms specific to nutrient deficiency.	6	Un
CO-2	discuss how root structure and functions influence the transfer of inorganic nutrients from the soil into the plants,	3	Un
CO-3	analyse the mechanism of assimilation of inorganic molecules into organic molecular components.	3	Un
CO-4	analyse light enhanced photochemical reactions that culminates in the synthesis of ATP and NADPH and fixation of carbon dioxide into organic compounds	3	Un
CO-5	describe respiration with its associated carbon metabolism and releasing of energy stored in chemical bonds in a controlled manner for cellular use	3	Re
CO-6	review systematically how plant's manage physiologically with respect to environmental stress.	7	Cr
CO-7	Remark on the hormone controlled and light mediated morphogenetic events in plants.	3	An
CO-8	design and conduct scientific experiments and analyze the data critically	6	Cr

SEMESTER - IV			
Core: XIII	**Plant Physiology**		
Course Code: 21PBOC41	**Hrs/week: 6**	**Hrs/Semester : 90**	**Credits: 4**

UNIT I: Water relations of plants - components of water potentials and their relation. Absorption of water - Mechanism of ascent of sap. Translocation - Mechanism of translocation of solutes- source sink relationship, phloem loading and unloading. Transpiration - stomatal movement, antitranspirants, guttation. Inorganic nutrient - ion uptake - passive and active uptake and transport. Role of mineral nutrients- deficiency and toxicity symptoms. Hydroponics and its significance.

UNIT II: Photosynthesis-General concepts, Principle of light absorption-action spectrum, absorption spectrum. Pigment system and quantum yield. Photosynthetic apparatus-organization of components in the thylakoid membrane, photochemical reaction- LHS, OEC, mechanism of electron transport -Z-scheme and cyclic; proton transport and chemiosmotic synthesis of ATP; regulation of photosynthetic machinery; carbon reaction-general aspects, activity of rubisco- Calvin Benson cycle, Inorganic carbon concentrating mechanism- C_4 carbon cycle, CAM, C_2 oxidative photosynthetic carbon cycle (photorespiration) significance of C_2 cycle-ecological aspects of photosynthesis. Accumulation and partitioning of photosynthates.

UNIT III: Respiration- overview, mitochondria-structural organization, glycolysis, regulation of glycolysis, PPP, Citric acid cycle, e^- transport system and chemiosmotic synthesis of ATP; alternative oxidase mechanism in plants (cyanide resistance respiration in plants); respiration and coupling of other metabolism. Assimilation of mineral nutrients in plants- N_2cycle, Nitrate assimilation. Ammonium assimilation and synthesis of aminoacids (GOGAT). Biological fixation of N_2. Assimilation of S and P in plants.

UNIT IV: Growth hormone- history, biosynthesis, molecular mechanism of action and physiological role of auxin-regulators of cell elongation, phototropism and gravitropism; gibberellin-regulators of plant height; cytokinin-regulators of cell division in shoots and roots, movement of nutrients, chloroplast development; abscisic acid-seed maturation, antistress signal (closes stomata in response to water stress), ethylene-fruit ripening, senescence, abscission, morphactins and brassinosteroids. Photo morphogenesis-phytochrome-mediated photo responses. Physiology of flowering. Biological clock-occurrence of circadian rhythm in plants-examples.

UNIT V: Stress physiology-concepts; types; biotic stress- role of secondary metabolites in plants defense mechanism against pathogens, insect and herbivores. Abiotic stress-types-salinity, drought, freezing, radiation and heavy metal. Biological impacts-morphological, anatomical, metabolical and physiological. Regulatory mechanism-stress sensing, signal transduction pathways, transcriptional regulation, regulatory hormones, ROS, phytochelatins, secondary messenger in plants-

cAMP, Ca-calmodulin.

Books for Reference

1. Beevers, L. *Nitrogen metabolism in plants.* London: William clowes& sons Ltd., 1976.
2. Bidwell, R.G.S. *Plant physiology*. New York: Macmillan publishing company. 1979.
3. Devlin, R.M. *Plant Physiology*. New Delhi: Narosa publishing House.1974.
4. Jain, V.K. *Fundamentals of Plant Physiology*. New Delhi: S.Chand and Co. Ltd., 2004.
5. Noggle, G.R. and Fritz, G.J. *Introductory plant physiology.* New Delhi: Prentice Hall. 2002.
6. Salisbury, F.B. and Ross. C.W. *Plant Physiology*. Thomson Wordsworth, 2007.
7. Taiz, L. and Zeiger. E. *Plant Physiology*. United States of America: Sinauer Associates. Publishers Massachusetts.1998.

Practical Hrs/ week: 2

- Hill activity - effect of light quality.
- Effect of antitranspirants in transpiration and determination of stomatal index and frequency (Single leaf method & calcium chloride method)
- Determination of water potential(any onemethod)
- Membrane permeability studies.(using different solvents and temperature)
- Nitrate reductase activity – any one factor (light conditions /age)
- Determination of amylase activity.
- Determination of peroxidase activity
- Estimation of proline (Under normal and stressed conditions)
- Determination of chlorophyll content during aging/ under different light conditions
- Study on nutrient ion uptake.
- Determination of sugar content in fruits during ripening process.

Submission - Record Note Book

Laboratory Manual for Reference:

1. Francis H Witham, David F Blaydes and Robert N Devlin, *Experiments in Plant Physiology.* New Delhi: Vanmostr and Rain hold Company. 1970.

SEMESTER IV			
Core XIV	**Horticulture and Seed Technology**		
Course Code: 21PBOC42	**Hrs/week:4**	**Hrs/Semester: 60**	**Credits: 4**

Objectives:

- To promote, develop, disseminate horticultural and strengthen in the field of seed science & technology.
- To understand the techniques and make significant contribution to an efficient and sustainable production of crops.
- To understand the importance of seed certification and seed testing.

Course Outcomes:

CO. No	Upon completion of this course, students will be able to	PSO addressed	CL
CO-1	understand the scope and potential of horticulture product in India and Tamil Nadu	4	Un
CO-2	classify the horticulture plants based on soil and climate	4	Ap
CO-3	Illustrate different systems of planting in orchard and suggest plant choices	4	Ap
CO-4	demonstrate the methods and types of pruning and explain the basics of soil science and justify the role of soil as a medium for plant growth	4, 7	Un
CO-5	explain about integrated nutrient management and demonstrate the skills of soil testing	7	An
CO-6	identify the diseases and pest of crops and their management	6	Ap
CO-7	acquire skills & handling operations of different equipment's inseed science laboratory	2	Ap
CO-8	learn the techniques of seed processing for quality up gradation and of storage for maintenance of seed quality.	1	Un

SEMESTER IV			
Core XIV	**Horticulture and Seed Technology**		
Course Code: 21PBOC42	**Hrs/week:4**	**Hrs/Semester : 60**	**Credits : 4**

UNIT I: Introduction to Horticulture – definition, special features of horticulture, divisions of horticulture, importance of horticulture. Plant growing structure – Hot beds, cold frames, green houses. Nutrition of horticulture plants, irrigation of horticulture plants.

UNIT II: Pomology: Definition, establishment of orchard: location and site, preliminary operation, planning of an orchard, laying out of the orchard, planting distance, planting season, planting method and transplantation. Training, pruning, cropping, harvesting, handling, storage and preservation of fruits.

UNIT III: Olericulture: Definition, Climate and soil requirement, spacing, water and weed management, nutrient requirement and management, training system for vegetables, harvest and yield of important vegetable crops – tomato, brinjal, chilly, Bhendi, cluster beans, dolichous bean, onion, cucumber, bitter guard. Storage and preservation of vegetable.

UNIT IV: Seed technology: definition, importance, principles of seed production. Foundation and certified seed production of varieties and hybrids. Principles of GM crop and organic seed production. Seed storage – principles- factors affecting seed longevity during storage – Seed treatments and packaging materials - measures for pest and disease control during storage and godown sanitation. Post-harvest handling of seeds - threshing methods - drying - methods of seed drying - Seed processing - seed cleaning and grading - Processing equipment -cleaner cum grader -Upgrading equipment - specific gravity separator, colour sorter, indented cylinder separator, spiral separator, magnetic separator, needle separator - working principles - Seed quality enhancement techniques - importance - seed fortification, seed priming, seed coating, seed pelleting.

UNIT V: Seed Quality and seed testing: Seed certification - phases of certification, procedure for seed certification, field inspection, field counts, field and seed standards. Post-harvest inspection - processing,

bagging and tagging. Seed testing: seed viability and longevity, pre and post-harvest factors affecting seed viability. Seed ageing – physiology of seed deterioration liquid peroxidation seed viability. Seed vigour and its concept, vigour test method. Factors affecting seed vigour. Physiological and basis of seed vigour in relation to crop performance and yield.

Books for Reference:

1. Allard John, R.W. *Principles of plant breeding New York:* Wiley & Sons, Inc. 1960.
2. Chopra, V.L *Plant Breeding Theory and Practice*. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd., 2000
3. Choudhri D and Amal Metha *Flower crops cultivation and management.* Jaipur: Oxford Book Company, 2010.
4. Edmund Senn - Andrew – Halfacre. *Fundamentals of Horticulture*. Tata Mc. Graw Hill, 1977.
5. Hartmann & Kester, – *Plant propagation*. New Delhi: Prentice – Hall of India Pvt. Ltd., 1989.
6. Mallikarjuna Reddy and Aparna Rao *Plant propagation in horticulture*. New Delhi: Pacific book international. 2010
7. Randahawa *Floriculture in India*. Allied publishers, 1985.
8. Utpal Banerji *Horticulture.* Jaipur: Mangal Deep Publication, 2008.
9. Agarwal, R.C. Seed Technology. New Delhi: Oxford and IBH Publishing Co., 1996.

Practicals:
Hrs / Week: 2

- Knowledge of garden implements and tools - Spade, Sprayer, Water can, Pruning scissor, Tiller, Digging fork, Pickaxe, Budding and Grafting Knife,
- Preparation of nursery and seed bed.
- Propagation - stem, leaf and root cutting.
- Propagation - air layering, budding and grafting technique.
- Designing kitchen garden, Rockery, Hanging basket, terrarium
- Seed sampling and testing: Physical purity, germination, viability, etc.
- Seed and seedling vigour test.

Laboratory Manual for Reference:

1. Horticulture Science lab manual. Dr. Chiwan W. Lee. Department of Plant Science, North Dakota State University
2. A Practical Manual of Seed Science and Technology Volume-1. Dr.Satya Prakash Gupta.

SEMESTER IV			
Core XV	**Plant Biotechnology**		
Course Code: 21PBOC43	**Hrs/week: 4**	**Hrs/Semester: 60**	**Credits:4**

Objectives:

- To acquire knowledge on laboratory organization and handling the tools of in-vitro culture of plant that of novel quality
- To understand the role of 21st century science (biotechnology) in increasing productivity of crop plants and to enhance the production of high value metabolites.
- To advance laboratory skill to get employment in biotechnology laboratories and industries.

Course Outcomes:

CO. No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO - 1	comprehend the basic principal of in-vitro tissue culture and develop skills in methods of tissue culture	3	Re, Un
CO - 2	practice *in-vitro* tissue culture techniques for getting required plants from explants	4	Un, Ap
CO - 3	expound *in-vitro* somatic hybridization and formation of somaclonal variation and its commercial application	4	Un
CO - 4	substantiate tissue culture is the viable option for the conservation of endangered plants	4	Re
CO - 5	grasp the techniques of mass cultivation of biofertilizer and defend biofertilizer a boon to sustainable agriculture	3	Un
CO - 6	categories different methods of synthesis of nanoparticles and understand the wide range of application of nanotechnology.	3	Un
CO - 7	describe what is plant molecular farming and highlight that transgenic plants are bioreactor for production of quality protein and other metabolites valuable to medicine and industries	4	Ap
CO - 8	utilize transferable skills obtained through the course for the professional accomplishment	1	Re

SEMESTER IV			
Core XV	**Plant Biotechnology**		
Course Code: 21PBOC43	**Hrs/week: 4**	**Hrs/Semester: 60**	**Credits:4**

UNIT I: **Biotechnology**: Historical development, scope. **Plant tissue culture:** Laboratory organization, preparation of different media and role of growth hormones in *in-vitro* plant development. Plant regeneration pathway: direct embryogenesis, **organogenesis:** organ culture – nodal culture, internodal culture. **Embryo culture**: embryo rescue, breaking of seed dormancy. Factors affecting regeneration, regulation of regeneration. **Production of haploids:** Anther and pollen culture. **Callus culture**.

UNIT II: C**ell culture:** single cell culture and production of secondary metabolites (Alkaloids) **Somatic embryogenesis:** Introduction, factors affecting embryogenesis. **Protoplast Culture:** Plant protoplast isolation, factors affecting protoplast isolation, Protoplast fusion and production of somatic hybrids, selection of hybrid cells and application of protoplast hybridization. **Somaclonal variation:** Isolation and characterization of variants -molecular basis and induced mutations, applications and limitations. **Micropropagation methods:** Apical meristerm culture and production of virus free multiple shoots.

UNIT III: **Industrial Biotechnology:** role of microbes, strain development, fermentation – **Types of fermentors:** process optimization and recent development in fermentation technology. **Commercial production**: Biopesticide, bio diesel, SLF, alcohol production, pharmaceutical and cosmetics from higher plants. **Enzyme technology:** Cell immobilization and microbial enzyme production at commercial scale.

UNIT IV: **Phytoremediation:** Microbial degradation of toxic chemicals from soil and water: Plants as a phytoremediating agents. **Biofertilizers:** Mass production of *Rhizobium*, *Azospirillum* and Blue Green Algae (BGA), Vesicular Arbuscular Mycorrhizal Fungi (VAM), Single cell protein (*Scenedesmus, Spirulina, Saccharomyces)*. Algae in bioengineering.

Nanotechnology – role of bio sensor in environmental monitoring. Outline of green synthesis of nanoparticles and their characterization.

UNIT V: **Transgenic plants: Transformation for resistance to biotic stress** – pathogens, insects, virus and bacteria. **Transformation for resistance to abiotic stress** – herbicide resistance, resistance to drought. **Transgenic plant and improved quality:** extended self life, fruit ripening and prevention of discoloration of fruits. **Transgenic plant for improved nutrition** – golden rice, improved seed quality. **Transgenes and immune protective drugs** – edible vaccine, plantibody **Regulations in Biotechnology:** Biosafety: definition, requirement, biosafety in relation to transgenic research, biosafety guidelines and implementation. Intellectual property rights: process of patenting of biotechnological products. Farmer's Rights and plant breeder's Rights.

Books for Reference:

1. Colin Rattledge and K. Bjon. *Basic biotechnology*. New York: Cambridge University Press, 2001.
2. Dubey R.C. *Textbook of Biotechnology*. New Delhi: S. Chand & Co. 2005.
3. George E.F. and Sherrington P.D. *Plant propagation by tissue culture.* London: Exegetic Ltd. 1984.
4. Gupta, P.K. *Elements of Biotechnology*. Meerut: Rastogi publication 2000.
5. Kalyan Kumar De. *An Introduction to Plant Tissue Culture*. Calcutta: New Central Book Agency 2004.
6. Kumar, H.D. *Molecular biology and Biotechnology*. New Delhi: Vikas publishers 1993.
7. Mahesh. *Paddy molecular Biotechnology*. New age international, publishers. (p) Ltd. 2008.
8. Mukhopadhyay S.N, Prabhakar Sharma and Rabindra Narain. *A text book of DNA recombinant technology.* New Delhi: Wisdom press, 2011.

9. Ramavat K. G. *Plant Biotechnology* , New Delhi: S. Chand & Co. 2000.

10. Reinort J and Yeoman M. M. *Plant cell and tissue culture*. Delhi: Narosa publishing house 1983.

11. Satyanarayana U. *Biotechnology.* Kolkatta: Books and Allied (P) Ltd. 2006.

12. Singh, B.D. *Biotechnology - Expanding Horizons.* New Delhi: Kalyani Publishers 2005.

Practicals:

(Hrs. /week - 2)

- Isolation of Rhizobium
- Isolation of rhizosphere bacteria
- Isolation of phosphate solubilizing microorganism
- Synthesis and characterization of nanoparticles
- Preparation of synthetic seeds
- Isolation of protoplast
- Callus induction
- Embryo culture
- Single cell Isolation
- Isolation of BGA
- Nodal Culture
- Protoplast isolation

Set up / pictures / photographs/ demonstration

- Golden rice
- Edible vaccine
- Fermentor

Submission - Record Note Book

Laboratory Manual for Reference:

1. Chawla, HS. *Introduction to Plant Biotechnology*. New Delhi: Oxford & IBH publishing company Pvt. Ltd. 2009.

Submission: Record Note Book

SEMESTER - IV			
Core Elective	**Entrepreneurship Botany**		
Course Code: 21PBOE41	**Hrs / Week: 4**	**Hrs /Semester: 60**	**Credits: 4**

Objectives:

- To able to understand the available natural resources and explore the greatest opportunity to increase and achieve sustainable competitive business advantage.
- To introduce organizations and agencies that can backup entrepreneurial initiatives.
- To expose students to various business opportunities emerging from the plant resources.

Course Outcomes:

CO.No.	Upon completion of this course, students will be able to	PSO addressed	C L
CO-1	adapt the methods of preservation of vegetables and fruits and identify the industrial scope of these resources	6	Un
CO-2	determine the quality of oil and prepare aesthetic product to find out good marketing capacity	6	Ap
CO-3	understand contemporary opportunities in business situations of value added products and develop skills needed to successfully convert them into entrepreneurial ventures	6	Un
CO-4	explore how the value added products can enhance the profitability of local farmers	6	Un
CO-5	acquire knowledge on primary forest product, wood products and secondary wood products and infer wood industries are major sector in many economy	2,6	Un
CO-6	able to differentiate natural and synthetic wood able to dictate the their pros and cons	3	Un
CO-7	develop ideas that will lead them to start their own business and enable them to be professionally competent	6	Ap
CO-8	able to start entrepreneurship (small scale/medium scale industries) , extract the financial support available and manage the targeted customers to enhance profitability	6	Re

SEMESTER - IV			
Core Elective	**Entrepreneurship Botany**		
Course Code: 21PBOE41	**Hrs / Week: 4**	**Hrs / Semester: 60**	**Credits: 4**

UNIT I: **Fruits and Vegetables preservation:** Fruits and vegetables preservation methods: Dehydrating, canning, salting, pickling and freezing. Fruits and Vegetables Products: tutti frutti, health drink, mango pulp, pickle, jam, jelly, amla candy and raisin. Factors influencing the growth of microorganisms in food. Sources of contamination of fruits. Types of spoilage.

UNIT II: **Bioventure:** Industry, overview of *Spirulina*, *Pleurotus* sajor-caju, *Ganoderma*, *Lentinus edodes*, drumstick and coconut. Straight Vegetable Oil (SVO) and Pure Plant Oil (PPO): methods and marketing. Fresh and dry flowers for aesthetics.,

UNIT III: **Value added plant based products:** Mushroom recipes (soup, omelette, pakoda and briyani). Preparation of - Coco peat, Banana products, Palm products, fiber products; Packing techniques – low, trans wrap, deep drawing, doy, sachet, top seal, vacuum: Cost management and estimation.

UNIT IV: **Commercial Wood products:** Natural durability of wood. Wood preservation: Nonpressure processes, Pressure process, Chemical processing of wood. Commercial wood species and identification, Synthetic woods, Marine plywood, Fuel wood, pulp and paper making woods, matchstick wood. Economic importance of pulp and wood

UNIT V: **Marketing and trade :** Steps for starting a small scale industry. Registration as SSI. Role of SIDBI. Advantages and problems of SSI. Government Schemes for SSI: NABARD, NCDC, MSME, NSIC. Marketing and entrepreneurship: different types of marketing, identification of types of consumer and their needs, building consumer relationship. FSSAI, FAO, ICDS, import and export business development and strategies.

Text Books:

1. Bahi N. *Hand Book on Mushrooms*. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd. Print, Fourth edition, 2015.

2. Desrosier N.W. and Desrosier J.N. *The Technology of Food Preservation*. New Delhi: CBS Publishers & Distributors. Fourth edition, 1987.

3. Narayanaswami R.V. and Rao K.N. *Outlines of Botany*, Chennai: India: Esvee Press, 1976.

Books for Reference

1. Taneja S. and Gupta S.L. *Entrepreneurship development*, New Delhi: New venture creation, Galgeha Publication Company, 2015.

2. Desai V. *Entrepreneurship development*, Mumbai: Himalaya publication house, First edition, 2015.

3. Khanna S.S. *Entrepreneurial development*. New Delhi: S. Chand Company Ltd., 2016.

4. Manohar D. *Entrepreneurship of small scale industries*, New Delhi: Deep and deep publication, 1989.

5. Lal G., Siddhapa G.S. and Tandon G.L. *Preservation of fruits and vegetables*. New Delhi: Indian council of Agricultural Research (ICAR), 2009.

6. Ranganna S. *Hand book of analysis and quality control of fruits and vegetable products*. New Delhi: Tata mcgraw hill, Second edition, 2001.

7. Cruses W.V. and Fellows P.J. *Commercial fruits and vegetable processing*. United States: CRC press, 2000.

8. Franz F.P. Kollmann. *Wood Science and Technology*. New York: Springer Verlag, 1988.

9. Pearson and Brown. *Commercial Timbers of India*. New Delhi: Government of India Publication, 1984.

10. Tieuran H.D. *Wood Technology*. New York: Pituran Publishing Company, 1951.

SEMESTER – IV			
Core Elective	**Nanobiotechnology**		
Course Code: 21PBOE42	**Hrs/Week: 4**	**Hrs/Semester: 60**	**Credits: 4**

Objectives:

- To provide a broad overview of fundamental principles and current research directions and future scope in nanoscience and nanotechnology.
- To familiarise in synthesis, detection and characterization of nano particle using modern tools.
- To apply nanotechnology for developing new products for various industries (good/ agriculture/ health/ cosmetics)

Course Outcomes:

CO.No.	Upon completion of this course, students will be able to	PSO's Addressed	CL.
CO-1	understand the fundamental principles of nanotechnology and types of nano particle	1	Un
CO-2	apply engineering and physics concepts to the nano-scale and non-continuum domain.	2	Cr
CO-3	understand the wide range of applications of nanotechnology and its interdisciplinary aspect	1	Re
CO-4	apply and transfer interdisciplinary systems ngineering approaches to the field of bio- and nanotechnology projects	3	Re
CO-5	practice and explain state-of-the-art characterization methods for nanomaterials, understanding and critiquing nanomaterial safety and handling methods required during characterization	4	An
CO-6	correlate the impact of nanotechnology and nanoscience in a global, economic, environmental, and societal context.	6	En
CO-7	gain a knowledge in nanotechnology techniques (synthesis, fabrication, characterization) and its applications in the various field like engineering, biomedicine and agricultural/environmental issues	4	An
CO-8	identify career paths at the interface of nanotechnology, biology, environmental and agricultural engineering and medicine	6, 7	An

SEMESTER – IV			
Core Elective	**Nanobiotechnology**		
Course Code: 21PBOE42	**Hrs/Week:4**	**Hrs/Semester: 60**	**Credits: 4**

UNIT I: Nanoparticles – definition and historical background of nanotechnology. Principles: quantization effects - inverse relationship between size and reactive surface area. Properties: surface effects, the effects of size, shape, surface and bulk composition, and solubility and persistence. Types of nanoparticles: liposomes, albumin-bound, polymeric iron oxide, quantum dot and gold.

UNIT II: Physical, chemical and biogenic synthesis of nanomaterials – biomimetics, green plants, and microorganisms. Role of biomolecules - reducing and/or capping agents: proteins, viruses and carbohydrates.

UNIT III: Detection and measurement of nanoparticles – physical characterization by UV, FTIR, SEM, FESEM, DLS, X-ray diffraction and Zeta potential.

UNIT IV: Targeted nanoparticles: active & passive targeting. Application: medicine, manufacturing & materials, delivery vehicles, cancer therapy, tissue engineering, fluorescent biological labels, biological assays, imaging agents and biosensors.

UNIT V: Interactions between nanoparticles and living systems, interaction with cells, exposure of living systems to nanomaterials - toxicity effects. Factors influencing the interaction of nanomaterials over mammalian cells: uptake, transport and biodistribution of nanoparticles in living system, toxicity on cellular processes.

Books for Reference:

1. Pradeep Kumar Srivastava*, Nanotechnology, The Hidden potential of science*. New Delhi: MPS Publisher & Distributors, 2008.
2. Shanmugam S. *Nanotechnolgy,* www.MJP publishers.com, 2010.
3. Barbara Panessa-Warren. *Understanding cell-nanoparticle interactions - making Nanoparticles more biocompatible.* Upton: Brookhaven National Laboratory, 2006.
4. Bhushan Bharat (Ed.) *Encyclopedia of Nanotechnology,* Springer, 2012.
5. Chand A., Mirkin, Christof Niemeyer. *Nanobiotechnology II: more concept and applications.* New Jersey: Wiley-VCH Publisher, First edition, 2007.

6. Jain K.K. *Nanobiotechnology molecular diagnostics: Current techniques and application (Horizon Bioscience).* United Kingdom: Taylor & Francis, First edition, 2006.
7. Johan Ach, Ludwig Siep. *Nano–Bio–Ethics: Ethical dimension of nanobiotechnology.* New York City: lit ver leg publication, First edition, 2007.
8. Jain, K. K. *Handbook of Nanomedicine,* New York: Springer, 2012.
9. Kelsall Robert W., Ian Hamley, Mark Geoghegan. *Nanoscale Science and Technology*, New Jersey: Wiley Eastern, 2004.
10. Mark Ratner and Daniel Ratner. *Nanotechnology: A gentle introduction to the next big idea.* New York: Pearson Education Publishers, 2002.
11. Michael Kohler, Wolfgang, Fritzsche. *Nanotechnology: Introduction to Nanostructuring Techniques.* New Jersey: Wiley publishers, 2004.
12. Sharon, M. & Sharon, M. Bio-*Nanotechnology- Concepts and Applications.* Florida: CRC Press, 2012.
13. Volker Mailander and Katharina Landfester. *Interaction of nanoparticles with cells. Biomacromolecules*. Washington: ACS Publication, 2009.
14. Yao N. and Zhong Ling Wang. *Hand book of microscopy for nanotechnology.* Amsterdam: kluwer academic publishers, 2005.

Online Resources:

http://ieet.org/index.php/IEET/more/bionanotechnology20141007 Institute of Ethics & Emerging Technologies
https://phys.org/news/2014-10-endless-possibilities-bio-nanotechnology.html
http://www.particle-works.com/applications/controlled-drug-release/Application
https://jnanobiotechnology.biomedcentral.com/articles/10.1186/1477-3155-2-3
DOI: 10.1186/1477-3155-2-3
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3865110/
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC419715/