

GONDWANA UNIVERSITY, GADCHIROLI



(According to NEP-2020)

SYLLABUS

For
Master of Science

M. Sc.
BOTANY

Based on NEP-2020
(With effect from 2023-24)

SEMESTER III & IV

Board of Studies in Botany

Science and Technology

From session - 2024-2025

NEP-2020

M.Sc. Botany Syllabus
Semester III
Course Code:
Paper- I Angiosperms- II

Credit - 04

Unit I:

General account, distinguished characters, floral variation and evolution, affinities of :- Magnoliidae, Hamamelidae, Dilleniidae, Rosidae, Asteridae, circumscription as per Cronquist, 1968

Unit II:

Alismatidae, commelinidae, Aracidae, Lilidae; Interesting features and systematic position of Cucurbitaceae, Cactaceae, Asteraceae, Amentiferae, Lemnaceae, Palmae, Orchidaceae.

Unit III:

Probable ancestors of angiosperms, primitive living angiosperms, speciation and extinction, IUCN categories of threat, distribution and global pattern of biodiversity.

Unit IV:

Biological diversity concept and levels, role of biodiversity in ecosystem functions and stability, Endemism, hotspots and hottest hotspots, invasions and introductions, local plant diversities and its socioeconomic importance.

Laboratory Exercises:

1. Description of a specimen from representative, locally available families.
2. Description of a species based on various specimens to study intra specific variation: collective exercise.
3. Description of various species of a genus, location of key characters and preparation keys at generic level.
4. Location of key characters and use of keys at family level.
5. Field trips within and around the campus; compilation of field notes and preparation herbarium sheets of such plants, wild or cultivated as are abundant.
6. Training in using floras herbaria for identification of specimens described in the class.
7. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera.
8. Comparison of different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms.

Suggested Reading :

1. Devis, P.H. and Heywood, V. H. 1973. Principles of angiosperms taxonomy. Robert Kreiger Pub. Co. Newyork.
2. Grant, V. 1971. Plant Speciation, Columbia University press, London.
3. Grant W. F. 1984. Plant Biosystematics. Academic press, London.
4. Harisson, H.J. 1971. New concept in flowering plant Taxonomy. Hickman educational books Ltd. London.

5. Hislop-Harrison, J. 1967. Plant Taxonomy. English Language Book Sco. And Edward Arnold Pub. Ltd, UK.
6. Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.
7. Jones, A. D. and Wiggins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co. New York.
8. Jones, S. B., Jr. and Luchsinger, A. E. 1986. Plant Systematics (2nd edition). McGraw-Hill Book Co., New York.
9. Nordstrom, B., El Gazaly, G. and Kasser, M. 2000. Plant systematics for 21st century. Portland press. Ltd, London.
10. Radford, A. E. 1986. Fundamentals of plant systematics. Harper and Row publication, USA.
11. Solbrig, O.T. 1970. Principles and methods of plant Systematics. The Macmillan Co. Publication Co. Inc., USA.
12. Woodland, D. W. 1991. Contemporary Plant Systematics, Prentice Hall, New Jersey.
13. Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.
14. Stebbins, G. L. 1974. Flowering Plants-evolution Above species Level. Edward Arnold Ltd, London.
15. Jones, A. D. and Wiggins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co.
16. Jones, S. B., Jr. and Luchsinger, A. E. 1986. Plant Systematics (2nd edition). McGraw-Hill Book Co., New Delhi.

NEP-2020
M.Sc. Botany Syllabus
Semester III
Course Code: **Credit - 04**
Paper- II Cytology and Genetics

UNIT – I

Mendel's laws of inheritance; chromosome theory of inheritance; deviations from Mendel's findings; Penetrance and expressivity; Modifiers, suppressors and pleiotropic genes; multiple alleles and isoalleles (example Corn, Drosophila and Nicotiana); multigene families (globin and immunoglobulin genes); sex determination and dosage compensation in plants, Drosophila, C. elegans.

UNIT – II

Chromatin organization: Chromosome structure and packaging of DNA; molecular organization of centromere and telomere, rRNA genes, euchromatin and heterochromatin; Karyotype analysis and evolution, banding patterns; specialized types of chromosomes: polytene, lampbrush, B-chromosome, sex chromosome; molecular basis of chromosome pairing, C-value paradox, Cot curve and its significance.

UNIT – III

Structural and numerical changes in chromosomes; origin, breeding behavior of duplications, deficiency, inversion and translocation heterozygotes; effect of aneuploidy on plants; transmission of trisomics and monosomics and their use in chromosome mapping; complex translocation heterozygotes, translocation tester sets; Robertsonian translocation.

UNIT – IV

Mutations: Spontaneous and induced; physical and chemical mutagens; molecular basis; transposable genetic elements; site directed mutagenesis; role of mutations in crop improvement; induction of polyploidy Epigenetics: Introduction; paramutations in maize; Callipygh sheep; role of histones; DNA methylation; Epigenetics and Lamarckism; Epigenome and epigenomics.

Laboratory Exercises: -

1. To study the effect of mutagen treatment on germination, seedling height and cell division.
2. To study the spontaneous and induced chromosomal aberrations in pollen mother cells.
3. To study the effect of mutagen treatment on pollen fertility.
4. To study the karyotype of given organism.
5. To study the chiasma frequency in the given material.
6. To study linear differentiation of chromosomes by chromosome banding.
7. To perform the site directed mutagenesis in the given system.

Suggested Reading

1. Gupta P K 2007 Genetics: Classical to Modern. Rastogi Publications, Meerut. 18
2. Hexter W and Yost Jr. H T 1977 The Science of Genetics. Prentice Hall of India Pvt. Ltd., New Delhi.
3. Hartl D L and Jones E W 1998 Genetics: Principles and Analysis (4th ed.). JonesandBarflett Publishers, USA.
4. Khush G S 1973 Cytogenetics of Aneuploids. Academic press, New York.
5. Snustad D P and Simmons M J 2000 Principles of Genetics (2nd ed.) John Wiley and SonInc., USA.

NEP-2020
M.Sc. Botany Syllabus
Semester III
Course Code:
Paper- III- Plant Biochemistry

Credit - 04

Unit – I

Carbohydrates: Definition and classification, Aldoses & Ketoses, Monosaccharide, Triose, Tetrose, Pentose, Hexose (Examples and Structure) derived Monosaccharide, Disaccharide - Glycoside Linkage – Lactose, Maltose and Sucrose; Oligosaccharides – Trisaccharides – structure of raffinose. Polysaccharides – Homo and Hetero polysaccharides (structure of starch, cellulose, Hyaluronic acid); Properties and role of carbohydrates, Biological significance of carbohydrates.

Unit- II: Lipids: Definition and classification, types of Lipids – simple lipids- triglycerides properties of fatty acids and fats, structure and uses of fatty acids, conjugated lipids- phospholipids, Derived lipids-cholesterol, oil & waxes, Biological importance of lipids, Biological functions of lipids.

Unit – III: Proteins & Nucleic Acids

Proteins: Definition, Characteristics of proteins, classification of proteins, structure of protein – peptide bond and peptide, Disulphide bond, Hydrogen bond, Hydrophobic bond, classification of amino acids, uncommon amino acids and their functions, primary, secondary, tertiary, quaternary structure of proteins, Biological importance of proteins.

Nucleic Acids: Nitrogenous base composition of nucleic acids, structure of purines, pyrimidines, pentose sugar (Ribose, Deoxyribose), phosphodiester bond, Nucleosides and Nucleotides Base, Base composition of DNA (Chargaff's Rule) Basic Structure of DNA (Watson-Crick model) forms of DNA . RNA – Structure of m-RNA, t-RNA, r-RNA

Unit IV:

Enzymology: Basics of Enzymology Introduction of terminologies used in enzymology, characteristics and properties of enzymes, nomenclature and classification based on IUB system and EC, Enzymes and catalyst – Activation energy, mechanism of enzyme action – Lock and Key model, induced FIT model. Active sites, Allosteric Site, Enzyme substrate interactions (Emil Fischer Hypothesis and Daniel Koshland's Model) Holoenzyme, Apoenzyme, co-enzyme and co-factors. Enzyme Kinetics – Michaelis Menten equation, Lineweaver – Burk plot Enzyme Inhibition – Competitive, uncompetitive & Non- competitive Factors affecting enzyme activity - pH, temperature and substrate concentration.

Laboratory Exercises:

1. Quantitative estimation of carbohydrates
2. Qualitative estimation of proteins
3. Qualitative estimation of lipids.
4. Estimation protein by Lowry method
5. Estimation of sugar by DNS method
6. Estimation of DNA by diphenylamine method
7. Estimation of RNA by Orcinol method
8. Partial purification of protein by fractional precipitation.
9. To prepare the standard curve of protein and determine the protein content in plant samples.
10. Colorimetric/spectro photometric estimation of sugar and starch in suitable plant materials.
11. To study the activity of enzyme amylase from germinating wheat grains.
12. To study the enzyme activity of peroxidase in suitable plant materials influenced by temperature.
13. To study the enzyme activity of catalase in suitable plant material as influenced by temperature.
14. Determination of acid value of fat.
15. Preparation of leaf protein concentrates from green vegetables.
16. To study the enzyme activity of lipase.
17. To study enzyme activity of protease.

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M.Sc. Botany Syllabus

Semester III

Course code - (Elective - DSE)

Credit-2

Paper IV -Molecular Biology and Plant Biotechnology – III

UNIT I:

Isolation of gene and nucleotide sequence: DNA manipulation enzymes; General methods of gene isolation.

Molecular probing: Recombinant DNA libraries (gDNA and cDNA, oligonucleotide probes); nucleic acid hybridization (southern, northern, dot-blot and slot-blot); antibodies as probe for proteins (immunoblotting or western blotting, immunoprecipitation, southwestern screening).

UNIT II:

Splicing of foreign DNA into cloning vector: Vectors for prokaryotes and eukaryotes; ligation.

Introduction of foreign DNA into host cell: Transformation; transfection; transgenesis

Isolation of genes or protein products from clones: Expression vectors- Characteristics; vectors producing fusion proteins

Polymerase chain reaction: Types of PCR, working principles and their applications in molecular biology

UNIT III:

Genomics: Definition; genome analysis (genetic polymorphisms, genetic mutations); DNA microarrays technology and applications (gene expression and diseases).

Proteomics: Definition; Protein stability and folding; application of hydrophobicity; Protein structure- evolution, classification, prediction and modelling, prediction of function, mass spectrometry, network and graphs, protein complexes and aggregates, protein interaction networks, regulatory networks, DALI (Distance-matrix alignment).

UNIT IV:

Bioinformatics: Introduction, History, Definition and applications of bioinformatics.

Database: Types and classification of databases – Primary Databases (Nucleic acid sequence, protein sequence, protein structure), Secondary databases (Genomic, cDNA, Organellar, gene expression), Special databases (Human, *Escherichia coli*, *Saccharomyces cerevisiae* and *Arabidopsis thaliana*), Literature database (PubMed, OMIM), Information Retrieval system (Entrez). Other databases: Gene Bank, KEGG, Taxonomy databases

Data analysis, prediction and submission tools and their uses: ORF finder, BLAST, FASTA,

RASMOL, Prediction of pro- and eukaryotic genes and promoters (Genscan); protein structure (SWISS-Prot, Pfam, PDB, PIR); sequin, webin, Auto Dep tools.

Sequence alignment and phylogenetic trees: Dot plots, sequence similarity, pairwise and multiple alignment, significance of alignment, phylogeny and phylogenetic tree evaluation.

Laboratory Exercises:

Major Exercises –

1. Detection of DNA damage by mutagens.
2. Bacterial transformation and selection of transformed cells.
3. To detect molecular polymorphism of different species.
4. To demonstrate the presence of particular polypeptide by Western blotting.
5. To design PCR primers for isolation of given gene and to clone it in the given vector.
6. Amplification and sequencing of nr DNA by PCR

Minor Exercises-

1. To search literature of different organisms and genes from NCBI.
2. Use of various tools to retrieve information available from NCBI.
3. To retrieve gene and protein sequences of various organisms from NCBI.
4. To locate gene(s) on chromosomes for a given disease/disorder.
5. To find the sequences of a given protein in SWISS-Prot, Uni-Prot.
6. To work out the sequence from given autoradiogram and to identify it from Gene Bank byBLAST method.
7. To generate Pairwise and multiple sequence alignment of a given organisms.

8. To generate phylogenetic tree using given sequences.
9. To predict a protein from given sequence by using online tools from NCBI.

Suggested Readings:

- Alberts, Bruce; Johnson Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter, C. 2002 Molecular Biology of the Cell, Garland Science, New York and London.
- Baxevanis, A. D. and Ouellate, B. F. F. 2009 Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.
- Baxevanis, A. D., Davison, D. B.; Page, R. D. M.; Petsko, G. A.; Stein, L. D. and Stormo, G. D. 2008 Current Protocols in Bioinformatics.
- Bergman, N.H 2007 Comparative Genomics Humana Press Inc., Part of Springer Science+Business Media.
- Brown, T. A. 1999. Genomes, John Wiley & Sons(Asia) Pvt. Ltd., Singapore.
- De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology 8th Ed. B. I. Waverly Pvt. Ltd., New Delhi.
- Glover, D.M. and. Hames, D.B 1995 DNA Cloning: A practical approach, R.L. Press, Oxford.
- Hackett, P. B. Fuchs, J. A. and Messing, J. W. 1988. An Introduction to Recombinant DNA Techniques. Basic Experiments in Gene Manipulation. The Benjamin Cummings Publishing Co., Inc. Menlo Park, California.
- Jolles, O. and Jornvall, H. (Eds) 2000. Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
- Karp, G. 1999 Cells and Molecular Biology; Concepts and Experiments. John Wiley & Sons, Inc., USA.
- Lehninger 2005 Principles of biochemistry- Nelson, Cox, 4th Edn., W.H. Freeman and Co.
- Lewin, B. 2000 Gene VII Oxford Univ. press, New York.
- Lewin, B. 2010 Gene X Oxford Univ. press, New York.
- Lodish, H., Berk, A. Zipursky, S. L. Matsudaira, P., Baltimore, D. and Darnell, J. 2000 Molecular Cell Biology Edi. W.H. Freeman and Co., New York, USA.
- Mount W. 2004 Bioinformatics and sequence genome analysis 2nd Edi. CBS Pub. New Delhi.
- Old and Primrose, 1994, Principles of gene manipulation. Blackwell Scientific Publ.
- Raymond Schuler and Zielinski, E. 2005, Methods in plants Molecular biology - Acad. Press.
- Russel, P. J. 1998 Genetics (5th Edi.) The Benjamin/ Cummings Publishing Com. Inc., USA.
- Sambrook and Russel. 2001. Molecular cloning Vol. 1-3 CSH press.
- Shaw, C.H. 2006, Plant Molecular Biology: A practical approach. Panima Pub. Corp.
- Stryer, Berg, Biochemistry- 6th Edition, W. H. Freeman and Co., 2007.
- Voet, D.; Voet, J.; Biochemistry – 3rd Edn. John Wiley and sons Inc., 2004.
- Wilson Keith and Walker John 2005 Principles and techniques of biochemistry and molecular biology, 6th Ed. Cambridge University Press, New York.

- Wolf, S.L. 1993. Molecular and Cellular Biology, Wadsworth Publishing Co., California, USA.

NEP-2020
M.Sc. Botany Syllabus
Semester III
Course code - (Elective - DSE)
Paper IV: Reproductive Biology of Angiosperm-III **Credit – 02**

Unit 1:

Fertilization: Cellular nature of sperm, the sperm cytoskeleton, the male germ unit, isolation and characterization of sperm, attraction of pollen tubes to the female gametophyte, growth of the pollen tube through the style, passage of sperm into the embryo sac, fusion of nuclei, double fertilization, triple fusion and its significance, cytoplasmic transmission in gametes, unusual features, Gynogenesis. In-vitro approaches to the study of fertilization-Intra-ovarian pollination, test tube fertilization, *in vitro* pollination, placental pollination, Cybrids, *in vitro* fertilization.

Unit II:

Post fertilization changes and Endosperm: Types of endosperms, ruminant endosperm, salient features of helobial endosperm in the monocots, wall formation in endosperm, cytological status. endosperm haustoria, chemical composition of endosperm, food reserve in endosperm, embryo-endosperm relationship, role of endosperm in embryo development, Incorporation of nucellus and integument in endosperm formation, endosperm mutants.

Polyembryony: Definition, causes, classification, induction of polyembryony, practical importance of polyembryony..

Unit III:

Embryogenesis: Zygote and its ultra-structure, milieu of the developing embryo, symmetry and polarity, rest period in zygote embryonic formulae, embryonomic laws. Types of embryogeny, Embryogenesis in dicots and Monocots, Structure of dicot & Monocot Embryo.

Suspensor-Ultra structure of suspensor cells, cytology of suspensor cell, physiology and biochemistry of suspensor; Nutrition of embryo- nutrient supply of the zygote, embryo-endosperm relation.

Unit IV:

Development of seed and seed types- Determination of physiological maturity of seed, Changes occurring during seed development, Factors affecting seed development, Seed viability or Longevity of Seeds, Factors affecting seed Germination, Types of Seed , Structure of a Dicotyledonous and monocotyledonous Seed, different steps of

seed germination, types of seed germination (1) Hypogeal Germination (2) Epigeal Germination and (3) Vivipary (Viviparous Germination).

Seed appendages and special Structures, Adaptations, and Functions (Sarcotestal Seeds, Arillate Seeds, Jaculator, Winged Seeds, Haired Seeds, Dust and Balloon Seeds, Hydrochoric Seeds, Mucilage Seeds).

Major Exercises:

1. To study dicot (non-endospermic) and monocot (endospermic) seeds
2. To study dicot and monocot embryo development through various stages in given seeds (slides/photographs/fresh material).
3. To demonstrate seed viability test by T.T.C. (Triphenyl-Tetrazolium-chloride).
4. To study factors affecting seed germination.
5. To study Intra-ovarian pollination (slides/photographs/fresh material).
6. To study test tube fertilization. (slides/photographs/fresh material).
7. To study *in vitro* pollination. (slides/photographs/fresh material).
8. To study different types of Endosperms.
9. To study seed germination types Hypogeal Germination and Epigeal Germination.
10. Dissection of young seeds for endosperm with free-nuclear haustoria.

Minor exercises:

10. To study polyembryony. (slides/photographs/fresh material).
11. To study different appendages and special structure in seed (slides/photographs/fresh material).
 - a. Sarcotestal seeds.
 - b Arillate seeds.
 - c. Winged Seeds.
 - d. Haired Seeds
 - e. Dust and Balloon Seeds.
 - f. Hydrochoric Seeds
 - g. Mucilage Seeds
12. To study the Vivipary. (Floral buds and Seeds) (slides/photographs/fresh material).

Suggested Readings:

- Bewley, J.D. and Black, M. (1994). Seeds Physiology of Development and Germination. Plenum Press, New York. 15.
- Bhojwani S.S/Bhatnagar S.P. & Dantu P.K. 2015. The Embryology of Angiosperms, 6th Edition Front Cover Vikas Publishing House.
- Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms. Vikas Publishing House, Delhi.
- Geber, M.A., Dawson, T.E. and Delph, L.F. (1999). Gender and Sexual dimorphism in Flowering Plants. Springer Berlin-Heidelberg.

- Howell, S.H. (1998). *Molecular Genetics of Plant Development*. Cambridge University press, Cambridge.
- Johri, B. M., Srivastava, P. S., & Singh, N. (2001). Reproductive Biology of Angiosperms. *Reproductive Biology of Plants*, 237–272. doi:10.1007/978-3-642-50133-3_11
- Johri, B.M. (1984). *Embryology of Angiosperms* ; Editors · Brij Mohan Johri ; DOI · ; Publisher · Springer Berlin, Heidelberg. <https://doi.org/10.1007/978-3-642-69302-1>
- Lakshmanan, K.K., Ambegaokar, K.B. (1984). Polyembryony. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_9
- Maheshwari, P. , 1950. *An Introduction to Embryology of Angiosperms*. Tata McGrew Hill Publishing Co. , New Delhi.
- Mauro Cresti, Stephen Blackmore, Jacobus L. van Went (2012). *Atlas of Sexual Reproduction in Flowering Plants*. Springer Verlag Berlin.
- Mishra SR (2009) *Understanding Plant Reproduction*. Discovery Publishing House New Delhi.
- Natesh, S., Rau, M.A. (1984). The Embryo. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_8
- Raghavan, V. (1997). *Molecular Embryology of Flowering Plants*. Cambridge University Press, Cambridge.
- Raghavan, V. (2000). *Developmental Biology of Flowering Plants*. Springer-Verlag, New York.
- Raghvan, V. (2006). *Double fertilization*. Springer Verlag, Berlin-Heidelberg.
- Rajeshwari Sharma & A.K. Sharma (2009). *Structure Development and Reproduction in Flowering Plants*. Jagdhamba Publishing Co. New Delhi.
- Russell, S. D. (2009). Fertilization in Angiosperms. *Plant Developmental Biology - Biotechnological Perspectives*, 283–300. https://doi.org/10.1007/978-3-642-02301-9_14
- Shi J. (2018). *Plant Development & Reproduction*. Magnum Publishing House New Delhi.
- Swamy, B. G. L. and D. Padmanabhan. 1962. A reconnaissance of angiosperms embryogenesis. *Jour. Indian Bot. Soc.* 41: 422-430. <http://210.212.232.211:8080/jspui/bitstream/123456789/4995/1/CMFRI-%20133%20article%2038.pdf>
- The Plant Cell. Special issue on Reproductive Biology of Plants, Vol. 5(10) (1993). The American society of Plant Physiologists. Rockvills, Maryland, USA.
- Ueli GrossniklausEdt. (2019). *Plant Development and Evolution*. Academic Press.
- van Went, J.L., Willemse, M.T.M. (1984). Fertilization. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_6

- Vijayaraghavan, M.R., Prabhakar, K. (1984). The Endosperm. In: Johri, B.M. (eds) Embryology of Angiosperms. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_7
- <https://courseware.cutm.ac.in/courses/reproductive-biology-of-angiosperms/>

NEP-2020
M.Sc. Botany Syllabus
Semester III
Course code - (Elective - DSE)
Paper IV: Paleobotany-III

Credit – 02

Unit- I

Prebiotic Environment; chemical evolution and origin of life; Pre-Cambrian life; Indian Pre-cambrian stratigraphy and life forms; Fossil- algae, fungi and bryophytes.

Unit- II

Applied Palaeobotany- Life as fuel maker; sources of natural fossil fuels, Peat, coal and its varieties; constitution of coal; Coal Palynology; coal maceral. Petroleum-its origin, migration and concentration; palynology in oil exploration.

Unit- III

Fundamentals of Paleofloristics, Palaeogeography and Palaeoclimatology; Application of Paleopalynology; Plant and animal interactions correlation; Archaeobotany with special reference to phytoliths and palynological studies.

Unit- IV

Techniques in Palaeontology - megafossils - microfossils - nannofossils - ichnofossils - collection, reformation and illustration. Integration of Remote Sensing and GIS techniques and its applications in Geological Sciences; Principles and applications of GPS. Concepts of Parataxa and Eutaxa.

Laboratory and Field Exercises

1. Study of different fossils by using Peel Technique.
2. Study of Fossils of - algae, fungi and bryophytes.
3. Study of Indian Pre-cambrian stratigraphy and life forms.
4. Study of natural fossil fuels- Peat, coal and its varieties.
5. Study of Remote Sensing, GIS and GPS techniques for fossil study.
6. Exploration and excursion to different fossiliferous localities.

Suggested readings:

1. Stewart W.N. Palaeobotany and evolution of plant. Cambridge University Press, New York 405 p(1)
- 2 Stewart W. and G.W.Rathwell, 1993 Palaeobotany and the evolution of plant. 2 ed. Cambridge University Press, New York 521 p (1)
3. Thomas N. Taylor Edith L. Taylor Michael Krings Palaeobotany: The biology and Evolution of Fossil Plants Amsterdam; Boston.
1. Eames, A.J. (1936) Morphology of Vascular plant-lower group. Tata Mc Graw Hill, New Delhi.
5. Stewart W.N., Palaeobotany and evolution of plant. Cambridge University Press, New York 405 p (1)
6. Stewart, W., and G.W. Rothwell (1993) Palaeobotany and the evolution of plant. 2 ed. Cambridge University Press, New York 521 p(1)
7. Taylor Michael Krings (2009) - Palaeobotany. The biology and Evolution of Fossil Plants Amsterdam; Boston, Mass.: Academic Press, 2009
14. Wilson N Stewart and Gar W. Rothwell (1993)- Palaeobotany and the evolution of plants. Cambridge university press.
8. Edith L. Taylor, Thomas N. Taylor, Michael Krings (2009) - Palaeobotany: The Biology and Evolution of Fossil Plants. Academic Press.
9. Gupta, R.P. (1991) - Remote Sensing Geology, Springer-Verlag.
10. Prothero, D.R. (2004) - Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
11. Raup, D.M. and Stanley, S.M. (1985) - Principles of Paleontology, CBS Publishers, New Delhi.
12. Smith, A.B. (1994) - Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
13. Stearn, C.W. and Carroll, R.L. (1989) - Paleontology – the record of life, John

NEP-2020
M.Sc. Botany Syllabus
Semester III
Course code - (Elective - DSE)
Paper IV: Advanced Phycology- III

Credit – 02

Unit-I:

1. Definition, types and description of biofertilizer
2. Sources of nitrogen and its assimilation., importance and activity of biofertilizers and biotechnological implication
3. Biotechnology and the international market Nif gene transformation and present status of genetic engineering.
4. Hydrogen (fuel to tomorrow) production by algae

Unit II:

1. Algae as food, feed and medicine
2. **Toxic algae** :Phycotoxin, characteristic and their effect on human beings
3. **Prochlorophyta** :*Prochloron*
4. **Chlorophyta** :*Microspora, Draparnaldiosis, Trentopohlia, Fritschiella, Cosmarium, Codium, Bryopsis*

Unit III:

1. **Bacteria** : Strain selection, sterilization, growth, fermentation production, application technology for major biofertilizers, viz. *Rhizobium, Azatobactor, Azospirilum, Bacillus megaterium*(PSB), *Pseudomonus fluroscence*
2. **Cynobacteria** :*Phormidium, Aulosira, Cylindrospermum, Rivularia*, symbiotic algae and their role in other plants.

Unit-IV:

1. Industrial products from algae of marine and fresh water
2. **Pheophyta** :Thallus range, cell structure, alteration of generation, *Cutleria, Padina, Laminaria, Turbinaria*
3. **Rhodophyta**: *Nemalion, Gelidium, Gracilaria, Corallina, Polysiphonia*
4. **Euglenophyta**: *Euglena, Phacus*
5. **Bacillariophyta**: *Cyclotella, Synedra, Cymbella, Navicula, Gomphonema*
6. **Chrysophyta**: *Synura and Dinobryon*

Laboratory Exercises:

1. Collection of atleast 25 algal and bacterial specimen / materials (Description, sketching, identification and classification). Preparation of atleast 25 permanent slides (microtechniques, whole mount and smear technique).
2. Techniques of isolation, sterilization, seeding and culture of algae, biofertilizer in different media and isolation in cultures. Preparation of stock culture.
3. Camera lucida drawing of plant material.
4. Monographic study of algae.
5. Isolation, Identification and Characteristics of Biofertilizer- eg. *Rhizobium*, *Azotobactor*, *Azospirillum*, *Bacillus megaterium*(PSB)
6. Isolation, Identification and Characteristics of Cyanobacteria- eg. *Phormidium*, *Aulosira*, *Cylindrospermum*, *Rivularia*
7. Industrial and Biotechnological Applications of Algae

Suggested readings:

1. F. E. Fritsch 1961, The structure and reproduction of algae. Vol-I, Cambridge University, Press.
2. F. E. Fritsch 1977, The structure and reproduction of algae. Vol-II, Cambridge University, Press.
3. J. R. Stein 1973 Hand book of phycological methods (culture methods and growth measurement) Cambridge University, Press.
4. J. A. Hellebust & J. S. Craige 1978 Physiological & biochemical methods, Cambridge University, Press.
5. T. V. Desikachay Taxonomy and biology of blue green algae.
6. K. E. Carpenter Life in inland waters.
7. C. E. Hutchinson A treatise of Limnology Vol I and II.
8. W. T. Edmondson 1992 Fresh water biology international book of periodical supply service
9. C. C. Davis The marine and fresh water plankton.
10. H. B. N. Haynes the Biology of Polluted waters.
11. T. T. Mecom Fresh water ecology.
12. Amorgonfield book of Ponds and streams.
13. F. Rutter Fundamentals of Limnology
14. H. W. Ward & C. H. Whipple Fresh water Biology.
15. P. S. Welen Limnology.
16. P. S. Welen Limnology methods.
17. APHA/ AWWA 1989 Standard methods for examination of waters and waste. waters. *American Public Health Association.*
18. Mr. Motsara P. M. Bhattacharya & Beena Shrivastva Biofertilizer Technology Marketing.
19. C. F. Masco "Biology of fresh water pollution".
20. W. D. P. Stewart 1974 Algal physiology and biochemistry, *Blackwell Scientist Publication.*
21. J. D. Dodge 1975 The fine structure of algal cell Academic Press Lindon.

22. A. B. Hope and N. A. Walkar 1975 The physiology of green algal cells. Cambridge University Press.
23. Maudhe Forward 1966 The Chromosome of algae Edward Arnold (Publ) Ltd.
24. J. L. Rapoport 1977 Calcareous algae *Elsevier Sci. Pub. Com.*
25. Flight 1977 Fossil algae Springer-Verlag Berlin Heidelberg. New York.
26. J. E. Zajac Properties and products of algae.
27. M. T. Philipose Chlorococcales.
28. K. R. Ramnathan 1964 Ulotrichales, *Indian Agriculture Research Institute*
29. M. S. Randhawa 1959 Zygnemataceae, *Indian Agriculture Research Institute*

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M.Sc. Botany Syllabus

Semester III

Course code - (Elective-DSE)

Paper IV: Mycology and Plant Pathology- III

Credit – 02

Unit-I

Fungi in Agriculture: Mycorrhizae Ectotrophic, endotrophic and Ectendotrophic mycorrhizae; Role and importance of arbuscular mycorrhiza fungi in agriculture; Fungi as biological control of pest; Endogenous fungi, Nematophagous fungi; Mycoherbicides; Fungi as biofertilizers;

Rhizosphere and Phyllosphere: General account and importance of Rhizosphere and Phyllosphere., Mycoflora.

Unit II:

Fungi in Industry:

Fungal Metabolites: General account of production and applications; Primary metabolites (Vitamin, Proteins); Secondary Metabolites (Antibiotics, Pigments alkaloids).

Antibiotics: - Penicillin, Cephalosporins, Griseofulvin

Enzymes: Amylase, Protease, Lipase, Cellulases;

Organic acids: Citric acid, Gluconic acid, Lactic acid; Production of Alcohol.

Unit III:

Nonindustrial Fungal Metabolism: Marine environment an introduction, Culture medium and methods, Cultivation of macro and microalgae, Seaweed farming for potential application in food industries;

Phytoalexins: General account, Types and importance;

Mycotoxins: General account, Types, and importance;

Aflatoxins: General account, types and importance.

Unit-VI

Fungi in Pharmaceuticals: Endophytic fungi and their secondary metabolites; Drug development from fungal secondary metabolite; Bioactive molecules from fungi and their applications; Fungal compounds as anticancer agents; Biomass for fuel, Cosmetics, Integrated aquaculture, Wastewater treatment, Treatment of wastewater to reduce nitrogen and phosphorus containing compounds, Removal of toxic metals from industrial wastewater.

Laboratory Exercise: -

1. Isolation of Endophytic fungi.
2. Isolation of Secondary Metabolites from fungi.
3. To isolate & identify the Phyllosphere mycoflora.
3. To demonstrate the antifungal activity of various antibiotics and leaf, flower and root extract.
4. To study the toxicity of fungi in relation to seed germination and seedling abnormality.
5. To isolate the soil fungi by soil plate (War cup) and serial dilution (Walksman) method.
6. To isolate and identify the rhizosphere mycoflora.
7. To isolate the external and internal seed borne mycoflora (Cereals, pulses, oil seeds, fruit-seeds) by blotter and agar plate method.
8. To demonstrate the Koch's postulates.
9. To perform qualitative estimation of fungal enzymes— cellulases, lipase, protease and amylases.
10. To estimate the sugars, proteins and amino acids in fungal mycelium and culture filtrate.
11. To study the mycorrhiza (VAM).
12. To conduct field visits to different localities and to visit the Agriculture University, Plant pathology research centres etc.

Suggested Readings:

1. Agrios, G.N. (1980) Plant Pathology, Academic Press, INC, New York.
2. Ainsworth, G.C. and A.S.Sussman (eds). The Fungi, An advance Treatise Vol.I, II, III & IV. Academic Press, New York.
3. Alexopoulos, C.J. and Mims C.W. (1979). Introductory Mycology 3rd Edition, John Wiley and Sons, Inc. Wiley, New York.
4. Alexopoulos, C.J., Mims and Black well (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York.
5. Aneja, K.R. (1993) Experimental in Microbiology, Plant Pathology & Tissue Culture, WiswaPrakashan, New Delhi.
6. Barnett, J.H. (1968) Fundamentals of Mycology. The English Language Book Society and Edward Arnold Publication, Limited.
7. Bilgrami, K.S. and H.C.Dube (1985) A text Book of Modern Plant Pathology, Vikas Publication House, New Delhi.
8. Dube, R.C. and D.K.Maheshwari (1999) A Text Book of microbiology, S.Chand & Co. Ltd.

9. Dube, R.C. and D.K.Maheshwari (2000) Practical Microbiology -S.Chand& Co. Ltd.
10. Gupta, V.K. and M.K.Behl (1994) Indian Plant Viruses and Mycoplasma Kalyani Publishers,Ludhiana.
11. Jha, D.K. (1993) A Text Book of Seed Pathology, Vikas Publication House.
12. Mehrotra, R.S. (1989) Plant Pathology, Tata McGraw Hill.
13. Mehrotra, R.S. and K.R.Aneja (1998) An Introduction to Mycology, New Age Intermediate Press.
14. Marimuthu T. Krishnamoorthy, A.S. Sivaprakasam, K. Jayaranjan. R (1991) Oyster Mushroom, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbtore.
15. Pelzer, M.J., Jr.Cahn, E.C.S. and N.R.Krieg (1993) Microbiology, Tata McGraw Hill.
16. Preece and Dickeson. Ecology of leaf surface microorganism Academic Press, New York.
17. Rangaswamy, G. and A.Mahadevan (1999) Diseases of Crop Plant in India, Prentice Hall of India.
18. Raychoudhari, S.P. and Nariani, T.K. (1977) Virus and Mycoplasma Diseases of Plant in India,Oxford and IBH Publication Co.
19. Schlegel, H.G. (1996) General Microbiology, 7th Edition, Cambridge University Press.
20. Snowdon, A.L. (1991) A colour Atlas of Post harvest diseases & disorders of fruits & vegetables Vol.I& II Wolfe Scientific, London.
21. Sunder Rajan, S. (2001) Tools and Techniques of Microbiology, Anmol Publ.New Delhi.
22. Thind, T.S. (1998) Diseases of field crops and their management, National Agricultural Technology, Information Centre, Ludhiana.
23. Swaminathan M. (1990) Food and Nutrition.Bappco, The Bangalore Printing and Publishing Co. Ltd., No.88, Mysore Road, Bangalore- 560018.
24. Tewari, Pankaj Kapoor, S.C., (1988) Mushroom Publications, Delhi.
25. Nita Bahl (1984-1988) Hand Book of Mushrooms, II Edition Vol. I & Vol. II.
26. Vaidya, J.G. (1995) Biology of the fungi, Satyajeet Prakashan, Pune.
27. Walker, J.C. (1968) Plant Pathology, McGraw Hill, New York.
28. Walker, J.G. (1952) Diseases of Vegetables Crops. McGraw Hill, New York.

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M. Sc. Botany Syllabus
Semester IV
Course code-
Paper I -Plant Ecology

Credit-4

Unit I:

Vegetation organization: Concepts of community and continuum, analysis of communities (analytical and synthetic characters): interspecific associations, concept of ecological niche.
Vegetation development: Temporal changes (cyclic and non-cyclic); mechanism of ecological succession (relay floristics and initial floristic composition; facilitation, tolerance and inhibition models); changes in ecosystem properties during succession, Autecology.

Unit II:

Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies); litter fall and decomposition (mechanism, substrate quality and climatic factors); global biogeochemical cycles of C, N, P, and S; mineral cycles (pathways, processes, budgets) in terrestrial and aquatic ecosystems.

Unit III:

Air, Water and Soil pollution: Kinds; sources; quality parameters; effects on plant and ecosystems. Climate change: Greenhouse gases (CO₂, CH₄, N₂O, CFCs; sources, trends and role); ozone layer and ozone hole; consequences of climate change (Global warming, sea level rise, UV radiation).

Unit IV:

Ecosystem stability: Concept (resistance and resilience); Ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems; ecology of plant invasion; environmental impact assessment; ecosystem restoration.
Ecological management: Concepts; sustainable development; sustainability indicators.

Laboratory Exercises: - Practical – I Credit – 02

1. A trip to the grass land/ forest/ water body to get acquainted with their plant species.
2. Distribution pattern of different plant species determined by Quadrat/ Transat/ PointCentered Quarter methods.
3. Qualitative parameters of distribution of plant species, Frequency, Density, Basal cover, dominance, Abundance and IVI.
4. Analysis of soils of two different areas i.e. Cropland and forest/ grassland for certain nutrients, CO₃, NO₃, Base deficiency.
5. Analysis of water quality for physical properties like colour, BOD, COD, O₂, CO₂ contents etc.
6. Study of adaptations in plants of Hydrophytic, Xerophytic and Halophytic zones.

Suggested Readings:

1. Ambast R.S. 1968. Freshwater ecosystem- Manual of Ecology 123-137 (See Misra KC et al., 1968)
2. Ambast R.S. 1966 Conservation Ecology, Abs Proc School on Plant Ecol (Full paper in press Oxford and IBH Calcutta).
3. Ambast R.S. 1995 A text book of plant ecology Student and co. Varanasi-5
4. Anderson JM Ecology for environmental sciences: biosphere ecosystems and man
5. Billings WB 1964 Plants and the ecosystem Macmillan & co, London.
6. Clements FE 1916 Plant succession, An analysis of the development of vegetation. Carnegie Institute of Washington.
7. Cragg, J. B 1968 The theory and practice of conservation, IUCN Publ, New Series No. 12, 25-35.
8. Dash, M.C. 1993 Fundamentals of Ecology WB Saunders and co. Philadelphia USA.
9. Deangelis, D.L. Energy flow, nutrient cycling and ecosystem resilience. Ecology 56, 238-243.
10. Dwivedi Rama Shankar 1968. The decomposer system manual of ecology
11. Frankel, O. H., & Soule, M. E., 1981, Conservation and Evolution, Cambridge Univ Press.
12. Grace, J. 1983 Plant atmosphere relationships. Chapman & Hall.
13. Greig Smith P 1983, Quantitative plant ecology, Univ California Press, California.
14. Hutchings, M. J. (ed) 1988, Plant population biology, Blackwell.
15. Hutchinson, G. E. 1978, An introduction to population ecology. Yale Univ. Press.
16. Kochhar, P. L. 1986 Plant Ecology Ratan prakashan, Mandi, Agra.
17. Krebs, G. J. 1972 Ecology Harper and Row Publ, New York.
18. Kumar, H. D. 1994 Modern concepts of ecology. Vikas publishing house pvt ltd, New Delhi.
19. May, R. M. (ed) 1981 Theoretical Ecology, Blackwell.
20. Odum, E. P. 1963 Ecology Holt Reinhart and Winston Inc.
21. Odum, E. P. 1983 Basic Ecology, Saunders Publ Philadelphia.
22. Reynolds, C. S. 1984 The ecology of phytoplankton, Cambridge Univ Press
23. Silvertown, J. W. 1982 Introduction to plant population ecology, Longman.
24. Southwick, C. H. 1983 (ed) Global Ecology Sinauer.
25. Whittaker, R. H. 1975 Communities and Ecosystems (2nd ed) MacMillan, New York

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Semester IV
Course Code: **Credit - 04**
Paper- II -Plant Breeding and Biostatistics

Unit I:

Methods of plant breeding: Introduction, selection, (Pure line selection, W. L. Johansons experiments on beans and their significance, Variety acclimatization, genetic significance of pollination methods, methods of breeding self and cross pollinated crops and asexually and vegetatively propagated crops;

Heterosis breeding: i) Historical aspects, ii) Interbreeding depression, iii) Homozygous and heterozygous balance, iv) Genetic basis of inbreeding, v) Genetic and physiological basis of heterosis.

Unit II:

Incompatibility in plant breeding: Methods of induction and overcoming, incompatibility as a tool in breeding crops;

Male sterility: Definition and classification, Male sex expression and chemical Induction of male sterility, perspectives;

Seed production and distribution: Introduction variety evaluation, variety maintenance, availability of new varieties, seed production and regulation, seeds industry development. Breeding crops with special reference to maharashtra like Wheat. Jowar, Cotton, Groundnut, etc

Unit III

Resistance breeding:

- A. Disease resistance: nature, mechanism of resistance, methodology problems and achievements.
- B. Insect resistance: Nature, mechanism of resistance, methodology, problem and achievements.
- C. Drought resistance, importance, types, nature of resistance methods and examples.

Quality breeding: Nature of quality, Genetic and biochemical basis, Genetic manipulation of quality and quantity.

Distant Hybridization: Importance, Interspecific, intergeneric gene transfers, methodology, problem and remedial measures, manmade species.

Seed production and distribution: Introduction variety evaluation, variety maintenance, availability of new varieties, seed production and regulation, seeds industry development. Breeding crops with special reference to maharashtra like Jowar, Groundnut, etc.

UNIT-IV

Means, Variance, Standard deviation, Standard error, Chi-square and its application, Concept of Probability, Addition and multiplication of rule; Level of significance ; One-Way ANOVA and Two way ANOVA; t-test; Introduction to computer; Use of word and power point presentation of document; Use of Internet and World Wide Web in Research; Basic Concept of Bioinformatics.

Laboratory Exercises: - Practical – II Credit – 02

1. Study of floral biology of different crop plants.
2. Demonstration of hybridization technique in self- and cross-pollinated crops.
3. Study of pollen germination and demonstration of incompatibility.
4. Demonstration of male sterility in Jowar.
5. Study of pollen fertility.
6. Study of pollen viability.
7. Study of seed protein profile by native and SDS-PAGE.
8. Estimation of oils from edible oil crops.
9. Problems in Biostatistics :
 - a. Graphic representation of data :Histogram,
 - b. Mean, Median, Mode, Variance, Standard Deviation and Standard Error
 - c. Chi-square and Student's "t" test.
 - d. Concept of Probability: Addition and multiplication rule.

Suggested readings:

1. Plant Breeding- B.D.Sitigi.
2. Plant Breeding- J. R. Sharma.
3. An Introduction of plant breeding- H. K. Chaudhary.
4. Evolution of crop plants - Edited by Simmonds N.W(1986)
5. Breeding field crops- Poehlrnann and Sleper.
6. Plant Breeding perspectives- Edited by Sheep and Mendnkasen.
7. Crop Breeding, P. B. Vose and S. G. Blixt
8. Manual of mutation breeding by FAO/IAEA.
9. Mutation Research-Aurebach.
10. Chemical mutagenesis –Fish beirietal.,
11. Khan, I.A. and A. Khanum. 1994 Fundamentals of Biostatistics
12. B .N .Mishra and K.K.Mishra. NayaPrakash. 1983. Introductory practical Biostatistics.
13. Jain, v. k. Computers for beginners. Pustak Mahal.

14. Bennet Falk. 2000.The Internet road map .BPB Publications.
15. Cynthia Gibas.O'Reilly&Assoc.2000.Developing Bioinformatics Computer skills.

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M.Sc. Botany Syllabus
Semester IV
Course Code: (Elective- DSE) Credit - 04
Paper- III -Molecular Biology and Plant Biotechnology – IV

UNIT- I:

Transgenics: Cloning vectors for higher plants; Methods for gene transfer, *Agrobacterium tumefaciens* mediated- Basis of tumor formation, features of Ti and Ri plasmids, mechanisms of DNA transfer, role of virulence genes, use of Ti and Ri genetic markers, use of reporter genes and introns; Direct DNA transfer; particle bombardment; electroporation; microinjection; macroinjection;liposomes; electrophoretic; pollen tube method; pollen transformation; PEG method; transformation of monocots; transgene stability and gene silencing; chloroplast transformation.

UNIT- II:

Applications of transformation: Herbicide resistance; insect resistance; Bt genes, disease resistance; nutritional quality; biopesticides and biofertilizers; hazards and safety regulations for transgenic plants.

Metabolic engineering through transgenic plants: Production of secondary metabolites; industrial enzymes; biodegradable plastics (PHB and others); edible vaccines; antibody production and other important drugs.

UNIT- III:

Plant tissue culture: History, basic concepts; principles and scope; tissue culture media;

Culture types: callus culture, organ culture, suspension culture for production of secondary metabolites, protoplast culture, fusion and somatic hybrids, somatic embryogenesis, anther and pollen culture, haploid plants, somaclonal variations, organogenesis (direct and indirect).

Gene expression: Gene expression in Mitochondria, chloroplast, yeast

Regulation of gene expression: Regulation of gene expression in translation and post-translation level.

UNIT- IV:

Nitrogen fixing genes: Organization, function and regulation of nitrogen fixing genes in *Klebsiella*, up genes.

DNA fingerprinting and marker assisted breeding: RFLP maps; linkage analysis; RAPD markers; STS; SSR (microsatellites); ISSR; SCAR (sequence characterized amplified regions);

SSCP (single strand conformational polymorphism); AFLP; QTL: map-based cloning; molecular marker assisted selection.

Cleaner Biotechnology: Pollution control through genetically modified organisms.

Suggested Readings:

- Alberts, Bruce; Johnson Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter, C.2002 Molecular Biology of the Cell, Garland Science, New York and London.
- Bhojwani SS and Rajdhan MK 1996 Plant tissue culture: Theory and Practice. Elsevier Sci. Publ., New York.
- Callow, J. A., Ford-Lloyed, B. V. and Newbury, H. J. 1997. Biotechnology and Plant Genetic Resources: Conservation and Use, CAB International, Oxon UK.
- Charlwood, B. Y. and Rhodes, M.V. 1999 Secondary products from plant tissue culture, Clarendon Press. Oxford.
- Chrispeels, M. J. and Sadava, D. E. 1994, Plants, Genes and Agriculture. Jones & Barlett Publishers, Boston, USA.
- Collins HA and Edwards S 1998 Plant cell culture. BIOS Sci. Publ., Oxford UK.
- Dicosmo F and Misawa, M. 1996 Plant Cell culture: Secondary metabolism towards industrial application, CRC press, Boca Raton, New York.
- Glazer, A. N. and Nikaido, H. 1995. Microbial Biotechnology. W. H. Freeman & Company, New York, USA.
- Gustafson, R. J. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA.
- Henry, R. J. 1997. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
- Jain S M, Sopory S K and Veilleux RE 1996 In vitro haploid production in higher plants. Vol.1, Kluwer Acad. Publ., The Netherlands.
- Kurz, W.G.W 1989 Primary and Secondary metabolism of plant and Cell cultures, SpringerVerlag, Berlin.
- Old, R. W. and Primrose, S. B. 1989. Principles of Genome Analysis. Blackwell Scientific Publications. Oxford, UK.
- Primrose, S. B. 1995. Principles of Genome Analysis. Blackwell Scientific Ltd., Oxford, UK.
- Raghavan, V. 1997. Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.
- Shantharam, S. and Montgomery, J. F. 1999. Biotechnology, Biosafety, and Biodiversity. Oxford & IBH Publication Co., Pvt., Ltd., New Delhi.
- References: Online journals available on UGC V-SAT programme.

Suggested Readings for laboratory Exercises:

- Gelvin, S. B. and Schilperoort, R. A (eds) 1994. Plant Molecular Biology Manual, 2nd edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Glick, B. R. and Thompson, J. E. 1993, Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.

- Glover, D. M. and Hames, B. D.(Eds) 1995. DNA Cloning 1: A Practical Approach: Core Techniques, 2nd edition PAS, IRL Press at Oxford University Press, Oxford.
- Hackett, P. B. Fuchs, J. A. and Messing, J. W. 1988. An Introduction to Recombinant DNA Techniques. Basic Experiments in Gene Manipulation. The Benjamin/Cummings Publishing Co., Inc. Menlo Park, California.
- Hall, R. D. (Ed.), 1999. Plant Cell Culture Protocols. Humana Press. Inc. New Jersey, USA.
- Maniatis et al. Molecular cloning Vol. I, II and III. Cold-Spring Harbor Lab Press.
- Sambrook and Russel. 2001. Molecular cloning Vol. 1-3 CSH press.
- Shaw, C. H. (Ed.) 1988, Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.
- Smith, R. H. 2000. Plant Tissue Culture: Techniques and Experiments. Academic Press, New York.

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M.Sc. Botany Syllabus
Semester IV
Course Code: (Elective-DSE)
Paper- III-Reproductive Biology of Angiosperms– IV Credit - 04

Unit 1:

Seed Dormancy: Types of Seed Dormancy (Exogenous Dormancy, Endogenous Dormancy) Factors Responsible for Seed Dormancy (Environmental Factors and Reasons for Seed Dormancy) Importance of Seed Dormancy, Methods to Overcome Dormancy, Bud Dormancy.

Seed Dispersal: Active Dispersal of Seeds (Autochoric Seeds), types of seed dispersal and mechanism, Significance of seed dispersal.

Unit II:

Development of Fruit and Fruit types- Fruit development, Effect of growth regulators on fruit development, Fruit Types (On basis of origin, composition, fruit ripening) Dehiscence of Fruits, Dynamics of Fruit Growth, Fruit set, Fruit growth, Fruit Maturation, Fruit Ripening/senescence. Fruit dispersal.

Biochemical Changes during the fruit Ripening - Chloroplast to chromoplast conversion and colour change, Flavour and aroma biochemistry, Sugars and Acids, Volatiles. Regulation of Ethylene Synthesis during fruit development and ethylene signalling.

Unit III:

Apomixis: Definition, causes, classification, - Diplospory, Apospory, pseudogamy, autogamous development of endosperm, causes of apomixes, significance.

Mellitopalynology: Pollen analysis of honey, Role of apiary in crop production.

Biotechnology: Concept and scope of biotechnology; Cell structure, cellular totipotency

a) **Anther and pollen culture,**

b) **Ovule and nucellus culture**

c) **Endosperm culture and its practical applications**

d) **Embryo culture:** Techniques, nutritional aspects of embryo culture morphological and physiological considerations, culture of mature embryo and proembryo.

e) **Somatic embryogenesis:** historical background, embryogenesis from callus, direct embryogenesis- recurrent embryogenesis; cytology of somatic embryogenesis, nutritional factors, hormonal factors.

Unit IV:

a) **Protoplast culture and somatic hybridization-** isolation of protoplast, culture methods, fusion of protoplast, selection of fusion products, consequences of fusion, production of Cybrids and hybrids.

b) **Biotransformation and production of useful compounds** through cell culture, factor affecting yield, biotransformation, bioreactors, perspective.

Suggested Readings:

- Asker S. 1979, Progress in apomixis research. *Hereditas* 91, 231-240.
- Barnier, G. 1986, The flowering process as an example of plastic development. *Soc. Expt. Biol.* 40: 257-286.
- Barth, F.G. 1991, insects and flowers, Princeton Univ. Press. Princeton.
- Battaglia, E. 1963. Apomixis In recent advances in the embryology of angiosperms (ed P. Maheshwari), pp- 264, Intt. Soc. Plant Morphologists, Univ. Delhi.
- Bhandari N. N. 1984, The microsporangium in embryology of angiosperms (ed B.M. Johri) Springer- Verlag, Berlin, pp. 53-121.
- Bhandari N.N., M. Bhargava and P. Chitralkha 1986, Cellularization of free nuclear endosperm of *Pappaversomniferum* L. *Phytomorphology*, 36, 357-366.
- Bhojwani S.S. and M.K. Rajdan 1983, Plant tissue culture, Theory and Practice Elsevier, Amsterdam. Boesewinkel F.D. and Boman F. 1984, The seed structure in embryology of angiosperms (ed B.M.Johri), Springer- Verlag, Berlin, pp. 567-610.
- Boesewinkel, F.D., Bouman, F. (1984). The Seed: Structure. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_12
- Bouman F. 1984 The ovule in embryology of angiosperms (ed B.M.Johri), Springer-Verlag, Berlin, pp. 123-157.
- Cartson P.S. (1973) The use of protoplasts of genetic research. *Proc. Nat. Acad. Sci. USA*, 70, 598-602.
- Cartson P.S., Smith N.H., Dearing R.D. (1972) Parasexual interspecific plant hybridization. *Proc. Nat. Acad. Sci. USA*, 69, 2292-2294.
- Chitralkha P. and N.N. Bhandari 1991, Post fertilization development of antipodal cells in 31 *Ranunculusscferatus*. *Phytomorphology* 41, 200-212.
- Ciampolini F.M., Nepi and E. Pacini 1993, tapetum development in *Cucurbita pepo* (*Cucurbitaceae*) *Pt. Syst. Evol. (Suppl)* 7-13-22.
- Cocking E.C. 1960, A method for the isolation of plant protoplasts and vacuoles. *Nature (London)* 187-927-929.

- Cocking E.C. 1970, Virus uptake, cell wall regeneration and virus multiplication in isolated plant protoplasts. *Int. Rev. Cytol* 28-89-124.
- D'Amato, F. (1984). Role of Polyploidy in Reproductive Organs and Tissues. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_11
- Jacobsen, J.V. (1984). The Seed: Germination. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_13
- Johri, B.M. (1984). *Embryology of Angiosperms*; Editors · Brij Mohan Johri; DOI ·; Publisher · Springer Berlin, Heidelberg. <https://doi.org/10.1007/978-3-642-69302-1>
- Nogler, G.A. (1984). Gametophytic Apomixis. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_10
- <https://courseware.cutm.ac.in/courses/reproductive-biology-of-angiosperms/>

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M.Sc. Botany Syllabus
Semester IV
Course code - (Elective-DSE)
Paper III: Paleobotany-IV

Credit – 04

Unit- I

The colonization of land: Environmental changes before terrestrialization; Land adaptive features; Evolution of land plants- different evidences.

Stratigraphy: Outline; Principles of uniformitarianism and superposition; gaps in the time record; code of stratigraphic nomenclature; Biostratigraphy, Lithostratigraphy, Chronostratigraphy, stratigraphic correlation.

Unit- II

Mystery of angiosperm origin: reasons for the late arrival in the fossil record, Pre-Cretaceous angiosperms; early angiosperms and their possible habit; evolution of C4 and CAM plants; first grasses.

Brief concept of mass extinction: evidence in the geological record: plants versus animals; Floral changes across the Cretaceous-Palaeocene boundary (K/Pg).

Unit- III

Evolutionary theories (Lamarckism, Darwinism, Mutation theory); Evolutionary and environmental changes: Phyletic gradualism, Punctuated equilibrium, Pattern of evolutionary change in the plant fossil record; Mechanisms driving evolutionary change.

Ancient DNA and other fossil biomolecules and their potential in evolutionary research; Stable isotopes and tree ring in reconstruction of palaeoclimate.

Unit- IV

Aspects and Appraisal of Palaeobotany: Palaeobotanical study in exploring - mysteries in the living planet; origin, evolution, diversification and extinction of species. Geological age and correlation of strata.

Quaternary palynology in understanding global warming, climate changes, eustatic sea level change; coastal evolution with special reference to Bengal basin.

Suggested Readings:

1. Agashe, S. N. (1995) - Palaeobotany, Plants of the past, their evolution, palaeoenvironment and application in exploration of fossil fuels. Oxford & IBH publishing company-New Delhi.
2. Andrews, H.N. (1961) - Studies in Palaeobotany, Willey and Sons –New York.
3. Meyen, S.V. (1987) – Fundamentals of Palaeobotany Chapman and Hill, London, New York.
4. Parihar, N.S. (1995) –Essentials of Palaeobotany, Central Book –Allahabad.
5. Stewart, W.N. & Rothwell, G.V. (1993) - Palaeobotany and Evolution of Plants, Cambridge Univ., Press-Cambridge.
6. Venkatchala, B.S. & Maheshwari, H.K. (1991) - Palaeobotanical Researches in India. Jour. Ind. Bot. Society-70; 1-12.
7. Wadia, D.N (1953) - Geology of India, Mac, Millan-Co. London.
8. Prasad, K.N. (1999) - An introduction to palaeobotany, APH Pub.
9. Cleal, J. Christopher. & B.A. Thomas (2009) - Introduction to Plant Fossils, Cambridge Univ., Press-Cambridge.
10. Willis, K. J. & Mc Elwain, J. C. (2014) - The Evolution of Plants (second edition) OXFORD University Press.
11. Stewart, W.N. and Rothwell G.W. (1993) - Palaeobotany and the Evolution of Plants, Cambridge University Press.
12. Arnold, C.A. (1947) - Introduction to Palaeobotany, Mc-Graw Hill Book Co. Inc., New York and London.
13. Agashe, S.N. (1995) - Palaeobotany, Oxford & IBH, New Delhi.
14. Siddiqui, K.A. (2002) - Elements of Palaeobotany, Kitab Mahal, Allahabad.
15. Thomas, B.A. & Spicer R.A. (1987) - The Evolution and Palaeobiology of land plants. Discordies Press, Fort land, USA.
16. Spicer, R.A. & Thomas, B.A. (1986) - Systematic and taxonomic approaches in Palaeobotany. Systematic Association Special Volume.
17. Singh Savindra (1998) - Geomorphology, Prayag Publication, Allahabad.
18. Chorley, R.G. (1972) - Spatial Analysis in Geomorphology, Methuen, Londonpta
19. Dr. V.S. Kale & Abhijit Gupta - Introduction to Geomorphology.
20. Garner H.F. (1974) - The origin of the Landscape- A syntheses of Geomorphology, Oxford University Press London.

NEP-2020
M.Sc. Botany Syllabus
Semester IV
Course code - (Elective-DSE)
Paper III: Advanced Phycology-IV

Credit – 04

Unit- I

Algae Physiology, and Cultivation:

1. Cyanide resistance, respiration in algae, heavy metal pollution and their role in Biotechnology
2. Intracellular substance of *Spirulina*, *Scenedesmus*, *Chlorella* and marine algae.
3. Algae culture, mass cultivation of algae in laboratory and their field application.

Unit- II

Hydrobiology /Limnology:

1. **Lentic Environment:** General consideration, physio-chemical factor, and their influence, Phytoplankton nature and adaptation of plankters, periodicity and succession, vertical distribution, productivity and factors influencing it.
2. **Lotic Environment:** General consideration, physio-chemical factors, and their influence.
3. **Marine benthic:** General Principal, shore types, zonation patterns and factors governing them, Life forms, geographical distribution, marine algae in india.

Unit- III

Study of Phytoplankton:

1. Terminology, population, adaptation
2. Distribution, productivity and succession
3. Primary productivity and measurement of growth rate and natural mortality.
4. Chemical feature and chemical cycles in epilimnion and hypolimnion.

Unit- IV

Ecology and Environmental Biotechnology:

1. Distribution, community structure in fresh and marine water. Role of algae as indicators of pollution and its concept.
2. Algae in waste water treatment, use of algal bacterial system in sewage and other waste effluent, Biomonitoring of water quality. Algae stabilization Pond.

3. Ecobiotechnology for the remediation of eutrophic lentic and lotic water bodies.

Suggested readings:

1. F. E. Fritsch 1961, The structure and reproduction of algae. Vol-I, Cambridge University, Press
2. F. E. Fritsch 1977, The structure and reproduction of algae. Vol-II, Cambridge University, Press
3. J. R. Stein 1973, Hand book of phycollogical methods (culture methods and growth measurement) Cambridge University, Press
4. J. A. Hellebust & J. S. Craige 1978, Physiological & biochemical methods, Cambridge University, Press
5. T. V. Desikachay Taxonomy and biology of blue green algae.
6. K. E. Carpenter Life in inland waters
7. C. E. Hutchinson A treatisa of limonology Vol I and II
8. W. T. Edmondson 1992, Fresh water biology internation book of periodical supply service.
9. C. C. Davis The marine and fresh water plankton.
10. H. B. N. Haynes the Biology of Polluted waters.
11. T. T. Mecom Fresh water ecology.
12. AmorgonField book of Ponds and streams.
13. F. Rutter Fundamentals of limnology.
14. H. W. Ward & C. H. Whipple Fresh water Biology.
15. P. S. Welen limnology.
16. P. S. Welen Limnology methods.
17. APHA/ AWWA 1989, Standard methods for examination of waters and waste waters. American Public Health Association.
18. Mr. Motsara P.M, Bhattacharya & Beena Shrivastva Biofertilizer Technology Marketing.
19. C. F. Masco Biology of fresh water pollution.
20. W. D. P. Stewart 1974, Algal Physiology and Biochemistry, BlackwellScientist Publication.
21. J. D. Dodge 1975, The fine structure of algal cell,*Academic Press Lindon*.
22. A. B. Hope and N. A. Walkar 1975, The physiology of Grant algal cells., Cambridge University Press.
23. Maudhe Forward 1966, The Chromosome of algal Edward Arnold (Publ) Ltd.
24. J. L. Wrap 1977, Calcareous algae Elsevier Sci. Pub. Com.
25. Flight 1977 Fossil algae spunger -verlagBerlinNeidelhery. New York
26. J. E. Zajie Properties and of product of algae.
27. M. T. Philipose Chlorococcales.
28. K. R. Ramnathan 1964,Ulotrichales Indian Agriculture Research Institute.
29. M. S. Randhawa 1959,Zygnemacae,Indian Agriculture Research Institute.

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M.Sc. Botany Syllabus Semester IV

Course code - (Elective-DSE)
Paper III: Mycology and Plant Pathology – IV Credit – 04

Unit-I

Fungi as Food: Mushroom definitions, Characteristics of mushrooms, Edible mushrooms and their cultivation practices, General account and importance of Oyster, white, button, paddy straw, Morels, Truffles & Poisonous mushrooms, Cultivation and economics of *Agaricus bisporus*, *Pleurotus* and *Volvoriella* Medicinal and nutritional value of edible and poisonous mushrooms, General techniques and their application in improving mushroom production.

Unit II:

Fungi as welfare to human beings Biodeterioration and Biodegradation: Biodeterioration of non-cellulosic material (leather, Plastics, Hydrocarbons, Pesticides) Biodeterioration of cellulosic materials Role of microorganisms in biodegradation of organic wastes; Factor affecting the process of biodegradation;

Management of plant diseases: Cultural, chemical, biological, biopesticides, breeding for resistant varieties, plant quarantine, integrated pest management

Unit III: -

Medical Mycology:

Dermatophytic Fungi- Knowledge of common dermatophytes and human diseases caused by them viz., *Tinea pedis*, *Tinea capitis*, *Tinea barbae*, *Tinea corporis* and *Tinea manuum*, Aspergillosis; fungi allergic to human beings.

Bioactive phenolic compounds in seaweeds; seaweeds as a source of bioactive proteins; peptides and amino acids; lipid and fatty acid profile of major seaweeds; Minerals in edible seaweeds.

Unit-IV

Fungal Nanotechnology: Introduction; Myconano technology; Mycosynthesis; Role of Fungi in Synthesis of Nanoparticles; Synthesis of Different Nanoparticles using Fungi; Mechanism of Synthesis; Applications of nanoparticles synthesized by Fungi.

Suggested readings:

1. Eggins, H.O.W. and Allsop (1975) The Filamentous Fungi Vol. I Industrial Mycology (Biodeterioration and Biodegradation by Fungi) Eds. J.E. Smith and D.R. Berry Edward Arnold, London.

2. Emmons, C. W., C. H. Binford, J.P. Utz and Know Chung (1977) *Medical Mycology*, Lea and Febigo, Philadelphia.
3. *Illustrated Generic names of Fungi* Miguel Ulloa, E. Aguirre-Acosta APS PRESS 2019.
4. *Illustrated Dictionary of Mycology* Miguel Uloa, Richard T. Hanlin Amer Phytopathological Society; 2000 ISBN-10: 0890542570; ISBN-13: 978-0890542576.
5. *Introductory Mycology*, 4ed C.J. Alexopoulos, C.W. Mims, M. Blackwell Wiley; Fourth edition, 2007 ISBN-10: 8126511087; ISBN-13: 978-8126511082.
6. K. R. Aneja *An Introduction to Mycology* New Age International Private Limited; Second edition; 2015 ISBN-10: 8122437966; ISBN-13: 978-8122437966.
8. Alexopoulos, Mims and Blackwell. *Introductory Mycology*, Fourth Edition. John Wiley & Sons, New York, 1996.
9. Arora, David, Shepherd, Glenn, *Economic Botany*, Vol. 62, #3, The New York Botanical Garden Press, Bronx, NY, 2008.
10. Ainsworth, G.C. and A. S. Sussman (eds). *The Fungi, An advance Treatise* Vol. I, II, III & IV Academic Press, New York. 48. Alexopoulos, C.J. and Mims C.W. (1979).
11. *Introductory Mycology* 3rd Edition, John Wiley and Sons, Inc. Wiley, New York.
12. Alexopoulos, C.J., Mims and Blackwell (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York.
13. Aneja, K.R. (1993) *Experimental in Microbiology, Plant Pathology & Tissue Culture*, Wiswa Prakashan, New Delhi.
14. Bessey, E.A. (1950) *Morphology and Taxonomy of Fungi*. The Blakiston Co. Philadelphia.
15. Bilgrami, K.S. and H.C. Dube (1985) *A text Book of Modern Plant Pathology*, Vikas Publication House, New Delhi.
16. Butler E.J. and S. J. Jones (1949) *Plant Pathology*, Macmillan & Co. New York.
17. Dube, R.C. and D. K. Maheshwari (2000) *Practical Microbiology - S. Chand & Co. Ltd.*
18. Gupta, V.K. and M. K. Behl (1994) *Indian Plant Viruses and Mycoplasma* Kalyani Publishers, 1/1, Rejinder Nagar, Ludhiana.
19. Jha, D.K. (1993) *A Text Book of Seed Pathology*, Vikas Publication House.
20. Manibhushan Rao, K. and A. Mahadevan - *Recent Development in biocontrol of plant pathogens. Today and Tomorrow publishers, New Delhi.*
21. Mehrotra, R.S. and K. R. Aneja (1998) *An Introduction to Mycology*, New Age Intermediate Press. . Mukadam, D.S. and L.V. Gangawane (1978) *Experimental Plant Pathology* (edited) Marathwada University Aurangabad.
22. Pande, P.B. (1997) *Plant Pathology*, S. Chand & Co. New Delhi.
23. Preece and Dickeson. *Ecology of leaf surface microorganism* Academic Press, New York.
24. Rangaswamy, G. and A. Mahadevan (1999) *Diseases of Crop Plant in India*, Prentice Hall of India. . Sing, R.S. (1994) *Plant Pathology*, Oxford and IBH Publication Co. New Delhi.
25. Thind, T.S. (1998) *Diseases of field crops and their management*, National Agricultural Technology, Information Centre Ludhiana.
26. C. Manohara chary, K. V. B. R. Tilak, K. V. Mallaiah and I. K. Kunwar 2016, *Mycology and Microbiology*, Scientific Publishers, Jodhpur Rajasthan.
27. KR Aneja, R.S. Mehrotra 2015 *An Introduction to Mycology*, New Age International Private Limited. 67. *Introduction to Fungi, Bacteria and Viruses* 2017 HC Dubey Agri bios, India
28. *Text Book Of Fungi* 2010, R.C. Gupta, Omprakash Sharma Oxford publication.
29. *Text Book of Fungi* Omprakash Sharma, Tata McGraw-Hill Publishing Company, 1989

Gondwana University, Gadchiroli Practical Examination
M.Sc. Botany Semester III (NEP 2020)
Practical based on Major (Paper 1, 2, 3) **Credit:2**
Course code –

Time : 4 Hours	Full Marks : 30
Q. 1 One experiment from Major Paper I (DSC) [A]	5
Q. 2 One experiment from Major Paper II (DSC) [B]	5
Q. 3 One exercise from Major Paper III (DSC) [C]	5
Q. 4 Spotting : D Angiosperm- II E Cytology and genetics F Plant Biochemistry	6
Q. 5 Viva voce	4
Q. 6 Practical record and tour report	5

Gondwana University, Gadchiroli Practical Examination
M.Sc. Botany Semester III (NEP 2020)
Credit:2
Practical based on Elective Paper
Course code –

Time : 4 Hours	Full Marks : 30
Q. 1 One exercise from Paper IV (ELECTIVE -DSE) [A]	5
Q. 2 One exercise from Paper IV (ELECTIVE -DSE) [B]	5
Q. 3 One exercise from Paper IV (ELECTIVE -DSE) [C]	5
Q. 4 Spotting : D (Core Elective -DSE) E (Core Elective -DSE) F (Core Elective-DSE)	6
Q. 5 Viva voce	4
Q. 6 Practical record and tour report	

Gondwana University, Gadchiroli Practical Examination

M.Sc. Botany Semester IV (NEP 2020) Credit:2

Practical based on Major (Paper 1-Plant Ecology)

Course code –

Time : 4 Hours

Full Marks : 30

Q. 1 Experiment from Major Paper I (DSC) [A]	5
Q. 2 Experiment from Major Paper I (DSC) [B]	5
Q. 3 Exercise from Major Paper I (DSC) [C]	5
Q. 4 Spotting :	6
D Plant Ecology	
E Plant Ecology	
F Plant Ecology	
Q. 5 Viva voce	4
Q. 6 Practical record and tour report	5

Gondwana University, Gadchiroli Practical Examination

M.Sc. Botany Semester IV (NEP 2020)

Credit:2

Practical based on Major (Paper II-Plant Breeding & Biostatistics)

Course code –

Time : 4 Hours

Full Marks : 30

Q. 1 Experiment from Major Paper II (DSC) [A]	5
Q. 2 Experiment from Major Paper II (DSC) [B]	5
Q. 3 Exercise from Major Paper II (DSC) [C]	5
Q. 5 Spotting :	6
D Plant Breeding	
E Plant Breeding	
F Biostatistics	
Q. 6 Viva voce	4
Q. 7 Practical record and tour report	5

Gondwana University, Gadchiroli

NEP-2020

Theory Question Paper Pattern

M.SC BOTANY (All Semester)

Note: 1) All questions are compulsory and carry equal marks.

2) Draw well labelled diagram wherever necessary.

Question 1. Unit – I	16
OR	
a) Unit – I	8*2
b) Unit – I	
Question 2. Unit – II	16
OR	
a) Unit – II	8*2
b) Unit – II	
Question 3. Unit – III	16
OR	
a) Unit – III	8*2
b) Unit – III	
Question 4. Unit – IV	16
OR	
a) Unit – IV	8*2
b) Unit – IV	
Question 5.	
a. Unit – I	4*4
b. Unit – II	
c. Unit – III	
d. Unit-IV	