ಬೆಂಗಳೂರು
ನಗರ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

BENGALURU
CITY UNIVERSITY

Office of the Registrar, Central College Campus, Dr. B.R. Ambedkar Veedhi, Bengaluru – 560 001.
PhNo.080-22131385, E-mail: registrarbcu@gmail.com

No.BCU/Ph.D-Syllabus /68 /2025-26 Date. 21.05.2025

NOTIFICATION

Sub: Botany Ph.D Course Work Syllabus of Bengaluru City University

Ref: 1. The recommendations of the Board of Studies in Botany (PG)
2. Approval of the Vice-Chancellor dated.20.05.2025

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In pursuance to the recommendations of the Board of Studies in Botany (PG) and pending approval of the Academic Council, the Syllabus for Botany Ph.D Course Work of Bengaluru City University with is hereby notified for information of the concerned. Effective from the academic year 2025-26

The copy of the Syllabus is notified in the University Website: www.bcu.ac.in for information of the concerned.

REGISTRAR

To,

1. The Dean, Faculty of Science, BCU.
2. The Chairman & Members of BOS in Botany (PG), BCU.
3. The Principals of the concerned affiliated Colleges of BCU – through email.
4. The P.S. to Vice-Chancellor/Registrar/Registrar (Evaluation), BCU.
5. Office copy / Guard file.

ಬೆಂಗಳೂರು ನಗರ ವಿಶ್ವವಿದ್ಯಾಲಯ
BENGALURU CITY UNIVERSITY

Ph.D. Botany-Course Work Syllabus
(2025-26)

ಬೆಂಗಳೂರು ನಗರ ವಿಶ್ವವಿದ್ಯಾಲಯ
BENGALURU CITY UNIVERSITY

Ph.D. (Botany) Course Work Syllabus (2025-26)

Preamble

The syllabus for Ph. D. Course Work for Botany has been prepared by the BOS in Botany, Bengaluru City University (BCU) for the academic year 2025-26 on wards (No. BCU/Ph. D.-Course Work /414/2024-25 Dated 19.03.2025) and adapted as per the Regulations Governing Doctoral Degree Program -2016 of Bangalore University. The structure of Course Work approved as given below. The credit assigned to the Ph.D. course work shall be a minimum of 12 credits, as per UGC notification May 5, 2016, Clause 7. The course work for Ph.D. program shall comprise of three COURSES of 100 marks each, viz., COURSE-I: **Research Methodology**, COURSE-II: **Advances in Botany** and COURSE- III **Field of Specialization** (Research Area of the Research Guide). Besides, a candidate shall also work and prepare the Research Proposal under the supervision of the identified research supervisor. There shall be a comprehensive viva-voce for 50 marks at the end of the Course Work. The continuous assessment shall be for 30 Marks for each Course. Courses–I and II are common for all the research candidates in the Department/ Botany. Course–III shall be for all the research candidates working under a particular Research Supervisor. Each course shall have 52 contact hours. Classes for Courses- I and II shall be arranged by the Chairperson of the University P.G Department / Principal of a Constituent College / Head of the Recognized Research Center. Course-III shall be offered by the concerned research supervisor in the subject specialization in Botany. Both the full-time and part-time research candidates shall attend the course work classes and a minimum of 75% attendance is compulsory for each course, to be eligible to appear for the term end examinations. The question paper pattern and scheme of examination shall be as described in the PG program for M.Sc., Botany of Bengaluru City University.

Ph. D. COURSE WORK (PROGRAM STRUCUTRE) 12 CREDITS

Sl. No.	Name of the Courses	Contact Hours/ Week	Maximum Marks (IA and Termina Exam)			Total Credits
			Continuous Assessment	Course End Examination	Total	
RCT 101	Course -I: Research Methodology	04	30	70	100	04
RCT 102	Course-II: Advances in Botany	04	30	70	100	04
RCT 103 RCT 104	Course-III: Field of Specacialization (RCT-103; RCT-104) Offered by the Research Guide)	04	30	70	100	04
			90	210	300	12
Viva-Voce			50		350	

COURSE I RCT-101: RESEARCH METHODOLOGY
52 HOURS (4 CREDITS)

Course Outcome: *As a core course, this module prepares research students to understand research methods for inter disciplinary and multi-disciplinary areas of research including Thrust Areas of Research notified by the University Grant Commission (UGC). The students are prepared in this course with fundamentals of what, why, and how to do Research.*

Unit-1: Introduction to Research: Definition of Research and Significance. Types of Research, Career opportunities in Research. Selecting a research problem. Formulating hypothesis. Formulation of research objectives. Literature collection- textual and digital resources (internet); Research Review; Formulation of objectives; Research plan and its components; Experimental Design, Data Collection & Interpretation; Sampling techniques, collection and documentation, presentation, analysis and interpretation of data. **8Hrs**

Unit-2: **Synopsis/Scientific/Thesis Writing:** What is synopsis? How to write synopsis? Qualities of good synopsis; Reporting and thesis writing- Structure and components of reports/scientific reports; Type of report Technical Reports and thesis; Significance; Different steps in the preparation; Layout, structure and language of typical reports; Illustrations and tables; Bibliography, referencing and footnotes; Oral presentation - Planning - Preparation - practice - Making Presentation; Use of visual aids; Transparencies/PowerPoint for effective Communication; Criteria for the evaluation of the research report. Major scientific publishers; Impact factor and citation index and individual and institutional rating. **10 Hrs.**

Unit-3: Biostatistics and its Applications: Standard deviation, Standard error, Co-efficient of variation, probability distributions - Binomial, Poisson and Normal Distributions (areas method only) including problems; Sample statistics and parameters, population null hypothesis, level of significance; Definitions and applications of Chi-square test, 't' and 'f' test; Analysis of variance with linear models; Analysis of variance for one-way and two-way classified data. MS office, excel, power point, graphics, statistical software (SPSS). Bioinformatics – brief introduction. **8 Hrs.**

Unit-4: Microscopy, Microphotography and Plant Tissue Culture: Principles of Microscopy; Specimen preparation for light and electron microscopy; Types of Microscopies and Photo-micrography; Microbial culture techniques; Advanced techniques Preservation of Microorganisms; World Microbial Culture Collections; Plant tissue culture techniques - Media preparation, sterilization, in vitro regeneration, Synthetic Seeds. **4 Hrs.**

Unit-5: Plant micro-techniques: Fixatives and staining (single and double); Fixation for histological and histochemical study; Microtomy; Histochemical methods in Pharmacognosy and Forensic Botany; Organoleptic evaluation of market drugs; **Spectroscopy**: UV, Visible, NMR and Atomic Absorption Spectroscopy and Autoradiography. Measurement of radioisotopes and their applications in biological systems. **5 Hrs.**

Unit-6: Separation Techniques: Centrifugation and ultracentrifugation, density gradient centrifugation and continuous centrifugation Principle and applications of Column chromatography, TLC, High pressure liquid Chromatography (HPLC), LCMS, Gas chromatography, FPLC Chromatography Gel electrophoresis (native, SDS and 2-D and Agarose), isoelectric focusing. **5 Hrs.**

Unit 7: Techniques in Molecular Biology: Principles of genomic DNA/RNA isolation. Separation; Basic concepts of Recombinant DNA technology. Gene cloning, DNA fingerprinting technique, Polymerase Chain Reaction and Southern blotting. Proteomics: MALDI-TOF, LC-MS, Gel documentation system Isolation of genomic and plasmid DNA, PCR, RT-PCR, Ribotyping, AFLP, RFLP, FISH, blotting techniques, sequencing, EST, Microarray, Genome editing tools. **6 Hrs**

Unit-8: Ethical issues in Research/Plagiarism /Integrity in Academic Research: Ethical issues in Research; Ethical Committees; Copy rights; Royalty; Intellectual property rights and patent Laws; Trade Related aspects of Intellectual Property Rights; Reproduction of published materials; Plagiarism; Citation and acknowledgement; Reproducibility and Accountability; Preparation of Projects; Society oriented research linkages; Capacity building; Research Collaborations (MOU). **6 Hrs**

Suggested Readings:

1. Research Methodology - Methods & Techniques, CR Kothri CR (1990), Vishva Prakashan, New Delhi.

2. Research Methodology & Statistical Techniques, S Gupta (1999) Deep & Deep Publications, New Delhi.
3. Research Methodology for Biological Sciences, N Gurumani (2007), MJP Publishers, Chennai.
4. Introduction to Biostatistics, L Forthofer (1995), Academic Press, New York.
5. Biostatistical Analysis, JH Zar (2006), Prentice-Hall.
6. Research Design: Qualitative, Quantitative & Mixed Method Approaches, John W. Creswell (2009), Sage Publication, USA.
7. Experimental Design & Data Analysis for Biologists. PQ Gerry & JK Michael (2002), Cambridge University Press.
8. Choosing & Using Statistics: A Biologists Guide, D Calvin (2003), Blackwell Publisher. Unit V (20h)
9. Chromatography - Concepts & Contrasts, JM Miller (2005), John Wiley & Sons, New Jersey, USA.
10. Modern Practice of Gas Chromatography, RL Grab & EF Barry (2004), fourth edition, John Wiley & Sons, New Jersey, USA.
11. High Performance Liquid Chromatography- Fundamental Principles and Practices, WJ Ough & IW Wainer (1995), Blackie Academic & Professional, Glasgow, Scotland.
12. Gel Electrophoresis of Protein- A Practical Approach, BD Hames (2002), Oxford University Press Inc., New York, USA.
13. Principles and Techniques of Biochemistry and Molecular Biology, K Wilson & J Walker (2010), 7th edition, Cambridge University Press.
14. Applications of Infrared, Raman and Resonance Raman Spectroscopy in Biochemistry, FS Parker (1983), Plenum Press, New York, USA.
15. Centrifugal Seperation in Biotechnology, Woon-Fong Leung (2007), Elsevier.
16. Biotechnology: A Laboratory Course, JM Becker, GA Caldwell, EA Zachgo (1996), second edition, Academic Press, California.
17. Phytochemical Methods - A Guide to Modern Techniques of Plant Analysis, JB Harborne (1998), Chapman & Hall, London, UK.
18. Biochemical Methods, S Sadasivam & A Manickam (2005), New Age International Private Ltd, New Delhi.
19. Analytical Techniques for Atmospheric Measurements, D Heard (2006), Blackwell Publishing Ltd, UK.
20. Plant Proteomics- Technologies, Strategies and Application, GK Agrawal & R Rakwal (2008), John Wiley & Sons, New York, USA.
21. Research Methodology- G.R. Basotia and K.K. Sharma.
22. Research Methodology- C.H. Chaudhary, RBSA Publication
23. Research Methodology: An Introduction- Wayne Goddard & Stuart Melville.

COURSE II: RCT-102: ADVANCES IN BOTANY
52 HOURS (4 CREDITS)

Course Outcome: *As a core Advanced Course in Botany, this module prepares research students of Botany to understand and assimilate the developing research areas and its inter and multi-disciplinary areas including the Thrust Areas of Research in Botany. The students are exposed this course with advanced aspects of Botany.*

Unit-1: Plants- Microbe Interactions: Beneficial and harmful microorganisms with suitable examples; Plant growth promoting microorganism and their role in agriculture. Plant Growth promoting rhizobacteria. Microbes for crop productivity and crop protection NPV, Pseudomonas sp., Rhizobium sp., Mycorrhizae, Trichoderma sp. **5 Hrs.**

Unit-2: Plant Immunity: Genetic basis of disease resistance and pathogenicity; concept of QTL mapping; Breeding for disease resistance; IPM; Innate & acquired; chemical and morphological defense in plants; Elicitors; receptors: Basal resistance and innate biochemical host defense; Basic ROSs' Cycle and adaptation during stress. Studies on Plant-microbe interaction at the cellular, biochemical and molecular levels. **8 Hrs.**

Unit-3: Innovative Crop Management Strategies: Biotechnological approaches to disease management. Engineering resistance to viral, bacterial, fungal and insect diseases of crop plants. Potential of plant derived genes in the genetic manipulation of crops for insect resistance and control of fungal, bacterial and viral diseases. Role of genome editing in plants and its applications. **5 Hrs**

Unit -4: Algal and Fungal Biotechnology: Commercial potential of Cyanobacteria and other algae; use of algae for the treatment of waste water; bio mass utilization in energy, hydrogen production - immobilized and inactivated; Cyanobacterial biomass for heavy metal removal. Fungal secondary metabolites and their utilization; Fungal pigments and applications, Macro fungi and micro fungi from different habitats for their biological significance. Myco-remediation. **8 Hrs**

Unit-5: Plant Physiology: Abiotic and biotic stress; HR & SAR mechanisms; biotechnological approaches for Stress tolerance in plants; Molecular mechanism of stress tolerance; Role of engineering in stress tolerance; Manipulation of plant metabolism to enhance the nutritional quality of plants and crop yield. Food and Nutritional security. **5 Hrs**

Unit-6: Plant Molecular Biology and Biotechnology: Plants as model organisms for genetic research. Molecular markers; types and their applications; Methods to introduce genes to crop plants; Engineering plants for abiotic and biotic stresses; Molecular pharming and farming; Small RNAs and their significance in plants RNA silencing and epigenetics. **5 Hrs**

Unit-7: Medicinal and Aromatic Plants, Phytochemistry and Herbal Technology: Medicinal and aromatic plants and their utilization; Principles of Phytochemistry; Fundamental

and practical aspects of plant material handling; Phytochemicals and analytical methods; Applications of phytochemicals in industry and health care. Techniques used for extraction, separation, purification; pharmacognosy and validation of phytochemicals isolated from plant sources. 8 **Hrs**

Unit-8: **Plant Taxonomy, Biodiversity and Conservation:** Recent developments in molecular taxonomy; Molecular markers for plant identification; DNA barcoding and its significance in plant/microbe identification. Cladistics- construction of dendrogram and primary analysis; biodiversity. Global biodiversity assessment; measure of biodiversity indices and RET species; Agro-biodiversity and its importance. Climate change and its impact on Biodiversity. **8 Hrs**

Suggested Readings:

1. Modern Soil Microbiology (2006), JD van Elsas, JK Jansson, JT Trevors (eds), Second Edition, CRC Press, USA
2. Soil Microbiology, Ecology and Biochemistry (2014), EA Paul, 4th Edition, Associate Press.
3. Principles of Plant-Microbe Interactions: Microbes for Sustainable Agriculture (2015), Ben Lugtenberg (ed.), Springer.
4. The Biology of Cyanobacteria, NG Car & BA Whitton (1982), Blackwell.
5. Microalgal Biotechnology, MA Borowitzka & LJ Borowitzka (1988), Cambridge University Press, New York, USA
6. Algae and Cyanobacteria in Extreme Environment, J Seckbach (2007), Springer.
7. Protocols on Algal and Cyanobacterial Research, SN Bagchi, D Kleiner, P Mohanty, (2010), Narosa publication, New Delhi.
8. Algae and their Biotechnological Potential, Chen Feng & Y Jiang, (2001), Kluwer.
9. The Molecular Biology of Cyanobacteria, DA Bryant (1994), Kluwer Academic Publishers
10. The Ecology of Cyanobacteria. Their Diversity in Time and Space, BA Whitton & Malcolm Potts (2000). Kluwer Academic Publishers.
11. Cyanobacteria: An Economical Perspective, NK Sharma, AK Rai, LJ Stal (2013), Wiley & Sons, UK.
12. Pharmacognosy, CK Kokate, AP Purohit, SB. Gokhale (1996), Nirali Prakashan, 4th Ed.
13. Natural Products in Medicine: A Biosynthetic approach (1997), Wiley, UK
14. Cultivation & Processing of Medicinal Plants, L Hornok (ed.) (1992), John Wiley & Sons, Chichister, UK.
15. Herbal Biotechnology & Pharmocognosy, V Kumaresan (2015), Saras Publication.
16. Plant Tissue Culture: Theory and Practice, SS Bhojwani, MK Razdan (1996), a revised edition, Elsevier Science Publishers, New York, USA.
17. Biotechnology: Fundamentals and Applications, SS Purohit (2000), Agrobios, New Delhi.
18. Plant Propagation by Tissue Culture, Volume 1, EF George, MA Hall, G-J De Klerk, (2008), The background (3rd ed.), Dordrecht: Springer.
19. Plant Physiology, L Taiz, E Zeiger (2010), fifth edition, Sinurer Associates
20. Plant Pathology, GN Agrios (2006), fifth Edn, Elsevier Academic Press.

21. Diseases of Crop Plants in India, Rangaswamy & Mahadevan.
22. Introductory Mycology, CJ Alexopoulos, CW Mims, M Blackwell (1996), JohnWiley & Sons.
23. Enzyme Technology by Martin Chaplin and Christopher Bucke (1990) Cambridge University Press.
24. Biocatalysts and Enzyme Technology by Klaus Buchholz, Volker Kasche, Uwe Theo Bornscheuer (2005), 1 edition, Wiley-VCH.
25. Enzyme Technology, edited by Ashok Pandey, Colin Webb and Carlos icardo Soccol (2006), Springer US.
26. Introduction to plant physiology by W. G. Hopkins and NPA Huner, Wiley Int.3rd Ed.
27. Old and Primrose (1984). Principles of gene manipulation. Blackwell
28. Patterson, 1996. Genome mapping in plants, Academic Press.330p. Weising, K., H.Nybom, K.Wolff, W. Me.

COURSE III-RCT-103: PHYTOCHEMISTRY AND PHARMACOGNOSY

52 HOURS (4 CREDITS)

Course Outcome: *As a specialization course, this module prepares research students to understand the role of natural sources in drug discovery and development. Also, research students are able to gain skills in authentication and quality evaluation of plant materials, correlating phytoconstituents, their biological actions and appreciate the significance of global guidelines in herbal drug quality assurance as one of the courses for leading to the award of the Ph.D. Degree in Botany.*

Unit- 1: Plant Biomolecules: Introduction to Phyto biomolecules; Classification; Structural characterization; outline of major biosynthetic pathways – **Shikimate Pathway; Acetate-Malonate Pathway; Mevalonate Pathway;** MEP pathway; phenylpropanoid pathway, alkaloid biosynthetic pathway, Cyanogenic Glycoside Pathway, Glucosinolate Pathway, Importance of pathway-specific precursors in drug discovery. Isolation – Methodology and functional characterization. **7 Hrs**

Unit-2: **Phytochemistry:** Discovery and Characterization of Novel Phytochemicals; Phytochemicals in Personalized Medicine; Integration of Phytochemicals in Functional Foods and Nutraceuticals; Sustainable Production of Phytochemicals via Biotechnology; Phytochemicals in Environmental Applications. **5 Hrs**

Unit-3: Herbal Drug Extraction: Extraction methods – conventional - maceration; Infusion; decoction, percolation, distillation – hydro distillation, steam distillation; Soxhlet extraction; Modern ultra sound assisted (UAE), microwave assisted extraction (MAE), Supercritical fluid extraction (SFE), Pressurized Liquid Extraction (PLE) / Accelerated Solvent Extraction (ASE).

3Hrs.

Unit-4 : Phytochemical Products – Current Scenario: Current scenario of phytochemical Products (local, regional global); analysis of phytochemicals - *in vivo* - animal models for evaluating anti-inflammatory, analgesic, anti-diabetic, neuroprotective, hepatoprotective properties; ethical considerations and CPCSEA guidelines; LD_{50}, chronic and acute toxicity studies and *in vitro* - Phytochemical screening (qualitative and quantitative tests); Antioxidant assays: DPPH, ABTS, FRAP, nitric oxide scavenging; Enzyme inhibition assays: acetylcholinesterase, tyrosinase, α-amylase; Cytotoxicity testing (e.g., MTT assay on cell lines); material on herbal and phytochemical processing. **10 Hrs**

Unit-5: Pharmacological Profiling: Metabolomic profiling of medicinal plants using advanced techniques (LC-MS/MS, NMR, HPLC, FTIR, etc.): Pharmacological evaluation of phytochemicals for anti-cancer, anti-inflammatory, antidiabetic, neuroprotective, and antimicrobial activities etc. **4 Hrs**

Unit-6: Methods of Drug Evaluation: Organoleptic -Assessment using senses (sight, smell, taste, touch); **Parameters:** Color, odor, taste, texture, size, and shape.; Microscopic- sectioning and staining to observe tissues, cells, trichomes, stomata, vessels, etc.; macroscopic - visible features (leaf shape, stem type, flower structure); physical - Moisture content (loss on drying), Ash values (total ash, acid-insoluble ash, water-soluble ash),Extractive values (alcohol, water); Foreign matter, Crude fiber content, chemical – qualitative and quantitative and biological - Measures pharmacological effects (e.g., anti-inflammatory, antimicrobial, antioxidant) and models used: Animal models, cell cultures, enzyme inhibition assays and toxicological evaluation - Mutagenicity, teratogenicity, and carcinogenicity. **10 Hrs**

Unit-7: Standardization and Quality Control: Standardization of Herbal Drugs: Objectives; WHO guidelines and regulatory aspects (Indian (AYUSH, API, ISM), US FDA, EMA, and other global frameworks); GMP (Good Manufacturing Practices) and GLP (Good Laboratory Practices) in herbal drug industries. **4 Hrs**

Unit-8: Quality Control: Quality standards for finished products: tablets, syrups, powders, oils, ointments, etc; Contaminants and residues: Heavy metals, Pesticide residues, Microbial load, Aflatoxins; Marker-based standardization; Safety and efficacy of herbal drugs. **Applications of Pharmacology:** Types of adulteration: intentional and unintentional; Methods of detection; Role of DNA barcoding, molecular markers in authentication; Evaluation of proprietary herbal formulations; Industrial approaches and challenges. **6 Hrs**

Suggested Readings:

1. **Pulok, K. Mukherjee.** *"Quality Control of Herbal Drugs: An Approach to Evaluation of Botanicals"* Business Horizons, New Delhi, Latest Edition,
2. **Kokate C.K., Purohit A.P., Gokhale S.B.** *"Pharmacognosy"*Nirali Prakashan, 50th Edition or latest
3. **Trease and Evans** *"Pharmacognosy"* Elsevier, 16th Edition
   Harborne J.B. *"Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis"* Springer, 3rd Edition
4. **Pharmacopoeias**

5. Mukherjee, P. K., et al. (2008). *"Bioactive compounds from natural resources against skin aging." Phytomedicine*, 15(10), 798–805.
6. Ekor, M. (2014). *The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety." Frontiers in Pharmacology*, 4, 177.
7. Gupta, A.K., et al. *"Standardization of Herbal Drugs: An Overview International Journal of Pharmaceutical Sciences Review and Research*

COURSE III RCT-104: PHYTOPHARMCOGNOSY AND NANOTECHNOLOGY

52 HOURS (4 CREDITS)

Course Outcome: *As a specialization course, this module prepares research students to understand the role of plant resources in development of drugs, nanoparticles synthesis and its application. It enables the research scholar to gain skills in authentication and quality evaluation of plant materials with emphasis on correlating phytoconstituents with their biological actions appreciating the significance of herbal drugs and nanotechnology giving an insight into nanostructures at a nano-scale which finds application in diverse fields.*

Unit-1: Plant Biomolecules: Introduction to Plant biomolecules; Classification; Major biosynthetic pathways – Shikimic acid pathway, Malonate Pathway, Mevalonate Pathway, MEP pathway, phenylpropanoid pathway, alkaloid biosynthetic pathway, Cyanogenic Glycoside Pathway and Glucosinolate Pathway; Importance of precursors in drug discovery; Fractionation and purification, Identification and Characterization of phytochemicals (TLC, HPLC, LC-MS, GC MS, NMR etc); Qualitative and quantitative phytochemical analysis. **8 Hrs.**

Unit-2: Phytochemistry: Introduction to Phytochemistry, Discovery and Characterization of Novel Phytochemicals; Phytochemicals in Personalized Medicine; Integration of Phytochemicals in Functional Foods and Nutraceuticals; Sustainable Production of Phytochemicals via Biotechnology; Phytochemicals in Environmental Applications. **4 Hrs.**

Unit-3:Extraction of Phytopharmaceuticals: Selection of plant material, collection, identification, drying and grinding, cutting, processing and powdering of herbs; Choice of solvent; Extraction methods – **Conventional extraction techniques** – Maceration, Digestion, Infusion and Percolation, Decoction, Soxhlet extraction and **Modern extraction techniques** - Accelerated solvent extraction (ASE), Microwave-assisted extraction (MAE), also known as microwave extraction,

Ultrasound-assisted extraction or UAE (sonication extraction), Supercritical fluid extraction (SFE), Enzyme-assisted extraction (EAE), Pressurized hot water extraction (PHWE). **8 Hrs.**

Unit-4: Pharmacological evaluation of drugs - organo, macro and micro, physical and chemical Organoleptic evaluation (assessment using organs of senses - eye, ear, nose, tongue) – colour, odour, taste, texture, size and shape; **Macroscopic evaluation** – Structure of Plant parts - root, stem, leaf, flower and fruit; **Microscopic evaluation** – sectioning and staining to evaluate the leaf constants, stomata, trichomes or plant hairs, calcium oxalate crystals and others; **Physical evaluation** – Moisture content, solubility, ash values (total ash, acid-insoluble ash and water-soluble ash) and extractives (water and alcohol), foreign organic and inorganic matter; **Chemical evaluation** – qualitative and quantitative (Alkaloids, Phenolic compounds including tannins, saponins and related compounds); **Pharmacological Profiling:** Metabolomic profiling of medicinal plants using advanced techniques (LC-MS/MS, NMR, HPLC, FTIR, etc.). **8 Hrs.**

Unit-5: Biological Evaluation of Herbal drugs: Analysis of Pharmacological effects (Anti-microbial Studies, anti-inflammatory studies (Both in vitro and in vivo), anti-cancer studies (Both In vitro and in vivo), and antioxidant - DPPH, ABTS, FRAP, nitric oxide scavenging; Enzyme inhibition assays: acetylcholinesterase, tyrosinase, α-amylase; toxicity studies (Both In vitro and in vivo – MTT assay on cell lines) of phytochemicals, Introduction to In silico studies - molecular docking) and **models used:** Animal models, cell cultures, enzyme inhibition assays and toxicological evaluation - Mutagenicity, teratogenicity, and carcinogenicity (in vitro and in vivo), Introduction to In silico studies. **7 Hrs**

Unit-6: Applications of Pharmacology: Types of adulteration: intentional and unintentional; Methods of detection; Role of DNA barcoding, molecular markers in authentication; Evaluation of proprietary herbal formulations; Industrial approaches and challenges. **3 Hrs.**

Unit-7: Synthesis of nanoparticles and nanostructured materials & characterization: History of nanotechnology, origins of nanotechnology, beyond Moore's Law; Definitions and scales; size scale effects (effects in optical, electrical and thermal properties); Current status and future of Nanotechnology. **Synthesis of nanoparticles** - Use of natural plants for synthesis of nanoparticles-synthesis of metal nanoparticles using phytochemicals; **Characterization-** Spectral, structural and surface characterization - X-ray diffraction (XRD), Microscopy - Scanning electron microscopy (SEM), Atomic Force Microscopy (AFM), Scanning Tunnelling Microscopy (STM), Transmission electron Microscopy (TEM), Spectroscopy - UV-Vis –Spectroscopy and Fourier Transformed Infrared Spectroscopy (FTIR), Raman Spectroscopy, Photoluminescence (PL); X-Ray-Related Characterization Techniques- Energy Dispersive X-ray Analysis (EDX); Zeta (potential). **8 Hrs.**

Unit-8: Applications of Nanotechnology: Agriculture: Plant disease diagnostics, Seed germination, Crop protection - nano fertilizer, and smart delivery systems; **Food Industry:** Food processing, food sensors, intelligent packaging, and edible coatings; **Medicine and Healthcare technology:** Cancer nanotechnology, Nano-regenerative medicine, Nano pharmacology (nanomedicine), drug delivery; bio imaging and nano robots; Nanotechnology solutions to environmental problems; Application in water purification; The Ethics of Nanotechnology-Potential Benefits, Potential Dangers. **6 Hrs.**

Suggested Readings:

1. Kokate C.K., Purohit A.P., Gokhale S.B. *"Pharmacognosy"* Nirali Prakashan, 50th Edition or latest
2. Trease and Evans *"Pharmacognosy"* Elsevier, 16th Edition
3. Harborne J.B. *"Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis"* Springer, 3rd Edition
4. Pharmacopoeias
5. Mukherjee, P. K., et al. (2008).*"Bioactive compounds from natural resources against skin aging." Phytomedicine*, 15(10), 798–805.
6. Ekor, M. (2014). *The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety." Frontiers in Pharmacology*, 4, 177.
7. Nanobiotechnology: Concepts, Applications and Perspectives (2004), Christof M.Niemeyer (Editor), Chad A. Mirkin (Editor), Wiley VCH.
8. Nanobiotechnology - II more concepts and applications. (2007) - Chad A Mirkin and Christof M. Niemeyer (Eds), Wiley VCH.
9. Nanotechnology in Biology and Medicine: Methods, Devices, and Applications.
10. Horst – Gunter Rubahn, "Basics of Nano Technology", Wiley – VCH VerlagGmbh& Co, 2008.
11. Chris Binns, "Introduction to Nanoscience and Nanotechnology", John Wiley and Sons 2010.
12. Synthesis, Properties, and Applications of Oxide Nanomaterials, edited by José A. Rodriguez, Marcos Fernández-García
13. Nanomaterial Interfaces in Biology: Methods and Protocols, Paolo Bergese, Kimberly Hamad- Schifferli
14. Handbook of Immunological Properties of Engineered Nanomaterials, By Marina A.Dobrovolskaia, Scott E. McNeil
15. Nanomaterials Imaging Techniques, Surface Studies, and Applications, edited by OlenaFesenko, Leonid Yatsenko, MikhayloBrodin.

Sd/-
PROF. G. R. JANARDHANA
Chairman, BOS in Botany, BCU, Bengaluru/
Senior Professor, DOS in Botany, University of Mysore