

# KASHI NARESH UNIVERSITY, BHADOHI

## (National Education Policy-2020) Syllabus of Botany (w.e.f. Academic Session 2026-2027) For B.Sc.

Approved by  
Board of Studies  
Department of Botany  
Faculty of Science  
Kashi Naresh University, Bhadohi



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| Semester-wise Titles of the Papers in B.Sc. (Botany)         |      |                    |                                                             |                      |         |
|--------------------------------------------------------------|------|--------------------|-------------------------------------------------------------|----------------------|---------|
| Year                                                         | Sem. | Course Code        | Paper Title                                                 | Theory/<br>Practical | Credits |
| Certificate Course In Microbial Technology & Applied Botany  |      |                    |                                                             |                      |         |
| FIRST<br>YEAR                                                | I    | B040101T           | Microbiology & Plant Pathology                              | Theory               | 4       |
|                                                              |      | B040102P           | Techniques in Microbiology & Plant Pathology                | Practical            | 2       |
|                                                              | II   | B040201T           | Archegoniates & Plant Architecture                          | Theory               | 4       |
|                                                              |      | B040202P           | Land Plants Architecture                                    | Practical            | 2       |
|                                                              |      | B040203TM<br>Minor | Introduction to Plant Diversity (Multidisciplinary Minor)   | Theory               | 6       |
| Diploma in Plant Identification, Utilization & Ethnomedicine |      |                    |                                                             |                      |         |
| SECOND<br>YEAR                                               | III  | B040301T           | Flowering Plants Identification & Aesthetic Characteristics | Theory               | 4       |
|                                                              |      | B040302P           | Plant Identification technology                             | Practical            | 2       |
|                                                              | IV   | B040401T           | Economic Botany, Ethnomedicine & Phytochemistry             | Theory               | 4       |
|                                                              |      | B040402P           | Commercial Botany & Phytochemical Analysis                  | Practical            | 2       |
|                                                              |      | B040403R           | Research Project/ Field Survey                              |                      | 3       |
|                                                              |      | B040404TM<br>Minor | Plant Resource Utilization (Multidisciplinary Minor)        | Theory               | 6       |
| Bachelor of Science                                          |      |                    |                                                             |                      |         |
| THIRD<br>YEAR                                                | V    | B040501T           | Plant Physiology, Metabolism & Biochemistry                 | Theory               | 4       |
|                                                              |      | B040502T           | Molecular Biology & Bioinformatics                          | Theory               | 4       |
|                                                              |      | B040503P           | Experiments in physiology, Biochemistry & molecular biology | Practical            | 2       |
|                                                              | VI   | B040601T           | Cytogenetics, Plant Breeding & Nanotechnology               | Theory               | 4       |
|                                                              |      | B040602T           | Ecology & Environment                                       | Theory               | 4       |
|                                                              |      | B040603P           | Cytogenetics, Conservation & Environment management         | Practical            | 2       |
|                                                              |      |                    |                                                             |                      |         |







## SUBJECT: BOTANY

### Subject prerequisites:

1. To study Botany, a student must have had the subject Biology/Biotechnology learnt at 10+2 level.
2. Keen interest in plants and plant-related research, Potential in mathematics, biology and chemistry
3. Skills and aptitude for scientific study and research
4. Creativity and good comprehension while working on scientific procedures and research
5. Computer aptitude.

### COURSE INTRODUCTION

The new curriculum of B.Sc. in Science (Botany) offers essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core, elective and vocational papers with significant inter-disciplinary components.

Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

B.Sc. Botany Programme covers academic activities within the classroom sessions along with practical concepts at laboratory sessions. Infield, outstation activities and projects are also required to be organized for real-life experience and learning.

Candidates who have curiosity in plants kingdom, ecosystem, love exploring exotic places and wish to work as researchers or professions like Botanist, Conservationist, Ecologist, etc. can choose B.Sc. Botany course.

### Programme outcomes (POs):

Transformed curriculum shall develop educated outcome-oriented candidature, fostered with discovery- learning, equipped with practice & skills to deal practical problems and versed with recent pedagogical trends in education including e-learning, flipped class and hybrid learning to develop into responsible citizen for nation-building and transforming the country towards the future with their knowledge gained in the field of plant science.

|             |                                                                                                                                                                                                                                                                                                                                             |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PO 1</b> | CBCS syllabus with a combination of general and specialized education shall introduce the concepts of breadth and depth in learning                                                                                                                                                                                                         |
| <b>PO2</b>  | Shall produce competent plant biologists who can employ and implement their gained knowledge in basic and applied aspects that will profoundly influence the prevailing paradigm of agriculture, industry, healthcare and environment to provide sustainable development.                                                                   |
| <b>PO 3</b> | Will increase the ability of critical thinking, development of scientific attitude, handling of problems and generating solutions, improve practical skills, enhance communication skill, social interaction, increase awareness in judicious use of plant resources by recognizing the ethical value system.                               |
| <b>PO 4</b> | The training provided to the students will make them competent enough for doing jobs in Govt. and private sectors of academia, research and industry along with graduate preparation for national as well as international competitive examinations, especially UGC-CSIR NET, UPSC Civil Services Examination, IFS, NSC, FCI, BSI, FRI etc. |
| <b>PO 5</b> | Certificate and diploma courses are framed to generate self- entrepreneurship and self-employability, if multi exit option is opted.                                                                                                                                                                                                        |



|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                      |
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| <b>PO 6</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Lifelong learning be achieved by drawing attention to the vast world of knowledge of plants and their domestication. |
| <b>Programme specific outcomes (PSOs):</b><br><b><i>B.Sc. I Year</i></b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                      |
| <p>This Programme imparts knowledge on various fields of plant biology through teaching, interactions and practical classes. It shall maintain a balance between the traditional botany and modern science for shifting it towards the frontier areas of plant sciences with applied approach. This syllabus has been drafted to enable the learners to prepare them for self-entrepreneurship and employment in various fields including academics as well as competitive exams. Students would gain wide knowledge in following aspects:</p> <ol style="list-style-type: none"> <li>1. Diversity of plants and microbes, their habitat, morphology, architecture and reproduction.</li> <li>2. Plant disease causing microbes, symptoms &amp; control.</li> <li>3. Economic value of plants and their use in Human Welfare.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                      |
| <b>Programme specific outcomes (PSOs):</b><br><b><i>B.Sc. II Year</i></b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                      |
| <p>This course provides a broad understanding of identifying, growing and using plants. This course is primarily aimed to introduce people to the richness of plant diversity found in surrounding areas. Lecture sessions are designed to cover fundamental topics concerning classification of plants and their utilization required for understanding the flora and vegetation. Practical sessions are organized following theory for easy understanding of the various parts of the plants, structural organization of floral parts and diversity therein. Participants are taken to different locations covering a variety of habitats and forest types to acquaint them with the native flora. in the long run, will contribute towards building momentum for people's participation in environmental conservation without compromising on academic rigor and our rich wealth of knowledge inherited over generations.</p> <ol style="list-style-type: none"> <li>1. The course will cover conventional topics in Field Botany like Evolutionary History &amp; Diversity of plants, Complete Morphology, Nomenclature of plants, Systems of Classification, Keys to important Families of Flowering Plants, Field Data Collection &amp; Herbarium Techniques.</li> <li>2. The course is designed to become a commercial crop grower, florist, protected cultivator, green belt plant advisor to industries, pharmacologist &amp; taxonomist.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                      |
| <b>Programme specific outcomes (PSOs):</b><br><b><i>B.Sc. III Year</i></b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                      |
| <p>The learning outcomes of a three years graduation course are aligned with programme learning outcomes but these are specific to-specific courses offered in a program. The core courses shall be the backbone of this framework whereas discipline electives, generic electives and skill enhancement courses would add academic excellence in the subject together with a multi-dimensional and multidisciplinary approach.</p> <ol style="list-style-type: none"> <li>1. Understanding of plant classification systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various life-forms.</li> <li>2. This course is suitable to produce expertise in conservation biology like ex-situ conservation, response to habitat change, genotype characterization and reproductive biology.</li> <li>3. Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as a human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.</li> <li>4. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and the application of statistics to biological data.</li> <li>5. Entrepreneurship Skill Development, Understand the issues of environmental contexts and sustainable development, Inculcation of human values,</li> <li>6. Strengthen mathematical and computational skills. Enable students to use ICT &amp; AI effectively.</li> <li>7. Develop good skills in the laboratory such as observation and evaluation by the use of modern tools and technology.</li> </ol> |                                                                                                                      |

***Certificate Course in Microbial Technology & Applied Botany***  
***(Semester I and Semester II)***

**B.Sc.-I Semester**

PSA wh 4 May 2014

|                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|--------------------------|
| B.Sc                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Year: I             | Semester: I/Paper-I      |
| Course Code: B040101T                                                                                                                                        | Course Title: Microbiology & Plant Pathology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                     |                          |
| <b>Course outcomes:</b> After the completion of the course the students will be able to:                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| 1. Develop understanding about the classification and diversity of different microbes including viruses, Algae, Fungi & Lichens & their economic importance. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| 2. Develop conceptual skill about identifying microbes, pathogens, biofertilizers & lichens.                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| 3. Gain knowledge about developing commercial enterprise of microbial products.                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| 4. Learn host –pathogen relationship and disease management.                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| 5. Learn Presentation skills (oral & writing) in life sciences by usage of computer & multimedia.                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| 6. Gain Knowledge about uses of microbes in various fields.                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| 7. Understand the structure and reproduction of certain selected bacteria algae, fungi and lichens                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| 8. Gain Knowledge about the economic values of this lower group of plant community.                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| Credits: 4                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Core Compulsory     |                          |
| Max. Marks: 25+75                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Min. Passing Marks: |                          |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                          |
| Unit                                                                                                                                                         | Topic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     | No. of Lectures (60 hrs) |
| I                                                                                                                                                            | <b>A. Introduction to Indian ancient, Vedic and heritage Botany and contribution of Indian Botanists, in context with the holistic development of modern science and technology, has to be taught, practiced and assessed via class interaction/ assignments / self-study mentioned under Continuous Internal Evaluation (CIE).</b><br><b>B. Microbial Techniques &amp; instrumentation</b><br>Microscopy – Light, phase contrast, electron, scanning and transmission electron microscopy, staining techniques for light microscopy, sample preparation for electron microscopy. Common equipment of microbiology lab and principle of their working – autoclave, oven, laminar air flow, centrifuge. Colorimetry and spectrophotometry, immobilization methods, fermentation and fermenters. |                     | 8                        |
| II                                                                                                                                                           | <b>Microbial world</b><br>Cell structure of Eukaryotic and prokaryotic cells, Gram positive and Gram-negative bacteria, Structure of a bacteria; Bacterial Chemotaxis and Quorum sensing, Bacterial Growth curve, factors affecting growth of microbes; measurement of growth; Batch culture, fed batch culture and continuous culture; Synchronous growth of microbes; Sporulation and reproduction and recombination in bacteria.<br>Viruses, general characteristics, viral culture, Structure of viruses, Bacteriophages, Structure of T4 & λ-phage; Lytic and Lysogenic cycles, viroid, Prions & mycoplasma & phytoplasma, Actinomycetes & plasmids and their economic uses.                                                                                                              |                     | 8                        |
| III                                                                                                                                                          | <b>Phycology</b><br>Range of thallus organization in Algae, Pigments, Reserve food –Reproduction - Classification and life cycle of –<br><i>Nostoc, Anabaena, Oscillatoria, Chlorella, Volvox, Hydrodictyon, Oedogonium, Chara; Sargassum, Ectocarpus, Polysiphonia.</i><br>Economic importance of algae - Role of algae in soil fertility- biofertilizer – Nitrogen fixation-Symbiosis; Commercial products of algae –biofuel, Agar.                                                                                                                                                                                                                                                                                                                                                          |                     | 7                        |
| IV                                                                                                                                                           | <b>Mycology</b><br>General characteristics, nutrition, life cycle, Economic importance of Fungi, Classification upto class. Distinguishing characters of Myxomycota: General characters of Mastigomycotina, Zygomycota: <i>Rhizopus</i> , <b>Ascomycota:</b> <i>Saccharomyces, Penicillium, Peziza</i> . <b>Basidiomycotina:</b> <i>Ustilago, Puccinia, Agaricus</i> ; <b>Deuteromycotina:</b> <i>Fusarium, Alternaria</i> . Heterothallism, Physiological specialization. Heterokarvosis & Parasexuality.                                                                                                                                                                                                                                                                                     |                     | 7                        |

|   |                                                                                                                                                                                                                                     |   |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| V | <b>Mushroom Cultivation, Lichenology &amp; Mycorrhiza</b><br>Mushroom cultivation.<br>General account of lichens, reproduction and significance; <i>Mycorrhiza: ectomycorrhiza</i> and <i>endomycorrhiza</i> and their significance | 7 |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|

|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| VI   | <b>Plant Pathology</b><br>Disease concept, Symptoms, Etiology & causal complex, Primary and secondary inoculum, Infection, Pathogenicity and pathogenesis, Koch's Postulates. Mechanism of infection (Brief idea about Pre-penetration, Penetration and Post- penetration), Disease cycle (monocyclic, polycyclic and polyetic). Defense mechanism with special reference to Phytoalexin, Resistance- Systemic acquired and Induced systemic fungicides- Bordeaux mixture, Lime Sulphur, Tobacco decoction, Neem cake & oil                                                                                                                                       | 7 |
| VII  | <b>Diseases and Control</b><br>Symptoms, Causal organism, Disease cycle and Control measures of – Early & Late Blight of Potato, False Smut of Rice/ Brown spot of rice, Black Stem Rust of Wheat, <i>Alternaria</i> spot' and 'White rust of Crucifers, Red Rot of Sugarcane, Wilting of Arhar, Mosaic diseases on tobacco and cucumber, yellow vein mosaic of bhindi; Citrus Canker, Little leaf of brinjal; Damping off of seedlings, Disease management: Quarantine, Chemical, Biological, Integrated pest disease management                                                                                                                                 | 8 |
| VIII | <b>Applied Microbiology</b><br>Food fermentations and food produced by microbes, amino acids, Production of antibiotics, enzymes, vitamins, alcoholic beverages, organic acid & genetic recombinant vaccines. Mass production of bacterial biofertilizers, blue green algae, <i>Azolla</i> and <i>mycorrhiza</i> . Plant growth promoting rhizobacteria & biopesticides— <i>Trichoderma sp.</i> and <i>Pseudomonas</i> , Single cell proteins, Organic farming inputs, Microbiology of water, Biopolymers, Bioindicators, biosensors, Bioremediation, Production of biofuels, biodegradation of pollutants and biodeterioration of materials & Cultural Property. | 8 |

**Suggested Readings:**

**Course Books published in Hindi may be prescribed by the Universities.**

1. Microbiology Fundamental and Applications (hindi) (pb)
2. ISBN: 9788188826230 Edition: 03Year : 2016Author : Dr. Purohit SS, Dr. Deo Publisher : Student Edition Language : Hindi
3. पादपोगतवज्ञानपरिभाषा-कोश: Definitional Dictionary of Plant Pathology. Publisher Commission for Scientific and Technical Terminology.
4. Modern Microbiology (hindi) (hb) ISBN: 9788177543599Edition : 1Year : 2018Author : Dr. Purohit SS , Dr. Singh T Publisher : Agrobios (India)
5. Suggested books "Plant pathology by R.S. Mehrotra, Tata McGraw-Hill Education" are included in reading resources list

**Unit-I A:**

- i. <https://indianculture.gov.in/rarebooks/economic-botany-india> <https://www.infinityfoundation.com/mandala/t es/t es tiwar botany frameset.htm>
- ii. [https://www.researchgate.net/publication/335715457\\_Ancient\\_Indian\\_rishi's\\_Sages\\_knowledge\\_of\\_botany\\_and\\_medicinal\\_plants\\_since\\_Vedic\\_period\\_was\\_much\\_older\\_than\\_the\\_period\\_of\\_Theophrastus\\_A\\_case\\_study-who\\_was\\_the\\_actual\\_father\\_of\\_botany](https://www.researchgate.net/publication/335715457_Ancient_Indian_rishi's_Sages_knowledge_of_botany_and_medicinal_plants_since_Vedic_period_was_much_older_than_the_period_of_Theophrastus_A_case_study-who_was_the_actual_father_of_botany)
- iii. <https://www.scribd.com/presentation/81269920/Botany-of-Ancient-India>
- iv. [https://insa.nic.in/writereaddata/UpLoadedFiles/IJHS/Vol17\\_2\\_17\\_PKBhattacharyya.pdf](https://insa.nic.in/writereaddata/UpLoadedFiles/IJHS/Vol17_2_17_PKBhattacharyya.pdf)
- v. *vi Ancient Botany (Sciences of Antiquity) Paperback – 1 October 2015by Gavin Hardy (Author), Laurence Totelin (Author)*
- vi. <https://www.plantsdiseases.com/p/symptoms.html>
- vii. <https://www.plantsdiseases.com/p/pathogenic-diseases-in-plants.html>

**UNIT-I B**

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
4. Aggarwal, S. K. 2009. Foundation Course in Biology, A one books Pvt. Ltd., New Delhi.

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5. Aneja, K. R. 1993. Experiments in Microbiology, Pathology and Tissue Culture, Vishwa Prakashan, NewDelhi.

6. Annie Ragland, 2012. Algae and Bryophytes, Saras Publication, Kanyakumari, India.
7. Basu, A. N. 1993. Essentials of Plant Viruses, Vectors and Plant diseases, New Age International, New Delhi.
8. Chopra. G. L. 1984. A text book of Algae, Rastogi publications, Meerut, India.
9. Desikachari, T. V. 1959. Cyanophyta, ICAR, New Delhi.
10. Dubey, R. C. and Maheshwari. D.K. 2012. Practical Microbiology, S. Chand & Company, Pvt. Ltd., NewDelhi.
11. Fritsch, R. E. 1977. Structure and Reproduction of Algae, Cambridge University Press, London.
12. Kodo, C.I. and Agarwal, H.O. 1972. Principles and techniques in Plant Virology, Van Nostrand, Reinhold Company, New York.
13. Agrios, G.N. (1997). Plant Pathology, 4th edition. Cambridge, U.K.: Academic Press.
14. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, 4th edition. Singapore, Singapore: John Wiley & Sons.
15. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies. Noida, U.P.: Macmillan Publishers India Ltd.
16. Reven, F.H., Evert, R. F., Eichhorn, S.E. (1992). Biology of Plants. New York, NY: W.H. Freeman and Company.
17. Sharma, P.D. (2011). Plant Pathology. Meerut, U.P.: Rastogi Publication.
18. Webster, J., Weber, R. (2007). Introduction to Fungi, 3rd edition. Cambridge, U.K.: Cambridge University Press..
19. Pandey B.P. 2001. College Botany Volume 1, S Chand & Company Pvt.Ltd, New Delhi.
20. Pandey. B.P. 2014 Modern Practical Botany, (Vol-I) S. Chand and Company Pvt. Ltd., New Delhi.
21. Pelzar, 1963. Microbiology, Tata Mc Graw Hill, New Delhi
22. Rangaswamy, G. 2009, Disease of Crop Plants in India, Prentice Hall of India, New Delhi.
23. Sambamurty. A.V.S.S. 2006, A Text book of Algae, I. K. International Publishing House, Pvt. Ltd., New Delhi.
24. Sharma, P. D. 2012, Microbiology and Plant Pathology, Rastogi Publication Pvt Ltd., Meerut, India.
25. Singh, R. P. 2007. Microbial Taxonomy and Culture Techniques, Kalyani Publication, New Delhi.
26. Smith. G. M. 1996. Cryptogamic Botany Volume I, Tata Mc Graw Hill, New Delhi.
27. Sundar Rajan. S. 2010. College Botany Volume I, Himalaya Publications, Mumbai.
28. Vashishta, B.R. Sinha, A.K. and Singh, V. P. 1991. Algae, S. Chand and Company, Pvt. Ltd., New Delhi

**This course can be opted as an elective by the students of following subjects: Open to all but special for B.Sc. Biotech, B.Sc. Microbiology, B.Sc. Agriculture, B.A. (Curators), B.A. Archaeology, B.A. Geology, BAMS.**

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall

| Internal Assessment                                              | Marks     |  |
|------------------------------------------------------------------|-----------|--|
| Class Interaction                                                | 5         |  |
| Quiz                                                             | 5         |  |
| Seminar                                                          | 7         |  |
| Assignment (Charts/Flora/Rural Service/Technology Dissemination) | 8         |  |
|                                                                  | <b>25</b> |  |

**Course prerequisites:**

**Qualification:** To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry/ Microbiology/Gardening /biomedical Science.

**Facilities: Smart and Interactive Class**

**Other Requisites: Video collection, Books, CDs, Access to On-line resources, Display Charts**

**Suggested equivalent online courses:**

<https://indianculture.gov.in/rarebooks/economic-botany-india>

<https://community.plantae.org/tags/mooc>

[futurelearn.com/courses/teaching-biology-inspiring-students-with-plants-in-science](https://futurelearn.com/courses/teaching-biology-inspiring-students-with-plants-in-science)

<https://www.coursera.org/courses?query=plants>

<http://egyankosh.ac.in/handle/123456789/53530>

<https://www.classcentral.com/tag/microbiology>

<https://www.edx.org/learn/microbiology>

<https://www.mooc-list.com/tags/microbiology>

<https://www.udemy.com/topic/microbiology/>

<https://ucmp.berkeley.edu/bacteria/bacteria.html>

<https://www.livescience.com/53272-what-is-a->

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|--------------------------|
| BSc                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Year: I                                                    | Semester: I/Paper-II     |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                            |                          |
| Course Code: B040102P                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Course Title: Techniques in Microbiology & Plant Pathology |                          |
| Course outcomes: After the completion of the course the students will be able:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                            |                          |
| <div>1. Understand the instruments, techniques, lab etiquettes and good lab practices for working in a microbiology laboratory.</div> <div>2. Develop skills for identifying microbes and using them for Industrial, Agriculture and Environment purposes.</div> <div>3. Practical skills in the field and laboratory experiments in Microbiology &amp; Pathology.</div> <div>4. learn to identify Algae, Lichens and plant pathogens along with their Symbiotic and Parasitic associations.</div> <div>5. Can initiate his own Plant &amp; Seed Diagnostic Clinic</div> <div>6. Can start own enterprise on microbial products</div> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                            |                          |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Core Compulsory                                            |                          |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Min. Passing Marks:                                        |                          |
| Total No. of Lectures- Tutorials-Practicals (in hours per week): 0-0-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                            |                          |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Topic * (Minimum Any three from each unit depending on facilities)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                            | No. of Lectures (60 hrs) |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>INSTRUMENTS &amp; TECHNIQUES</b> <div>1. Laboratory safety and good laboratory practices</div> <div>2. Principles and application of Laboratory instruments-microscope, incubator, autoclave, centrifuge, LAF, filtration unit, shaker, pH meter.</div> <div>3. Buffer preparation &amp; titration</div> <div>3. Cleaning and Sterilization of glasswares</div> <div>4. Preparation of media- Nutrient Agar and Broth</div> <div>5. Inoculation and culturing of bacteria in Nutrient agar and nutrient broth</div> <div>6. Preparation of agar slant, stab, agar plate</div> <div>7. Phenol Coefficient method to test the efficacy of disinfectants</div> |                                                            | 7                        |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>BACTERIAL IDENTIFICATION</b> <div>1. Isolation of bacteria.</div> <div>2. Identification of bacteria.</div> <div>3. Staining techniques: Gram’s, Negative, Endospore, Capsule and Cell Wall.</div> <div>4. Cultural characteristics of bacteria on NA.</div> <div>5. Pure culture techniques (Types of streaking).</div> <div>6. Biochemical characterization:<br/>IMViC, Carbohydrate fermentation test, Mannitol motility test, Gelatin liquefaction test,<br/>Urease test, Nitrate reduction test, Catalase test, Oxidase test, Starch hydrolysis, Casein hydrolysis.</div>                                                                              |                                                            | 8                        |
| III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>MYCOLOGICAL STUDY:</b> <div>1. Isolation of different fungi: Saprophytic, Coprophilous, Keratinophilic.</div> <div>2. Identification of fungi by lactophenol cotton blue method. <i>Rhizopus</i>, <i>Saccharomyces</i>, <i>Penicillium</i>, <i>Peziza</i>, <i>Ustilago</i>, <i>Puccinia</i>; <i>Fusarium</i>, <i>Curvularia</i>, <i>Alternaria</i>.</div> <div>3. <i>Agaricus</i>: Specimens of button stage and ful grown mushroom; Sectioning of gills of <i>Agaricus</i>.</div> <div>4. Lichens: crustose, foliose and fruticose specimens.</div>                                                                                                        |                                                            | 8                        |
| IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>PHYCOLOGY:</b> <div>1. Type study of algae and Cyanobacteria –<i>Spirullina</i>, <i>Nostoc</i>.</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                            | 7                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Chlorophyceae - <i>Chlorella</i> , <i>Volvox</i> , <i>Oedogonium</i> , <i>Cladophora</i> , and <i>Chara</i> ; Xanthophyceae –<br>–<br><i>Vaucheria</i> ; Bacillariophyceae – <i>Pinnularia</i> Phaeophyceae – <i>Sargassum</i><br>Rhodophyceae - <i>Polysiphonia</i>                                                                                                                                                                                                                                                                                                                                                                                           |                                                            |                          |

|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| V    | <b>EXPERIMENTAL PLANT PATHOLOGY</b><br>1. Preparation of fungal media (PDA) & Sterilization process.<br>2. Isolation of pathogen from diseased leaf.<br>Identification: Pathological specimens of Brown spot of rice, Bacterial blight of rice, Loose smut of wheat, Stem rot of mustard, Late blight of potato; Slides of uredial, telial, pycnial & aecial stages of <i>Puccinia</i> , Few viral and bacterial plant diseases.                                                                                                     | 8 |
| VI   | <b>PRACTICALS IN APPLIED MICROBIOLOGY-1</b><br>1. Isolation of nitrogen fixing bacteria from root nodules of legumes.<br>2. Enumeration of rhizosphere to non rhizosphere population of bacteria.<br>3. Isolation of antagonistic <i>Pseudomonas</i> from soil.<br>4. Microscopic observations of root colonization by VAM fungi.<br>5. Isolation of <i>Azospirillum</i> sp. from the roots of grasses.<br>6. Isolation of phyllosphere microflora.<br>7. Isolation of P solubilizing microorganisms                                 | 8 |
| VII  | <b>PRACTICALS IN APPLIED MICROBIOLOGY-2</b><br>1. Wine production.<br>2. Isolation of lactic acid bacteria from curd.<br>3. Isolation of lipolytic organisms from butter or cheese.<br>4. Immobilized bacterial cells for production of hydrolytic enzymes.<br>5. Enzyme production and assay – cellulase, protease and amylase.<br>6. Immobilization of yeast.<br>7. Isolation of cellulolytic and anaerobic sulphate reducing bacteria.<br>8. Isolation and characterization of acidophilic, alkalophilic and halophilic bacteria. | 8 |
| VIII | 1. Cultivation of <i>Spirulina</i> , & <i>Chlorella</i> in lab for biofuel<br>2. Visit to NBAIM, Mau, Varanasi (Kashi)/ IMTECH (Institute of Microbial Technology), Chandigarh for viewing Culture Repository<br>3. Visit to biofertilizers and biopesticides unit to understand about the Unit operation procedures<br>4. Mushroom cultivation for Protein<br>5. Alcohol production. from Sugarcane Juice.                                                                                                                          | 6 |

**Suggested Readings:**

**Course Books published in Hindi may be prescribed by the Universities.**

1. प्रयोगात्मकवनस्पतितत्वज्ञानभाग 1 लेखक अशोक बेंद्रे, विभा अशोक कुर्, प्रकाशनिस्तोगी, 1981
2. प्रयोगात्मकवनस्पतितत्वज्ञान-1 Dhankar - Sharma – Trivedi ISBN Code: 978-81-8142-697-0 65, RBD Publishing House Shivaji Nagar Civil Lines, Jaipur - 302006 (Rajasthan)
3. प्रायोगिकवनस्पतितत्वज्ञानबी.एस.सी-1 एबी अग्रवाल प्रकाशक : तशवलाल अग्रवाल एण्ड कंपनी प्रकाशित शिवपुर : 2018
4. Practical Botany (Part I) ISBN #: 81-301-0008-8 Sunil D Purohit, Gotam K Kukda & Anamika Singhvi Edition: 2013 Apex Publishing House Durga Nursery Road, Udaipur, Rajasthan ( bilingual)
5. Modern Mushroom Cultivation And Recipes (hindi) (hb) ISBN : 9788177545180 Edition : 01 Year : 2017 Author : Singh Riti, Singh UC Publisher : Agrobios (India)
6. Biofertilizer Production Manual (hindi) (hb) ISBN : 9788177541274 Edition : 01 Year : 2014 Author : Gehlot D Publisher : Agrobios (India) Language : Hindi
1. Aneja, K. R. 1993. Experiments in Microbiology, Pathology and Tissue Culture, Vishwa Prakashan, New Delhi.
2. Dubey, R. C. and Maheshwari. D.K. 2012. Practical Microbiology, S. Chand & Company, Pvt. Ltd., New Delhi.
3. Kodo, C.I. and Agarwal, H.O. 1972. Principles and techniques in Plant Virology, Van Nostrand, Reinhold Company, New York.
4. Madhavee Latha, P. 2012, A Textbook of Immunology, S. Chand & Company Pvt. Ltd., New Delhi.
5. Pandey. B.P. 2014 Modern Practical Botany, (Vol-I) S. Chand and Company Pvt. Ltd., New Delhi.
6. Sambamurty. A.V.S.S. 2006, A Textbook of Algae, I. K. International Publishing House, Pvt. Ltd.,
7. Singh, R. P. 2007. Microbial Taxonomy and Culture Techniques, Kalyani Publication, New Delhi.
8. <https://agrimoon.com/wp-content/uploads/Mashroom-culture.pdf>
9. <http://nhb.gov.in/pdf/Cultivation.pdf>
10. [https://www.k-state.edu/fungi/Greeting/Publications\\_files/2006%20Handbook.pdf](https://www.k-state.edu/fungi/Greeting/Publications_files/2006%20Handbook.pdf)
11. Sen, Surjit, Acharya, Krishnendu, Rai, Manjula 2019 IBSN - 978-93-88347-23-5 - Biofertilizers and Biopesticides . Technoworld, Kolkata
12. <http://www.kvkkendrapara.org/pdf/Bio%20Fertilizer%20Production%20and%20marketing.pdf>

*Handwritten signatures and initials at the bottom of the page.*

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 13.                                                                                                                                                                                                                                                                                                                           | <a href="http://www.gbv.de/dms/tib-ub-hannover/751302945.pdf">http://www.gbv.de/dms/tib-ub-hannover/751302945.pdf</a>                                                                        |
| 14.                                                                                                                                                                                                                                                                                                                           | Hochman, Gal, Zilberman, David 2014 ISBN-1461493285- Algae Farming and Its Bio-Products Springer                                                                                             |
| 15.                                                                                                                                                                                                                                                                                                                           | Gokare A. Ravishankar, Ranga Rao Ambati 2019 Handbook of Algal Technologies and Phytochemicals Volume II: Phycoremediation, Biofuels and Global Biomass Production Print ISBN: 9780367178192 |
| 16.                                                                                                                                                                                                                                                                                                                           | Amos Richmond Ph.D., Prof. Emeritus, Qiang Hu Ph.D 2013. Handbook of Microalgal Culture: Applied Phycology and Biotechnology, Second Edition Print ISBN:9780470673898                        |
| <b>This course can be opted as an elective by the students of following subjects: Open to all but special for B.Sc. Biotech, B.Sc. Microbiology, B.Sc. Agriculture, B.A. (Curators), B.A. Archaeology, B.A. Geology, BAMS.</b>                                                                                                |                                                                                                                                                                                              |
| <b>Suggested Continuous Evaluation Methods:</b>                                                                                                                                                                                                                                                                               |                                                                                                                                                                                              |
| Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall                                                                                                                                                                                                                         |                                                                                                                                                                                              |
| <b>Internal Assessment</b>                                                                                                                                                                                                                                                                                                    | <b>Marks</b>                                                                                                                                                                                 |
| Class Interaction                                                                                                                                                                                                                                                                                                             | 5                                                                                                                                                                                            |
| Quiz                                                                                                                                                                                                                                                                                                                          | 5                                                                                                                                                                                            |
| Seminar                                                                                                                                                                                                                                                                                                                       | 7                                                                                                                                                                                            |
| Minor field work/excursion/lab visit/technology dissemination etc.                                                                                                                                                                                                                                                            | 8                                                                                                                                                                                            |
|                                                                                                                                                                                                                                                                                                                               | <b>25</b>                                                                                                                                                                                    |
| <b>Course prerequisites:</b>                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                              |
| <b>Qualification:</b> To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry/ Microbiology/Gardening /biomedical Science.                                                                       |                                                                                                                                                                                              |
| <b>Facilities: Smart and Interactive Class</b>                                                                                                                                                                                                                                                                                |                                                                                                                                                                                              |
| <b>Other Requisites: Video collection, Books, CDs, Access to On-line resources, Display Charts</b>                                                                                                                                                                                                                            |                                                                                                                                                                                              |
| <b>Suggested equivalent online courses:</b>                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                              |
| <a href="https://community.plantae.org/tags/mooc">https://community.plantae.org/tags/mooc</a>                                                                                                                                                                                                                                 |                                                                                                                                                                                              |
| <a href="https://futurelearn.com/courses/teaching-biology-inspiring-students-with-plants-in-science">futurelearn.com/courses/teaching-biology-inspiring-students-with-plants-in-science</a>                                                                                                                                   |                                                                                                                                                                                              |
| <a href="https://microbiology.society.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html">https://microbiology.society.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html</a>                                                                       |                                                                                                                                                                                              |
| <a href="https://microbiologyonline.org/file/7926d7789d8a2f7b2075109f68c3175e.pdf">https://microbiologyonline.org/file/7926d7789d8a2f7b2075109f68c3175e.pdf</a>                                                                                                                                                               |                                                                                                                                                                                              |
| <a href="http://allaboutalgae.com/benefits/https://repository.cimmyt.org/xmlui/bitstream/handle/10883/3219/64331.pdf">http://allaboutalgae.com/benefits/https://repository.cimmyt.org/xmlui/bitstream/handle/10883/3219/64331.pdf</a>                                                                                         |                                                                                                                                                                                              |
| <a href="https://www.mooc-list.com/tags/microbiology">https://www.mooc-list.com/tags/microbiology</a>                                                                                                                                                                                                                         |                                                                                                                                                                                              |
| <a href="https://www.agrifs.ir/sites/default/files/A%20text%20book%20of%20practical%20botany%201%20%7BAshok%20Bendre%7D%20%5B8171339239%5D%20%281984%29.pdf">https://www.agrifs.ir/sites/default/files/A%20text%20book%20of%20practical%20botany%201%20%7BAshok%20Bendre%7D%20%5B8171339239%5D%20%281984%29.pdf</a>           |                                                                                                                                                                                              |
| <a href="https://www.coursera.org/courses?query=plants">https://www.coursera.org/courses?query=plants</a> <a href="http://egyankosh.ac.in/handle/123456789/53530">http://egyankosh.ac.in/handle/123456789/53530</a> <a href="https://www.classcentral.com/tag/microbiology">https://www.classcentral.com/tag/microbiology</a> |                                                                                                                                                                                              |
| <a href="https://www.edx.org/learn/microbiology">https://www.edx.org/learn/microbiology</a>                                                                                                                                                                                                                                   |                                                                                                                                                                                              |
| <a href="https://www.mooc-list.com/tags/microbiology">https://www.mooc-list.com/tags/microbiology</a>                                                                                                                                                                                                                         |                                                                                                                                                                                              |
| <a href="https://www.udemy.com/topic/microbiology/">https://www.udemy.com/topic/microbiology/</a>                                                                                                                                                                                                                             |                                                                                                                                                                                              |







## **B.Sc.-II Semester**

25/11/2020

|                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|--------------------------|
| BSc                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                 | Year: I                                            | Semester: II/Paper-I     |
| Subject: Botany                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |                          |
| Course Code: B040201T                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                 | Course Title: Archegoniates and Plant Architecture |                          |
| Course outcomes: After the completion of the course the students will be able:                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |                          |
| 1. Develop critical understanding on morphology, anatomy and reproduction of Bryophytes, Pteridophytes and Gymnosperms                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |                          |
| 2. Understanding of plant evolution and their transition to land habitat.                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |                          |
| 3. Understand morphology, anatomy, reproduction and developmental changes therein through typological study and create a knowledge base in understanding the basis of plant diversity, economic values & taxonomy of plants |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |                          |
| 4. Understand the details of external and internal structures of flowering plants.                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |                          |
| Credits: 4                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                 | Core Compulsory                                    |                          |
| Max. Marks: 25+75                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                 | Min. Passing Marks:                                |                          |
| Total No. of Lectures- Tutorials-Practicals (in hours per week): 4-0-0                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |                          |
| Unit                                                                                                                                                                                                                        | Topic                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                    | No. of Lectures (60 hrs) |
| I                                                                                                                                                                                                                           | Introduction to Archegoniates & Bryophytes<br>Unique features of archegoniates, Bryophytes: General characteristics, adaptations to land habit, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction of <i>Riccia</i> , <i>Marchantia</i> , <i>Anthoceros</i> and <i>Sphagnum</i> . (Developmental details not to be included). economic importance of bryophytes .               |                                                    | 7                        |
| II                                                                                                                                                                                                                          | Pteridophytes<br>General characteristics, Early land plants ( <i>Rhynia</i> ). Classification (up to family) with examples, Heterospory and seed habit, stelar evolution, economic importance of Pteridophytes.                                                                                                                                                                                                                 |                                                    | 8                        |
| III                                                                                                                                                                                                                         | Gymnosperms<br>Classification and distribution of gymnosperms; Salient features of Cycadales, Ginkgoales, Coniferales and Gnetales, their examples, structure and reproduction; economic importance                                                                                                                                                                                                                             |                                                    | 8                        |
| IV                                                                                                                                                                                                                          | Palaeobotany<br>General account of Cycadofilicales, Bennettitales and Cordaitales; Geological time scale; Brief account of process of fossilization & types of fossils and study techniques ; Contribution of Birbal Sahni                                                                                                                                                                                                      |                                                    | 8                        |
| V                                                                                                                                                                                                                           | Angiosperm Morphology (Stem, Roots, Leaves & Flowers, Inflorescence)<br>Morphology and modifications of roots; Stem, leaf and bud. Types of inflorescences; flowers, flower parts, fruits and types of placentation; Definition and types of seeds.                                                                                                                                                                             |                                                    | 7                        |
| VI                                                                                                                                                                                                                          | Plant Anatomy: Meristematic and permanent tissues, Organs (root, stem and leaf). Apical meristems & theories on apical organization - Apical cell theory, Histogen theory, Tunica - Corpus theory. Secondary growth - Root and stem- cambium (structure and function) annular rings, Anomalous secondary growth - <i>Bignonia</i> , <i>Boerhaavia</i> , <i>Dracaena</i> , <i>Nyctanthes</i>                                     |                                                    | 7                        |
| VII                                                                                                                                                                                                                         | Reproductive Botany<br>Plant Embryology, Structure of microsporangium, microsporogenesis, , Structure of megasporangium and its types, megasporogenesis, Structure and types of female gametophyte, types of pollination, Methods of pollination, Germination of pollen grain, structure of male gametophyte, Fertilization, structure of dicot and monocot embryo, Endosperm, Double fertilization, Apomixis and polyembryony. |                                                    | 8                        |
| VIII                                                                                                                                                                                                                        | Palynology: Pollen structure, pollen morphology, pollen allergy , Applied Palynology: Basic concepts, Palaeopalynology, Aeropalynology, Forensic palynology, Role in taxonomic evidences.                                                                                                                                                                                                                                       |                                                    | 7                        |



**Suggested Readings:****Course Books published in Hindi may be prescribed by the Universities.**

1. प्रयोगात्मकवनस्पतितत्वज्ञानभाग 1 लेखकअशोकबेद्रे, अशोककुर्, प्रकाशनिस्तोगीर्, ठि
2. प्रयोतगकवनस्पतितत्वज्ञान-1 Dhankar - Sharma – Trivedi ISBN Code: 978-81-8142-697-0 65, RBD Publishing House Shivaji Nagar Civil Lines, Jaipur - 302006 ( Rajasthan )
3. प्रायोतगकवनस्पतितत्वज्ञानबी.एस-सी-1 एबीअग्रवालप्रकाशक : तशवलालअग्रवालएण्डकंपनीप्रकाशिवषण : 2018
4. Practical Botany (Part I) ISBN #:81-301-0008-8 Sunil D Purohit, Gotam K Kukda & Anamika Singhvi Edition:2013 Apex Publishing House Durga Nursery Road, Udaipur, Rajasthan ( bilingual)
1. Gangulee H. S. and K. Kar 1992. College Botany Vol. I and II. (New Central Book Agency)

2. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
3. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
4. Rashid A (1999) An Introduction to Pteridophyta, Vikas Publishing House Pvt. Ltd. New Delhi.
5. Sharma OP (1990) Textbook of Pteridophyta. MacMillan India Ltd. Delhi.
6. Vashishtha BR, Sinha AK and Kumar A (2010) Botany for Degree Students – Pteridophyta, S. Chand and Company,
7. Vashishtha BR, Sinha AK and Kumar A (2010) Botany for Degree Students – Gymnosperms, S. Chand and
8. Parihar NS (1976) Biology and Morphology of Pteridophytes. Central Book Depot.
9. Bhatnagar SP (1996) Gymnosperms, New Age International Publisher.
10. Pandey BP (2010) College Botany Vol II S. Chand and Company, New Delhi
11. Maheswari, P. 1971. An Introduction to Embryology of Angiosperms. McGraw Hill Book Co., London
12. Bhattacharya et. al. 2007. A textbook of Palynology, Central, New Delhi.
13. Bhojwani, S.S. and S. P. Bhatnagar. 2000. The Embryology of Angiosperms (4th Ed.), Vikas Publishing House,.
14. P.K.K. Nair- A textbook of Palynology.
15. Johri, B. M. 1984. Embryology of Angiosperms. Springer-Verleg, Berlin.
16. Dutta A.C. 2016. Botany for Degree Students. Oxford University Press.
17. E.J.Eames . Morphology of Vascular Plants, Standard University Press.
18. Dickinson, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
19. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
20. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.

**This course can be opted as an elective by the students of following subjects: Open to all but special for B.Sc. Biotech, B.Sc. Microbiology, B.Sc. Agriculture, B.A. (Curators), B.A. Archaeology, B.A. Geology, BAMS.**

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall

| Internal Assessment                                                 | Marks     |  |
|---------------------------------------------------------------------|-----------|--|
| Class Interaction                                                   | 5         |  |
| Quiz                                                                | 5         |  |
| Seminar                                                             | 7         |  |
| Assignment (Charts/ Flora/ Rural Service/ Technology Dissemination) | 8         |  |
|                                                                     | <b>25</b> |  |

**Course prerequisites:**

**Qualification:** To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry/ Microbiology/Gardening /biomedical Science.

**Facilities: Smart and Interactive Class**

**Other Requisites: Video collection, Books, CDs, Access to On-line resources, Display Charts**

*Handwritten signatures and initials at the bottom of the page.*

**Suggested equivalent online courses:**

<https://www.anbg.gov.au/bryophyte/what-is-bryophyte.html>

<https://pteridoportal.org/portal/index.php>

<https://www.conifers.org/zz/gymnosperms.php>

<http://www.mobot.org/MOBOT/research/APweb/>

<https://milneorchid.weebly.com/plant-id-for-beginners.html>

<https://www.botany.org/PlantImages/PlantAnatomy.phphttp://webapp1.dlib.indiana.edu/inauthors/view?docId=VAC0868&doc.view=print>

<https://palynology.org/>

<http://www2.estrellamountain.edu/faculty/farabee/biobk/Biobookflowers.html>

<https://www.sciencelearn.org.nz/resources/100-plant-reproduction>

<https://palaeobotany.org/>

25/11/2020

|                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |                                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------------------------------|
| BSc                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Year: I                                | Semester: II<br>Paper-II (Practical) |
| Subject: Botany                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |                                      |
| Course Code: B040202P                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Course Title: Land Plants Architecture |                                      |
| Course outcomes:                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |                                      |
| 1. The students will be made aware of the group of plants that have given rise to land habit and the flowering plants. Through field study they will be able to see these plants grow in nature and become familiar with the biodiversity. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |                                      |
| 2. Students would learn to create their small digital reports where they can capture the zoomed in and zoomed out pictures as well as videos in case they are able to find some rare structure or phenomenon related to these plants.      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |                                      |
| 3. Develop an understanding by observation and table study of representative members of phylogenetically important groups to learn the process of evolution in a broad sense.                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |                                      |
| 4. Understand morphology, anatomy, reproduction and developmental changes therein through typological study and create a knowledge base in understanding plant diversity, economic values & taxonomy of lower group of plants              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |                                      |
| 5. Understand the composition, modifications, internal structure &architecture of flowering plants for becoming a Botanist.                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |                                      |
| Credits: 2                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Core Compulsory                        |                                      |
| Max. Marks: 25+75                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Min. Passing Marks:                    |                                      |
| Total No. of Lectures- Tutorials-Practicals (in hours per week): 0-0-2                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |                                      |
| Unit                                                                                                                                                                                                                                       | Topic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                        | No. of Lectures (60 hrs)             |
| I                                                                                                                                                                                                                                          | <b>Bryophytes:</b><br>Marchantia- morphology of thallus, W.M. rhizoids and scales, V.S. thallus through Gemma cup, W.M. gemmae (all temporary slides), V.S. antheridiophore, archegoniophore, L.S. sporophyte (all permanent slides). <i>Sphagnum</i> - morphology, W.M. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, L.S. capsule and protonema.                                                                                                                    |                                        | 8                                    |
| II                                                                                                                                                                                                                                         | <b>Pteridophytes:</b><br><i>Lycopodium</i> : Habit, stem T. S. strobilus V. S., <i>Selaginella</i> : Habit, rhizophore T. S, stem T . S, axis with strobilus, V.S. of strobilus, Megasporophyll and microsporophyll.<br><i>Equisetum</i> - Habit, rhizome and stem T.S. and V. S. of strobilus.<br><i>Azolla</i> – Habitat & its structure                                                                                                                                                                                                                    |                                        | 7                                    |
| III                                                                                                                                                                                                                                        | <b>Gymnosperms</b><br>1. <i>Cycas</i> – seedling, coralloid root and coralloid root T. S., T. S. of leaflet and Rachis, micro and megasporophyll, male cone V. S., microsporophyll T. S. entire and V. S. of ovule. <i>Pinus</i> - Branch of indefinite growth, spur shoot, T. S of old stem and needle R.L.S and T. L. S. of stem, male and female cone, V.S. of male and female cone.<br>2. <i>Ephedra</i> & <i>Thuja</i> : Habit, stem T. S (young and mature), leaf T. S, male and female strobilus, V. S. of male and female cone, ovule V. S. and seed. |                                        | 8                                    |
| IV                                                                                                                                                                                                                                         | <b>Palaeobotany &amp; Palynology</b><br>1. Morphology of <i>Rhynia</i> and fossils gymnosperms & other groups.<br>2. Visit Birbal Sahni Institute of Palaeosciences or virtual conference with their scientis to learn fossilization.<br>3. Mark and know about Indian geographical sites rich in plant fossils.                                                                                                                                                                                                                                              |                                        | 6                                    |



|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |
|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| V  | <b>Angiosperm Morphology</b> <ol style="list-style-type: none"> <li>To study diversity in leaf shape, size and other foliar features.</li> <li>To study monopodial and sympodial branching.</li> <li>Morphology of Fruits</li> <li>Inflorescence types- study from fresh/ preserved specimens</li> <li>Flowers- study of different types from fresh/ preserved specimens</li> <li>Fruits- study from different types from fresh/preserved specimens</li> <li>Study of ovules (permanent slides/ specimens/photographs)- types (anatropous, orthotropous, amphitropous and campylotropous)</li> <li>Modifications in Roots, stems, leaves and inflorescences</li> </ol> | 8 |
| VI | <b>Plant Anatomy:</b><br>Normal & Anomalous secondary thickening - <i>Bignonia</i> , <i>Dracaena</i> , <i>Boerhaavia diffusa</i> , <i>Nyctanthes</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 8 |

|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
|      | <i>Nyctanthes</i><br>Study of primary and secondary growth in the root and stem of monocots and dicots by section cutting and permanent slides.<br>Study of internal structure of dicot and monocot leaves.<br>Study of structure of stomata.                                                                                                                                                                                                                                                                                                                                                                                                                                                       |   |
| VII  | <b>Reproductive Botany</b> <ol style="list-style-type: none"> <li>Structure of anther, microsporogenesis and pollen grains</li> <li>Structure of ovule and embryo sac development (through slides).</li> <li>Study of embryo development in monocots and dicots.</li> <li>Vegetative propagation by means of cutting, budding and grafting exercises.</li> <li>Study of seed germination.</li> <li>Study of pollen morphology of the following plants –<i>Hibiscus</i>, <i>Vinca</i>, <i>Balsam</i>, <i>Ixora</i>, <i>Crotalaria</i>, <i>Bougainvillea</i> by microscopic observation.</li> <li>Calculation of pollen viability percentage using in vitro pollen germination techniques.</li> </ol> | 8 |
| VIII | <b>Commercial Uses and Production technology</b> <ol style="list-style-type: none"> <li><i>Azolla</i> production</li> <li>Production technology of Resins</li> <li>Production and propagation of Ornamental <i>Pteris</i>, Cycadales, Coniferales for landscaping.</li> <li>Lab method for qualitative testing/ extraction of Ephedrine, Taxol and <i>Thuja</i> oil.</li> </ol>                                                                                                                                                                                                                                                                                                                     | 7 |

**Suggested Readings:**

**Course Books published in Hindi may be prescribed by the Universities.**

- प्रयोगात्मक वनस्पति विज्ञान भाग II, लेखक अशोक बेंद्रे, आशोक कुरा, प्रकाशन: विस्तोगी प्रकाशन, रीठ
- प्रयोगात्मक वनस्पति विज्ञान भाग I, II, III लेखक शरण बोहोहा, अधिनखड़
- प्रयोगात्मक वनस्पति विज्ञान भाग 2 लेखक अशोक बेंद्रे, आशोक कुरा, प्रकाशन : विस्तोगी प्रकाशन, रीठ
- प्रयोगात्मक वनस्पति विज्ञान बी.एस.-सी.-II। एस.बी. अग्रवाल प्रकाशक तशवलाल अग्रवाल एण्ड कम्पनी

- Pandey, BP and Trivedi, P.S. 1997. Botany Vol. I (10th edition). Vikas Publishing House. Pandey, BP; Misra; Trivedi, P.S. 1997. Botany Vol. II. Vikas Publishing House.
- Pandey, BP and Chadha. 1997. Botany Vol. III. Vikas Publishing House.
- Santra, SC and Chatterjee. 2005. College Botany Practical Vol. I. New Central Book Agency (P) Ltd.
- Kumar, S and Kashyap. 2003. Manual of Practical Algae. Campus Books International, New Delhi Bendre and Kumar A text book of Practical Botany. Vol I, II., Rastogi Pub. Meerut.
- Suresh Kumar, Amar Singh Kashyap Manual of Practical Algae.. Campus Books Internet, New Delhi.
- Santra, SC. 2005. College Botany Practical Vol. II. New Central Book Agency (P) Ltd.

**This course can be opted as an elective by the students of following subjects:**

**Open to all but special for** B.Sc. Biotech, B.Sc. Forestry, B.Sc. Agriculture, B. Pharma, B.A.

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall be as follows:

| Internal Assessment | Marks |
|---------------------|-------|
|---------------------|-------|

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|                                                                                             |           |
|---------------------------------------------------------------------------------------------|-----------|
| Class Interaction                                                                           | 6         |
| Field work /Virtual/E-learning /Participation in group discussions                          | 7         |
| <b>Industrial or Central laboratory training of two weeks in summer/winter (Compulsory)</b> | 12        |
|                                                                                             | <b>25</b> |

**Course prerequisites:**

**Qualification:** To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry).

**Facilities:** Smart and Interactive Class

**Other Requisites:** Microscopes, Stains, Dissection box, Haemocytometer, Specimens, Permanent slides, Autoclave, incubator, Oven, laminar flow cabinet, balance

**Suggested equivalent online courses:**

<https://www.easybiologyclass.com/topic-botany>

<http://www3.botany.ubc.ca/bryophyte/index.html>

[http://ecflora.cavehill.uwi.edu/bio\\_courses/bl14apl/practical\\_3.1.htm](http://ecflora.cavehill.uwi.edu/bio_courses/bl14apl/practical_3.1.htm)

<http://mydunotes.blogspot.c>

<http://www.fao.org/3/a-v9236e.pdf>

<https://iinrg.icar.gov.in/library/nrg/nrg.pdf>

[https://agritech.tnau.ac.in/banking/nabard\\_pdf/Azolla%20Cultivation/Model\\_project\\_on\\_Azolla\\_cultivation.pdf](https://agritech.tnau.ac.in/banking/nabard_pdf/Azolla%20Cultivation/Model_project_on_Azolla_cultivation.pdf)

<http://arnoldia.arboretum.harvard.edu/pdf/articles/1977-37-1-propagation-manual-of-selected-gymnosperms.pdf>

[https://www.fs.fed.us/rm/pubs\\_other/wo\\_AgricHandbook730/wo\\_AgricHandbook727\\_153\\_175.pdf](https://www.fs.fed.us/rm/pubs_other/wo_AgricHandbook730/wo_AgricHandbook727_153_175.pdf)

<om/p/botany.html>

PSA wh E Mayr CS

## BOTANY MINOR

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                            |                                                |                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-----------------|
| Program/Class:<br>B.Sc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                            | Year : I                                       | Semester: II    |
| Course Code : B040203TM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                            | Course Title : INTRODUCTION TO PLANT DIVERSITY |                 |
| Course Outcomes:<br>After the completion of the course the students will be able to:<br>1. Understanding basic knowledge of plants belong to Kingdom Plantae.<br>2. Understanding progressive evolution of plants.<br>3. Understanding their morphology, structure reproduction and economic importance.                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                            |                                                |                 |
| Credits: 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                            | Minor Elective                                 |                 |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                            | Min. Passing Marks                             |                 |
| Total No. of Lectures-Tutorial-Practicals (in hour per week) L-T-P : 4-0-0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                            |                                                |                 |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Topics                                                                                                                                                                                     |                                                | No. of Lectures |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Microbial world Cell structure of Eukaryotic and prokaryotic cells, Gram positive and Gram-negative bacteria, Structure of a bacteria; general characteristics of Viruses and Phytoplasm.  |                                                | 8               |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Mushroom Cultivation, General account of lichens, reproduction and significance & Mycorrhiza.                                                                                              |                                                | 4               |
| III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Phycology Range of thallus organization in Algae, Pigments, Reserve food. Structure, reproduction and life cycle of Oscillatoria and Chara. Economic importance of Oscillatoria and algae. |                                                | 8               |
| IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Mycology General characteristics, nutrition, life cycle of Rhizopus and Saccharomyces. Economic importance of Fungi.                                                                       |                                                | 8               |
| V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Bryophytes: General characteristics, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction of Riccia and Marchantia.                          |                                                | 8               |
| VI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Pteridophytes General characteristics. Life-cycle of Lycopodium and Selaginella.                                                                                                           |                                                | 8               |
| VII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Gymnosperms General characteristics. Life-cycle of Cycas and Pinus.                                                                                                                        |                                                | 8               |
| VIII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Angiosperms Angiosperm Morphology (Stem, Roots, Leaves & Flowers, Inflorescence) Morphology and modifications of roots; Stem, leaf and bud, flower parts.                                  |                                                | 8               |
| <b>Suggested Readings</b><br>1. Gangulee H. S. and K. Kar 1992. College Botany Vol. 1 and 11. (New Central Book Agency)<br>2. Bhatnagar, S.P. and Mostra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India<br>3. Parihar, NS. (1991) An introduction to Embryophyta. Vol. I. Bryophyta, Central Book Depot, Allahabad<br>4. Rashid A (1999) An Introduction to Pteridophyta, Vikas Publishing House Pvt. Ltd New Delhi<br>5. Sharma OP (1990) Textbook of Pteridophyta. MacMillan India Ltd. Delhi<br>6. Vashishtha BR, Sinha AK and Kumar A (2010) Botany for Degree Students Pteridophyta, S. Chand and Company, |                                                                                                                                                                                            |                                                |                 |

7. Vashishtha BR, Sinha AK and Kumar A (2010) Botany for Degree Students Gymnosperms, S. Chand and
8. Parihar NS (1976) Biology and Morphology of Pteridophytes, Central Book Depot
9. Bhatnagar SP (1996) Gymnosperms, New Age International Publisher.
10. Pandey BP (2010) College Botany Vol II S. Chand and Company, New Delhi
11. Maheswari, P. 1971. An Introduction to Embryology of Angiosperms. McGraw Hill Book Co., London
12. Bhojwani, S.S. and S. P. Bhatnagar 2000. The Embryology of Angiosperms (4th Ed 1, Vikas Publishing House.
13. Dutta A.C. 2016. Botany for Degree Students. Oxford University Press
14. EJEames. Morphology of Vascular Plants, Standard University Press

PSA wh E Mayr CS

***Diploma in Plant Identification, Utilization & Ethnomedicine***  
***(Semester III and Semester IV)***

**B.Sc.-III Semester**

PSA wh 4 Mayr CS

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     |                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|--------------------------|
| BSc                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Year: II            | Semester: III/Paper-I    |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     |                          |
| Course Code: B040301T                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Course Title: Flowering Plants Identification & Aesthetic Characteristics                                                                                                                                                                                                                                                                                                                                                                        |                     |                          |
| <b>Course outcomes:</b> After the completion of the course the students will be able to:<br>1. To gain an understanding of the history and concepts underlying various approaches to plant taxonomy and classification.<br>2. To learn the major patterns of diversity among plants, and the characters and types of data used to classify plants.<br>3. To compare the different approaches to classification with regard to the analysis of data.<br>4. To become familiar with major taxa and their identifying characteristics, and to develop in depth knowledge of the current taxonomy of a major plant family.<br>5. To discover and use diverse taxonomic resources, reference materials, herbarium collections, publications.<br>6. For the entrepreneur career in plants, one can establish a nursery, Start a landscaping business, Set up a farm Or Run a plantation consultancy firm |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     |                          |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Core Compulsory     |                          |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Min. Passing Marks: |                          |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     |                          |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Topic                                                                                                                                                                                                                                                                                                                                                                                                                                            |                     | No. of Lectures (60 hrs) |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Taxonomic Resources &amp; Nomenclature</b><br>Components of taxonomy (identification, nomenclature, classification) ; Taxonomic resources: Herbarium- functions & important herbaria, Botanical gardens, Flora, Keys- single access and multi-access.<br>Principles and rules of Botanical Nomenclature according to ICN (ranks and names; principle of priority, binomial system; type method, author citation, valid- publication).         |                     | 7                        |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Types of classification &amp; Evidences</b><br>Artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series) angiosperm phylogeny group (APG IV) classification. Introduction to taxonomic evidences from palynology, cytology, phytochemistry & Molecular biology data (Protein and Nucleic acid homology).                                                                                        |                     | 8                        |
| III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Identification of Angiospermic families -I: (Families can be chosen University wise as per local available flora)</b><br>A study of the following families with emphasis on the morphological peculiarities and economic importance of its members (based on Bentham & Hooker’s system) Ranunculaceae, Malvaceae, Rutaceae, Fabaceae, Myrtaceae , Cucurbitaceae, Rubiaceae, Asteraceae, Apocynaceae, Acanthaceae, Asclepiadaceae, Solanaceae. |                     | 8                        |
| IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Identification of Angiospermic families -II: (Families can be chosen University wise as per local available flora)</b><br>A study of the following families with emphasis on the morphological peculiarities and economic importance of its members (based on Bentham & Hooker’s system)- Amaranthaceae, Euphorbiaceae, Papaveraceae, Apiaceae, Lamiaceae, Orchidaceae, Liliaceae, Musaceae, Poaceae.                                         |                     | 7                        |
| V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Modern trends in Plant taxonomy:</b><br>Brief idea on Phenetics, Biometrics, Cladistics (Monophyletic, polyphyletic and paraphyletic groups; Plesiomorphy and apomorphy).                                                                                                                                                                                                                                                                     |                     | 8                        |
| VI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>TOOLS &amp; SOFTWARES IN PLANT IDENTIFICATION-</b><br>GIS ( Mapping of (i) Patterns(ii) Features (iii) Quantities 0P02.010H11YLIP - Free Phylogenetic Software, Digital Taxonomy (e-flora), Description Language for Taxonomy – DELTA Internet directory for botany.                                                                                                                                                                          |                     | 7                        |

|            |                                                  |          |
|------------|--------------------------------------------------|----------|
| <b>VII</b> | <b>Computer usage &amp; Android Applications</b> | <b>7</b> |
|------------|--------------------------------------------------|----------|

|             |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|             | MS Office: PPT, Microsoft Excel, data entry, graphs, aggregate functions, formulas and functions, number systems, conversion devices, secondary storage media. GPS tagging, Plant Identification Apps.                                                                                                                                                                                                                                            |          |
| <b>VIII</b> | <b>Aesthetic Characteristics of Plants:</b><br>Aesthetic characteristics of plants, English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Trees, shrubs and shrubberies, climbers and creepers, rockery, Flower beds, Shrubbery, Borders, Water garden). Some Famous gardens of India. Conservatory, green houses, Indoor garden, Roof garden, Topiary, Bonsai. | <b>8</b> |

**Suggested Readings:**

1. Propagation And Nursery Management (hindi) (hb) ISBN : 9788177546200 Edition : 01 Year : 2016 Author : Pandey
2. S.K. , Soni N. Publisher : Agrobios (India)
3. Dr. Amar Singh. पादपवर्तमणकी- Plant Taxonomy (An Old and Rare Book) from the category Ayurveda in our Books collection. Uttar Pradesh Hindi Sansthan, Lucknow
1. Plant Systematics. Arun K. Pandey & Shruti Kansana. 2020. Jaya Publishing House.
2. Bole, P. V. and Vaghani, Y. (1986) Field guide to the common trees of India. Oxford University Press; Bombay.
3. Brandis, D. (1906) Indian Trees (London, 5th edition. 1971). International Book Distributors; Dehra Dun.
4. Dallwitz, M. J., Paine, T. A. and Zurcher, E. J. (2003). Principles of interactive keys.
5. <http://delta-intkey.com>
6. <https://www.naace.co.uk/school-improvement/ict-mark/>
7. <https://www.socitm.gov.uk>, (2002) Learning in the 21st century Executive briefing A Socitm Insight publication, July 2002 Socitm.
8. K. B. Anjaria, (2015) "Electronic Herbarium and Digital Database Preparation of Common Trees of Anand District, Gujarat" MRP submitted to UGC, WRO, Pune 2015 (unpublished)
9. Lizeron Eremias and R. Subash. (2013) "E-Content Development: A Milestone In The Dynamic Progress Of E-Learning" International Journal of Teacher Educational Research (IJTER) Vol.2 No.1 January, 2013 ISSN: 2319- 4642
10. Pandey, B.P. 2007. Botany for Degree Students: Diversity of Seed Plants and their Systematics, Structure, Development and Reproduction in Flowering Plants. S. Chand & Company Ltd, New Delhi.
11. Stace, C. A. 1989. Plant Taxonomy and Biostatistics (2nd Ed.). Edward Arnold, London.
12. Singh, G. 1999. Plant Systematics: Theory and Practice. Oxford and IBH, New Delhi.
13. Dutta A.C. 2016. Botany for Degree Students. Oxford University Press.
14. Davis, P. H. and V. H. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd, London.
15. Heywood, V. H. and D. M. Moore (Eds). 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
16. Austin, R. 2002. Elements of planting design. New York: John Wiley & Sons.
17. Bertauski, T. 2005. Designing the landscape: An introductory guide for the landscape designer. Upper Saddle River, NJ: Pearson Prentice Hall.
18. Thomas, H., and S. Wooster. 2008. The complete planting design course: Plans and styles for every garden. London: Octopus Publishing Group.
19. Scarfone, S. 2007. Professional planting design: An architectural and horticultural approach for creating mixed bed plantings. New York: John Wiley & Sons.
20. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied Publishers.

**This course can be opted as an elective by the students of following subjects: Open to all but special for B.Sc. Biotech, B.Sc. Microbiology, B.Sc. Agriculture, B.A. (Curators), B.A. Archaeology, B.A. Geology, BAMS.**

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall be as follows:

|                     |       |  |
|---------------------|-------|--|
| Internal Assessment | Marks |  |
| Class Interaction   | 5     |  |
| Quiz                | 5     |  |

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|                                                                  |           |
|------------------------------------------------------------------|-----------|
| Seminar                                                          | 7         |
| Assignment (Charts/Flora/Rural Service/Technology Dissemination) | 8         |
|                                                                  | <b>25</b> |

**Course prerequisites:**

**Qualification:** To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry)

**Facilities:** Smart and Interactive Class

**Other Requisites:** Video collection, Books, CDs, Flora, Herbarium, Access to On-line resources, Display Charts

**Suggested equivalent online courses:**

<https://www.easybiologyclass.com/topic-botany/>

<http://egyankosh.ac.in/handle/123456789/53530>

<https://www.delta-intkey.com/www/desc.htm>

<https://milneorchid.weebly.com/plant-id-for-beginners.html>

<https://plants.usda.gov/classification.html>[https://www.senecaahs.org/pages/uploaded\\_files/Plant%20Classification.pdf](https://www.senecaahs.org/pages/uploaded_files/Plant%20Classification.pdf)

[https://www.ladykeanecollege.edu.in/files/userfiles/file/Dr\\_%20S\\_%20Nongbri%20III%20Sem%20ppt.pdf](https://www.ladykeanecollege.edu.in/files/userfiles/file/Dr_%20S_%20Nongbri%20III%20Sem%20ppt.pdf)[https://www.brainkart.com/article/Bentham-and-Hooker-s-classification-of-plants---Dicotyledonae,-Gymnospermae-and-Monocotyledonae\\_1000/](https://www.brainkart.com/article/Bentham-and-Hooker-s-classification-of-plants---Dicotyledonae,-Gymnospermae-and-Monocotyledonae_1000/)

<https://libguides.rutgers.edu/c.php?g=336690&p=2267037>

<https://www.delta-intkey.com/>

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                               |                                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|-----------------------------------------|
| BSc                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Year:<br>II                                   | Semester: III<br>Paper-I<br>(Practical) |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                               |                                         |
| Course Code: B040302P                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Course Title: Plant Identification technology |                                         |
| Course outcomes: After the completion of the course the students will be able to:<br>1. To learn how plant specimens are collected, documented, and curated for a permanent record.<br>2. To observe, record, and employ plant morphological variation and the accompanying descriptive terminology.<br>3. To gain experience with the various tools and means available to identify plants.<br>4. To develop observational skills and field experience.<br>5. To identify a taxonomically diverse array of native plants.<br>6. To recognize common and major plant families.<br>7. To Understand aesthetic characters of flowering plants by making-landscapes,gardens,bonsai,miniatures<br>8. Comprehend the concepts of plant taxonomy and classification of Angiosperms. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                               |                                         |
| Credits: 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Core Compulsory                               |                                         |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Min. Passing Marks:                           |                                         |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                               |                                         |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Topic*<br>*(Perform Any three experiments from each unit as per facility)                                                                                                                                                                                                                                                                                                                                                                                                                           |                                               | No. of Lectures<br>(60 hrs)             |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Herbarium: Plant collecting, Preservation and Documentation:<br>Stepwise Practicing Herbarium techniques: a. FIELD EQUIPMENTS, Global Positioning System (GPS) instrument & Collection of any wild 25 plant specimens b. Learn to handle Herbarium making tools c. Pressing and Drying of collected plant specimens d. Special treatments for all varied groups of plants e. Mount on standard herbarium sheets f. Label them using Standard method g. Organize them and give Index Register Number |                                               | 7                                       |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Taxonomic Identification using plant structure<br>Classify 25 plants on the basis of Taxonomic description (Plant Morphology, Anatomy, Reproductive parts, Habit, adaptation anomalies) according to Bentham and Hooker natura system of classification in the following families: Malvaceae, Fabaceae (Papilionaceae), Solanaceae, Scrophulariaceae, Acanthaceae, Labiatae (Lamiaceae), Rubiaceae.                                                                                                 |                                               | 8                                       |

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|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>III</b> | <b>Identification during excursions</b><br>a. Conducting Spot identification (Binomial, Family) of common wild plants from families included in the theoretical syllabus (list to be provided) and making FIELD NOTE BOOK and filling Sample of a page of field-book, used in Botanical Survey of India.<br>b. Describe/compare flowers in semi-technical language giving V.S. of flowers, T.S. of ovaries, floral diagrams and Floral Formulae. Identify and assign them to their respective families giving reasons. | <b>8</b> |
| <b>IV</b>  | <b>COLLECTION, PRESERVATION AND STORAGE OF ALGAE, FUNGI BRYOPHYTES,</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>7</b> |

|             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|             | <b>PTERIDOPHYTES (Two each)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |
| <b>V</b>    | <b>Botanical Nomenclature &amp; reporting Method:</b><br>a. Give nomenclature to collected plants as per ICN rules and prepare labels as per BSI<br>b. Author Citation, Effective Publication and Principle of Priority: To show a specimen paper on Basic structure of a taxonomic Research published on a new species in taxonomic journal                                                                                                                                         | <b>7</b> |
| <b>VI</b>   | <b>COMPUTERS</b><br>1. Learning to use EXCEL Microsoft PowerPoint and Word., WORKING WITH FOLDER AND WINDOWS UTILITY., CREATE AND MANAGE FILES AND FOLDER TREE,<br>2. Practice browsing different sites using search engines. practice and understand different E-Mail services – Outlook, Yahoo mail, rediffmail etc. Practice Creating E-Mail accounts, Sending, Receiving & Storing of mails.<br>3. Create and Participate in virtual conferencing in an interactive Zoom Meeting | <b>7</b> |
| <b>VII</b>  | <b>Computer usage &amp; Android Applications</b><br>1. Use Taxonomic Softwares (Dichotomous Key)<br>2. Practicals on Phylogenetic analysis<br>3. Make line drawing of Plants for description<br>4. Using of plant identification apps on android phones                                                                                                                                                                                                                              | <b>8</b> |
| <b>VIII</b> | 1. Create a Bonsai of any plant<br>2. Develop a miniature garden<br>3. Draw Layouts of various types of gardens<br>4. Plant Propagation methods practice                                                                                                                                                                                                                                                                                                                             | <b>8</b> |



**Suggested Readings:****Course Books published in Hindi may be prescribed by the Universities.**

1. प्रयोगात्मक वनस्पतितत्वज्ञानभाग 2 लेखक : अशोक बेंद्रे तथा अशोक कुमार प्रकाशन: रस्तोगी प्रकाशन, मेरठ
2. प्रयोगात्मक वनस्पतितत्वज्ञानभाग 3 लेखक : अशोक बेंद्रे तथा अशोक कुमार प्रकाशन: रस्तोगी प्रकाशन, मेरठ
3. प्रायोगिक वनस्पतितत्वज्ञान बीएस-सी-I, II, III एसबी अग्रवाल प्रकाशक : अग्रवाल एण्ड कम्पनी
4. प्रायोगिक वनस्पतितत्वज्ञान **II Author Name: - Dhankar - Sharma - Trivedi RBD Publication House**
1. Day, S.C. (2003) A Art of Miniature Plant Culture. - Agrobios. Jodhpur, India.
2. Practical Taxonomy of Angiosperms By : R K Sinha ISBN : 9789386768520 I.K International Publishing House Pvt. Ltd.
3. Day, S.C. (2003) Complete Home Gardening. (2003) Agrobios, Jodhpur, India.
4. Dhopte, A.M. (2003) Principles and Techniques for Plant Scientists. - Agrobios, Jodhpur, India.
5. Khan, M.R. (1995) Horticulture and Gardening. - Nirali Prakashan, Pune. India.
6. Pramila Mehra Gardening for everyone-. Hind pocket book private limited, New Dehli.
7. Kumarsen V. Horticulture, Saras Publication
8. Ramesh Bangia Learning Computer Fundamentals.,, Khanna Book Publishers
9. Bose T.K. & Mukherjee, D., 1972, Gardening in India, Oxford & IBH Publishing Co., New Delhi.
10. Sandhu, M.K., 1989, Plant Propagation, Wile Eastern Ltd., Bangalore, Madras.
11. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied Publishers.
12. Bole, P. V. and Vaghani, Y. (1986) Field guide to the common trees of India. Oxford University Press; Bombay.
13. Womersley, J. S. 1981. Plant collecting and herbarium development: A manual.
14. Brandis, D. (1906) Indian Trees (London, 5th edition. 1971). International Book Distributors; Dehra Du
15. Dallwitz, M. J., Paine, T. A. and Zurcher, E. J. (2003). Principles of interactive keys. <http://delta-intkey.com>  
<https://www.naace.co.uk/school-improvement/ict-mark/>
16. Manilal, K. S. and M. S. Muktesh Kumar (ed.) (1998) A Hand book of Taxonomy Training, DST, N. Delhi
17. Naik, V. N. (1984) Taxonomy of Angiosperms Tata McGraw-Hill Publication Com. Ltd., New Delhi
18. Primak, R. B. (2004) A Primer of Conservation Biology. Sinauer Associates, Inc. Publishers
19. Quicke, Donald, L. J. (1993) Principles and Techniques of Commemorative Taxonomy. Blakie, Academic and Professional, London
20. Singh, G (2004) Plant Systematics: Theory and practice Oxford and YBH Publishing Co. Pvt. Ltd., New Delhi
21. Bridson, D. & L. Forman. eds. 1998. The Herbarium Handbook. 3rd ed. Royal Botanic Gardens, Kew (Reprinted 1999).
22. De Vogel, E.F. 1987. Manual of Herbarium Taxonomy: Theory and Practice. UNESCO, Jakarta.
23. Fosberg, F.R. & M.-H. Sachet. 1965. Manual for tropical herbaria. Int. Bur. Pl. Tax. & Nom., Regnum Vegetabile Vol. 39. Utrecht.
24. Jain, S.K. & R.R. Rao. 1977. A handbook of field and herbarium methods. Today & Tomorrow's Printer and Publishers, New Delhi.
25. Victor, J.E., M. Koekemoer, L. Fish, S.J. Smithies, M. Mossmer. 2004. Herbarium essentials: the South African Herbarium user manual. Southern African Botanical Diversity Network Report No. 25. SABONET, Pretoria.

**This course can be opted as an elective by the students of following subjects: Open to all but special for B.Sc. Biotech, B.Sc. Microbiology, B.Sc. Agriculture, B.A. (Curators), B.A. Archaeology, B.A. Geology, BAMS.**

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall be as follows:

| Internal Assessment             | Marks     |  |
|---------------------------------|-----------|--|
| Class Interaction               | 5         |  |
| Botanical Excursion- compulsory | 12        |  |
| Assignment                      | 8         |  |
|                                 | <b>25</b> |  |

**Course prerequisites:**

**Qualification:** To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry)

**Facilities:** Smart and Interactive Class

**Other Requisites:** : Video collection, Books, CDs, Flora, Herbarium, Access to On-line resources, Display Charts

**Lab Requisites:** Microscopes (Compound, Stereo) Dissection box, stain, Herbarium, Herbarium press, Dryers, Grinder, Reference Flora

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**Suggested equivalent online courses:**

1. <http://egyankosh.ac.in/bitstream/123456789/13096/1/Unit-5.pdf>
2. <https://www.for.gov.bc.ca/hfd/pubs/docs/wp/wp18.pdf>
3. [https://www.researchgate.net/publication/267510854\\_The\\_Flowering\\_Plants\\_Handbook](https://www.researchgate.net/publication/267510854_The_Flowering_Plants_Handbook)

**Any Other :**

**Botanical Excursions:** One teacher along with a batch not more than 7 students be taken for botanical excursion to places of Botanical interest, one in each term. If there are female students in a batch of 7 students, one additional lady teacher is permissible for excursion.

Each excursion will not be more than SEVEN days during college working days. T.A. and D.A. for teachers and non-teaching staff participating in excursions should be paid as per rules. Tour report duly certified by tour in charge teacher and Head of the Department should be submitted at the time of practical examination. For every study tour take the prior permission of the head of the department and Principal.

The marks will be counted under Internal assessment and external assessment both. In external assessment student will have to present his excursion report along with industrial training/central labs visits and BSI or Museum visits. In internal assessment he shall have to label the campus plants with botanical details/develop herbal/floristic garden/conservé plants in botanical garden/contribute specimens via collection.

A project supported along with photographs taken during field study to be submitted giving comprehensive idea about different types of inflorescence, flowers and fruits/

At least three field excursions at hills/Oceans/Deserts including one Compulsory excursion to Botanical Garden, FRI/BSI and Central National Herbarium (CNH). Central Research Institutes/Hot Spots

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## **B.Sc.-IV Semester**

25/11/2020

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------------|
| BSc                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Year: II            | Semester: IV<br>Paper-I     |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                             |
| Course Code: B040401T                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Course Title: Economic Botany, Ethnomedicine and<br>Phytochemistry                                                                                                                                                                                                                                                                                                                                                                                        |                     |                             |
| Course outcomes: After the completion of the course the students will be able to:<br>1. Understand about the uses of plants –will know one plant-one employment<br>2. Understand phytochemical analysis related to medicinally important plants and economic products produced by the plants<br>3. know about the importance of Medicinal plants and its useful parts, economically important plants in our daily life and also about the traditional medicines and herbs, and its relevance in modern times. |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                             |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Core Compulsory     |                             |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Min. Passing Marks: |                             |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                             |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Topic                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     | No. of Lectures<br>(60 hrs) |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Origin and domestication of cultivated plants<br>Centers of diversity of plants, origin of crop plants. Domestication and introduction of crop plants. Concepts of sustainable development; cultivation, production and uses of Cereals, legumes, Spices & beverages.                                                                                                                                                                                     |                     | 7                           |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Botany of oils, Fibers, timber yielding plants & dyes<br>Study of the plants with Botanical names, Family, part used, and economic uses yielding Edible & essential oils; Sugar, Starch; Fibers; Paper, Fumitories & Masticatories, Rubber, Dyes, Timber, biofuel crops.                                                                                                                                                                                  |                     | 7                           |
| III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Commercial production of Flowers, Vegetables, and fruits (To be Chosen area wise)<br>Commercial greenhouse cultivation of rose, Gerbera, Gladiolus, Anthurium/lilium/lily, tomato, bell pepper, cucumber, strawberry & Exotic leafy vegetables using Hydroponics.                                                                                                                                                                                         |                     | 7                           |
| IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | IPR & Traditional Knowledge<br>IPR and WTO (TRIPS, WIPO), Patent Act 1970 and its amendments, TIFAC, NRDC, Rights, Procedure of obtaining patents, Working of patents, Infringement, Copyrights, Trademarks, Geographical Indications, Traditional Knowledge Digital Library, Protection of Traditional Knowledge & Protection of Plant Varieties and Biotech inventions.                                                                                 |                     | 8                           |
| V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Ethnobotany<br>Methodologies of ethnobotanical research: Field work, Literature, Herbaria and Musea and other aspects of ethnobotany. Importance of ethnobotany in Indian systems of medicine (Siddha, Ayurveda and Unani), Role of AYUSH, NMPB, CI-MAP and CARI. Tribal knowledge towards disease diagnosis, treatment, medicinal plants, plant conservation and cultivation.                                                                            |                     | 8                           |
| VI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Medicinal aspects<br>Study of common plants used by tribes ( <i>Aegle marmelos</i> , <i>Ficus religiosa</i> , <i>Cynodon dactylon</i> , <i>Eclipta alba</i> , <i>Oxalis</i> , <i>Ocimum sanctum</i> and <i>Trichopus zeylanicus</i> )<br>Ethnobotanical aspect of conservation and management of plant resources, Preservation of primeval forests in the form of sacred groves of individual species and Botanical uses depicted in our epics. Plants in |                     | 8                           |

|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |   |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
|      | primary health care: common medicinal plants: <i>Tinospora</i> , <i>Acorus</i> , <i>Ocimum</i> , <i>Turmeric</i> and <i>Aloe</i> . Indian Pharmacopeia, Quality Evaluation of crude drugs & adulteration                                                                                                                                                                                                                                                                                                                                                                                                                         |   |
| VII  | <b>Pharmacognosy</b><br>Preparation of drugs for commercial market - Organoleptic evaluation of drugs - Microscopic evaluation of drugs - Physical evaluation of drugs - Active and inert constituents of drugs - Classification of drug plants - individual drugs - drug adulteration. Sources of crude drugs – roots, rhizome, bulb, corm, leaves, stems, flowers, fruits and seeds ; organoleptic study of <i>Adhatoda vasica</i> , <i>Andrographis paniculata</i> , <i>Azadirachta indica</i> , <i>Coriandrum sativum</i> , <i>Datura metel</i> , <i>Eclipta alba</i> , <i>Emblica officinalis</i> , <i>Ocimum sanctum</i> , | 8 |
|      | <i>Phyllanthus amarus</i> , <i>Ricinus communis</i> , <i>Vinca rosea</i> and <i>Zingiber officinale</i> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |   |
| VIII | <b>Herbal Preparations &amp; Phytochemistry :</b><br>Collection of wild herbs - Capsules - compresses - Elixirs - Glycerites - Hydrotherapy or Herbal bath - Herbal oils - Liquid extracts or Tincture - Poultices - Salves - Slippery elm slurry and gruel<br>- Suppositories - Teas. Plant natural products , general detection, extraction and characterization procedures. Glycosides and Flavonoids and therapeutic applications. Anthocyanins and Coumarins and therapeutic applications, Lignans, Terpenes, Volatile oils and Saponins, Carotenoids and Alkaloids Carotenoids and pharmacological activities.             | 7 |







**Suggested Readings:**

1. Aushdhiye Poudhe (Hindi) by R.P. Sharma | 1 January 2013 YKING BOOKS
1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
2. Sambamurthy, AVSS & Subrahmanyam, NS (2000). Economic Botany of Crop Plants. Asiatech Publishers. New Delhi.
3. Singh, D.K and K.V. Peter. 2014. Protected cultivation of horticultural crops. New India Publishing Agency, India.
4. Reddy P. Parvatha. 2016. Sustainable crop protection under protected cultivation. Springer, Singapore.
5. Amit Deogirikar. 2019. A Text Book on Protected Cultivation and Secondary Agriculture. Rajlaxmi Prakashan, Aurangabad, India.
6. Singh, B., B. Singh, N. Sabir and M Hasan. 2014. Advances in protected cultivation. New India Publishing Agency, India.
7. Sharma, OP. 1996. Hill's Economic Botany (Late Dr. AF Hill, adopted by OP Sharma). Tata McGraw Hill Co. Ltd., New Delhi.
8. Joe J. Hanan. 1997. Greenhouses: Advanced Technology for protected horticulture. CRC Press.
9. Krishnamurthy, K.V. (2004). An Advanced Text rbook of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi
10. N.K. Acharya: Textbook on intellectual property rights, Asia Law House (2001).
11. Manjula Guru & M.B. Rao, Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications (2003).
12. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill (2001).
13. Arthur Raphael Miller, Micheal H.Davis; Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers (2000).
14. Jayashree Watal, Intellectual property rights in the WTO and developing countries, Oxford University Press, Oxford.
15. Jain, S. K. and V. Mudgal. 1999. A Handbook of Ethnobotany. Bishen Singh Mahendra Pal Singh, Dehradun.
16. Jeffrey, C. 1982. An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge. London.
17. Joshi, S. G. 2000. Medicinal Plants. Oxford and IBH, New Delhi.
18. Kokate, C. and Gokeale- Pharmacognacy- Nirali Prakashan, New Delhi.
19. Lad, V. 1984. Ayurveda – The Science of Self-healing. Motilal Banarasidass, New Delhi.
20. Lewis, W. H. and M. P. F. Elwin Lewis. 1976. Medical Botany. Plants Affecting Man's Health. A a. Wiley Inter science Publication. John Wiley and Sons, New York.
21. Farooqui, A. A. and Sreeraman, B. S. 2001. Cultivation of medicinal and aromatic crops. Universities Press.
22. Harborne, J. B. 1998. Phytochemical methods – a guide to modern techniques of plant analysis 3 rd edition, Chapman and Hall.
23. Yesodha, D., Geetha, S and Radhakrishnan, V. 1997. Allied Biochemistry. Morgan publications, Chennai. 1. Gurdeep Chatwal, 1980. Organic chemistry of natural productis. Vol. I. Himalaya Publishing house.
24. Kalsi, P. S. and Jagtap, S., 2012. Pharmaceutical medicinal and natural product chemistry. N.K. Mehra for Narosa Publishing House Pvt. Ltd. New Delhi.
25. Wallis, T. E. 1946. Text book of Pharmacognosy, J & A Churchill Ltd.
26. Roseline, A. 2011. Pharmacognosy. MJP Publishers, Chennai.
27. Jain S. K. 1989. Methods and approaches in Ethnobotany, Society of Ethnobotanists, Lucknow.
28. Sharol Tilgner, N. D. 1999. Herbal medicine - From the heart of the earth. Edn. 1, Printed in the USA by Malloy Lithographing Inc.
29. Pal, D.C. & Jain, S.K., 1998. Tribal Medicine. Naya Prakash Publishers, Calcutta.
30. Datta & Mukerji, 1952. Pharmacognosy of Indian roots of Rhizoms drugs. Bulletin No.1 Ministry of Health, Govt. of India.
31. Young Ken, H.W., 1948. Text Book of Pharmacognosy. Blakiston C., Philadelphia.

32. Shukla, R.S., 2000. Forestry for tribal development. A.H. Wheeler & Co. Ltd., India.
33. Raychudhuri, S.P., 1991. (Ed.) Recent advances in Medicinal aromatic and spice crops. Vol.1, Today & Tomorrow's printers and publishers, New Delhi.
34. Bajpai, P.K. 2006. Biological Instrumentation and methodology. S. Chand & Co. Ltd.
35. K. Wilson and J. Walker Eds. 2005. Biochemistry and Molecular Biology. Cambridge University Press.
36. k. Wilson and KH Goulding. 1986. Principles and techniques of Practical Biochemistry. (3 edn Edward Arnold, London.

**This course can be opted as an elective by the students of following subjects: Open to all but special for B.Sc. Biotech, B.Sc. Microbiology, B.Sc. Agriculture, B.A. (Curators), B.A. Archaeology, B.A. Geology, BAMS.**

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall be as follows:

| Internal Assessment | Marks |  |
|---------------------|-------|--|
|---------------------|-------|--|

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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| Class Interaction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 5         |
| Quiz                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 5         |
| Seminar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 7         |
| Assignment (Charts/ Flora/ Rural Service/ Technology Dissemination)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 8         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>25</b> |
| <b>Course prerequisites:</b><br><b>Qualification:</b> To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry)<br><b>Facilities: Smart and Interactive Class</b><br><b>Other Requisites: : Video collection, Books, CDs, Flora, Herbarium, Access to On-line resources, Display Charts</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |
| <b>Suggested equivalent online courses:</b><br><a href="https://www.pnas.org/content/104/suppl_1/8641">https://www.pnas.org/content/104/suppl_1/8641</a><br><a href="https://www.journals.uchicago.edu/doi/pdfplus/10.1086/659998">https://www.journals.uchicago.edu/doi/pdfplus/10.1086/659998</a><br><a href="https://bsi.gov.in/page/en/ethnobotany">https://bsi.gov.in/page/en/ethnobotany</a><br><a href="http://www.legalserviceindia.com/article/198-Intellectual-Property-and-Traditional-knowledge.html">http://www.legalserviceindia.com/article/198-Intellectual-Property-and-Traditional-knowledge.html</a><br><a href="https://www.brainkart.com/article/Economic-importance-Plants---Food,-Rice,-Oil,-Fibre,-Timber-yielding-plant_1095/">https://www.brainkart.com/article/Economic-importance-Plants---Food,-Rice,-Oil,-Fibre,-Timber-yielding-plant_1095/</a><br><a href="https://www.loc.gov/rr/scitech/tracer-bullets/economic-botanytb.html">https://www.loc.gov/rr/scitech/tracer-bullets/economic-botanytb.html</a><br><a href="http://nsdl.niscair.res.in/bitstream/123456789/127/1/Fibre%20crops%2C%20bamboo%2C%20timber%20-%20Final.pdf">http://nsdl.niscair.res.in/bitstream/123456789/127/1/Fibre%20crops%2C%20bamboo%2C%20timber%20-%20Final.pdf</a><br><a href="https://www2.palomar.edu/users/warmstrong/econpls.htm">https://www2.palomar.edu/users/warmstrong/econpls.htm</a><br><a href="https://www.longdom.org/proceedings/phytochemistry-and-phytoconstituents-of-herbal-drugs-and-formulations-1668.htm">https://www.longdom.org/proceedings/phytochemistry-and-phytoconstituents-of-herbal-drugs-and-formulations-1668.htm</a> |           |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-----------------------------|
| BSc                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Year:<br>II                                              | Semester: IV<br>Paper-II    |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                          |                             |
| Course Code: B040402P                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Course Title: Commercial Botany & Phytochemical Analysis |                             |
| Course outcomes: After the completion of the course the students will be able to:<br>1. Know about the commercial products produced from plants.<br>2. Gain the knowledge about cultivation practices of some economic crops.<br>3. Understand about the ethnobotanical details of plants.<br>4. Learn about the chemistry of plants &herbal preparations<br>5. Can become a protected cultivator, aromatic oil producer, Pharmacologist or quality analyst in drug company. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                          |                             |
| Credits: 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Core Compulsory                                          |                             |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Min. Passing Marks:                                      |                             |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-2                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                          |                             |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Topic<br>(Perform minimum any three experiments from each unit)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                          | No. of Lectures<br>(60 hrs) |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Economic Botany & Microtechnique:<br>Cereals: Wheat (habit sketch, L.S./T.S. of grain, starch grains, micro-chemical tests); rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests)                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                          | 8                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Legume: Pea or ground nut (habit, fruit, seed structure, micro-chemical tests)<br>Source of sugars and starches: Sugarcane (habit sketch; cane juice- micro-chemical tests); potato (habit sketch, tuber morphology, T.S. of tuber to show localization of starch grains, W.M. of starch) grains, micro-chemical tests.<br>Tea- tea leaves, tests for tannin<br>Mustard- plant specimen, seeds, tests for fat in crushed seeds<br>Timbers: section of young stem. Jute- specimen, transverse section of stem, tests for lignin on T.S. of stem and study of fiber following maceration technique.<br>Study of specimens of economic importance mentioned in Unit I-& II |                                                          |                             |



|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| II   | <b>Commercial Cultivation</b><br>Field visit to Green houses for understanding Floriculture & vegetables production<br>Development of hydroponics nutrient solutions & running models for cultivation of vegetables<br>Development of hydroponics nutrient solutions & running models for cultivation of fodder                                                                                                                                                                                                | 8 |
| III  | <b>Cultivating Medicinal and aromatic plants &amp; Essential oil extraction</b><br>a. Lemon grass/ Neem/ Zinger /Rose/Mint                                                                                                                                                                                                                                                                                                                                                                                     | 7 |
| IV   | <b>Documentation from</b> Traditional Knowledge Digital Library, Mark the Geographic Indications on Map,<br>Understand –Nakshtra Vatika, Navgrah vatika and develop in your college<br>To extract the names of the plants and Botanical uses depicted in our epics. Visit NISCAIR, New Delhi                                                                                                                                                                                                                   | 7 |
| V    | <b>Ethnobotany</b><br>Study of common plants used by tribes. <i>Aegle marmelos</i> , <i>Ficus religiosa</i> , <i>Cynodon dactylon</i> . Visit a tribal area and collect information on their traditional method of treatment using crude drugs.<br>Familiarize with at least 5 folk medicines and study the cultivation, extraction and its medicinal application.<br>Observe the plants of ethnobotanical importance in your area.<br>Visit to an Ayurveda college or Ayurvedic Research Institute / Hospital | 7 |
| VI   | <b>Instrumentation and herbal Preparations</b><br>Develop Capsules of herbs/ Develop Herbal oils/ Develop Poultice/cream Analyse some active ingredients using chromatography /Spectrophotometry                                                                                                                                                                                                                                                                                                               | 8 |
| VII  | <b>Pharmacognosy</b><br>Organoleptic studies of plants mentioned in the theory :<br>1. Morphological studies of vegetative and floral parts.<br>2. Microscopic preparations of root, stem and leaf.<br>3. Stomatal number and stomatal index.<br>4. Vein islet number.<br>5. Palisade ratio.<br>6. Fibres and vessels (maceration).<br>7. Starch test<br>8. Proteins and lipid test                                                                                                                            | 8 |
| VIII | <b>Phytochemistry:</b><br>Determination of the percentage of foreign leaf in a drug composed of a mixture of leaves. Dimensions of Calcium oxalate crystals in powdered crude drug.<br>Preliminary phytochemical tests for alkaloids, terpenoids, glycosides, volatile oils, tannins & resins.<br>Any 5 herbal preparations.                                                                                                                                                                                   | 7 |

**Suggested Readings:**

**Course Books published in Hindi may be prescribed by the Universities.**

1. Plant Ecology And Economic Botany by Dhankar - Sharma - Trivedi, RBD Publication
2. फार्माकोगोसी, Shiva Kant, Pankaj Kumar Brahmiya : Thakur Publication
3. PHARMACOGNOSY ...Hindi Edition (Paperback, Hindi, Dr. Aancha Rashi, KHUSHAL JASWANI), RM Publication.
4. प्रयोगात्मक वनस्पति विज्ञान भाग 2 लेखक अशोक बेंद्रे, वि. अशोक कुरा, प्रकाशनः स्तोत्री प्रकाशन, रं. ठि
1. Wallis, T. E. 1946. Textbook of Pharmacognosy, J & A Churchill Ltd.
2. Roseline, A. 2011. Pharmacognosy. MJP Publishers, Chennai.
3. Jain S. K. 1989. Methods and approaches in Ethnobotany, Society of Ethnobotanists, Lucknow.
4. Pal, D.C. & Jain, S.K., 1998. Tribal Medicine. Naya Prakash Publishers, Calcutta.
5. Datta & Mukerji, 1952. Pharmacognosy of Indian roots of Rhizome drugs. Bulletin No.1 Ministry of Health, Govt. of India.
6. Young Ken, H.W., 1948. Text Book of Pharmacognosy. Blakiston C., Philadelphia.
7. Shukla, R.S., 2000. Forestry for tribal development. A.H. Wheeler & Co. Ltd., India.
8. Raychudhuri, S.P., 1991. (Ed.) Recent advances in Medicinal aromatic and spice crops. Vol.1, Today & Tomorrow's printers and publishers, New Delhi.
9. Khasim S.M Botanical Microtechniques: Principles and Practice-
10. Sambamurthy, AVSS & Subrahmanyam, NS (2000). Economic Botany of Crop Plants. Asiatech Publishers. New Delhi.
11. Singh, D.K and K.V. Peter. 2014. Protected cultivation of horticultural crops. New India Publishing Agency

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| <b>This course can be opted as an elective by the students of following subjects: Open to all but special for B.Sc. Biotech, B.Sc. Microbiology, B.Sc. Agriculture, B.A. (Curators), B.A. Archaeology, B.A. Geology, BAMS.</b> |           |  |
| <b>Suggested Continuous Evaluation Methods:</b>                                                                                                                                                                                |           |  |
| Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall be as follows:                                                                                                           |           |  |
| Internal Assessment                                                                                                                                                                                                            | Marks     |  |
| Class Interaction                                                                                                                                                                                                              | 5         |  |
| Quiz                                                                                                                                                                                                                           | 5         |  |
| Seminar                                                                                                                                                                                                                        | 7         |  |
| Assignment (Charts/ Flora/ Rural Service/ Technology Dissemination)                                                                                                                                                            | 8         |  |
|                                                                                                                                                                                                                                | <b>25</b> |  |
| <b>Course prerequisites:</b>                                                                                                                                                                                                   |           |  |
| <b>Qualification:</b> To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry)                    |           |  |
| <b>Facilities: Smart and Interactive Class</b>                                                                                                                                                                                 |           |  |
| <b>Other Requisites: :</b> Video collection, Books, CDs, Flora, Herbarium, Access to On-line resources, Display Charts                                                                                                         |           |  |
| <b>Lab requisites: Repository of economic products, Microscopes/ Botanical /Herbal Garden, TLC, Spectrophotometer.</b>                                                                                                         |           |  |
| <b>Suggested equivalent online courses:</b>                                                                                                                                                                                    |           |  |
| <a href="https://www.entrepreneurindia.co/Document/Download/pdfanddoc-144615-.pdf">https://www.entrepreneurindia.co/Document/Download/pdfanddoc-144615-.pdf</a>                                                                |           |  |
| <a href="http://nopr.niscair.res.in/handle/123456789/45825">http://nopr.niscair.res.in/handle/123456789/45825</a>                                                                                                              |           |  |
| <a href="https://www.wipo.int/export/sites/www/tk/en/resources/pdf/medical_tk.pdf">https://www.wipo.int/export/sites/www/tk/en/resources/pdf/medical_tk.pdf</a>                                                                |           |  |
| <a href="https://www.bentoli.com/commercial-farming-agriculture/">https://www.bentoli.com/commercial-farming-agriculture/</a>                                                                                                  |           |  |







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| <b>BSc</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                       | <b>Year: II</b>        | <b>Semester: IV<br/>Paper-III</b> |
| <b>Subject: Botany</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                       |                        |                                   |
| Course Code: B040403R                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Course Title: <b>Project in Botany for Graduation</b> |                        |                                   |
| <p><b>Course outcomes:</b> After completing this course a student will have:</p> <p>Project work will supplement field experimental learning and deviations from classroom and laboratory transactions.</p> <p>Project work will enhance the capability to apply gained knowledge and understanding for selecting, solving and decision-making processes</p> <p>It will promote creativity and the spirit of enquiry in learners.</p> <p>They will learn to consult Scientists, libraries, laboratories and her bariums and learn importance of discussions, Botanical &amp; field trips, print and electronic media, internet etc. along with data documentation, compilation, analysis &amp; representation in form of dissertation writing.</p> <p>It will enhance their abilities,enthusiasm and interest.</p> |                                                       |                        |                                   |
| Credits: <b>3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                       | <b>Core Compulsory</b> |                                   |
| Max. Marks: <b>100</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                       | Min. Passing Marks:    |                                   |
| Total No. of Lectures-Tutorials-Practical (in hours per week): <b>1-0-2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                       |                        |                                   |
| <div><div></div><div><div>1. Rural Areas: Flora of a city/village, Biodiversity of Village, Soil &amp; Seed testing service provision to farmers.</div><div>2. Industrial Waste Management</div><div>3. Water Pollution status of rural water &amp; promotion of WASH in Villages</div><div>4. Plant Disease identification in farms, nurseries and orchards.</div><div>5. Digital portal for plants: Campus, city or particular area.</div><div>6. Rare and endangered plants and their conservation &amp; domestication</div><div>7. Phytochemistry of medicinal plant &amp; their antimicrobial, nutraceutical and antioxidant properties</div></div></div>                                                                                                                                                     |                                                       |                        |                                   |
| <p><b>Note:-</b> The student shall be required to submit a research project at the end of 2nd year. In case, the student is unable to submit the project at the desired period, he/she shall have to submit it in the V semester of III year, otherwise he/she will not be considered to have passed 2nd year.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                       |                        |                                   |







## BOTANY MINOR

|                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                             |                                           |                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|------------------------|
| Program/Class:<br>B.Sc.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                             | Year : II                                 | Semester: IV           |
| <b>Subject: Botany</b>                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                             |                                           |                        |
| Course Code : B040404TM                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                             | Course Title : PLANT RESOURCE UTILIZATION |                        |
| Course Outcomes:<br>After learning the course the students will be able to:<br>1. Understand the utilization of plant resources in various fields food & nutrition, medicine, economic benefits, (timber & fibre), cultural 4 Aesthetic Values and Ethnobotanical Value<br>2. Knowledge about Patent rights, Green house cultivation and soilless culture. |                                                                                                                                                                                                                                                             |                                           |                        |
| Credits: 6                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                             | Minor                                     |                        |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                             | Min. Passing Marks:                       |                        |
| Total No. of Lectures-Tutorial-Practicals (in hour per week) L-T-P : 4-0-0                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                             |                                           |                        |
| <b>Unit</b>                                                                                                                                                                                                                                                                                                                                                | <b>Topics</b>                                                                                                                                                                                                                                               |                                           | <b>No. of Lectures</b> |
| I                                                                                                                                                                                                                                                                                                                                                          | Centres of diversity of plants, Domestication and introduction of crop plants. Concepts of sustainable development;.                                                                                                                                        |                                           | 10                     |
| II                                                                                                                                                                                                                                                                                                                                                         | Cultivation, production and uses of Cereals, millets, pseudocereals, legumes, Spices & beverages.                                                                                                                                                           |                                           | 9                      |
| III                                                                                                                                                                                                                                                                                                                                                        | Economic uses of plants Study of the plants with Botanical names, Family, part used, and economic uses yielding Edible & essential oils; Sugar, Timber, biofuel crops                                                                                       |                                           | 9                      |
| IV                                                                                                                                                                                                                                                                                                                                                         | Greenhouse cultivation and Hydroponics Commercial greenhouse cultivation of rose and Gladiolus. Production of tomato, cucumber, and exotic leafy vegetables using Hydroponics.                                                                              |                                           | 5                      |
| V                                                                                                                                                                                                                                                                                                                                                          | Patents IPR & Traditional Knowledge IPR and WTO (TRIPS, WIPO), Patent Act 1970 and its amendments.                                                                                                                                                          |                                           | 5                      |
| VI                                                                                                                                                                                                                                                                                                                                                         | Ethnobotany Importance of ethnobotany in Indian systems of medicine (Siddha, Ayurveda and Unani), Role of AYUSH and CIMAP.                                                                                                                                  |                                           | 5                      |
| VII                                                                                                                                                                                                                                                                                                                                                        | Medicinal importance of plants Medicinal importance of Adhatoda vasica, Azadirachta indica, Coriandrum sativum, Datura metel, Eclipta alba, Emblica officinalis, Ocimum sanctum, Phyllanthus amarus, Ricinus communis, Vinca rosea and Zingiber officinale. |                                           | 10                     |

|      |                                                                                                                                                                                                                            |   |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| VIII | -Other uses of plants : Biofertilizer algal compost and microbial compost Green manure plants, energy plantations, anti-pollution plants. bioindicator plants, Phytoremediation, biopesticides derived from plant extract. | 7 |
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**Suggested Readings:**

1. A Text Book On PLANT RESOURCES UTILIZATION AND CONSERVATION by R. K. Behera et al..
2. Plant Resources Utilization and Conservation by P. C. Trivedi & Niranjana Sharma.
3. Plant Resource Utilisation Palynology and Biostatistics by Singh, Pande, & Jain.
4. Plant Resources Management Utilization by Auti, Khairnar, & Mahajan (for Pune University syllabus).
5. Underutilized Plant Resources of the Himalayas by Sood (focusing on medicinal, edible, fodder plants).
6. Economic Botany: A Comprehensive Study by S. L. Kochhar (often cited in its 5th Edition).
7. A Textbook of Economic Botany by A. V. S. S. Samba Murty & S. Subrahmanyam.
8. Textbook of Economic Botany by V. Verma.
9. Economic Botany by B.P. Pandey.
10. A Textbook of Modern Economic Botany (various editions/publishers).
11. Textbook of Economic Botany by Mishra S. R.

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***Bachelor of Science***  
***(Semester V and Semester VI)***

**B.Sc.-V Semester**

25/11/2020

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                     |                             |
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| BSc                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Year: III           | Semester: V<br>Paper-I      |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                     |                             |
| Course Code:<br>B040501T                                                                                                                                                                                                                                                                                                                                                                                                                                               | Course Title: Plant Physiology, Metabolism & Biochemistry                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                     |                             |
| Course outcomes: After the completion of the course the students will be able to:<br>1. Understand the role of Physiological and metabolic processes for plant growth and development.<br>2. Learn the symptoms of Mineral Deficiency in crops and their management.<br>3. Assimilate Knowledge about Biochemical constitution of plant diversity.<br>4. Know the role of plants in development of natural products, nutraceuticals, dietary supplements, antioxidants |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                     |                             |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Core Compulsory     |                             |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Min. Passing Marks: |                             |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                     |                             |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Topic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     | No. of Lectures<br>(60 hrs) |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Plant water relation, Mineral Nutrition, Transpiration and translocation in phloem<br>Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.<br>Criteria of essentiality of elements; Role of essential elements; Symptoms of mineral deficiency in major crops,<br>Transport of ions across cell membrane, active and passive transport, Composition of phloem sap, girdling experiment; Pressure flow model.                                   |                     | 7                           |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Carbon Oxidation<br>Krebs cycle, Glycolysis, fate of pyruvate- aerobic and anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of Krebs cycle, mitochondrial electron transport, oxidative phosphorylation, ATP-Synthetase, Chemiosmotic mechanism, P/O ratio, cyanide-resistant respiration, factors affecting respiration.                                                                                                                    |                     | 7                           |
| III                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Nitrogen Metabolism<br>Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes), Physiology and biochemistry of nitrogen fixation, Ammonia assimilation (GS-GOGAT), reductive amination and transamination, amino acid synthesis.                                                                                                                                                                                                                                                                                    |                     | 8                           |
| IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Lipid Metabolism & Photosynthesis<br>Lipid Metabolism: Synthesis and breakdown of triglycerides, -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination, -oxidation. ; Photosynthesis: Pigments, Action spectra and Enhancement effect, Electron transport system and<br>Photophosphorylation, C3 & C4 photosynthesis, CAM- Reaction and Significance                                                                                                                                          |                     | 7                           |
| V                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Plant Development, Movements, Dormancy & Responses<br>Developmental roles of Phytohormones (auxins, gibberellins, cytokinins, ABA, ethylene.) autonomic & paratonic movements, Control and Coordination in plants, Photoperiodism (SDP,                                                                                                                                                                                                                                                                                                              |                     | 8                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red-light responses on photomorphogenesis, Seed physiology & Dormancy, Vernalization & Senescence                                                                                                                                                                                                                                                                                                                                                                       |                     |                             |
| VI                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Biomolecules<br>Carbohydrates: Nomenclature and classification; Role of monosaccharides (glucose, fructose, sugar alcohols – mannitol and sorbitol); Disaccharides (sucrose, maltose, lactose), Oligosaccharides and polysaccharides (structural-cellulose, hemicelluloses, pectin, chitin, mucilage; storage – starch, inulin).<br>Lipids: Storage lipids: Fatty acids structure and functions, Structural lipids: Phosphoglycerides; Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers bilayers |                     | 8                           |



|             |                                                                                                                                                                                                                                                                                                                                                                                  |          |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>VII</b>  | <b>Proteins:</b> Structure of amino acids; Peptide bonds; Levels of protein structure-primary, secondary, Ramchandran plot, tertiary and quaternary; Isoelectric point; Protein denaturation and biological roles of proteins<br><b>Nucleic acids:</b> Structure of nitrogenous bases; Structure and function of nucleic acids, Nucleic acid denaturation & Re-naturation, MiRNA | <b>7</b> |
| <b>VIII</b> | <b>Enzymes:</b> Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; mechanism of action (activation energy, lock and key hypothesis, induced-fit theory), enzyme inhibition and factors affecting enzyme activity, Allosteric enzymes & Abzymes.<br>Phytonutrients, Nutraceuticals, dietary supplements and antioxidants                      | <b>8</b> |

**Suggested Readings:**

1. Hopkins, W.G. & Hiiner, N.P. Introduction to Plant Physiology (3rd ed.) 2004, John Wiley & Sons.
2. A Handbook On Mineral Nutrition And Diagnostic Techniques For Nutritional Disorders Of Crops (pb) ISBN : 9788177543377 Edition : 01 Year : 2011 Author : Pathmanabhan G , Vanangamudi M , Chandrasekaran CN , Sathyamoorthi K , Babu CR , Babu RC , Boopathi PN Publisher : Agrobios (India)
3. Jain, V.K. Fundamental of Plant Physiology (7th ed.) 2004. S. Chand and Company.
4. Salisbury, F.B. & Ross, C.W. Plant Physiology (4th ed.), 1992, Wadsworth Publishing Company.
5. Panday, S.N. & Sinha, B.K. Plant Physiology (4th ed.), 2006, Vikas Publishing House Pvt. Ltd.
6. Mukherjee, S. & Ghosh, A. Plant Physiology (2nd ed.), 2005, New Central Book Agency.
7. Chaudhuri, D., Kar, D.K., and Halder, S.A. Handbook of Plant Biosynthetic Pathways 2008, New Central Book Agencies.
8. Voet, D. and Voet, J.G., Bio-Chemistry (3rd ed.), 2005, John Wiley & Sons.
9. Mathews, C.K., Van Holder, K.E. & Ahren, K.G. Bio-Chemistry (3rd ed.), 2000, Pearson Education.
10. Lehninger Principles of Biochemistry. Sixth Edition. 2013. David L. Nelson, Michael M. Cox. Freeman, Macmillan.
11. Srivastava, HN. 2006. Pradeep's Botany Vol. V. Pradeep Publications, Jalandhar.
12. Verma, SK. Plant Physiology and Biochemistry. S. Chand & Sons, New Delhi.
13. Buchanon, Gruissen and Jones. Plant Physiology & Biochemistry: Biochemistry and Molecular Biology of plants, 2000, I.K. International.
14. Ramesh Gupta. Efficacy, Safety and Toxicity brings together all current knowledge regarding nutraceuticals and their potential toxic effects. 2016. Elsevier.
15. Harborne, J.B. 1973. Phytochemical Methods. John Wiley & Sons, New York.
16. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., 2008 Molecular Biology of the Gene 6th edition. Cold Spring Harbour Lab. Press, Pearson Pub.
17. P.K. Gupta. BIOTECHNOLOGY AND GENOMICS. Rastogi Publications, 7th Reprint (1st Edition): 2016-2017

**This course can be opted as an elective by the students of following subjects:** Open to all but special for following: B.Sc. Math, B.Sc. Statistics, B.Sc. Nutrition, B.Sc. Biophysics, B.Sc. Biotech,

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests

|                                                                  |           |  |
|------------------------------------------------------------------|-----------|--|
| Internal Assessment                                              | Marks     |  |
| Class Interaction                                                | 5         |  |
| Quiz                                                             | 5         |  |
| Seminar                                                          | 7         |  |
| Assignment (Charts/Flora/Rural Service/Technology Dissemination) | 8         |  |
|                                                                  | <b>25</b> |  |

**Course prerequisites:**

**Qualification:** To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry)

**Facilities: Smart and Interactive Class**

**Other Requisites: Video collection, Books, CDs, Flora, Herbarium, Access to On-line resources, Display Charts**

**Suggested equivalent online courses:**

<https://www.classcentral.com/course/swayam-plant-physiology-and-metabolism-17732>

<https://www.wiziq.com/course/3249-plant-physiology-in-10-live-online-classes>

<https://www.easybiologyclass.com/plant-physiology-free-lecture-notes-online-tutorials-lecture-notes-ppts-mcqs/>

[https://onlinecourses.swayam2.ac.in/cec19\\_bt09/preview](https://onlinecourses.swayam2.ac.in/cec19_bt09/preview)

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------------|
| BSc                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Year: III           | Semester: V<br>Paper-II     |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                             |
| Course Code:<br>B040502T                                                                                                                                                                                                                                                                                                                                                                                                                                    | Course Title: Molecular Biology & Bioinformatics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     |                             |
| <b>Course outcomes:</b> After the completion of the course the students will be able to:<br>1. Understand nucleic acids, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.<br>2. Know about Processing and modification of RNA and translation process, function and regulation of expression.<br>3. Gain working knowledge of the practical and theoretical concepts of bioinformatics |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                             |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Core Compulsory     |                             |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Min. Passing Marks: |                             |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                             |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Topic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     | No. of Lectures<br>(60 hrs) |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Genetic material</b><br>Miescher to Watson and Crick- historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase, bacteriophage experiment, DNA structure, types of DNA, types of genetic material. DNA replication (Prokaryotes and eukaryotes): semi- conservative. DNA replication (Prokaryotes and eukaryotes): bidirectional replication, semi- conservative, semi discontinuous RNA priming, Ø (theta) mode of replication, replication of linear, dsDNA, replicating the 5' end of linear chromosome including replication enzymes. |                     | 7                           |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Transcription &amp; Regulation of gene expression</b><br>Types of structures of RNA (mRNA, tRNA, rRNA), RNA polymerase- various types; Translation, (Prokaryotes and eukaryotes), genetic code. Regulation of gene expression in Prokaryotes: Lac operon and Tryptophan operon; and in Eukaryotes                                                                                                                                                                                                                                                                      |                     | 7                           |
| III                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Principles &amp; Techniques of genetic engineering</b><br>Blotting techniques: Northern, Southern and Western Blotting, DNA Fingerprinting; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR. Hybridoma and monoclonal antibodies, ELISA and Immunodetection. Antibody Engineering.                                                                                                                                                                                                                                      |                     | 8                           |
| IV                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Applications of Genetic engineering</b><br>Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products, Biosafety concerns.                                                                                                                                         |                     | 7                           |
| V                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Bioinformatics &amp; its applications</b><br>Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics,                                                                                                                                                                                                                                                                                                                                           |                     | 8                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.                                                                                                                                                                                                                                                                                                                                                          |                     |                             |
| VI                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Biological databases :</b><br>Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss- Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, )                                                                                                                                                                                                                                              |                     | 8                           |
| VII                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Data Generation and Data Retrieval</b><br>Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation;                                                                                                                                                                                                                                                                            |                     | 7                           |

|             |                                                                                                                                                                                                                                                                                                                                                                               |          |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|             | Data retrieval systems (SRS,Entrez)                                                                                                                                                                                                                                                                                                                                           |          |
| <b>VIII</b> | <b>Phylogenetic analysis</b><br>Similarity, identity and homology, Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA);<br>Phylogenetic analysis: Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees. | <b>8</b> |

**Suggested Readings:**

Course Books published in Hindi may be prescribed by the Universities.

1. Dr Pooja Rai आण्विक जीववैज्ञान एवं जैवतकनीकी, Bhopal.
2. Sharma - Trivedi Molecular Biology And Biotechnology (आण्विक जीववैज्ञान एवं जैवप्रौद्योगिकी)
3. Plant Physiology and Biochemistry ISBN #: 81-301-0035-5 Author: Sunil D Purohit, K. Ahmed & Gotam K Kukda Edition: 2013 Pages: 368 + VII Type: Text Book (Hindi)
4. Molecular Biology Biotechnology ISBN #: 81-301-0033-9 Author: Sunil D Purohit & Gotam K Kukda Edition: 2013 Pages: 366 + X Type: Text Book (Hindi) Apex Publishing House, Udaipur, Rajasthan
5. Bioinformatics Paperback – 1 January 2015 by Dr Archana Pandeya (Author), Santosh Choubey (Editor), & 2 More Hindi AISECT Ltd.
6. BIOTECHNOLOGY AND GENETIC ENGINEERING (Hindi, Hardcover, Dr. Archana Nigam)
  1. Primrose, SB. 1995. Principles of Genome Analysis. Blackwell Science Ltd. Oxford, UK..
  2. E.J. Gardner and D.P. Snustad. PRINCIPAL OF GENETICS (1984), John Wiley & Sons, New York.
  3. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., 2008 Molecular Biology of the Gene 6th edition. Cold Spring Harbour Lab. Press, Pearson Pub.
  4. Freifelder - Molecular Biology.
  5. P.K. Gupta. BIOTECHNOLOGY AND GENOMICS. Rastogi Publications, 7th Reprint (1st Edition): 2016-2017.
  6. Ghosh, Z., Mallick, B. (2008). Bioinformatics – Principles and Applications, 1st edition. New Delhi, Delhi: Oxford University Press.
  7. Baxevanis, A.D. and Ouellette, B.F., John (2005). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd edition. New Jersey, U.S.: Wiley & Sons, Inc.
  8. Roy, D. (2009). Bioinformatics, 1st edition. New Delhi, Delhi: Narosa Publishing House.
  9. Andreas, D., Baxevanis, B.F., Francis, Ouellette. (2004). Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition. New Jersey, U.S.: John Wiley and Sons.
  10. Pevsner J. (2009). Bioinformatics and Functional Genomics, 2nd edition. New Jersey, U.S.: Wiley Blackwell.
  11. Xiong J. (2006). Essential Bioinformatics, 1st edition. Cambridge, U.K.: Cambridge University Press
  12. A Textbook Of Basic And Molecular Genetics (pb) ISBN : 9788188826193 Edition : 01 Year : 2018 Author : Dr. Parihar P

**This course can be opted as an elective by the students of following subjects:** Open to all but special for following: B.Sc. Math, B.Sc. Statistics, B.Sc. Nutrition, B.Sc. Biophysics, B.Sc. Biotech, B.Sc. Forestry, B.Sc. Agriculture.

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall be as follows:

| Internal Assessment                                              | Marks     |  |
|------------------------------------------------------------------|-----------|--|
| Class Interaction                                                | 5         |  |
| Quiz                                                             | 5         |  |
| Seminar                                                          | 7         |  |
| Assignment (Charts/Flora/Rural Service/Technology Dissemination) | 8         |  |
|                                                                  | <b>25</b> |  |

**Course prerequisites:**

**Qualification:** To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill

Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry)

**Facilities: Smart and Interactive Class**

**Other Requisites: Video collection, Books, CDs, Flora, Herbarium, Access to On-line resources, Display Charts**

**Suggested equivalent online courses:**

<https://www.edx.org/learn/molecular-biology>

<https://www.vlab.co.in/broad-area-biotechnology-and-biomedical-engineering>

<https://www.classcentral.com/course/swayam-genetic-engineering-theory-and-application-14090>

<https://www.coursera.org/courses?query=genetics> <https://www.coursera.org/courses?query=molecular%20biology>

<https://www.edx.org/learn/genetic-engineering>

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<https://www.mooc-list.com/tags/genetic-engineering>  
<https://www.classcentral.com/course/edx-molecular-biology-part-1-dna-replication-and-repair-2907>  
<https://nptel.ac.in/courses/102/103/102103013/>

|                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     |                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------------|
| BSc                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Year: III           | Semester: V<br>Paper-III    |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     |                             |
| Course Code:<br>B040503P                                                                                                                                                                                                                                                                                                                             | Course Title: Experiments in physiology, Biochemistry & molecular biology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                             |
| Course outcomes: After the completion of the course the students will be able to:<br>1. Know and authentic the physiological processes undergoing in plants along with their metabolism<br>2. Identify Mineral deficiencies based on visual symptoms<br>3. Understand and develop skill for conducting molecular experiments for genetic engineering |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     |                             |
| Credits: 2                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Core Compulsory     |                             |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Min. Passing Marks: |                             |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-2                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     |                             |
| Unit                                                                                                                                                                                                                                                                                                                                                 | Topic*<br>*(Perform any three from each unit based on facility)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     | No. of Lectures<br>(60 hrs) |
| I                                                                                                                                                                                                                                                                                                                                                    | Plant water relation, Mineral Nutrition and translocation in phloem<br>1. Determination of osmotic potential of plant cell sap by plasmolytic method using leaves of Rhoeo / Tradescantia.<br>2. Osmosis – by potato osmoscope experiment<br>3. Effect of temperature on absorption of water by storage tissue and determination of Q10.<br>4. Experiment to demonstrate the transpiration phenomenon with the bell jar method<br>5. Experiment for demonstration of Transpiration by Four-Leaf Experiment:<br>6. Structure of stomata (dicot & monocot)<br>7. Determination of rate of transpiration using cobalt chloride method.<br>8. Experiment to measure the rate of transpiration by using Farmer’s Potometer<br>9. Experiment to measure the rate of transpiration by using Ganong’s potometer<br>10. Effect of Temperature on membrane permeability by colorimetric method.<br>11. Study of mineral deficiency symptoms using plant material/photographs. |                     | 8                           |
| II                                                                                                                                                                                                                                                                                                                                                   | Nitrogen Metabolism, Photo Synthesis & Respiration<br>1. A basic idea of chromatography: Principle, paper chromatography and column chromatography; demonstration of column chromatography.<br>2. Separation of plastidial pigments by solvent and paper chromatography.<br>3. Estimation of total chlorophyll content from different chronologically aged leaves (young, mature and senescence) by Arnon method.<br>4. Effect of HCO3 concentration on oxygen evolution during photosynthesis in an aquatic plant and to find out the optimum and toxic concentration (either by volume measurement or bubble counting).<br>5. Measurement of oxygen uptake by respiring tissue (per g/hr.)<br>6. Determination of the RQ of germinating seeds.<br>7. Effect of light intensity on oxygen evolution in photosynthesis using Wilmott’ bubble                                                                                                                        |                     | 8                           |
| III                                                                                                                                                                                                                                                                                                                                                  | Plant Development, Movements, Dormancy & Responses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     | 8                           |



|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
|     | 1. Geotropism and phototropism — Klinostat<br>2. Hydrotropism<br>a. Measurement of growth — Arc and Liver Auxonometer<br>3. To study the phenomenon of seed germination (effect of light).<br>4. To study the induction of amylase activity in germinating grains.<br>5. Test of seed viability by TTC method.<br>6. To study the effect of different concentrations of IAA on Avena coleoptile elongation (IAA bioassay)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |
| IV  | <b>Techniques for biochemical analysis</b><br>1. Weighing and Preparation of solutions -percentage, molar & normal solutions, dilution from stock solution etc.<br>2. Separation of amino acids by paper chromatography.<br>3. Detection of organic acids: citric, tartaric, oxalic and malic from laboratory samples.,<br>4. Qualitative Analysis of carbohydrates,<br>5. Estimation of reducing sugar by anthrone method,<br>6. Qualitative Analysis of Lipids<br>7. Qualitative analysis of Amino acids and Proteins<br>8. Quantitative Analysis of Nucleic Acids,<br>9. Analysis of dietary supplements, nutraceuticals & antioxidants<br>10. Testing of adulterants in food items.                                                                                                                                                                                                                                                                                                                                                                                                                                        | 8 |
| V   | <b>Genetic material</b><br>1. Instruments and equipments used in molecular biology.<br>2. Preparation of LB medium and cultivating E.coli on it.<br>3. Isolation of Genomic DNA<br>4. Isolation of DNA from plants<br>5. Examination of the purity of DNA by agarose gel electrophoresis.<br>6. Quantification of DNA by UV-spectrophotometer<br>7. Estimation of DNA by diphenylamine method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 7 |
| VI  | <b>Preparation of models/ charts:</b><br>1. Study of experiments establishing nucleic acid as genetic material (Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)through photographs<br>2. Numericals based on DNA re-association kinetics (melting profiles and Cot curves)<br>3. Study of DNA replication through photographs: Modes of replication - Rolling circle, Theta and semi-discontinuous ; Semiconservative model of replication (Messelson and Stahl's experiment); Telomerase assisted end-replication of linear DNA<br>4. Study of structures of : tRNA (2D and 3D); prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs<br>5. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozymes and Alternative splicing<br>6. Understanding the regulation of lactose (lac) operon (positive & negative regulation) and tryptophan (trp) operon (Repression and De-repression & Attenuation) through photographs.<br>7. Understanding the mechanism of RNAi by photographs | 7 |
| VII | <b>Genetic Engineering</b><br>1. Isolation of protoplasts.<br>2. Construction of restriction map of circular and linear DNA from the data provided.<br>3. Isolation of plasmid DNA.<br>4. Restriction digestion and gel electrophoresis of plasmid DNA (demonstration/ photograph).<br>5. Calculate the percentage similarity between different cultivars of a species using RAPD profile. Construct a dendrogram and interpret results.<br>6. Agarose gel analysis of plasmid DNA<br>7. Restriction digestion of plasmid DNA -Demonstration of PCR                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 7 |



|             |                                                                                                                                                                                                                                                                                                                                                                                                     |          |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>VIII</b> | <b>Applications of Genetic engineering</b><br>1. ELISA Test,<br>2. Viability tests of cells<br>3. Study of methods of gene transfer through photographs: Agrobacterium- mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.<br>4. Study of steps of genetic engineering for production of Bt cotton, Golden rice, FlavrSavr tomato through photographs. | <b>7</b> |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|

**Suggested Readings:**

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.

2. A Laboratory Manual Of Plant, Physiology, Biochemistry And Ecology ISBN : 9788177544589 Edition : 01 Year : 2012 Author : Akhtar Inam Publisher : Agrobios (India)
3. Advanced Methods In Physiology And Biochemistry (pb) ISBN : 9789381191132 Edition : 01 Year : 2016 Author : Padmanaban G , Chandrasekaran CN , Thangavelu AU , Dr. Sivakumar R , Kalimuthu N, Dr. Boominathan P , Dr. Anbarasan P, Agrobios.
4. Methods in Plant Biochemistry and Molecular Biology. 1997. Dashek, WV (ed.). CRC Press.
5. Wilson and Walker .Practical Biochemistry: Principles and Techniques. Cambridge University Press.U.K.
6. Thimmaiah, SR. 2004. Standard Methods of Biochemical Analysis. Kalyani Publishers.
7. Henry, RJ. 1997. Practical Application of Plant Molecular Biology. Chapman & Hall, London

**This course can be opted as an elective by the students of following subjects:** Open to all but special for following: B.Sc. Math, B.Sc. Statistics, B.Sc. Nutrition, B.Sc. Biophysics, B.Sc. Biotech, B.Sc. Forestry, B.Sc. Agriculture.

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall be as follows:

| <b>Internal Assessment</b>                                       | <b>Marks</b> |  |
|------------------------------------------------------------------|--------------|--|
| Class Interaction                                                | 5            |  |
| Quiz                                                             | 5            |  |
| Seminar                                                          | 7            |  |
| Assignment (Charts/Flora/Rural Service/Technology Dissemination) | 8            |  |
|                                                                  | <b>25</b>    |  |

**Course prerequisites:**

**Qualification:** To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry)

**Facilities: Smart and Interactive Class**

**Other Requisites: Video collection, Books, CDs, Flora, Herbarium, Access to On-line resources, Display Charts**

**Lab requisites: Electrophoresis units, Gelrocker, UV-transilluminator, Vortex Mixer, Shaker, CVT, HiMedia Biotechnology & Molecular biology Kits/Chemicals, Micropipettes, Elisa reader/Microtitre Reader**

**Suggested equivalent online courses:**

<https://www.edx.org/learn/molecular-biology>

<https://krishikosh.egranth.ac.in/handle/1/5810039999>

<https://www.classcentral.com/course/swayam-genetic-engineering-theory-and-application-14090>

<https://www.coursera.org/courses?query=genetics>

<https://www.coursera.org/courses?query=molecular%20biology>

<https://www.edx.org/learn/genetic-engineering>

<https://www.mooc-list.com/tags/genetic-engineering>

<https://www.classcentral.com/course/edx-molecular-biology-part-1-dna-replication-and-repair-2907>

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## **B.Sc.-VI Semester**

25/11/2020

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     |                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------------|
| B.Sc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Year: III           | Semester:VI<br>Paper-I      |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     |                             |
| Course Code:<br>B040601T                                                                                                                                                                                                                                                                                                                                                                                                                                                | Course Title: Cytogenetics, Plant Breeding & Nanotechnology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                     |                             |
| Course outcomes: After the completion of the course the students will be able to:<br>4. Acquire knowledge on cell ultrastructure.<br>5. Understand the structure and chemical composition of chromatin and concept of cell division.<br>6. Interpret the Mendel’s principles, acquire knowledge on cytoplasmic inheritance and sex-linked inheritance.<br>7. Understand the concept of ‘one gene one enzyme hypothesis’ along with the molecular mechanism of mutation. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     |                             |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Core Compulsory     |                             |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Min. Passing Marks: |                             |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     |                             |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Topic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                     | No. of Lectures<br>(60 hrs) |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Cell biology<br>Structure and function of cell wall, plasma membrane, ribosomes, Endoplasmic reticulum, golgi apparatus, mitochondria, chloroplast, lysosomes, peroxisomes and cell inclusions - Organization of nucleus: nuclear envelope, nucleoplasm and nucleolus.<br>Chromosomal nomenclature- chromatids, centromere, telomere, satellite, secondary constriction.Organizational of chromosomes- Nucleic acid and histones- types and classification. Lampbrush chromosomes and polytene chromosomes- Karyotype and idiogram.Cell cycle: G0, G1, S and G2 phases – mitosis: open and closed mitosis – amitosis - meiosis. Variation in Chromosome number (Numerical aberrations)- aneuploidy and Euploidy-haploidy, polyploidy-significance (Structural aberrations) - deletion, duplication, inversion and translocation. |                     | 8                           |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Genetics<br>Chromosome theory of inheritance, crossing over and linkage; Incomplete dominance and codominance; Interaction of Genes; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Polygenic inheritance; Extra-nuclear Inheritance, Linkage, crossing over, Concept of sex determination and Sex chromosomes; Patterns of Sex determination in plants                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     | 7                           |
| III                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Plant breeding<br>Plant introduction. Agencies of plant introduction in India, Procedure of introduction - Acclimatization – Achievements, Selection - mass selection, pure line selection and clonal selection. Genetic basis of selection methods, Hybridization: Procedure of hybridization, inter generic, inter specific, inter varietal hybridization with examples. Composite and synthetic varieties, Male sterility, Heterosis and its exploitation in plant breeding, Mutation, Molecular Breeding (use of DNA markers in plant breeding), achievements in India, Breeding for pest, pathogenic diseases and stress resistance.                                                                                                                                                                                        |                     | 8                           |
| IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Biostatistics:<br>Definition, statistical methods, basic principles, variables- measurements, functions, limitations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                     | 7                           |



|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
|      | and uses of statistics. Biometry: Data, Sample, Population, random sampling, Frequency distribution- definition only, Central tendency– Arithmetic Mean, Mode and Median; Measurement of dispersion–Coefficient of variation, Standard Deviation, Standard error of Mean;<br>Test of significance: chi- square test for goodness of fit. Computer application in biostatistics - MS Excel and SPSS                                                                                                                                                                                                      |   |
| V    | <b>Plant tissue culture</b><br>Principles, components and techniques of in vitro plant cultures, Callus cultures, Cell culture, cell suspension cultures, Embryogenesis and organogenesis, Protoplast isolation and culturing of protoplast- principle and application, regeneration of protoplasts, protoplast fusion and somatic hybridization- selection of hybrid cells, Somaclonal variation, Plant secondary metabolites production.                                                                                                                                                              | 8 |
| VI   | <b>Nanotechnology</b><br>Fundamentals of nanoscale self-assembly process involved in important functional biomolecules such as Nucleic acid (DNA and RNA), Proteins, Enzymes. Cell structure and organelles, nanoscale assembly of cellular components (cell membrane and liposomes). Nanoscale assembly of microorganisms (virus). Nano-particles synthesis, Biological synthesis of Nanoparticles, Advantages and applications of biologically synthesized nanomaterials. Introduction to biological nanomaterials. Biomineralization, Magnetosomes, nano-pesticides, nano-fertilizers, nano-sensors. | 7 |
| VII  | <b>Artificial Intelligence in Plant Sciences</b><br>Big Data Analytics, Blockchain Technology, 3-D Printing, Machine learning, Algorithms of Machine Learning, Expert systems and Fuzzy logic , Artificial Neural Networks and Genetic algorithms, Predictive Analytics, Agents and Robotics, IoT Sensors, Object Image capture & analysis ; Applications of Artificial Neural Networks in Plant Science.                                                                                                                                                                                               | 8 |
| VIII | <b>Introduction to use of Digital technologies – AI, IoT &amp; ICT in Botany</b><br>Educational software- INFLIBNET, NICNET, BRNET, internet as a knowledge repository- google scholar, science direct. resource management, weather forecasting. IoT Database management, IoT platforms, IoT Graphical user interface • IoT application development for Android Mobile phones, ICT Applications for different crops and horticulture                                                                                                                                                                   | 7 |







**Suggested Readings:**

1. Cell Biology And Genetics (Hindi) 2/e PB Gupta P K (Hindi) rastogi Publications
2. PLANT BIOTECHNOLOGY (HINDI) October 2019 Publisher: Kindle Direct Publishing ISBN: ISBN: 9781698665283 Authors: H. R. Dagla Jai Narain Vyas University
3. Biotechnology: Fundamentals And Application (hindi) (hb) ISBN : 9788177544732 Edition : 03 Year : 2018 Author : Dr. Purohit SS , Mathur S
4. Biotechnology (Hindi) (Hindi, Paperback, B.D.Singh) Hindi Publisher: Kalyani Publishers ISBN: 9789327246070, 9327246071
5. Cytogenetics, Plant Breeding, Evolution and Biostatistics ISBN #: 978-81-301-0066-1 Sunil D Purohit & Gotam K Kukda, Apex Publishing House
6. Genetics and Biotechnology Sunil D Purohit, K. Ahmed & Gotam K Kukda Apex Publishing House
7. Padap Prajanan (Hindi) Hardcover – 1 January 2016 by Chandra Prakash Shukl (Author) Pointer Publishers, Jaipur
8. PLANT BREEDING : PRINCIPLE AND METHODS B D SINGH - IN HINDI
9. कोतशकािथाअरुजैतवकीशब्दसंग्रह Commission for Scientific and Technical Terminology (CSTT)
10. कोतशकाआनुवंतशकीपरिभाषाकोश **Commission for Scientific and Technical Terminology (CSTT)**
  1. G.M. Cooper. (2015). The cell: A Molecular Approach. 7th Edition. Sinauer Associates.
  2. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K., Walter, P. (2014). Molecular Biology of Cell. 6th Edition. WW. Norton & Co.
  3. Campbell, M.K. (2012) Biochemistry, 7th ed., Published by Cengage Learning.
  4. Campbell, P.N. and Smith, A.D. (2011). Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
  5. Tymoczko, J.L., Berg, J.M. and Stryer, L. (2012). Biochemistry: A short course, 2nd ed., W.H. Freeman.
  6. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2011) Biochemistry, W.H. Freeman and Company
  7. Nelson, D.L. and Cox, M.M. (2008). Lehninger Principles of Biochemistry, 5th Ed., W.H. Freeman and Company.
  8. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
  9. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell. 8th edition. Pearson Education Inc. U.S.A.)
  10. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th e
  11. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
  12. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A..
  13. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

14. M K Raxdan An Introduction to Plant Tissue Culture –; Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi
15. Aggarwal SK (2009) Foundation Course in Biology, 2nd Edition, Ane Books Pvt. Ltd
16. Allard RW (1960) Principles of Plant Breeding. John Wiley and Sons. Inc. New York
17. BD Singh (2003) Plant Breeding. Kalyani Publishers
18. Cohn, N.S. (1964) Elements of Cytology. Brace and World Inc, New Delhi
19. Darnel, J. Lodish, Hand Baltimore, D. (1991) Cell and molecular biology. Lea and Fibiger, Washington.
20. De Robertis, E.D.P and Robertis, E.M.P (1991) Cell and molecular biology Scientific American books.
21. Dobzhansky, B (1961) Genetic and origin of species, Columbia university Press New York
22. Durbin (2007) Biological Sequence Analysis. Cambridge University Press India Pvt. Ltd
23. Gerald Karp (1985) Cell biology, Mc Graw Hill company..
24. Lewin, B. (1994) Genes, Oxford University Press, New York.
25. Lewis, W.H (1980) Polyploidy. Plenum Press, New York.
26. Nicholl T (2007) An Introduction to Genetic Engineering, Cambridge University Press India Pvt. Ltd
27. Roy S.C. and Kalayan kumar De (1997) Cell biology. New central Books Calcutta
28. Sandhya Mitra, (1998) Elements of molecular biology. Macmillan, India Ltd.
29. Sharma JR (1994) Principles and Practices of Plant Breeding. Tata McGraw-Hill Pub. Co. New Delhi
30. Sharma, A.K and Sharma A (1980) Chromosome technique Theory and practice, Aditya Books, New York

**This course can be opted as an elective by the students of following subjects:** Open to all but special for B.Sc. Biotech, B.Sc. Forestry, B.Sc. Agriculture, B. Pharma, B.Sc. Food Science, B.A. (Curators), B.A. Geology.

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall be as follows:

| Internal Assessment                                              | Marks     |  |
|------------------------------------------------------------------|-----------|--|
| Class Interaction                                                | 5         |  |
| Quiz                                                             | 5         |  |
| Seminar                                                          | 7         |  |
| Assignment (Charts/Flora/Rural Service/Technology Dissemination) | 8         |  |
|                                                                  | <b>25</b> |  |

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| <b>Course prerequisites:</b><br><b>Qualification:</b> To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Forestry/ Biotech/ Math/Statistics/Chemistry/ Computer Science)<br><b>Facilities: Smart and Interactive Class</b><br><b>Other Requisites: Video collection, Books, CDs, Flora, Herbarium, Access to On-line resources, Display Charts</b>                                                                                                                                                                                                                                                                                                  |
| <b>Suggested equivalent online courses:</b><br><a href="https://www.cytology-iac.org/educational-resources/virtual-slide-library">https://www.cytology-iac.org/educational-resources/virtual-slide-library</a><br><a href="https://www.asct.com/ASCTWeb/Content/Cytopreparation_Online_Course.aspx">https://www.asct.com/ASCTWeb/Content/Cytopreparation_Online_Course.aspx</a> <a href="https://www.mooc-list.com/tags/genetics">https://www.mooc-list.com/tags/genetics</a><br><a href="https://www.coursera.org/learn/genetics-evolution">https://www.coursera.org/learn/genetics-evolution</a><br><a href="https://www.my-mooc.com/en/mooc/introduction-to-genetics-and-evolution/">https://www.my-mooc.com/en/mooc/introduction-to-genetics-and-evolution/</a> |
| <b>Further Suggestions:</b><br>Access to Statistics, Chemistry, Math and Biotechnology resources will be required                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------------|
| BSc                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Year: III           | Semester:VI<br>Paper-II     |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                     |                             |
| Course Code:<br>B040602T                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Course Title: Ecology & Environment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     |                             |
| <b>Course outcomes:</b> After the completion of the course the students will be able to:<br>1. acquaint the students with complex interrelationship between organisms and environment;<br>2. make them understand methods for studying vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography.<br>3. This knowledge is critical in evolving strategies for sustainable natural resource management and biodiversity conservation.. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                     |                             |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Core Compulsory     |                             |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Min. Passing Marks: |                             |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                     |                             |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Topic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                     | No. of Lectures<br>(60 hrs) |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Natural resources & Sustainable utilization: Land Utilization, Soil degradation and management strategies; Restoration of degraded lands. Water , Wetlands; Threats and management strategies, Ramsar sites ,Forests: Major and minor forest products; Depletion, Biological Invasion, Energy: Renewable and non-renewable sources of energy , Contemporary practices in resource management : EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting. |                     | 7                           |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Ecology & Ecosystem                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     | 8                           |

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |          |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|            | Definition of Ecology, Ecological Factors, Positive and negative interactions.<br>Ecosystem – Concept of an ecosystem-structure and function of an ecosystem.<br>Abiotic and biotic com-Energy flow in an ecosystem<br>Ecological Succession-Definition & types. Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary & secondary), Hydrosere and Xerosere.<br>Food chains and food webs, Ecological pyramids, production and productivity; And components. Types of ecosystems: Forest Ecosystem, Grassland, Crop land, aquatic Ecosystems<br>Ecological Adaptations – Hydrophytes, Xerophytes, Halophytes, Epiphytes and Parasites. |          |
| <b>III</b> | <b>Soil Formation, Properties &amp; Conservation</b><br>Soil: Origin, Formation, composition, Soil types, Soil Profile, Soil Microorganisms, soil processes, Soil Erosion, Biogeochemical cycles, Soil Conservation: Biological– Contour farming, Mulching, Strip cropping, Terracing and Crop rotation. Mechanical–Basin Listing, Construction of dams, Watershed Management, Soil reclamation                                                                                                                                                                                                                                                                 | <b>7</b> |



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| IV                                                                                                                                                                                                                                                                                                                                                                   | <b>Biodiversity and its conservation:</b><br>Definition -genetic, species, and ecosystem diversity. Value of biodiversity: social, ethical, aesthetic and option values; hotspots of Biodiversity threats to biodiversity, Biotic communities and populations, their characteristics and dynamics. Endemic and endangered species of plants in India. Ecological niche, ecotypes, ecological indicators.<br>Conservation of Biodiversity:<br>Ex-situ and in-situ conservation, Red data book, botanical gardens, National park, Sanctuaries, hot & hottest spots and Bioreserves. Role of Seed Bank and Gene Bank<br>Valuing plant resources, ecotourism, Role of NBPGR, FAO, BSI.                                                                                                                                                                                                | 7 |
| V                                                                                                                                                                                                                                                                                                                                                                    | <b>Phytogeography:</b><br>Biogeographic regions of India & world, Agroecological & Floristic zones of India. Natural vegetation of India, static and dynamic plant geography, basic principles governing geographical distribution of plants, Phytogeographical regions of India, Vegetational types in Uttar Pradesh.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 7 |
| VI                                                                                                                                                                                                                                                                                                                                                                   | <b>Environmental audit &amp; Sustainability</b><br>Concept of environmental audit; Guidelines of environmental audit; Methodologies adopted along with some industrial case studies; Environmental standards: ISO 14000 series; Scheme of labelling of environment friendly products (Ecomark); Life cycle analysis; Concept of energy and green audit, Strategies and debates on sustainable development; Concept of Sustainable Agriculture; India's environment action programme: issues, approaches and initiatives towards Sustainability;<br>Sustainable development in practice.                                                                                                                                                                                                                                                                                           | 8 |
| VII                                                                                                                                                                                                                                                                                                                                                                  | <b>Pollution, Waste management &amp; Circular Economy</b><br>Environmental pollution, Environmental protection laws, Bioremediation, Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor, neutralization, ETP sludge management; digesters, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bioscrubbers, biotrickling filters; regulatory framework for pollution monitoring and control; case study: Ganga Action Plan; Yamuna Action Plan; implementation of CNG ;Waste- Types , collection and disposal, Recycling of solid wastes (hazardous & non-hazardous) - classification, collection and segregation , Incineration, Pyrolysis and gasification , Sanitary landfilling ; composting, Biogas production<br>,Circular Economy & sustainability. | 8 |
| VIII                                                                                                                                                                                                                                                                                                                                                                 | <b>Environmental ethics, Carbon Credits &amp; Role of GIS</b><br>Carbon credit: concept, exchange of carbon credits. Carbon sequestration, importance, meaning and ways.<br>Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Wasteland reclamation. Consumerism and waste products. Clean development mechanism.<br>Geographical Information Systems: definitions and components; spatial and non-spatial data; GIS software packages; GPS survey, data import, processing, and mapping. Applications and case studies of remote sensing and GIS in land use planning, forest resources & agriculture studies.                                                                                                                                                                                                                  | 8 |
| <b>Suggested Readings:</b><br><b>Course Books published in Hindi may be prescribed by the Universities.</b><br>1. Environmental Studies (Hindi) ISBN 81-301-0004-5B. L. Chaudhary & Jitendra Pandey Edition: 2013 Pages: 340 + XII Apex Publishing House<br>2. Soil and Water Conservation ISBN #: 978-81-301-0071-5S. C. Mahnot & P. K. Singh Apex Publishing House |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |



3. Paryavaran Evam Paristhiti 5e (Hindi) Paperback – 20 February 2020 Majid Husain
4. Environmental Biology and Phytogeography ISBN #: 978-81-301-0064-7B. L. Chaudhary, Gotam K Kukda & Jitendra Kumar Joshi
5. Ugc Unified: Environmental Sciences (hindi) (pb) ISBN: 9788177545814 Edition : 01 Year : 2015 Author : Dr. Purohit SS , Dr. Deo PP , Dr. Agrawal Ashok K Publisher : Agrobios (India)
1. Chapman and Riss. Ecology: Principles and Applications, Latest Ed., Cambridge University Press
2. Shukla, R.S. & Chandel, P.S. Plant Ecology, Latest Ed., S. Chandel and Co.
3. Kumar, H.D. Modern Concept of Ecology, Latest Ed. Vikas Publishing House
4. Begon, M., Herper, J.L. and Townsend, C.R. Ecology- Individuals, Populations and Communities (3rd ed.), Oxford Blackwell Science
5. Verma, P.S. & Agarwal, U.K. Concept of Ecology, Latest Ed., S. Chand & Company.
6. Odum, F.P. Fundamentals of Ecology, Latest Ed., Saunders
7. Sharma, P.D. Elements of Ecology, Latest Ed., Rastogi Publications
8. Ambasht, R.S. & Ambasht, N.K. A Text Book of Plant Ecology, Latest Ed., CBS Publication & Distributors
9. Mani, M.S. Bio-Geography of India, Latest Ed., Springer-Verlag.
10. Mackenzie et al. Ecology, Latest Ed., Viva Books.
11. Gurevitch, J. (et al.), The Ecology of plants, 2002, Sinauer Associates.
12. Kimar, U. & Asija, M.J. Bio-diversity: Principles & Conservation, 2005, Student Edition, Agrobios (India)
13. Krishnamurthy, K.V. An Advanced Text Book on Biodiversity, 2003, Oxford & IBH Publishing Co. Ltd.
14. Mitra, D., Guha, J.K., Chowdhury, S.K. Studies in Botany, Vol. II (7th ed.) Moulik Library.
15. Primack, R.B. Essentials of Conservation Biology, 1993, Sinauer Associates.
16. Lo, C.P. & Yeung, A.K.W. Concepts and Techniques of Geographic Information Systems, 2002, Printice-Hall of India.
17. Cain, Bowman, Hacker. Ecology. 2014. 3rd Ed. Sinauer Associates
18. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
19. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
20. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.
21. Abbasi, S. A. (1998). Environmental Pollution and its Control. Cogent International, Pondicherry.
22. Abbasi, S. A. and Ramasamy, E. V. (1999). Biotechnological Methods of Pollution Control. Universities Press (India) Limited, Hyderabad.
23. Peavy, H. S., Rowe, D. R. and Tchobanoglaus, G. (1985). Environmental Engineering, Mc Graw Hill Book Company, Singapore.
24. Rand, M. C., Greenberg, A. E. and Taras, M. J. (Ed.) (1995). Standard methods for the examination of water and wastewater: 19th edition, American Public Health association (APHA), Washington, D.C.
25. Scragg, A. (1999). Environmental Biotechnology, Addison Wesley Longman, Singapore.
26. Tchobanoglaus, G. (1988). Wastewater Engineering: Treatment, Disposal, Reuse. Tata Mc Graw Hill, New Delhi.
27. Aarve, V. P., William, A. W. and Debra, R. R. (2002). Solid waste engineering. Cengage reading, USA.
28. George, T., Hilary, T. and Samuel, A. V. (1993). Integrated solid Waste Management, Engineering Principles and Management Issues, Mc Graw Hills.
29. George, T. and Frank, K. (2002). Handbook of solid waste management: (Second edition). Mc Graw Hills.
30. Kanthi, L. S. (2000). Basics of Solids and hazardous waste management Technologies. Prentice Hall.
31. Anonymous. 1997. National Gene Bank: Indian Heritage on Plant Genetic Resources (Booklet). National Bureau of Plant Genetic Resources, New York.
32. Gillespie, A. 2006. Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations. Martinus Nijhoff Publishers.
33. Hardy, J.T. 2003. Climate Change: Causes, Effects and Solutions. John Wiley & Sons.
34. Harvey, D. 2000. Climate and Global Climate Change. Prentice Hall.
35. Manahan, S.E. 2010. Environmental Chemistry. CRC Press, Taylor and Francis Group.
36. Maslin, M. 2014. Climate Change: A Very Short Introduction. Oxford Publications.
37. Mathez, E.A. 2009. Climate Change: The Science of Global Warming and our Energy Future. Columbia University Press.
38. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. & Sen, K. 2004. Climate Change and India. Universities Press, India.
39. Philander, S.G. 2012. Encyclopedia of Global Warming and Climate Change (2nd edition). Sage Publications.
40. Demers, M.N. 2005. Fundamentals of Geographic Information System. Wiley & Sons.
41. Richards, J. A. & Jia, X. 1999. Remote Sensing and Digital Image Processing. Springer.
42. Sabins, F. F. 1996. Remote Sensing: Principles an Interpretation. W. H. Freeman.
43. Gaston, K.J. & Spicer, J.I. 1998. Biodiversity: An Introduction. Blackwell Science, London,



45. Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. The Botanical Review 53:80-192.  
 46. Sodhi, N.S. & Ehrlich, P.R. (Eds). 2010. Conservation Biology for All. Oxford University Press.  
 47. Sodhi, N.S., Gibson, L. & Raven, P.H. 2013. Conservation Biology: Voices from the Tropics. Wiley-Blackwell, Oxford, UK.

**This course can be opted as an elective by the students of following subjects:** Open to all but special for B.Sc. Biotech, B.Sc. Forestry, B.Sc. Agriculture, B. Pharma, B.Sc. Food Science, B.A. (Curators), B.A. Geology.

**Suggested Continuous Evaluation Methods:**

Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall be as follows:

| Internal Assessment                                              | Marks     |  |
|------------------------------------------------------------------|-----------|--|
| Class Interaction                                                | 5         |  |
| Quiz                                                             | 5         |  |
| Seminar                                                          | 7         |  |
| Assignment (Charts/Flora/Rural Service/Technology Dissemination) | 8         |  |
|                                                                  | <b>25</b> |  |

**Course prerequisites:**

**Qualification:** To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry/ Microbiology/Gardening /biomedical Science.**Facilities: Smart and Interactive Class**

**Other Requisites: Video collection, Books, CDs, Flora, Herbarium, Access to On-line resources, Display Charts**

**Suggested equivalent online courses:**

<https://community.plantae.org/tags/mooc>

[futurelearn.com/courses/teaching-biology-inspiring-students-with-plants-in-science](https://futurelearn.com/courses/teaching-biology-inspiring-students-with-plants-in-science)

<https://www.coursera.org/courses?query=plants>

<http://egyankosh.ac.in/handle/123456789/53530>

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------------|
| BSc                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Year: III           | Semester:VI<br>Paper-III    |
| Subject: Botany                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                     |                             |
| Course Code:<br>B040603P                                                                                                                                                                                                                                                                                                                                | Course Title: Lab on Cytogenetics, Conservation & Environment management                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                     |                             |
| <b>Course outcomes:</b> After the completion of the course the students will be able to:<br>1. To perform all experiments related to the semester-i.e. Plant tissue cultured plants, conducting breeding on field, conserving and depolluting the environment.<br>2. Can be employed in environment impact assessment companies & start his own venture |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                     |                             |
| Credits: 2                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Core Compulsory     |                             |
| Max. Marks: 25+75                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Min. Passing Marks: |                             |
| Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-2                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                     |                             |
| Unit                                                                                                                                                                                                                                                                                                                                                    | Topic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                     | No. of Lectures<br>(60 hrs) |
| I                                                                                                                                                                                                                                                                                                                                                       | <b>Cell biology</b><br>1. Study of plant cell structure with the help of epidermal peal mount of Onion/Rhoeo/Crinum<br>2. Measurement of cell size by the technique of micrometry.<br>3. Counting cells per unit volume with the help of haemocytometer (Yeast/pollen grains)<br>4. Determination of mitotic index and frequency of different mitotic stages in pre-fixed root tips of Allium cepa.                                                                                                                                                          |                     | 7                           |
| II                                                                                                                                                                                                                                                                                                                                                      | <b>Genetics</b><br>1. Monohybrid cross (Dominance and incomplete dominance)<br>2. Dihybrid cross (Dominance and incomplete dominance)<br>3. Gene interactions (All types of gene interactions mentioned in the syllabus)<br>a. Recessive epistasis 9: 3: 1.<br>b. Dominant epistasis 12: 3: I<br>c. Complementary genes 9: 7<br>d. Duplicate genes with cumulative effect 9: 6: 1<br>e. Inhibitory genes 13: 3<br>4. Observe the genetic variations among inter and intra specific plants.                                                                   |                     | 8                           |
|                                                                                                                                                                                                                                                                                                                                                         | 5. Demonstration of Breeding techniques-Hybridization, case studies of mutation, polyploidy, emasculation experiment.                                                                                                                                                                                                                                                                                                                                                                                                                                        |                     |                             |
| III                                                                                                                                                                                                                                                                                                                                                     | <b>Biostatistics:</b><br>1. Univariate analysis of statistical data: Statistical tables, mean, mode, median, standard deviation and standard error (using seedling population / leaflet size).<br>2. Calculation of correlation coefficient values and finding out the probability.<br>3.Determination of goodness of fit in Mendellian and modified mono-and dihybrid ratios (3:1, 1:1, 9:3:3:1, 1:1:1:1, 9:7, 13:3, 15:1) by Chi-square analysis and comment on the nature of inheritance.<br>3. Computer application in biostatistics - MS Excel and SPSS |                     | 7                           |
| IV                                                                                                                                                                                                                                                                                                                                                      | <b>Plant tissue culture</b><br>1. Familiarization of instruments and special equipments used in the plant tissue culture experiments<br>2. Preparation of plant tissue culture medium, and sterilization, Preparation of stock solutions of nutrients for MS Media.<br>3. Surface sterilization of plant materials for inoculation (implantation in the medium)<br>4. Micropropagation of potato/tomato/ - Demonstration<br>5. Protoplast isolation and culturing – Demonstration                                                                            |                     | 8                           |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Ecology &amp; Environment</b> <ol style="list-style-type: none"> <li>1. Ecological Adaptations: Hydrophytes, Xerophytes, Halophytes, Epiphytes and Parasites</li> <li>2. Study of morphological adaptations of hydrophytes and xerophytes (four each).</li> <li>3. Study of biotic interactions of: Stem parasite (Cuscuta), Root parasite (Orobancha) Epiphytes, Predation (Insectivorous plants).</li> <li>4. Observation and study of different ecosystems mentioned in the syllabus.</li> <li>5. Field visit to familiarize students with ecology of different sites</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 8 |
| VI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Soil Formation, Properties &amp; Conservation</b> <ol style="list-style-type: none"> <li>1. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)</li> <li>2. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.</li> <li>3. Determination of organic matter of different soil samples by Walkley &amp; Black rapid titration method.</li> <li>4. Soil Profile study</li> <li>5. Soil types of India-Map</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 8 |
| VII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Biodiversity and Phytogeography:</b> <ol style="list-style-type: none"> <li>1. Study of community structure by quadrat method and determination of (i) Minimal size of the quadrat, (ii) Frequency, density and abundance of components (to be done during excursion/field visit).</li> <li>2. Marking of vegetation types of India, World &amp; Uttar Pradesh on maps</li> <li>3. Phytogeographical areas of India</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 7 |
| VIII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Pollution &amp; Waste management</b> <ol style="list-style-type: none"> <li>1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter</li> <li>2. Estimation of chloride and dissolved oxygen content in water sample</li> <li>3. Comparative anatomical studies of leaves from polluted and less polluted areas.</li> <li>4. Measurement of dissolved O<sub>2</sub> by azide modification of Winkler's method.</li> <li>5. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.</li> <li>6. Microbiological assessment of drinking water using MPN technique- water from well, river, water supply department and packaged drinking water</li> <li>7. Making kitchen waste from compost/vermicompost by Enzymes/Bio decomposer/ Whey with dung.</li> </ol> <b>Climate Change, Carbon Credits &amp; Role of GIS</b> <ol style="list-style-type: none"> <li>1. Conducting Waste Audit of your Institution -Demo</li> <li>2. Green auditing of the College/University -Demo</li> </ol> | 7 |
| <b>Suggested Readings:</b><br><b>Course Books published in Hindi may be prescribed by the Universities.</b> <ol style="list-style-type: none"> <li>1. Practical Botany (Part III) Author: Sunil D Purohit, Anamika Singhvi &amp; Kiran Tak 2013 Apex Publishing House, Raj.</li> <li>2. Practical Botany (Part II) Author: N. C. Aery, Sunil D Purohit &amp; Gotam K Kukda 2013 Apex Publishing House, Raj.</li> <li>3. A Handbook Of Soil, Fertilizer And Manure (2nd Ed.) (pb) ISBN : 9788177544152 Edition : 02Year : 2017Author : Gupta PKPublisher : Agrobios (India)</li> <li>4. Green Technology: An Approach For Sustainable Environment ISBN : 9788177543438 Edition : 01Year : 2021Author :</li> </ol> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |

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| : Dr. Purohit SSPublisher : Agrobios (India)<br><ol style="list-style-type: none"> <li>6. Laboratory Manual Of Chemical And Bacterial Analysis Of Water And Sewage ISBN : 9788177540802Edition : 01Year : 2011Author : Theroux FR , Eldridge EF , Mallmann WLPublisher : Agrobios (India)</li> <li>7. Methods In Environmental Analysis: Water Soil And Air (2nd Ed.) ISBN : 9788177543087Edition : 02Year : 2021Author : Gupta PKPublisher : Agrobios (India)</li> <li>8. Water Treatment And Purification Technology ISBN : 9788177540024Edition : 01Year : 2009Author : Ryan WJPublisher : Agrobios (India)</li> </ol> <a href="http://vidyamitra.inflibnet.ac.in/index.php/home/subjects?domain=Life+Science&amp;subdomain=Botany">http://vidyamitra.inflibnet.ac.in/index.php/home/subjects?domain=Life+Science&amp;subdomain=Botany</a><br><a href="http://heecontent.upsdc.gov.in/Home.aspx">http://heecontent.upsdc.gov.in/Home.aspx</a><br><a href="http://epathshala.nic.in/">http://epathshala.nic.in/</a> , <a href="http://epathshala.gov.in/">http://epathshala.gov.in/</a> |
| <b>This course can be opted as an elective by the students of following subjects:</b> Open to all but special for B.Sc. Biotech, B.Sc. Forestry, B.Sc. Agriculture, B. Pharma, B.Sc. Food Science, B.A. (Curators), B.A. Geology.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Suggested Continuous Evaluation Methods:</b><br>Continuous Internal Evaluation shall be based on allotted Assignment and Class Tests. The marks shall be as follows:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

| Internal Assessment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Marks     |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|--|
| Class Interaction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 5         |  |
| Quiz                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 5         |  |
| Seminar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 7         |  |
| Assignment (Charts/Flora/Rural Service/Technology Dissemination)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 8         |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>25</b> |  |
| <b>Course prerequisites:</b><br><b>Qualification:</b> To study this course, a student must have qualified 10+2 with Biology/ NSQF level 3 from Sector Skill Councils / Diploma holder from ITI in (Biology/ Agriculture/ Biotech/ Forestry)<br><b>Facilities: Smart and Interactive Class</b><br><b>Other Requisites: Video collection, Books, CDs, Flora, Herbarium, Access to On-line resources, Display Charts</b><br><b>Lab requisites: Biotech instruments, environmental lab instruments.</b>                                                                                                                                                                                                                                                                 |           |  |
| <b>Suggested equivalent online courses:</b><br><a href="https://www.cytology-iac.org/educational-resources/virtual-slide-library">https://www.cytology-iac.org/educational-resources/virtual-slide-library</a><br><a href="https://www.asct.com/ASCTWeb/Content/Cytopreparation_Online_Course.aspx">https://www.asct.com/ASCTWeb/Content/Cytopreparation_Online_Course.aspx</a> <a href="https://www.mooc-list.com/tags/genetics">https://www.mooc-list.com/tags/genetics</a><br><a href="https://www.coursera.org/learn/genetics-evolution">https://www.coursera.org/learn/genetics-evolution</a><br><a href="https://www.my-mooc.com/en/mooc/introduction-to-genetics-and-evolution/">https://www.my-mooc.com/en/mooc/introduction-to-genetics-and-evolution/</a> |           |  |
| <b>Further Suggestions:</b> Access to Statistics, Chemistry, Math and Biotechnology resources will be required                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |  |





