



Royal College of Arts Science and Commerce (Autonomous)

Affiliated to University of Mumbai

Program: B.Sc.

Course: BOTANY

Syllabus for Semester: III and IV

Syllabus for Undergraduate Programme as per
National Education Policy (NEP-2020) with effect from the
academic year 2025-2026

NEP Credit Structure for Science

Level	Sem	Major		Minor	OE	VSC	SEC	AEC	IKS	VEC	OJT/FP /RP/CC /CEP	Cumulative Credits	
		DSC	DSE										
4.5	I	6 (4Th + 2 Pr)		4+2 (4Th + 2 Pr)	2	2		2	2	2		22	UG Certificate Cumulative Credit:44
	II	6 (4Th + 2 Pr)		4+2 (4Th + 2 Pr)	2		2	2		2	2	22	
Exit Option: Award of UG Certificate in Major with 40 -44 Credits and an Additional 4 Credits Core NSQF Course / Internship OR Continue with Major and Minor													
5	III	8 (6Th + 2 Pr)		4 (2 Th + 2 Pr)	2+2		2	2			2	22	UG Diploma Cumulative Credit:88
	IV	8 (6Th + 2 Pr)		4 (2 Th + 2 Pr)	2+2		2	2			2	22	
Exit Option: Award of UG Diploma in Major and Minor with 80-88 Credits and an Additional 4 Credits Core NSQF Course / Internship OR Continue with Major and Minor													
5.5	V	10 (8Th + 2 Pr)	4 (2Th + 2 Pr)			4					4	22+	UG Degree Cumulative Credit:132
	VI	10 (8Th + 2 Pr)	4 (2Th + 2 Pr)			4					4	22	
	Total	48	8	20	12	10	6	8	2	4	14	132	

..

PROGRAM LEARNING OUTCOMES	
PLO1	To demonstrate a deep understanding of the fundamental principles and theories in Botany along with their practical applications
PLO2	Analyse the diversity of plants interpret their intricate relationships within various ecosystems.
PLO3	Evaluate the influence of environmental factors, genetics, diversity, and evolutionary processes on the morphology, physiology, and behaviour of plants, enabling a nuanced understanding of their adaptation and survival strategies
PLO4	Apply critical thinking skills to assess complex biological phenomena and solve problems encountered in botanical research, and raise awareness about ethical and environmental issues to address contemporary challenges in biological research.
PLO5	Achieve proficiency in laboratory techniques in fields of applied sciences which includes molecular biology, plant tissue culture, bioinformatics, microscopy

Semester III

Syllabus

Sem. - III (Minor)

Name: Plant Systematics and Cytogenetics

Course/ Paper Title	Plant Systematics and Cytogenetics
Course offered as	Minor
Course Code	RUSBOMN31
Semester	3
No. of Credits	2
No. of lecture Hours/week	2

Course Learning Objectives (CLO): To enable students:	
CLO. 1	To introduce the fundamental principles of plant taxonomy, including identification, classification, and nomenclature.
CLO. 2.	To familiarize students with the structure, function, and significance of herbaria, botanical gardens, and taxonomic classifications by Bentham & Hooker and Engler & Prantl
CLO. 3.	To study the distinguishing characteristics, classification, and economic importance of key plant families.
CLO. 4.	To identify chromosomal variations, sex determination mechanisms, and extranuclear inheritance in plants.
CLO. 5.	To explore the sources, extraction, and therapeutic applications of plant secondary metabolites, along with concepts of crude drug classification and adulteration in pharmacognosy

Course Outcomes (CO): The students will be able to:	
CO. 1	Classify, identify, and name plants systematically, applying the principles.
CO. 2.	Identify and compare different classification systems and their significance in plant taxonomy.
CO. 3.	Gain knowledge of chromosomal aberrations, their genetic effects, and mechanisms of sex determination in plants.
CO. 4.	Comprehend extranuclear inheritance and its role in heredity, including chloroplast and mitochondrial genetics.
CO. 5.	Develop an understanding of plant secondary metabolites, their medicinal properties, and the significance of crude drug classification and adulteration

Module I: Plant Systematics (15 L)

- Introduction to plant taxonomy: Identification, Classification, Nomenclature. Taxonomic hierarchy, Ranks, categories and taxonomic groups Identification Functions of Herbarium, important herbaria and botanical gardens of the world and India;
- Morphology of Fruits.
- Classification: Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series).
- Taxonomy, important distinguishing characters, classification, and economic importance of the following families:
 - a. Malvaceae.
 - b. Apocyanaceae.
 - c. Rubiaceae
 - d. Solanaceae
 - e. Cruciferae
 - f. Asteraceae
 - g. Amaryllidaceae

Module II: (15 L)

1.1: Cytogenetics:

- Variation in Chromosome structure (Chromosomal Aberrations) Definition, Origin, Cytological and Genetic Effects of the following: Deletions, Duplications, Inversions and Translocations.
- Extranuclear Genetics Organelle heredity- Chloroplast determines heredity - Plastid transmission in plants, Streptomycin resistance in Chlamydomonas. Male sterility in maize

1.2: PHARMACOGNOSY

- Study of secondary metabolites: Sources, properties and therapeutic uses of alkaloids, glycosides, phenolic compounds (tannins, flavonoids), saponins and terpenoids (volatile oils).
- Classification of crude drugs, drug adulteration.

References:

- Daniel, M. 1991. Methods in Plant Chemistry and Economic Botany. KaiyaniPublishers, Ludhiana, India.
- Daniel, M. and S.D. Sabnis .1990. A Phytochemical Approach to Economic Botany.Kaiyani Publishers, Ludhiana, India

- Davis P.H and V.H Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd London.
- Evans, W.C. (2002). *Pharmacognosy*, Saunders.
- Gupta, P.K. (2008). *Cytogenetics, Genetics, Molecular Biology and Evolution*, Rastogi Publications.
- Gurucharan Singh. 2005. Systematics theory and practice (Oxford IBH)
- Harborne, T.C. 1981. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. Chapman and Hall, London, U.K
- Heywood V.H. 1967. Plant Taxonomy, London.
- Heywood, V.H., Brummitt, R.K., et al. (2007). *Flowering Plant Families of the World*, Royal Botanic Gardens, Kew.
- Klug, W.S., Cummings, M.R. et al. (2015). *Concepts of Genetics*, Pearson.
- Kokate, C.K., Purohit, A.P., Gokhale, S.B. (2014). *Pharmacognosy*, Nirali Prakashan.
- Lawrence, G.H.M. (1951). *Taxonomy of Vascular Plants*, Macmillan.
- Lawrence, G.H.M. 1951. Taxonomy of Vascular Plants. N.Y.
- Pandey, B.P. (Latest Ed.). *Taxonomy of Angiosperms*, S. Chand Publications.
- Rendle, A.B. (1925). *The Classification of Flowering Plants*, Vol I & II. Cambridge University Press.
- Richard J. Lewis. 2012. Sax's Dangerous Properties of Industrial Materials. 12th Edition. John Wiley & Sons, Inc. ISBN: 978-0-470-62325-1.
- Sharma, O.P. (2010). *Plant Taxonomy*, Tata McGraw Hill.
- Sharma, O.P. 1993. Plant Taxonomy. Tata McGraw Hill. Publ. Co. Ltd. New Delhi, India.
- Singh, G. (2019). *Plant Systematics: Theory and Practice*, 3rd Ed., CRC Press.
- Singh, M. P., Nayar, M.P. and R. P. Roy. 1994. Text Book of Forest Taxonomy, Anmol Publ. P. (Ltd.) New Delhi, India.
- Singh, V. 1993. Taxonomy of Angiosperms Rastogi Publication. Meerut (U.P.) India.
- Singh, V., Pande, P.C. and D. K. Jain 1994. A Text Book of Botany: Angiosperms. Rastogi Publications, Meerut (U. P.), India.
- Snustad, D.P., Simmons, M.J. (2012). *Principles of Genetics*, Wiley.
- Swingle D.B. 1946. A Text book of Systematic Botany. McGraw Hill Book Co. New York.
- Takhtajan A. 1969. Flowering Plants; Origin and Disposal.
- Theodore Cooke. 1903. The flora of The Presidency of Bombay Vol. I, II, III.
- Trease, G.E. & Evans, W.C. (2009). *Pharmacognosy*, 16th Ed., Saunders/Elsevier.
- Tyler, V.E., Brady, L.R., & Robbers, J.E. (1988). *Pharmacognosy*, Khosla Publishing.
- Verma, P.S. & Agarwal, V.K. (Latest Ed.). *Cell Biology, Genetics, Molecular Biology, Evolution & Ecology*, S. Chand.
- Wallis, T.E. (1985). *Textbook of Pharmacognosy*, CBS Publishers.
- Wallis. T.E. 2014. Text book of pharmacognosy. CBS publishers and distributor New Delhi.

Course/ Paper Title	Botany Practicals Semester III
Course offered as	Minor
Course Code	RUSBOMNP31
Semester	3
No. of Credits	2
No. of lecture Hours/week	4

Course Objectives:

1. To study and identify the characteristic features of representative plant species from the families.
2. To perform qualitative tests for the detection of secondary metabolites, such as alkaloids, glycosides, tannins, flavonoids, and saponins, in selected plant samples.
3. To analyze adulteration in commonly used medicinal and food products like black pepper, cinnamon bark, turmeric powder, and chili powder.
4. To understand the principles of extranuclear inheritance by studying plastid inheritance patterns.
5. To examine cytological consequences of chromosomal aberrations (such as laggards, chromosomal bridges, ring chromosomes) using permanent slides or photomicrographs.

Course Outcomes:

1. Students will be able to identify key morphological and taxonomic characteristics of selected plant families.
2. Learners will develop hands-on skills in detecting plant secondary metabolites and understanding their pharmacological importance.
3. Students will gain knowledge of methods used to detect adulterants in medicinal and food products, ensuring quality control.
4. Learners will understand the mechanisms of extranuclear inheritance and its significance in plant genetics.
5. Students will acquire practical skills in analyzing chromosomal aberrations and their genetic implications using cytological preparations.

List of Practical's:

1. Study of one plant from each family prescribed for theory.
2. Morphology of Fruits.
3. Tests for secondary metabolites:
 - Tests for alkaloids from *Strychnos* (seeds) / *Holarrhoena* (bark).
 - Tests for glycosides from *Glycyrrhiza* rhizome/ *Aloe* leaf.
 - Tests for tannins from *Terminalia arjuna* bark / *Acacia catechu*.
 - Tests for flavonoids from *Momordica charantia*/ *Clitorea* flowers.
 - Tests for saponins from *Sapindus laurifolius*/ *Trigonella foenum- graecum*.

4. Study of drug adulterants in black pepper seeds, cinnamon bark, turmeric powder, chilli powder)
5. Study of inheritance pattern with reference to Plastid Inheritance.
6. Study of cytological consequences of chromosomal aberrations (Laggards, Chromosomal Bridge, Ring chromosome, Chromosomal ring) from permanent slides or photomicrographs.
7. Aberrations – Karyotypes- Cri-du-chat, Philadelphia, D.G. translocation, Down Syndrome.
8. Preparation of herbarium and wet preservation technique.
9. Study of Streptomycin resistance in *Chlamydomonas*.
10. Study of male sterility in maize through diagrams and seed samples.
11. Identification of plant specimens using taxonomic keys.

References:

- Esau, K. – *Plant Anatomy*, Wiley India.
- Gupta, P.K. – *Cytogenetics*, Rastogi Publications.
- Gupta, P.K. – *Genetics*, includes examples and genetic basis of male sterility.
- Gupta, P.K. – *Genetics*, Rastogi Publications.
- Jain, S.K. – *A Manual of Plant Taxonomy*, Scientific Publishers.
- Jain, S.K. & Rao, R.R. – *A Handbook of Field and Herbarium Methods*, Today & Tomorrow Printers.
- Klug & Cummings – *Concepts of Genetics* (organelle inheritance case studies).
- Klug & Cummings – *Concepts of Genetics*, Pearson.
- Klug, W.S., Cummings, M.R. – *Concepts of Genetics*, Pearson.
- Kokate, C.K. et al. – *Practical Pharmacognosy* (includes organoleptic and chemical test methods).
- Kokate, C.K., Purohit, A.P., Gokhale, S.B. – *Pharmacognosy*, Nirali Prakashan.
- Online resources: *NCBI*, *PubMed*, and medical cytogenetics diagrams (for accurate visuals).
- Pandey, B.P. – *Plant Morphology*, S. Chand.
- Pandey, B.P. – *Taxonomy of Angiosperms*, includes practical herbarium making methods.
- Pandey, B.P. – *Taxonomy of Angiosperms*, S. Chand.
- Practical Botany lab manuals may have clear labeled diagrams.
- Regional floras or field guides (e.g., *Flora of Maharashtra*, *Flora of the Presidency of Bombay*) – for local key practice.
- Sharma, A.K. & Sharma, A. – *Chromosome Techniques: Theory and Practice*, Butterworths.
- Sharma, O.P. – *Plant Taxonomy*, Tata McGraw Hill.
- Sharma, O.P. – *Plant Taxonomy*.
- Singh, G. – *Plant Systematics: Theory and Practice*, CRC Press.
- Snustad & Simmons – *Principles of Genetics*, Wiley.
- Snustad & Simmons – *Principles of Genetics*, Wiley.
- Snustad & Simmons – *Principles of Genetics*.
- Trease & Evans – *Pharmacognosy* (for adulteration examples and detection).

- Trease, G.E., Evans, W.C. – *Pharmacognosy*, Saunders/Elsevier.
- Verma & Agarwal – *Cell Biology, Genetics, Molecular Biology*, S. Chand.
- Verma & Agarwal – *Genetics & Plant Breeding*, S. Chand.
- Wallis, T.E. – *Textbook of Pharmacognosy*, CBS Publishers.

Semester IV

Syllabus

Sem. - IV (Minor)

Name: Environment, Phytogeography and Evolution

Course/ Paper Title	Environment, Phytogeography and Evolution
Course offered as	Minor
Course Code	RUSBOMN41
Semester	3
No. of Credits	2
No. of lecture Hours/week	2

Course Learning Objectives (CLO): To enable students:	
CLO. 1	To understand ecological factors such as soil composition, water availability, climatic conditions, and their impact on plant distribution and survival.
CLO. 2.	To study population characteristics, growth patterns, and ecological interactions that influence plant communities and ecosystems.
CLO. 3.	To explore the principles of community ecology, including succession, ecotones, and the edge effect.
CLO. 4.	To examine the concepts of evolution, including macro and microevolution, phylogeny, and various evolutionary theories such as Lamarckism, Darwinism, and Neo-Darwinism.
CLO. 5.	To analyze phytogeographical principles, including continental drift, the theory of tolerance, and the phytogeographical regions of India, with a focus on endemism and its influencing factors.

Course Outcomes (CO): The students will be able to:	
CO. 1	Explain the impact of ecological factors on plant survival and distribution.
CO. 2.	Analyze population characteristics, ecological interactions, and community succession.
CO. 3.	Understand evolutionary processes, phylogenetics, and species formation.
CO. 4.	Identify and classify phytogeographical regions and factors influencing plant endemism.
CO. 5.	Apply ecological and evolutionary concepts to assess biodiversity patterns and conservation strategies.

Module I: Environment studies (15 L)

Ecological factors: Concept of environmental factors, Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types; Light, Temperature (Thermal stratification in water bodies and atmosphere) and Wind; Ecological amplitude; Leibig's law of minimum; Shelford law of tolerance.

Plant communities: Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)

Community ecology- Characters of community - Quantitative characters and qualitative characters

Module II: (15 L)

1.1: Evolution:

Introduction to Evolution: Origin and history of life; Macro and microevolution; Phylogeny and the tree of life. Evolution of Species: Lamarckism and Neo-Lamarckism; Darwinism – selection (natural and artificial), Neo Darwinism; Species concept and modes of speciation.

1. 2: Phytogeography:

Principles; Continental drift; Theory of tolerance, Phytogeographical regions of India; Endemism (definition, factors and types).

References:

- Campbell, N.A., Reece, J.B. (2009)., *Biology*, Pearson Education.
- Champion, H.G. & Seth, S.K. (1968)., *A Revised Survey of the Forest Types of India*, Government of India Press.
- Futuyma, D.J. (2009)., *Evolution*, Sinauer Associates.
- Gleason, H.A. & Cronquist, A. (1991)., *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*.
- Kumar, H.D. (1996)., *Modern Concepts of Ecology*, Vikas Publishing.
- Misra, R. (1968)., *Ecology Workbook*, Oxford and IBH.
- Odum, E.P. & Barrett, G.W. (2005)., *Fundamentals of Ecology*, 5th Ed. Brooks/Cole.
- Puri, G.S. (1960)., *Indian Forest Ecology*, Oxford Book Company.
- Raven, P.H., Evert, R.F., & Eichhorn, S.E. (2012)., *Biology of Plants*, 8th Ed. Freeman & Co.
- Sharma, P.D. (2014)., *Ecology and Environment*, Rastogi Publications.
- Singh, J.S., Singh, S.P. & Gupta, S.R. (2008)., *Ecology, Environment and Resource Conservation*, Anamaya Publishers.

- Verma, P.S. & Agarwal, V.K. (Latest Edition)., *Cell Biology, Genetics, Molecular Biology, Evolution & Ecology*, S. Chand Publications.

Course/ Paper Title	Botany Practicals Semester IV
Course offered as	Minor
Course Code	RUSBOMNP41
Semester	3
No. of Credits	2
No. of lecture Hours/week	4

Course Objectives:

1. To understand the influence of ecological factors such as soil, water, and climate on plant survival and distribution.
2. To study population dynamics, growth patterns, and ecological interactions within plant communities and ecosystems.
3. To explore community ecology concepts, including succession, ecotones, and the edge effect.
4. To examine evolutionary processes, including phylogeny, macroevolution, and microevolution, along with key evolutionary theories.
5. To analyze phytogeographical patterns, the impact of continental drift, and the factors influencing plant endemism in India.

Course Outcomes:

1. Students will be able to explain how ecological factors shape plant distribution and survival.
2. Learners will understand population interactions and their role in maintaining ecological balance.
3. Students will gain insights into community ecology and ecological succession.
4. Learners will comprehend evolutionary mechanisms and their impact on biodiversity.
5. Students will classify phytogeographical regions and evaluate factors affecting plant endemism.

List of Practical's:

1. Principle and operation of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.

2. Determination of pH and detection of carbonates, chlorides, nitrates, sulphates, soil carbon, organic matter and base deficiency from atleast two soil samples by rapid titration tests.
3. Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*), Epiphytes (Orchids), Predation (Insectivorous plants).
4. Determination of minimal quadrat size and number for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
5. Chlorophyll content of biomass production by a community.
6. Construct phylogenetic tree using MEGA and interpret evolutionary relationships.
7. Estimation of soil moisture content and soil texture.
8. Estimation of soil water-holding capacity.
9. Measurement of dissolved oxygen (DO) and pH in water samples from different sources.
10. Mapping and classification of phytogeographical regions of India.
11. Case study on endemic plant species and factors affecting their distribution.

References

- APHA (2012). *Standard Methods for the Examination of Water and Wastewater*.
- Arnon, D.I. (1949). *Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris*. Plant Physiology.
- Barbour, Burk & Pitts. (1987). *Terrestrial Plant Ecology*.
- Black, C.A. (1965). *Methods of Soil Analysis*.
- Champion, H.G. & Seth, S.K. (1968). *A Revised Survey of the Forest Types of India*.
- **Field Guide:** USDA Soil Texture Triangle and Feel Test method
- Hall, B.G. (2011). *Phylogenetic Trees Made Easy: A How-To Manual*.
- Heywood, V.H. & Watson, R.T. (1995). *Global Biodiversity Assessment*, Cambridge University Press.
- ICAR Manual: *Handbook of Soil Analysis* – Available in many university libraries.
- ICAR Manual: *Practical Manual for Soil Science*
- ICAR: *Soil Fertility and Fertilizer Use – A Guide for Students*
- Jackson, M.L. (1958). *Soil Chemical Analysis*.
- Jackson, M.L. (1958). *Soil Chemical Analysis*. Prentice Hall India.
- Kumar, H.D. (1996). *Modern Concepts of Ecology*. Vikas Publishing House.
- Misra, R. (1968). *Ecology Workbook*. Oxford & IBH Publishing.
- MoEF&CC Reports on Biodiversity Hotspots in India.
- NEERI Lab Manuals – Widely available in college libraries
- Odum, E.P. (2005). *Fundamentals of Ecology*, Cengage Learning.
- **Online:** WMO Guide to Meteorological Instruments and Methods of Observation (<https://library.wmo.int/>)
- Puri, G.S. (1960). *Indian Forest Ecology*.
- Raven, P.H., Evert, R.F., & Eichhorn, S.E. (2012). *Biology of Plants*.
- Sawhney, S.K. & Randhir, Singh. (2005). *Introductory Practical Biochemistry*. Narosa Publishing.
- Saxena, K.G. (1994). *Manual for Field Ecology*, UNESCO MAB Programme.
- Sharma, P.D. (2014). *Ecology and Environment*, Rastogi Publications.

- Singh, J.S., Singh, S.P. & Gupta, S.R. (2008). *Ecology, Environment and Resource Conservation*.
- Smith, R.L. & Smith, T.M. (2009). *Elements of Ecology*, Pearson.
- **Software Tutorial:** www.megasoftware.net
- Subbaiah, B.V. & Asija, G.L. (1956). *A rapid procedure for the estimation of available nitrogen in soils*.
- Tamura, K., Stecher, G., et al. (2021). *MEGA11: Molecular Evolutionary Genetics Analysis version 11*.
- Trivedi, R.K. & Goel, P.K. (1986). *An Introduction to Air Pollution*.
- Trivedi, R.K. & Goel, P.K. (1986). *Chemical and Biological Methods for Water Pollution Studies*.
- Yadav, B.R. (2011). *Soil Sampling and Methods of Analysis*. Agrotech Publishing.

Examination Pattern

Question Paper Pattern

(Internal and External)

Date :

Total Marks: 30

Duration: 1 Hour.

Q1)	Attempt the following	[5 M]
Q2)	Attempt the following (Any Two)	[10M]
Q3)	Attempt the following (Any Two)	[10M]

Internal Theory 20 marks

Continuous Evaluation Through	Quizzes, Class tests, Presentation, project, role play, creative writing, assignments etc
-------------------------------	---

Practical End Examination Total Marks= 50

Semester Examination	Marks
Laboratory work	35
Field Study	5
Journal	5
Viva	5
Total Marks	50

Field visits/ Industrial Visits to be taken according to the syllabus in both the semesters