



Rayat Shikshan Sanstha's
R. B. Narayanrao Borawake College, Shrirampur
(Autonomous)

(Affiliated to Savitribai Phule Pune University, Pune)

Department of Botany

M.Sc. I (Botany) Syllabus as per NEP-2020

Implemented
From
Academic Year: 2023-24

Course Structure of M. Sc.-I Botany (Semester-I)

Year	Semester	Cours Type	Course Code	Course Title	Theory/ Practical	Credits	No. of Lectures/ Practicals	Page No.
1 st	I	Major Core	BO-MJ-511T	Cryptogamic Botany	Theory	4	60L	4-7
			BO-MJ-512T	Cytogenetics and Plant Breeding	Theory	4	60L	8-10
			BO-MJ-513T	Botanical Techniques	Theory	2	30L	11-13
			BO-MJ-514P	Practical based on BO-MJ-511T, BO-MJ-512T (Part-A) and BO-MJ- 513T (Part-B)	Practical	4	15+15P	14-18
		Major Elective	BO-ME-515(A)T	Fruit and Vegetable processing Technology	Theory	2	30L	19-21
			BO-ME-516(A)P	Practical based on BO-ME-515(A)T	Practical	2	15P	22-23
			BO-ME-515(B)T	Biofertilizer and Algal Technology	Theory	2	30L	24-25
			BO-ME-516(B)P	Practical based on BO-ME-515(B)T	Practical	2	15P	26-27
		Research Methodology	BO-RM-517T	Research Methodology	Theory	4	60L	28-31

Course Structure of M. Sc.-I Botany (Semester-II)

Year	Semester	Course Type	Course Code	Course Title	Theory/ Practical	Credits	No. of Lectures/ Practicals	Page No.
1 st	I	Major Core	BO-MJ-521T	Ecology and Evolution	Theory	4	60L	33-36
			BO-MJ-522T	Cell and Molecular Biology	Theory	4	60L	37-39
			BO-MJ-523T	Computational Botany	Theory	2	30L	40-41
			BO-MJ-524P	Practical based on BO-MJ-521T, BO-MJ-522T (Part-A) and BO-MJ-23T (Part-B)	Practical	4	15+15P	42-45
		Major Elective	BO-ME-525(A)T	Mushroom cultivation and Biopesticide Technology	Theory	2	30L	46-47
			BO-ME-526(A)P	Practical based on BO-ME-525(A)T	Practical	2	15P	48-49
			BO-ME-525(B)T	Floriculture and Nursery Management	Theory	2	30L	50-52
			BO-ME-526(B)P	Practical based on BO-ME-525(B)T	Practical	2	15P	53-54
		OJT	BO-OJT-527	On Job Training	----	4	60	55-56

Syllabus for M. Sc.-I Botany

Semester-I

DISCIPLINE SPECIFIC CORE COURSE (BO-MJ-511T):
Cryptogamic Botany

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-MJ-511T – Cryptogamic Botany	4	4	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To make the students aware of applications of different plants in various industries
2. To provide thorough knowledge about various plant groups from primitive to highly evolve.
3. To make the students aware about conservation and sustainable use of plants
4. To facilitate students for taking up and shaping a successful career in Botany
5. To create foundation for further studies in Botany
6. To equipped the students with skills related to laboratory as well as field-based studies.
7. To provide a comprehensive knowledge on various aspects related to microbes and plants
8. To deliver knowledge on latest development in the field of plant sciences with practical approach.
9. To produce a student who thinks independently, critically and discuss various aspects of plant life
10. To imbibe love and curiosity towards nature through the living plants.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: To understand the diversity among Algae.

CO-2: To know the systematic, morphology and structure of Algae.

CO-3: To understand the life cycle pattern of Algae.

CO-4: To understand the Biodiversity of Fungi.

CO-5: To know the Economic Importance of Fungi.

CO-6: To learn the morphological diversity of Bryophytes.

CO-7: To understand the economic importance of the Bryophytes.

CO-8: To understand the morphological diversity and economic importance of the Pteridophytes.

SYLLABUS OF BO-MJ-511T:**[60 Hours]****Unit-I ALGAE****[15 Hours]**

1. Systematics and Taxonomy– Principles, Concept of species and hierarchical taxa, Classification of algae up to order level as per Fritsch system (1935).
2. Algological studies – General characteristic features, Origin and evolution of sexorgan, Contribution of algal studies in India and world (any three Phycologists).

3. Cyanophyta–Distinguishing characters, thallus organization, ultra-structure of heterocyst, its significance and Life cycle pattern.
4. Chlorophyta- Distinguishing characters, Thallus organization, reproduction and Life cycle pattern
5. Introduction, distinguishing characters, Comparative study of structure, reproduction and Life cycle pattern in Charophyta, Euglenophyta, Xanthophyta, Bacillariophyta and Chrysophyta.
6. Phaeophyta and Rhodophyta– distinguishing characters, morphology, reproduction and life cycle pattern.
7. Utilization of algae.

Unit-II: FUNGI**[15 Hours]**

1. Thallus structure, Nutrition, Cell structure, Classification of fungi as per Ainsworth *et. al.* system (1973), Contribution of fungal studies in India and world.
2. Myxomycotina- Distinguishing characters, thallus structure, types of Plasmodium and fruiting bodies and Life cycle pattern.
3. Mastigomycotina-Distinguishing characters, thallus structure, Reproduction and Life cycle pattern.
4. Zygomycotina- Distinguishing characters, thallus structure, Heterothallism, Reproduction and Life cycle pattern.
5. Ascomycotina- Thallus structure, Fructifications, Reproduction and Life cycle pattern.
6. Basidiomycotina–Distinguishing characters, thallus structure, Reproduction, types and structure of basidia and basidiocarps and Life cycle pattern.
7. Deuteromycotina – Distinguishing characters, thallus structure, Reproduction, fructifications, types of conidia and Life cycle pattern.
8. Applications of fungi.

Unit-III BRYOPHYTES**[15 Hours]**

1. Introduction, characters, Affinities with Thallophytes and Pteridophytes, Contributions of Bryologists in world and India (any three), System of classification according to G. M. Smith 1955. Pteridophytean and algal hypothesis, Evolution of sporophyte, Theory of sterilization and reduction, apogamy and apospory.
2. Distribution, Distinguishing characters, morphology and anatomy of gametophyte and sporophytes and Life cycle pattern of orders- Takakiales, Calobryales, Sphaerocarpaceae, Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Polytrichales, Funariales, Andreaeales and Eubryales.
3. Utilization of Bryophytes.

Unit-IV: PTERIDOPHYTES**[15 Hours]**

1. Distinguishing Characters, Classification as per Sporne System (1975), Apospory, Apogamy, Stelar evolution, Heterospory and Seed habit, Contributions of Indian and World Pteridologist (any three).
2. Distribution, Distinguishing Characters, Morphology and anatomy of sporophyte and gametophyte and Life cycle pattern of the orders- Psilotales, Lycopodiales, Selaginellales,

Isoetales, Equisetales, Ophioglossales, Marattiales, Osmundales, Filicales, Marsileales and Salviniaceae.

3. Utilization of Pteridophytes.

ESSENTIAL / RECOMMENDED READINGS:

Algae:

1. Brodie J. and Lewis J. (2007). (Ed.) Unravelling the algae: the past, present and future of algal systematics. CRC press, New York, pp 335.
2. Bellinger E.G. and Sigeo D.C.(2010). Fresh water algae: Identification and use as bioindicators, Willey-Blackwell, UK, pp. 271.
3. Cole K.M. and Sheath R.G. (1990). Biology of the red algae. Cambridge University Press. USA. pp. 503.
4. Desikachary T.V. (1959). Cyanophyta. ICAR, New Delhi. Graham L.E. and Wilcox L.W. (2000). Algae. Penticce-Hall, Inc, pp.640
5. Krishnamurthy V. (2000). Algae of India and neighboring countries I. Chlorophycota, Oxford & IBH, New Delhi.
6. Lee R.E. (2008). Phycology. Cambridge University Press, pp.547. Misra J. N. (1996). Phaeophyceae in India. ICAR, New Delhi.
7. Prescott G.W. (1969). The algae Smith G.M. (1950). The fresh water algae of the United States, McGraw Hill New York.
8. Srinivasan K.S.(1969). Phycologia India. Vol. I & II, BSI, Calcutta Das Dutta and Gangulee. College Botany Vol II, Central Book Depot.
9. Vashista B.R, Sinha A.K and Singh V.P. (2005). Botany for degree students Algae, S. Chand's Publication.

Fungi:

1. Ainsworth, Sussman and Sparrow (1973). The fungi. Vol IV A & IV B. Academic Press.
2. Alexopoulos C.J., Minns C.W. and Blackwell M. (1999). (4th edn) Introductory Mycology. Willey, New York, Alford
3. R.A. Deacon J. W. (2006). Fungal Biology (4th Ed.) Blackwell Publishing, ISBN.1405130660.
4. Kendrick B. (1994). The fifth kingdom (paperback), North America, New York Publisher: 3rd edn, ISBN-10: 1585100226.
5. Kirk et al. (2001). Dictionary of fungi, 9th edn, Wallingford: CABI, ISBN: 085199377X.
6. Mehrotra R.S. and Aneja K.R. (1990). An introduction to mycology. New Age Publishers, ISBN 8122400892.
7. Miguel U., Richard H., and Samuel A. (2000). Illustrated dictionary of the mycology. Elvira Aguirre Acosta, Publisher: St. Paul, Minn: AP Spress, ISBN 0890542570.
8. Webster J. and Rpland W. (2007). Introduction to fungi (3rd Edn) Cambridge University Press, 978-0-521-80739-5.

Bryophytes & Pteridophytes:

1. Cavers F. (1976). The interrelationships of the Bryophytes. S.R. Technic, Ashok Rajpath, Patana.
2. Chopra R.N. and Kumar P.K. (1988).Biology of Bryophytes. John Wiley & Sons, New York, NY.
3. Kashyap S.R. (1929). Liverworts of the Western Himalayas and the Punjab Plain.Part1, Chronica Botanica, New Delhi.
4. Kashyap S.R. (1932). Liverworts of the Western Himalayas and the Punjab Plain (illustrated):Part Chronica Botanica,New Delhi.
5. Parihar N. S. (1980).Bryophytes : An Introduction to Embryophyta. VolI. CentralBook Depot, Allahabad.
6. Prem Puri(1981).Bryophytes:Morphology, Growth and Differentiation. Atma Ramand Sons, New Delhi.
7. Udar R.(1975).Bryology in India. Chronica Botanica, New Delhi.
8. Udar R. (1970). Introduction to Bryophytes. Shashidhar Malaviya Prakashan.Lucknow.
9. Vashista B.R., Sinha A.K., Kumar A. (2008). Botany for degree students –Bryophyta, Pteridophytes S. Chands Publication
10. Balfour Austin(2016).Plant Taxonomy. Syrawood Publishing House
11. Chapman, J.L and Reiss, M. J. (1998). Ecology: Principles and applications.Cambridge, University Press.
12. Cooke, Theodore (1903-8). The Flora of the Presidency of the Bombay Vol. I, II,III (Repr.ed), Botanical Survey of India.
13. Datta S.C.(1988).Systematic Botany. New Age Publ.

**DISCIPLINE SPECIFIC CORE COURSE (BO-MJ-512T): Cytogenetics
and Plant Breeding**

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-MJ-512T – Cytogenetics and Plant Breeding	4	4	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To understand the fundamental principles of cytogenetics and its significance in genetics, research and medical diagnostics.
2. To explore techniques used in cytogenetics such as karyotyping.
3. To understand Linkages and Mapping.
4. To understand the fundamental definition of a mutation and its role in genetic variation and inheritance.
5. To understand the implications of different ploidy levels for an organism's genetics and development.
6. To understand the fundamental principles of plant breeding and its significance in agriculture and food production.
7. To study traditional breeding methods like mass selection, pure-line selection, and hybridization.

COURSE OUTCOMES:

After completion of this course student will be able to;

CO-1: Understand the relationship between genes, alleles, and genetic traits.

CO-2: Learn the techniques used for preparing and analyzing karyotypes, including staining and microscopic observation.

CO-3: Stay updated on the latest advancements and trends in cytogenetics, including new technologies and breakthroughs in chromosomal analysis.

SYLLABUS OF BO-MJ- 5 12T:

[60 Hours]

Unit I: GENETIC INHERITANCE

[15 Hours]

1. Principles of Mendelian inheritance and Interaction of genes-Introduction, Early concepts of inheritance, Mendel's Laws, Interaction of genes- Complementary, epistasis, inhibitory, polymeric, additive and Chromosomal theory of inheritance.
2. Cytoplasmic inheritance-Inheritance of chloroplast genes (*Mirabilis jalapa* and *Zea mays*), Inheritance of mitochondria genes (Petit yeasts and cytoplasmic male sterility in plants), Interaction between nuclear and cytoplasmic genes, Maternal effect in inheritance (*Limnaea peregra*).
3. Quantitative inheritance of traits- Continuous variation, Inheritance of quantitative traits,

(Polygenic traits) in - corolla length in *Nicotiana*, cob length in *Zea mays*, Introduction to complex traits, Heritability and its measurement and Marker assisted selection.

4. Concept of gene and alleles, Multiple alleles, Pseudo alleles and Complementation test.

Unit II: CYTOGENETICS AND MUTATION

[15 Hours]

1. Structure and Organization of chromosome, Concept of Karyotype, Chromosome banding, Preparation of chromosome for Karyotype, Karyotype evolution and Role of karyotype in plant species identification.
2. Numerical alterations of chromosome-Classification of polyoploids, Cytological and genetical method of identification of autopolyploids and allopolyploids, Classification, method of production, identification and meiotic behavior of aneuploids (Monosomics, Nullisomics and trisomics) and Application of ploidy in crop improvement.
3. Structural alterations of chromosomes-Deletion, duplication, inversion, translocation, complex, translocation heterozygotes, Robertsonian, BA translocations, Inversion heterozygote.
4. Mutation-causes and detection, types- Lethal, Conditional, Biochemical, Loss of function and Gain of Function, Germinal vs Somatic mutants, Insertional mutagenesis and Point mutagenesis.

Unit III: RECOMBINATION, LINKAGE AND MICROBIAL GENETICS

[15 Hours]

1. Recombination, Linkage and mapping of eukaryotes- Linkage and crossing over, Homologous and non-homologous recombination, Inducing transposition site specific recombination, Genetic markers, Linkage maps, lod score for linkage testing, mapping by 2 point and 3 point test cross, Mapping by tetrad analysis in Yeast (unordered) and *Neurospora* (ordered).
2. Microbial Genetics- Methods of genetic transfers viz transformation, conjugation and transduction in bacteria and genetic recombination, Mapping of bacterial genome by interrupted mating, Mutant phenotypes.
3. Phage genetics- Lytic and lysogenic cycles, Genetic recombination, specialized transduction, site specific recombination in phages, Mapping of bacteriophage genome, Fine structure analysis of rII gene in T4 bacteriophage, Phage mutants.

Unit IV: PLANT BREEDING

[15 Hours]

1. General Introduction to Plant Breeding- Definition, Scope, Objectives and History of Plant breeding in India.
2. Methods in plant breeding- Introduction, Selection, Hybridization, Back Cross, Test Cross, modes of pollination, self & cross pollination mechanism and Pure line theory.
3. Pureline Selection- Definition, Characters of Pureline selection, Procedure for Pureline selection, advantages and disadvantages of Pureline selection, achievements of pureline selection.
4. Mass Selection and Clonal Selection-Mass selection, Definition, Procedure for mass selection, advantages, disadvantages and achievements, Clonal selection, Definition, characters of clone, Procedure for Clonal selection, advantages, disadvantages and Achievements.
5. Plant Genetic Resources- Importance of plant genetic resources, Basic genetic resources and transgenes, Principles of *in vitro* and cryopreservation, Germplasm conservation- *in situ*, *ex*

situ, Registration of plant genetic resources and importance of NBPGR.

6. Breeding for nutritional traits- Breeding for special traits *viz* oil, protein, vitamins, amino acids, elimination of toxic substances, Success stories in vaccines, modified sugars, gums and starch through biopharming.

ESSENTIAL/RECOMMENDED READINGS:

1. Albert B. Bray, D Lewis, J Raff, M. Robert, K. and Walter 2022, MolecularBiology of the Cell (7th Edition) Garland Publishing Inc, New York.
2. Alan G. Atherly, Jack R. Girton, John F. McDonald 1999, The science of genetics, Saunders College Publishing, Fort Worth.
3. Burnham, C.R 1962. Discussions in Cytogenetics. Burgess Publishing Co. Minnesota.
4. Busch, H. and Rothblum., 1982. The Cell Nucleus: R-Dna, Part A (Vol 10) Academic Press.
5. Hartl D.L and Jones, E.W 1998 Genetics: Principles and Analysis (Fourth Edition). Jones and Bartlett Publishers, Massachusetts, USA.
6. Khush, G.S 1973. Cytogenetics of Aneuploids. Academic Press, New York, London.
7. Karp, G. 2019. Cell and Molecular Biology 9th Edition. John Wiley and Sons, Inc., USA.
8. Lewin, B. 2017. Gene VII. Oxford University Press, New York, USA.
9. Lewis, R. 2021. Human Genetics : Concepts and Application (13th Edition). WCB McGraw Hill, USA.
10. Malacinski, G.M and Freifelder, D. 2015 : Essentials of Molecular Biology (4th Edition). Jones and B. Artlet Publisher, Inc., London.

**DISCIPLINE SPECIFIC CORE COURSE (BO-MJ-513T): Botanical
Techniques**

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-MJ-513T – Botanical Techniques	2	2	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To make students open-minded and curious, we try our best to enhance and develop a scientific attitude.
2. To make them skilled in practical work, experiments, laboratory equipment and to interpret correctly on biological materials and data.
3. To encourage the students to do research in related disciplines.
4. To develop the ability of the students to transform the society through their education. Critical Thinking: to include creative thinking, innovation, inquiry and analysis, evaluation and synthesis of information.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Learn the basic knowledge of microscopy, their types and techniques to handling different microscopes.

CO-2: Get the basic knowledge of chromatography, their types and to study the different methodology of separation techniques and their application.

CO-3: Gain the basic concepts of different laws which are applied in different Spectroscopic techniques such as Nuclear Magnetic Resonance (NMR) spectroscopy, X-ray crystallography, Spectrofluorometry, AAS, MS, IR Spectroscopy etc.

CO-4: Get the idea about handling the different equipment's which are related to spectroscopy and also learn their Principle, Working and application.

CO-5: Acquire the knowledge Centrifugation, Electrochemical techniques and immunological techniques analysis of biostatistical data in Botany.

SYLLABUS OF BO-MJ- 513T:

[30 Hours]

Unit- I MICROSCOPY

[10 Hours]

1. Image formation (properties of light), Lens refraction, dispersion of light, magnification concept, resolution, Light microscopy, Electron microscopy (SEM and TEM),
2. Dissection, maceration, squash, peeling and whole mount- pre-treatment and procedures
3. Microtomy- serial sectioning, double or multiple staining, Lesser assisted Microtomy
4. Micrometry and camera lucida

5. Histochemical and cytochemical techniques- Localization of specific Compounds /reactions/ activities in tissues and cells.

Unit- II CHROMATOGRAPHY TECHNIQUE**[5 Hours]**

1. Introduction, Paper, TLC, Column, Gel filtration, Affinity, Ion exchange, HPLC, Gas chromatography (Principle, method and applications of each)
2. Electrophoretic Techniques- History, Principles, Agarose gel electrophoresis, Pulsed Field Gel Electrophoresis, Polyacrylamide Gel Electrophoresis (PAGE/ Native).

Unit- III SPECTROSCOPIC TECHNIQUES**[7 Hours]**

1. General principles, Beer and Lambert's Law, Spectrophotometer (working and application), UV- Visible spectroscopy, Nuclear Magnetic Resonance (NMR) spectroscopy, X-ray crystallography, IR Spectroscopy
2. Techniques in computational Biology, bioinformatics with computers specialized database – NCBI, EMBEL, Medicinal plant data bases.

Unit- IV CENTRIFUGATION TECHNIQUES**[8 Hours]**

1. Principles, Rotors, Factors affecting centrifugation, Ultra-centrifugation, Density Gradient Centrifugation, High speed centrifuges
2. Electrochemical Techniques: - Electrical conductivity, pH meter, Oxygenelectrode.
3. Immunological Techniques: - Principles, Antigen-antibody interaction, Immuno -diffusion, Immuno precipitation, Rocket immuno- electrophoresis, ELISA.
4. Molecular biology techniques: - Molecular Hybridization techniques.

ESSENTIAL/ RECOMMENDED READINGS:

1. P. Gunadegaram (1995). Laboratory Manual in Microbiology. New Age International (P) Ltd.
2. Srivistava M.L. (2008). Bioanalytical Techniques. Narosa Publishing House (P) Ltd.
3. Gamborg O.L., Philips G.C. (Eds.) (1995). Plant Cell, Tissue and Organ Culture Fundamental Methods. Narosa Publishing House (P) Ltd.
4. Krishnamurthy K.V. (1999). Methods in Cell Wall Cytochemistry. CRC Press.LLC. 5. Plummer David (1987). An Introduction to Practical Biochemistry. 3rd Eds. Tata McGraw-Hill Publishing Company Ltd.
5. Sadasivam S., Manickam A. (1996). Biochemical Methods. 2nd Edn. New Age International (P) Ltd.
6. Khasim S.M. (2002). Botanical Microtechniques: Principles and Practice. Capital Publishing Company.
7. Harborne J.B. (1998). Phytochemical Methods. Springer (I) Pvt. Ltd.
8. Wilson K., Walker J. (2005). Principles and Techniques in Biochemistry and Molecular Biology. Cambridge University Press.
9. Wilson K., Walker J. (2000). Practical Biochemistry Principles and Techniques. Cambridge University Press.
10. Egerton R.F. Physical Principle of Electron Microscopy: an Introduction to TEM, SEM and AEM.

11. Bisen P.S. Mathur S. (2006). Life Science in Tools and Techniques. CBS Publishers, Delhi.
12. Marimuthu R. (2008). Microscopy and Microtechnique. MJP Publishers, Chennai.
13. Sharma V.K. (1991). Techniques in Microscopy and Cell Biology. Tata McGraw-Hill Publishing Company Ltd.
14. Prasad and Prasad (1984). Outline of Microtechnique. Emkay Publications, Delhi.
15. Srivastava S. and Singhal V. (1995). Laboratory Methods in Microbiology. Anmol Publication Pvt. Ltd. Delhi.
16. Annie and Arumugam (2000). Biochemistry and Biophysics, Saras Publishing, Tamilnadu.
17. Sass John E. (1984). Botanical Microtechniques. Tata McGraw-Hill Publishing Company Ltd.
18. Pal and Ghaskadabi (2009). Fundamentals of Molecular Biology. Oxford Publishing Co.

DISCIPLINE SPECIFIC CORE COURSE (BO-MJ-514P):
Practical based on BO-MJ- 511T, BO-MJ-512T (Part-A) and BO-MJ-513T (Part-B)

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-MJ-514P - Practical based on BO-MJ- 511T, BO-MJ-512T (Part-A) and BO-MJ-513T (Part-B)	4	--	4

PART-A

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To make them skilled in practical work, experiments, laboratory equipment and to interpret correctly on biological materials and data.
2. Topics include the study of plant form, function and reproduction, and an overview of plant diversity including Algae, Fungi, Bryophytes, Pteridophytes.
3. To acquaint the students about the morphology, characters and importance of different Microorganisms.
4. To acquaint the students about the morphology, biology and importance of algal organisms, Fungi, Bryophytes, Pteridophytes.
5. To enable the students to perform experiments related to cell division.
6. To make them skilled in practical work-related Hybridization technique.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Know the systematic, morphology and structure, of Algae, Fungi, Lichen and Bryophytes and Pteridophytes.

CO-2: Get knowledge and understanding of the range of plant diversity in terms of structure and function.

CO-3: Understand the reproduction of Algae, Fungi, Lichen, Bryophytes and Pteridophytes.

CO-4: Understand the characters and classification of Algae, Fungi, and Bryophytes

CO-5: Understand that cell division functions in reproduction, growth, renewal and repair.

CO-6: describe the processes of the cell cycle, including events that take place during interphase, mitosis, and cytokinesis.

CO-7: The student will learn the aspect based on Gene mapping.

CO-8: Understand the floral biology and hybridization technique in plants.

SYLLABUS OF BO-MJ- 514P (Part-A):

PRACTICALS

[60 Hours]

1. Study of morphological characters, reproductive structures and classification according to Fritsch (1935) with reasons of taxa belonging to: Any one member from any six division- Charophyta, Euglenophyta, Basidiomycota, Chrysophyta, Cyanophyta, Phaeophyta, Chlorophyta and Rhodophyta. [2 P]
2. Study of the representative genera belonging to following sub-divisions of fungi w. r. t. vegetative, reproductive structures and classification with reasons according to Ainsworth *et al* (1973)- Any one member from each Sub-division: Myxomycotina, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina. [2 P]
3. Morphological, anatomical and reproductive studies of- Any one member from Hepaticopsida, Anthocerotopsida and any two members from Bryopsida (Musci). [1 P]
4. Morphological, anatomical and reproductive studies of- *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum*, *Pteris*, *Adiantum*, and *Marsilea*. [2 P]
5. Study of any six available fossil specimens from Gymnosperms and Pteridophytes. [1 P]
6. Preparation of fixative and preparation of stains. [1 P]
7. Preparation of C- metaphase chromosome of appropriate material (*Allium* / *Aloe*) and karyotype analysis of C- metaphase chromosome using photograph/slide. [1 P]
8. Study of Meiotic configuration in *Rhoeo* / *Tradescantia* buds. [1 P]
9. Numerical problem based on Gene mapping using two point and three-point test crosses. [1 P]
10. Numerical problem based on *Neurospora* tetrad analysis. [1 P]
11. Study of Floral Biology and Pollen Viability of any two major crops. [1 P]
12. Study of hybridization technique in locally available crops. [1 P]

ESSENTIAL / RECOMMENDED READINGS:

1. Prescott G.W.(1969).The algae Smith G.M. (1950).The fresh water algae of theUnited States, Mc-graw Hill New York.
2. Srinivasan K.S. (1969). Phycologia India. Vol.I &II, BSI, Calcutta Das DuttaandGangulee. College Botany VolII, Central Book Depot.
3. Vashista B.R, Sinha A.K and Singh V.P. (2005). Botany for degree students Algae,S. Chand's Publication.
4. Sharma O.P. Algae
5. Ainsworth, Sussman and Sparrow (1973). The fungi. Vol IV A & IV B.Academic Press.
6. Alexopolous C.J., Minms C.W. and Blackwell M. (1999).(4th edn) IntroductoryMycology. Willey, New York, Alford
7. R. A. Deacon J.W. (2006). Fungal Biology (4thEd.) Blackwell Publishing, ISBN.1405130660.
8. Kendrick B. (1994). The fifth kingdom (paperback), North America, NewYorkPublisher:3rd edn, ISBN-10: 1585100226.
9. Kirk et al. (2001). Dictionary of fungi, 9th edn, Wallingford: CABI,ISBN:085199377X.
10. Watson E.V. (1971). Structure and Life of Bryophytes.3rd Edn. Hutchinson University Library, London.
11. Vashista B.R., Sinha A.K., Kumar A. (2008). Botany for degree students –Bryophyta, Pteridophytes S. Chands Publication.

12. Johnson Lewis, Cell Biology (Sarup and sons, New Delhi, 2004).
13. B Alberts et al, Molecular Biology of Cell; 6th edition (Garland Science, Taylorand Francis, New York, 2014).
14. De Robertis and De Robertis, Cell and Molecular Biology (VIII) (B.I. Waverly Pvt. Ltd., New Delhi, 1997).
15. Watson et al, Molecular Biology of the Gene (V) (Pearses Educatias, Inc India, 2004)
16. AN Mortonosi (ed.) The enzymes of Biological Membranes Vol. I, II and III (Plenum Press, New York, 1985).
17. Verma P.S and Agarwal V.K. (2006) Cell Biology, Genetics, Molecular Biology, Evolution, Ecology. S. Chand and Company, New Delhi.
18. Alberts B., Bray D., Lewis J., Raff M., Roberts K., Watson J.D. (1989).
Molecular Biology of the Cell. 2nd Edn. Garlan Publ. Inc. New York

PART-B

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows:

1. The practical course Botanical Techniques is designed with an objective to encourage and support the growing demands and challenging trends in the educational scenario.
2. The program focuses on the all-round development of the students to face the competitive world.
3. Students will get practical knowledge which is important in day today life.
4. Students will develop the skills to handling different instruments which are essential for research work as well as industries.

COURSE OUTCOMES:

CO-1: Learned the basic knowledge of microscopy, their types and techniques to handling different microscopes.

CO-2: To get the basic knowledge of chromatography, their types and to study the different methodology of separation techniques and their application.

CO-3: To gain the basic concepts of different laws which are applied in different Spectroscopic techniques such as Nuclear Magnetic Resonance (NMR) spectroscopy, X-ray crystallography, AAS, MS, IR Spectroscopy etc.

CO-4: To get the idea about handling the different equipment's which are related to spectroscopy and also learn their Principle, Working and application.

CO-5: To acquire the knowledge of Centrifugation, Electrochemical techniques and immunological techniques analysis of biostatistical data in Botany.

SYLLABUS OF BO-MJ- 514P (Part-B):

PRACTICALS:

[60 Hours]

1. Study of microscopes. [1 P]
2. Study of Micrometry of Pollen Grains. [1 P]
3. Study of Maceration technique. [2 P]
4. Study of Electrical conductivity and pH measurements of given sample. [1 P]
5. Absorption spectra of BSA/DNA and determination of absorption maxima. [1 P]
6. Demonstrate the Rocket immune electrophoresis. [1 P]
7. Separation of leaf pigments by Paper chromatography and TL [2 P]
8. Separation of isozymes by native polyacrylamide gel electrophoresis [2 P]
9. Microtomy-Processing, double staining, sectioning. [2 P]
10. Cytochemical analysis-Nucleus, Golgi bodies, Mitochondria [1 P]
11. Databases and database searching and DNA and protein sequence comparison. [1 P]

ESSENTIAL/ RECOMMENDED READINGS:

1. P. Gunadegaram (1995). Laboratory Manual in Microbiology. New Age International (P)

- Ltd.
2. Srivastava M.L. (2008). Bioanalytical Techniques. Narosa Publishing House (P)Ltd.
 3. Gamburg O.L., Philips G.C. (Eds.) (1995). Plant Cell, Tissue and Organ Culture
 4. Fundamental Methods. Narosa Publishing House (P) Ltd.
 5. Krishnamurthy K.V. (1999). Methods in Cell Wall Cytochemistry. CRC Press.LLC. 5. Plummer David (1987). An Introduction to Practical Biochemistry. 3rd Eds. Tata McGraw-Hill Publishing Company Ltd.
 6. Sadasivam S.,Manickam A. (1996). Biochemical Methods. 2nd Edn. New Age International (P) Ltd.
 7. Khasim S.M. (2002). Botanical Microtechniques: Principles and Practice. Capital Publishing Company.
 8. Harborne J.B. (1998). Phytochemical Methods. Springer (I) Pvt. Ltd.
 9. Wilson K., Walker J. (2005). Principles and Techniques in Biochemistry and Molecular Biology. Cambridge University Press.
 10. Wilson K., Walker J. (2000). Practical Biochemistry Principles and Techniques. Cambridge University Press.
 11. Egerton R.F. Physical Principle of Electron Microscopy: an Introduction to TEM, SEM and AEM.
 12. Bisen P.S. Mathur S. (2006). Life Science in Tools and Techniques. CBS Publishers, Delhi.
 13. Marimuthu R. (2008). Microscopy and Microtechnique. MJP Publishers, Chennai.
 14. Sharma V.K. (1991). Techniques in Microscopy and Cell Biology. Tata McGraw-Hill Publishing Company Ltd.
 15. Prasad and Prasad (1984). Outline of Microtechnique. Emkay Publications, Delhi.
 16. Srivastava S. and Singhal V. (1995). Laboratory Methods in Microbiology. Anmol Publication Pvt. Ltd. Delhi.
 17. Annie and Arumugam (2000). Biochemistry and Biophysics, Saras Publishing, Tamilnadu.
 18. Sass John E. (1984). Botanical Microtechniques. Tata McGraw-Hill Publishing Company Ltd.
 19. Pal and Ghaskadabi (2009). Fundamentals of Molecular Biology. Oxford Publishing Co.

MAJOR ELECTIVE CORE COURSE [BO-ME-515(A)T]:
Fruit and Vegetable Processing Technology

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-ME-515(A)T – Fruit and Vegetable Processing Technology	2	2	---

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To focus on the cultivation, production, harvest and storage of fruits and their processing and to educate students about the same.
2. To provide farmers, growers and students with valuable information on how to maximize yields.
3. Pomology and Olericulture incorporates the creation, preparing and advertising of organic products and their development in daily life.
4. To provide the thorough knowledge about preservation of the colour, flavour, texture and nutrition of the fruits and vegetables.
5. To make the students aware about microbial infections to the fruits and how to eliminate the micro-organisms and to extend shelf life of fruits and processed materials.
6. To aware students about fruit products safety and marketing.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Get scientific knowledge and skills about pomology and technologies for fruit processing and preservation.

CO-2: Encouraged to develop new cultivars, improved fruit varieties and disease resistant varieties of fruits.

CO-3: Study and find out most effective strategies keeping fruit trees healthy and productive.

CO-4: Get practical knowledge and information for fruit preservation.

CO-5: Acquire knowledge that enables them to identify the main key processing steps used during fruit transformation, understand the main effect of the process on the quality characteristics of processed fruits.

CO-6: Get knowledge about job and entrepreneurial opportunities.

SYLLABUS OF BO-ME- 515(A)T:**[30 Hours]****Unit-I INTRODUCTION****[3 Hours]**

1. Scope and Importance of Fruit and Vegetable crops, Nutritive value of fruits and Vegetables in human nutrition, Classification of Fruits based on: climate adaptability, fruit morphology,

Botanical Classification.

2. Present status of fruit and vegetables growing: In India and Maharashtra, Scope of fruit growing in India and Maharashtra, Importance of fruit growing.

Unit II FRUIT AND VEGETABLE FARMING

[7 Hours]

1. Planning and Lay out of orchards: Location & site, Soil, Climate, Planning, Layout: Square system, Rectangular system, Hexagonal system, Quincunx system, Contour system.
2. Growth & Fruiting Habits: Growth & fruiting habits, Fruit bud differentiation, fruit setting, fruit drop, Seed-lessness, cracking of fruits, problems of fruiting, Bahar treatment, Unfruitfulness, Pruning and Training, role of plant growth substances.
3. Methods of Propagation: Vegetative and sexual Methods of propagation, its advantages and Disadvantages.
4. Vegetable Farming: Vegetable growing principles, Fundamentals of Vegetable management, Growth and development of vegetable crops, cultivation, principles of breeding of vegetable crops, irrigation, fertility and disease control.

Unit-III HARVESTING

[3 Hours]

1. Harvesting: Maturity indices, Estimation of Maturity, harvesting methods of fruits and vegetables and Post-Harvest Handling, Packaging, Storage, Basic Physiological and Biochemical changes during postharvest period.
2. Methods and Principles involved in processing of fruits and vegetables, preparation and preservation of fruit juices, squashes, syrup, ready to serve (RTS) drinks.

Unit- IV FRUIT AND VEGETABLE PRODUCTS

[7 Hours]

1. Preparation of Jam, Jelly and Marmalades: Types, Constituents, selection of fruits, processing and technology, defects, role of pectin, ratio, processing technology, defects.
2. Vegetable Processing: Tomato products: Selection of tomatoes, pulping and processing of tomato juice, tomato puree, paste, ketchup and soup, other Frozen vegetables, Vegetable juices, candies and vegetable powders.
3. Processing of different varieties of pickles and causes of spoilage in pickles, shelf-life study and role of preservatives in pickling. Drying of fruits and vegetables.

Unit- V FERMENTED PRODUCTS AND BYPRODUCTS WASTE UTILIZATION

[5Hours]

1. Fermented products: Production of alcoholic drinks like cider, wine, vermouth, vinegar and production of fermented fruit vegetable products like Kimchi, Kanji.
2. By Product Waste Utilization: Pomace, Seeds, Stones/Pits skin, Peel, Pomace, Vinegar, Peel oil, pectin powder, peel candy (citrus peel products). Oil and fiber from oil palm.

Unit – VI CANNING OF FRUITS AND VEGETABLES

[3 Hours]

1. Introduction and principle of canning, Cans and containers for packing, lacquering, syrups and brines for canning.
2. Spoilage in canned foods, problems in the storage of canned food and changes during

canning in fruits and vegetables.

3. Principles involved in various equipment employed in fruits and vegetables processing.
4. FSSAI regulations and specifications of products.

Unit- VII MARKETING

[2 Hours]

1. Market survey procedures, Marketing strategies, Methods of marketing feedback. Cost analysis & attractive packaging, Advertising procedure, systems of marketing, export potential, air transport, transport by sea, cold storage of fruits.
2. Job and entrepreneurial opportunities in Horticulture and Pomology.

ESSENTIAL/ RECOMMENDED READINGS:

1. D. P Singh 2015. Fruit Crops : Published by Agrotech Press, Jaipur & New Delhi
2. Jitendra singh 2014. Basic Horticulture, Published by Kalyani Publishers
3. S. N Gupta 2015. Instant Horticulture, 11th Edition, published by Jain Brothers.
4. Kunte Y. N, M. P Kawthalkar and K.S Yawalkar, 2005, Principles of Horticulture and Fruit Growing 10th edition, published by Agro-horticulture Publishing House, New Delhi
5. George Acquaah, 2009. HORTICULTURE: Principles & Practices, published by PHI Learning Pvt. Ltd.

MAJOR ELECTIVE CORE COURSE [BO-ME-516(A)P]:
Practical Based On BO-ME-515(A)T

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-ME-516(A)P – Practical based on BO-ME-515(A)T	2	--	2

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To focus on the cultivation, production, harvest and storage of fruits and their processing and to educate students about the same.
2. To provide farmers, growers and students with valuable information on how to maximize yields.
3. Pomology and Olericulture incorporates the creation, preparing and advertising of organic products and their development in daily life.
4. To provide the thorough knowledge about preservation of the colour, flavour, texture and nutrition of the fruits and vegetables.
5. To make the students aware about microbial infections to the fruits and how to eliminate the micro-organisms and to extend shelf life of fruits and processed materials.
6. To aware students about fruit products safety and marketing.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Get scientific knowledge and skills about pomology and technologies for fruit processing and preservation.

CO-2: Encouraged to develop new cultivars, improved fruit varieties and disease resistant varieties of fruits.

CO-3: Study and find out most effective strategies keeping fruit trees healthy and productive.

CO-4: Get practical knowledge and information for fruit preservation.

CO-5: Acquire knowledge that enables them to identify the main key processing steps used during fruit transformation, understand the main effect of the processing on the quality characteristics of processed fruits.

CO-6: Get knowledge about job and entrepreneurial opportunities

SYLLABUS OF BO-ME-516(A)P:**PRACTICALS:****[60 Hours]**

1. Study of Growth and Fruiting habit in any one locally cultivated fruit crop. [1 P]
2. Study of methods of Pruning and Training of fruit plants. [1 P]
3. Study of effect of Growth regulators in fruit ripening in any fruit and vegetables. [1 P]
4. Study of maturity indices and estimation of Maturity in locally grown Fruit plant [1 P]

5. Study of methods of Propagation of fruit trees and vegetables. [1 P]
6. Study of methods of harvesting. [1 P]
7. Preparation of Jam and Jelly from locally available fruits. [2 P]
8. Preparation of Marmalade and Syrup from locally available fruits. [1 P]
9. Performance of Drying operations of fruits and vegetables using different dryers. [1 P]
10. Preparation of Squash and Candy. [1 P]
11. Preparation of Kimchi and Kanji. [1 P]
12. Preparation of and Tomato sauce. [1 P]
13. Packing, labelling and sealing of prepared fruit and vegetable products. [1 P]
14. Demonstration of any one by-product of wastes of fruits or vegetables. [1 P]

Note: Visit to the orchard and fruit market in nearby area and prepare a report.

Note: Visit to Fruit Processing Industry and prepare Case study report.

ESSENTIAL/ RECOMMENDED READINGS:

1. D. P Singh 2015. Fruit Crops : Published by Agrotech Press, Jaipur & New Delhi
2. Jitendrasingh 2014. Basic Horticulture, Published by Kalyani Publishers
3. S. N Gupta 2015. Instant Horticulture, 11th Edition, published by Jain Brothers.
4. Kunte Y. N, M. P Kawthalkar and K.S Yawalkar, 2005, Principles of Horticulture and Fruit Growing 10th edition, published by Agro-horticulture Publishing House, New Delhi
5. George Acquaah, 2009. HORTICULTURE: Principles & Practices, published by PHI Learning Pvt. Ltd.

**MAJOR ELECTIVE CORE COURSE [BO-ME-515(B)T]: Biofertilizer
And Algal Technology**

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-ME-515(B)T – Biofertilizer and Algal Technology	2	2	---

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To exploit the microbial diversity in various agro-ecologies for biofertilizers application in diversified system.
2. To improve biofertilizer technology to ensure high quality and improved diversity.
3. To develop awareness among students for side effects of synthetic fertilizers and benefits of biofertilizers.
4. To provide the thorough knowledge about need and significance of biofertilizers in agriculture.
5. To aware the students about need and significance of biofertilizers in agriculture
6. To provide information about Potential of algae as food and feed.
7. Make students aware about algae as a biofertilizer, SCP and biodiesel.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Students will get scientific knowledge about the hazardous effects of synthetic fertilizers on human and animal life.

CO-2: Students belonging to rural and farmers family will be encouraged to use biofertilizers.

CO-3: Students will get idea algal technology and its uses in daytoday life.

CO-4: Students will get knowledge about potentiality of algae as a food, feed and nutritive values.

CO-5: Students will acquire knowledge about uses of algae in biofertilizer and biodiesel industries.

CO-6: Students will get knowledge about job and Entrepreneurial opportunities in subject related industries and sectors.

SYLLABUS OF BO-ME-515 (B)T:**[30 Hours]****BIOFERTILIZER****Unit- I INTRODUCTION AND TYPES OF BIOFERTILIZERS****[7 Hours]**

1. Introduction, Definition, need and significance of biofertilizers in agriculture, hazardous effects of synthetic fertilizers.
2. Types and scope of biofertilizers: Rhizobium, Azotobactor, Azospirillum, Phosphate solubilizing microorganisms, Cyanobacteria, Azolla, Mycorrhizae.

Unit- II PRODUCTION TECHNOLOGY AND APPLICATIONS**[8 Hours]**

1. Strain selection, multiplication, sterilization, large-scale biomass production of various strains.

2. Methods of Applications: Application for field and other crops, methods of application, quality control, agronomic importance. Application methods for different biofertilizers.
3. Use of Genetically Engineered Microorganisms for improvement of biofertilizers.

ALGAL TECHNOLOGY

Unit-III INTRODUCTION

[6 Hours]

1. Introduction to Algal Technology.
2. Potential of algae as food and feed, pigments, pharmaceuticals and nutraceuticals, fine chemicals and fuel.

Unit-IV ALGAL TECHNOLOGY

[9 Hours]

1. Algal biofertilizers, seaweed fertilizers – method of preparation and application.
2. Biodiesel from algae- cultivation and extraction methods.
3. Biohydrogen production from algae.
4. Algal Products- SCP-Spirulina mass cultivation & applications, Agar production.

ESSENTIAL/ RECOMMENDED READINGS:

1. Bio-fertilizers in Agriculture and Forestry, 1995, by N.S. Subba Rao
2. Biofertilizer Manual 2006 FNCA Biofertilizer Project Group Forum for Nuclear Cooperation in Asia (FNCA)
3. N.S. Subba Rao. 1995. Bio-fertilizers in Agriculture and Forestry.
4. N.S. Subba Rao. Soil microorganism. Oxford and IBH Publication Co. New Delhi
5. N.S. Subbarao, Advances in Agril. Microbiology by, Oxford and IBH Publication Co, New Delhi
6. Tilak, K.K. Pal, Rinku Dey. Microbes For Sustainable Agriculture
7. Bergy's manual of systematic bacteriology by Krieg N.R. and J.G. Holt, 1984, Williams and Witkins, Baltimore, U.S.A.
8. Rangaswamy G. and D.J. Bhagyaraj 1988. Agricultural Microbiology, Oxford and IBH Publication Co. New Delhi.

MAJOR ELECTIVE CORE COURSE [BO-ME-516(B)P]:
Practical Based On BO-ME-515(B)T

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-ME-516(B)P – Practical Based on BO-ME-515(B)T	2	---	2

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To exploit the microbial diversity in various agro-ecologies for biofertilizers application in diversified system.
2. To improve biofertilizer technology to ensure high quality and improved diversity.
3. To develop awareness among students for side effects of synthetic fertilizers and benefits of biofertilizers.
4. To provide the thorough knowledge about need and significance of biofertilizers in agriculture.
5. To aware the students about need and significance of biofertilizers in agriculture
6. To provide information about Potential of algae as food and feed.
7. Make students aware about algae as a biofertilizer, SCP and biodiesel.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Students will get scientific knowledge about the hazardous effects of synthetic fertilizers on human and animal life.

CO-2: Students belonging to rural and farmers family will be encouraged to use biofertilizers.

CO-3: Students will get idea algal technology and its uses in daytoday life.

CO-4: Students will get knowledge about potentiality of algae as a food, feed and nutritive values.

CO-5: Students will acquire knowledge about uses of algae in biofertilizer and biodiesel industries.

CO-6: Students will get knowledge about job and Entrepreneurial opportunities in subject related industries and sectors.

SYLLABUS OF BO-ME-516 (B)P:**PRACTICALS:****[60 Hours]**

1. Study of microorganisms used in biofertilizer production. [1P]
2. Isolation of Nitrogen fixing cyanobacteria. [1P]
3. Isolation/Study of Phosphate solubilizing micro-organisms from rhizosphere. [1P]
4. Isolation/Study of Rhizobium from root nodules of leguminous [1P]

crop.

5. Culture, Establishment and production of Azolla biofertilizers. [2P]
6. Isolation of Phycobiliprotein from Cyanobacteria. [1P]
7. Demonstrative study of biofertilizers available in local market. [1P]
8. Isolation of Nitrogen fixing cyanobacteria. [1P]
9. Mass multiplication of Rhizobium, Azotobacter and Azospirillum inoculum. [2P]
10. Study of production of algal fertilizers. [1P]
11. Study of any six sea weeds with applications. [1P]
12. Isolation and culture of *Spirulina*. [2P]

Note: Visit to biofertilizer industry.

Note: Visit to Spirulina production plant.

ESSENTIAL/ RECOMMENDED READINGS:

1. Bio-fertilizers in Agriculture and Forestry, 1995, by N.S. Subba Rao
2. Biofertilizer Manual 2006 FNCA Biofertilizer Project Group Forum for Nuclear Cooperation in Asia (FNCA)
3. N.S. Subba Rao. 1995. Bio-fertilizers in Agriculture and Forestry.
4. N.S. Subba Rao. Soil microorganism. Oxford and IBH Publication Co. New Delhi
5. N.S. Subbarao, Advances in Agril. Microbiology by, Oxford and IBH Publication Co, New Delhi
6. Tilak, K.K. Pal, Rinku Dey. Microbes For Sustainable Agriculture
7. Bergy's manual of systematic bacteriology by Krieg N.R. and J.G. Holt, 1984, Williams and Witkins, Baltimore, U.S.A.
8. Rangaswamy G. and D.J. Bhagyaraj 1988. Agricultural Microbiology, Oxford and IBH Publication Co. New Delhi.

RESEARCH METHODOLOGY CORE COURSE (BO-RM-517T):
Research Methodology

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-RM-517T – Research Methodology	4	4	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To understand a general definition of research design.
2. To know why educational research is undertaken, and the audiences that profit from research studies.
3. To identify the overall process of designing a research study from its inception to its report.
4. To get familiar with ethical issues in educational research, including those issues that arise in using quantitative and qualitative research.
5. To know the primary characteristics of quantitative research and qualitative research.
6. To identify a research problem stated in a study.
7. To get aware about how to write a good introduction to an educational research study and the components that comprise such an introduction.
8. Students would be familiar with conducting a literature review for a scholarly educational study:
 - The steps in the overall process.
 - The types of databases often searched.
 - The criteria for evaluating the quality of a study.
 - The ways of organizing the material found.
 - The different types of literature reviews.
9. Can distinguish a purpose statement, a research question or hypothesis, and a research objective.
10. Can understand the meaning of a variable, and to be able to identify independent, dependent, and mediating variables, categorical and continuous measures.
11. To understand theory, use in quantitative research.
12. Students will be able to design a good quantitative purpose statement and good quantitative research questions and hypotheses.

COURSE OUTCOMES:

After completion of this course student will able to;

CO -1: Students who complete this course will be able to understand and comprehend the basics in research methodology and applying them in research/ project work.

CO-2: This course will help them to select an appropriate research design. With the help of this

course, students will be able to take up and implement a research project/ study.

CO-3: The course will also enable them to collect the data, edit it properly and analyze it accordingly. Thus, it will facilitate students' prosperity in higher education.

CO-4: The Students will develop skills in qualitative and quantitative data analysis and

CO-5: presentation. Students will be able to demonstrate the ability to choose methods appropriate to research objectives.

SYLABUS OF BO-RM-517T:

[60 Hours]

Unit I: FOUNDATIONS OF RESEARCH

[6 Hours]

1. Meaning, Objectives, Motivation, Utility.
2. Concept of theory, empiricism, deductive and inductive theory.
3. Characteristics of scientific method - Understanding the language of Research Concept, Construct.
4. Funding agencies in Research- DST-FIST, NIH, Indian Council of social Science Research, NSF (National Science foundation), UGC (University Grant Commission).

Unit II: DEFINITION, VARIABLE. RESEARCH PROCESS

[6 Hours]

1. Problem Identification & Formulation.
2. Research Question, Investigation Question, Measurement Issues.
3. Hypothesis - Qualities of a good Hypothesis, Null Hypothesis & Alternative Hypothesis, Hypothesis Testing - Logic & Importance.

Unit III: RESEARCH DESIGN

[8 Hours]

1. Concept and Importance in Research - Features of a good research design.
2. Exploratory Research Design - concept, types and uses.
3. Descriptive Research Designs - concept, types and uses.
4. Experimental Design- concept of independent and dependent variables.

Unit IV: QUALITATIVE AND QUANTITATIVE RESEARCH

[6 Hours]

1. Qualitative research, Quantitative research.
2. Concept of measurement, causality, generalization, replication.
3. Merging the two approaches.

Unit V: MEASUREMENT

[6 Hours]

1. Concept of measurement.
2. What is measured?
3. Problems in measurement in research- Validity and Reliability.
4. Levelsof measurement- Nominal, Ordinal, Interval, Ratio.

Unit VI: IPR (INTELLECTUAL PROPERTY RIGHT)

[8 Hours]

1. Introduction and the need for intellectual property right (IPR).

2. Kinds of Intellectual Property Rights: Patent, Copyright, Trade Mark, Design, Geographical Indication, Plant Varieties and Layout Design , Genetic Resources and Traditional Knowledge ,Trade Secret.
3. IPR in India: Genesis and development.
4. IPR in abroad – Major International Instruments concerning Intellectual Property Rights, Paris Convention, 1883, the Berne Convention, 1886, the Universal Copyright Convention, 1952, the WIPO Conventions. 1967.
5. The Patent Co-operation Treaty, 1970, the TRIPS Agreement, 1994

Unit VII: ETHICS AND PLAGIARISM**[5 Hours]**

1. Ethics with respect to Science and research, Intellectual honesty and disintegrity, Scientific misconducts; Falsification, Fabrication and plagiarism.
2. Redundant publications: Duplicate and overlapping publications, salami slicing Selective reporting and misrepresentation of data.

Unit VIII: INTERPRETATION OF DATA AND PAPER WRITING**[5 Hours]**

1. Layout of a Research Paper, Journalism Computer Science.
2. Impact factor of Journals.
3. When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism.

Unit IX: DIFFERENT MODES OF SCIENTIFIC COMMUNICATION**[10 Hours]**

1. Details of steps involved in Proposal writing (Funding agencies), Research paper writing, Thesis writing.
2. Oral forms of scientific communication Popular and Scientific talks, Poster presentation, Power point presentation.
3. Journal, periodicals, monograph revision.
4. Concepts of Citations index, h-index, i10 index, impact factor, care list, Scopes, Web of science, ISSN, ISBN, Google Scholar.

ESSENTIAL/ RECOMMENDED READINGS:

1. Business Research Methods- Donald Cooper & Pamela Schindler, TMGH, 9th editions.
2. Dawson, C. (2002). Practical research methods, UBS Publishers, New Delhi. Indian Pharmacopoeia 2020.
3. Business Research Methods- Alan Bryman & Emma Bell, Oxford University Press.
4. Research Methodology- C. R. Kothari
5. Bird, A. (2006). Philosophy of Science. Routledge.
6. MacIntyre, Alasdair (1967) A Short History of Ethics. London.
7. P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865
8. National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). On Being a Scientist: A Guide to Responsible Conduct in Research. Third Edition. National Academies Press.

9. Resnik, D. B. (2011). What is ethics in research & why is it important. National Institute of Environmental
10. Health Sciences, 1-10. Retrieved from Beall, J. (2012). Predatory publishers are corrupting open access. *Nature*, 489(7415), 179-179
<https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm>
11. <https://doi.org/10.1038/489179a> Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN:978-81-939482-1-7.
<http://www.insaindia.res.in/pdf/Ethics Book.pdf>
12. Ahuja, V K. (2017). Law relating to Intellectual Property Rights.
13. India, IN: Lexis Nexis.
14. E-resources: Subramanian, N., & Sundararaman, M. (2018). Intellectual
15. Property Rights – An Overview. Retrieved from
 - <http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf>
 - World Intellectual Property Organization. (2004). WIPO
 - Intellectual property Handbook. Retrieved from
 - https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf
 - Reference Journal:
 - Journal of Intellectual Property Rights (JIPR): NISCAIR
 - Useful Websites:
 - Cell for IPR Promotion and Management (<http://cipam.gov.in/>)
 - World Intellectual Property Organization (<https://www.wipo.int/about-ip/en/>)
 - Office of the Controller General of Patents, Designs & Trademarks(<http://www.ipindia.nic.in/>)

Syllabus of M. Sc.-I Botany

Semester II

DISCIPLINE SPECIFIC CORE COURSE (BO-MJ- 521T):
Ecology and Evolution

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-MJ-521T – Ecology and Evolution	4	4	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To understand the basic concepts of ecology.
2. To understand the levels of ecological organization.
3. To learn about different population growth models.
4. To understand ecological succession and its impact on community development.
5. To study the impact of ecological niches on species coexistence.
6. To understand natural selection as the driving force of evolution.
7. To understand the significance of homologous and analogous structures in molecular biology.
8. To understand different modes of speciation.
9. To learn about fossil evidence, genetic studies, and the timeline of human evolution.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Students will demonstrate a clear understanding of fundamental ecological concepts, including the levels of ecological organization.

CO-2: Students will evaluate the importance of biodiversity conservation, understand the impacts of human activities on ecosystems.

CO-3: Students will apply ecological principles to real-world scenarios, such as analyzing the impact of climate change on ecosystems or designing habitat restoration plans.

CO-4: Students will understand how genetic variation within populations leads to evolutionary change and how speciation occurs through different mechanisms.

CO-5: Students will apply evolutionary concepts to real-world scenarios, such as studying antibiotic resistance in bacteria or analyzing the adaptation of species to changing environments.

SYLLABUS OF BO-MJ- 521T:**[60 Hours]****ECOLOGY****Unit I: THE CONCEPT AND SCOPE OF ECOLOGY****[2 Hours]**

1. Introduction.
2. Definition, concept, and scope of ecology.

3. Branches of ecology, autecology and synecology.

Unit II: ECOSYSTEM ECOLOGY**[5 Hours]**

1. Concept, nature, structure and function.
2. Organization of Ecosystem: biotic and abiotic components.
3. Plant interaction with abiotic factors such as climatic, edaphic and Topographic factors.
4. Structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

Unit III: POPULATION AND COMMUNITY ECOLOGY**[10 Hours]**

1. Population Ecology- Habitat and niche.
2. Characteristics of population: Distribution and size of the population, factors affecting population size.
3. Population growth curves, Ecological limits and the size of population.
4. Life history strategies, r and k selection.
5. Concept of meta population, extinction events, population viability analysis, Age structured populations.
6. Community Ecology-Definition, nature, composition and characteristics of community
7. Structure/ stratification of community, levels of species diversity and its measurement; edges and ecotones, habitat, niche and guild.

Unit IV: ECOLOGICAL SUCCESSION**[3 Hours]**

1. Types, mechanisms, changes involved in succession.
2. Concept of climax; relationship between ecosystem stability and diversity.
3. Ecological indicator plants.

Unit V: ENERGY FLOW IN ECOSYSTEM**[5 Hours]**

1. Species interaction- Definition, concept, Types of interactions, interspecific competition, herbivore, carnivore, pollination and symbiosis.
2. Energy flow-Food chain, food web, biogeochemical cycles (C, N, and P).
3. Primary production and decomposition.
4. Ecological pyramids, homeostasis, concept of limiting factors.

Unit VI: BIO - GEOGRAPHY**[2 Hours]**

1. Major terrestrial biomes.
2. Theory of island biogeography; floristic regions and vegetation zones of Maharashtra, India, and world and its characters, principals of classification, key species of each region.

Unit VII: APPLIED ECOLOGY**[3 Hours]**

1. Environmental pollution; global environmental change.
2. Biodiversity: status, monitoring and documentation.
3. Major drivers of biodiversity change; biodiversity management approaches.

EVOLUTION**Unit-I: INTRODUCTION****[3 Hours]**

1. Concept of Evolution
2. Theory of evolution of life, origin of eukaryotic cell (Origin of mitochondria, plastids and symbionts).

Unit-II: THEORIES OF EVOLUTION**[6 Hours]**

1. Steps and preview of evolution.
2. Lamarckism, Darwinism- Concepts of variation, adaption, struggle for fitness and natural selection.
3. Neo-Darwinism, Spontaneity of mutations
4. The evolutionary synthesis.

Unit-III: ORIGIN OF CELLS AND CELLULAR EVOLUTION**[6 Hours]**

1. Origin of basic biological molecules, abiotic synthesis of organic monomers and polymers,
2. Concepts of Oparin and Haldane.
3. Experiment of Miller (1953).
4. The first cell, evolution of prokaryote, origin of eukaryotic cells, evolution of unicellular eukaryotes, anaerobic metabolism, photosynthesis and aerobic metabolism.
5. RNA world theory.

Unit-IV: MOLECULAR EVOLUTION**[5 Hours]**

1. Concepts of natural evolution, molecular clocks.
2. Molecular tools in phylogeny, classification and identification, protein and nucleotide sequence analysis.
3. origin of new genes and proteins, gene duplication and divergence.

Unit-V: PALAEOLOGY AND EVOLUTIONARY HISTORY**[5 Hours]**

1. Evolutionary time scale; Eras, periods and epoch.
2. Major events in the evolutionary timescale.
3. Multicellular evolution, Major groups of plants and animals.
4. Fossils- Formation, Nature, Types, Geological time scale.

Unit-VI: POPULATION GENETICS**[5 Hours]**

1. Populations, Gene pool, Gene frequency, Hardy-Weinberg Law.
2. Concepts and rate of change in gene frequency through natural selection, migration, random genetic drift, Adaptive radiation, Isolating mechanisms.
3. Speciation; Allopatricity and Sympatricity.
4. Convergent evolution, Sexual selection.
5. Co-evolution.

ESSENTIAL/ RECOMMENDED READINGS:

1. Begon, M., Townsend, c. R., Harper, J. L. (2005). Ecology: From individuals to Ecosystems, 4th edition, Wiley-Blackwell.
2. Odum, E. P. (2007) Fundamentals of Ecology, 5th edition, Thomson books.
3. Coleman, D.C., Crossley, D. A., Handrix, P. F (2004) Fundamentals of Soil Ecology, 2nd edition, Elsevier academic press.
4. Ambhast, R. S. (1998) A Text Book Of Plant Ecology. (9th edition), Friend and co.
5. Canter L (1996) Environmental Impact Assessment, 2nd Edition, McGraw Hill Publishing Company.
6. Mark Ridley. Evolution. 3rd Edition. Blackwell Publishing. (2004).
7. Mathur, Tomar, Singh. Evolution and Behaviour. Rastogi Publication, Merrut.
8. Mohan P. Arora. Evolutionary Biology, Himalaya Publishing House, Bombay.
9. P. S. Vermin and V. K. Agarwal. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, Revised Edition. S. Chand Publication (2004).
10. Strickberger. Evolution. Prentic Hall. (2002).

**DISCIPLINE SPECIFIC CORE COURSE (BO-MJ-522T): Cell and
Molecular Biology**

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-MJ-522T – Cell and Molecular Biology	4	4	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To introduce various aspect of Cell biology to the students
2. To impart the knowledge of modern techniques in cell Biology
3. To motivate the students to take keen interest in applied aspects of cell biology
4. To give informative knowledge the characteristic features of cell and gene and molecular biology.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Understand the internal organization of the cell.

CO-2: Define the characteristic features of cell and gene.

CO-3: Know the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.

CO-4: Understand how these cellular components are used to generate and utilize energy in cells.

SYLLABUS OF BO-MJ- 522T:**[60 Hours]****Unit I: THE CELL****[15 Hours]**

1. Dynamic cell: Ultrastructure of Plant cell and cell organelles, organization and their functions.
2. Plasma membrane: Structure, models and functions, Channels and pumps, receptors: GPCR and RTK, transport: uniport, symport and antiport, Cell signaling: introduction, primary and secondary signaling molecules.
3. Cell wall: Structure and its functions.
4. Plasmodesmata and Gap junctions: Structure and role in intracellular transport of molecules.
5. Nuclear compartment: nucleus, nucleolus and chromosomes.
6. Giant chromosomes – lampbrush chromosomes, polytene chromosomes.

Unit II: CELL MOTILITY AND MULTIPLICATION**[15 Hours]**

1. Organellar Genomes: Organization and function of chloroplast and mitochondrial genome
2. Cell shape and motility: The cytoskeleton, organization and role of microtubules and microfilaments, motor movements, implications in flagellar and other movements.

3. Cell multiplication and turnover: Cell Cycle, Steps in cell cycle, control system, Cell cycle check points, Cyclin dependent kinases, and cyclines, Meiotic cell division and Dynamics of chromosome movement during cell division, proteolysis.
4. Programmed Cell death – molecular aspects, regulation of cell death.
5. Apoptosis- role of different genes and cell organelles during apoptosis.

Unit III: DNA, GENE AND ORGANIZATION OF GENETIC MATERIAL [15 Hours]**Gene and organization of genetic material:**

1. Structure, Function and Forms of DNA.
2. Concept of gene and overview of chemistry of gene.
3. Solenoid model, Packaging of DNA in Virus, bacterial, prokaryotes, eukaryotes

DNA Replication, damages and repair:

1. DNA replication in prokaryotes and eukaryotes.
2. DNA damage: spontaneous damage, damage due to physical and chemical mutagens.
3. DNA repair systems: Direct repair, Excision repair (NER, BER), Mismatch repair and SOS repair.
4. DNA modifications.
5. Repetitive and Unique DNA sequences.
6. Split genes, Overlapping genes, Pseudo genes and Cryptic genes.

Unit IV: GENE EXPRESSION AND GENE REGULATION IN PROKARYOTES AND EUKARYOTES [15 Hours]

1. Introduction, Central Dogma, Sense and antisense strand.
2. Transcription: Concept and requirement of transcription, Transcription Unit, Transcription process in Prokaryotes and Eukaryotes, Reverse transcription.
3. RNA processing and editing
4. Translation: Introduction, requirement, RNA, Ribosomal assembly, Genetic code and Translation Process in Prokaryotes and Eukaryotes
5. Posttranslational processing of proteins and protein transport
6. Regulation of Gene Expression: Introduction, levels of regulation, regulation of gene expression in Prokaryotes, and regulation of expression in eukaryotes with variety of mechanisms.

ESSENTIAL/ RECOMMENDED READINGS:

1. Johnson Lewis, Cell Biology (Sarup and sons, New Delhi, 2004.)
2. B Alberts et al, Molecular Biology of Cell; 6th edition (Garland Science, Taylor and Francis, New York, 2014).
3. De Robertis and De Robertis, Cell and Molecular Biology (VIII)(B.I. Waverly Pvt.Ltd., New Delhi, 1997).
4. Watson et al, Molecular Biology of the Gene (V) (Pearses Educatias, Inc India, 2004)
5. An Mortonosi (ed)The enzymes of Biological Membrane Vol. I, II and III (Plenumpress, New York, 1985).
6. Karp G. (1999). Cell and Molecular Biology - Concept and Expts. John Wiley and ScneIne.,

USA.

7. John PCL(Ed.), The Cell Cycle (Cambridge University Press, 1981).
8. Verma P.S and Agarwal V. K. (2006) Cell Biology, Genetics, Molecular Biology, Evolution, Ecology. S. Chand and Company, New Delhi.
9. Alberts B., Bray D., Lewis J., Raff M., Roberts K., Watson J. D. (1989).
10. Molecular Biology of the cell. 2nd Edition Garland Publication In New York

DISCIPLINE SPECIFIC CORE COURSE (BO-MJ-523T):
Computational Botany

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-MJ-523T – Computational Botany	2	2	--

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To develop interest in Biological research.
2. To facilitate students for taking up and shaping a successful career in Botany.
3. To develop a thirst to preserve the natural resources and environment.
4. To know utilization of IT in Biological sciences.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: The course consists of the utilization of IT in biological sciences, with focus on basic parameters like computer design, OS, Networking

CO-2: Databases design and upgradation and various tools and softwares for studying the various biological molecules.

CO-3: Understand the designing and function of various databases and Bioinformatic resources.

CO-4: Understand the modern strategies applied in Genetics and Plant Breeding to sequence and analyze genomes.

CO-5: Understand various emerging fields in Bioinformatics in relation to Biodiversity, Agriculture and Drug Designing.

SYLLABUS OF BO-MJ- 523T - III**[30 Hours]****Unit-I: BASIC BIOSTATISTICS****[8 Hours]**

1. Introduction to Statistics:
2. Measures of central tendency – mean, mode, median and their properties
3. Measures of dispersion–variance, standard deviation, coefficient of variance
Symmetry and skewness, measures of skewness, kurtosis
4. Sampling and sampling distributions – concept of sample and population, statistic,
5. Standard error, methods of sampling
6. Data collection- Definition, Types, Examples and Importance.

Unit-II: CORRELATION AND REGRESSION**[8 Hours]**

1. Bivariate correlation, positive correlation, negative correlation.
2. Measures of correlation– Scatter diagram.

3. Karl-Pearson's coefficient of correlation.
4. Pearman's rank correlation coefficient Regression–Equations of regression lines using least.
5. Square method, regression estimate and its standard error.

Unit-III: EXPERIMENTAL STATISTICS**[9 Hours]**

1. Statistics using R, SPSS and Excel: Introduction, features, installation, starting and ending of the sessions, R commands and case sensitivity.
2. Data types: Logical and Numerical, Vectors and vector arithmetic.
3. Data frames: Creation using data, frame, subset and transform commands.
4. Statistical methods using R: Sampling methods, Diagrams, graphs: Measures of central tendency, Dispersion, Skewness and Kurtosis.
5. Probability Distributions: Hyper geometric distribution, Binomial.
6. Normal and poison distribution, Correlation and Regression.

Unit-IV: SPSS AND EXCEL**[3 Hours]**

1. SPSS (Statistical Package for the Social Sciences)
2. Software: Concept and applications in Means, t – test, ANOVA and Correlation and linear regression.
3. Excel: concept and applications on Biology.

Unit-V: TESTING OF HYPOTHESIS**[5 Hours]**

1. Hypothesis, statistical hypothesis, critical region, level of significance, p-value, normal distribution
2. T- test: t-test for mean, equality of two means, paired t-test, unpaired t-test.
3. Chi-square test: chi square test for goodness of fit, independence of attributes, non-parametric test
4. Testing of Hypothesis: critical difference for pairs of treatments.

(NOTE–Emphasis is given non-methodology and numerical problem solving rather than derivations and proofs.)

ESSENTIAL/ RECOMMENDED READINGS:

1. P.N. Arora and P.K. Malhan (2002) Biostatistics, Himalaya publishing House.
2. Rama Krishnan, P. (1995) Biostatics, Saras publication A.R.P. camp Road, Periavilai, Kottar, po. Nagercoil, Kanyakumari-Dist. Pin-629 002.
3. Banerjee, P. K. (2005) Introduction to Biostatistics'S. Chand and Company Ltd. Ram Nagar, New Delhi-110 055.
4. Norman T. J. Bailey (2004), Statistical methods in biology (Third Edition) Cambridge University press (Low price Editions).
5. Dr. Mungikar A.N. (1997) an introduction to Biometry, Saraswati publication, Aurangabad.
6. Mungikar, A. M. (2003). Biostatistical Analysis. Saraswati Printing Press. Aurangabad.
7. Lab Math–Adams, D.S.I.K. Internations Pvt Ltd. New Delhi, 2004
8. T. M. Apostol: Mathematical Analysis (Narosa publishing house)

**DISCIPLINE SPECIFIC CORE COURSE (BO-MJ-524P): Practical based on
BO-MJ- 521T, BO-MJ-522T (Part-A) and BO-MJ-23T (Part-B)**

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-MJ-524P - Practical based on BO-MJ-521T, BO-MJ-522T (Part-A) and BO-MJ-23T (Part-B)	4	---	4

PART-A

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To understand the species area relationship.
2. To understand the Plant Population Density by Quadrature Method.
3. To know Allele frequency and Genotype frequency and Hardy-Weinberg Equilibrium.
4. To enable the students to perform experiments related to study of cell and molecular biology along with latest techniques.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Understand that how to calculate plant population density by Quadrature Method.

CO-2: Learn how to estimate of chlorides and alkalinity of the water sample.

CO-3: To make two genetically identical cells from a single cell.

CO-4: Understand that cell division functions in reproduction, growth, renewal and repair.

CO-5: Learn to the isolation technique for organelles.

CO-6: Able describe the processes of the cell cycle, including events that take place during interphase, mitosis, and cytokinesis.

CO-7: Learn the technique of estimation of DNA from plant tissues.

SYLLABUS OF BO-MJ-524P

[60 Hours]

PRACTICALS:

1. Find out the minimum area of quadrature by species- area curve method and Study of ecological indicator plants. **[1 P]**
2. Study of biotic components by List Counts Quadrant method to find out abundance, density and relative density. **[1 P]**
3. Numerical Problems based on Allele frequency and Genotype frequency and Hardy-Weinberg Equilibrium. **[1 P]**
4. Study of ecological adaptations in Hydrophytes with any two examples **[1 P]**
5. Study of ecological adaptations in Xerophytes with any two examples **[1 P]**
6. Study of phytoplanktons and macrophytes from clean and polluted water bodies and **[1 P]**

- estimation of chlorides and alkalinity of the water sample.
7. Study of polytene chromosome from chironomous larvae. [1 P]
 8. Isolation of cell fractions-Nuclear fraction and Isolation of chloroplast to study Hill reaction. [1 P]
 9. Differentiation centrifugation for isolation of cell fraction - nuclear fraction [1 P]
 10. Isolation of chloroplast to study [2 P]
 - a) Hill reaction to measure intactness
 - b) Chlorophyll estimation [1 P]
 11. Isolation of mitochondria for estimation of succinic dehydrogenase activity. [1 P]
 12. Isolation of DNA (Bacteria or Plant). [1 P]
 13. Study of enzyme catalase and acid phosphatase [1 P]

OR

Demonstration of nitrate reductase (Substrate inducible enzyme) and ATPase.

Note: Visit to Paleobotany Laboratory/Museum/Fossil Garden and submission of Visit Report.

ESSENTIAL/ RECOMMENDED READINGS:

1. Slingsby D., Practical Ecology, Dimensions of Science (DIMOSCI)
2. Henderson PA. Practical Methods in Ecology, Wiley-Blackwell.
3. Mishra T. Evolutionary Biology with Practical, Mahaveer Publications.
4. Mahajan N.G. Evolutionary Biology With Practicals, Prashant Publications.
5. Johnson Lewis, Cell Biology (Sarup and sons, New Delhi, 2004)
6. B Alberts et al, Molecular Biology of Cell; 6th edition (Garland Science, Taylor and Francis, New York, 2014)
7. De Robertis and De Robertis, Cell and Molecular Biology (VIII) (B.I. Waverly Pvt. Ltd., New Delhi, 1997)
8. Watson et al, Molecular Biology of the Gene (V) (Pearses Educatias, Inc India, 2004)
9. AN Mortonosi (ed.) The enzymes of Biological Membranes Vol. I, II and III (Plenum Press, New York, 1985)
10. John PCL (Ed.), The Cell Cycle (Cambridge University Press, 1981)
11. Karp G. (1999). Cell and Molecular Biology- Concept and Expts. John Wiley and Sons Inc., USA.
12. Verma P.S and Agarwal V.K. (2006) Cell Biology, Genetics, Molecular Biology, Evolution, Ecology. S.Chand and Company, New Delhi.
13. Alberts B., Bray D., Lewis J., Raff M., Roberts K., Watson J.D. (1989). Molecular Biology of the Cell. 2nd Edn. Garland Publ. Inc. New York.
14. Powar C.B. (2005) (3rd Edn). Cell Biology, Himalaya Publishing, Mumbai.

PART-B**LEARNING OBJECTIVES:**

The Learning Objectives of this course are as follows:

1. The course consists of the utilization of IT in biological sciences.
2. To developed firm base for hardwares, softwares, networking, processing of computers.
3. To understand the designing and function of various databases and bioinformatic resources.
4. Able to select specific softwares and tools to solve certain biological problems with respect to Nucleotides and Proteins.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Prepare documentation and report writing on experimental protocols, results and conclusions, study tours and field visits etc.

CO-2: Apply the principles of cell biology in designing experiment, statistical analysis, and interpretation of results

CO-3: Operate and solve exercise using computation statistics software.

CO-4: Get acquainted with basic approach in the research methodology.

CO-5: Demonstrate mastery of the core concepts of Bioinformatics, including computational biology, database design and implementation, and probability and statistics.

CO-6: Demonstrate the ability to apply skills in a professional environment via an industrial or academic internship in Bioinformatics.

CO-7: Effectively communicate scientific information in written and oral form.

SYLLABUS OF BO-MJ-524P:**[60 Hours]****PRACTICALS:**

1. Measurement of central tendency (mean, mode and median), variance and standard deviation from the given grouped and ungrouped data. **[1 P]**
2. Measurement of coefficient of variance and standard error from the given grouped and ungrouped data. **[1 P]**
3. Measures of skewness and measures of Kurtosis (grouped and ungrouped data). **[2 P]**
4. Determination of regression lines and calculation of correlation coefficient—grouped and ungrouped data. **[2 P]**
5. Examples based on t-test, Chi-square test for goodness of fit and independent attributes. **[2 P]**
6. Determination of Karl-Pearson's coefficient of correlation from the given grouped and ungrouped data. **[1 P]**
7. Study of Statistical softwares- SPSS, ANOVA and Excel. **[1 P]**
8. Databases and data base searching and DNA/protein sequence comparisons. **[2 P]**
9. Drawing a simple random sample with the help of table of random numbers. **[1 P]**
10. Analysis of variance on the given data (ANOVA) using R/SPSS/Excel. **[2 P]**

ESSENTIAL/ RECOMMENDED READINGS:

1. P.N. Arora and P.K. Malhan (2002) Biostatistics, Himalaya publishing House.
2. Ram Krishnan, P. (1995) Biostatistics, Saras publication A.R.P. camp Road, Periyavilai, Kottar, po. Nagercoil, Kanyakumari-Dist. Pin-629 002.
3. Banerjee, P.K. (2005) Introduction to Biostatistics' S. Chand and Company Ltd. RamNagar, New Delhi-110 055.
4. Norman T.J. Bailey (2004), Statistical method in biology (Third Edition) Cambridge University press (Low price Editions).
5. Dr. Mungikar A. N. (1997) an introduction to Biometry, Saraswati publication, Aurangabad.
6. Mungikar, A. M. (2003) Biostatistical Analysis. Saraswati Printing Press. Aurangabad.
7. LabMath—Adams, D.S.I.K. Internations Pvt Ltd. New Delhi, 2004.
8. T.M. Apostol: Mathematical Analysis (Narosa publishing house)

**MAJOR ELECTIVE CORE COURSE [BO-ME-525-(A)T]: Mushroom
Cultivation and Biopesticide Technology**

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-ME-525-(A)T - Mushroom Cultivation and Biopesticide Technology	2	2	---

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To strengthen the promotion of mushroom cultivation by establishing a well-equipped laboratory and offices.
2. To provide the Unit with appropriately trained personnel for the promotion of mushroom production in the country.
3. To increase the production and consumption of mushrooms. etc.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Understanding mushrooms, types (edible & poisonous) and mushroom production.

CO-2: Learning, cultivation of different edible mushrooms.

CO-3: Knowledge of harvesting and post harvesting processes of mushroom.

CO-4: Introduction with climatic requirements of mushroom cultivation.

CO-5: Learning value added products preparation from mushroom.

SYLLABUS OF BO-ME-525-(A)T**[30 Hours]****Unit-I: MUSHROOM CULTURE****[15 Hours]**

1. History of mushroom cultivation and Present status of mushroom cultivation in India and abroad
2. Nutritional and Medicinal Value of Mushroom, Edible and Poisonous Mushrooms.
3. Mushroom Spawn-Spawning, running and cropping
4. Cultivation of paddy straw mushroom- *Volvariella* and wood mushroom-*Lentinus*.
5. Cultivation of Wheat straw mushroom-*Pleurotus*
6. Cultivation of Button mushroom-*Agaricus*
7. Management of pest in mushroom cultivation
8. Recipes of edible mushrooms.

Unit-II: BIO-PESTICIDES**[15 Hours]**

1. Biological control of plant pathogens-concept and brief history.
2. Antagonism-Mechanism of biocontrol- Amensalism, Predation, Parasitism.

3. Applications of biological control in field- Crop rotation, irrigation, alteration of Soil pH, Organic amendments, Introduction of Antagonists, Seed inoculation, Use of Mycorrhizal fungi and biofertilizers.
4. Bacterial pesticides, Viral pesticides, Mycopesticides, Mycoherbicides, Mycoweedicides, Myconematicides, Insects as biocontrol agents.
5. Botanical pesticides-Pyrethrum, Nicotine, Rotenone, Neem, Karanja.
6. Commercialization of biopesticides.

ESSENTIAL/ RECOMMENDED READINGS:

1. Dubey R. C. 2014, A Textbook of Biotechnology.
2. Dhaliwal and koul2003, Biopesticides and pest management.
3. Kaul T. N. 1997, Introduction to mushroom science.
4. Nair M. C. 1995, Beneficial fungi and their utilization.
5. S. K. Sharma 2016, beneficial fungi.

MAJOR ELECTIVE CORE COURSE [BO-ME-526-(A)P]:
Practical Based On BO-ME-525(A)T

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-ME-526-(A)P - Practical Based On 525(A)T	2	---	2

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To strengthen the promotion of mushroom cultivation by establishing a well-equipped laboratory and offices.
2. To provide the Unit with appropriately trained personnel for the promotion of mushroom production in the country.
3. To increase the production and consumption of mushrooms. etc.

COURSE OUTCOMES:

After completion of this course student will able to;

- CO-1:** Understanding mushrooms, types (edible & poisonous) and mushroom production.
CO-2: Learning, cultivation of different edible mushrooms.
CO-3: Knowledge of harvesting and post harvesting processes of mushroom.
CO-4: Introduction with climatic requirements of mushroom cultivation.
CO-5: Learning value added products preparation from mushroom.

SYLLABUS OF BO-ME-526-(A)P

PRACTICALS

[30 Hours]

1. Morphology of any six mushrooms [1P]
2. Sterilization of glassware, equipments, and culture media used in mushroom cultivation. [1P]
3. Preparation of culture media: Potato Dextrose medium. [1P]
4. Preparation of spawn for mushroom cultivation [1P]
5. Preparation of compost and known compost formulations. [1P]
6. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. [1P]
7. Cultivation of Dhingri mushroom [1P]
8. Cultivation of White button mushroom. [1P]
9. Study of any six recipes of mushroom [1P]
10. Hands on training in Mushroom cultivation farm. [1P]
11. Study of Pests and Diseases management of Mushrooms. [1P]
12. Study of any six botanical pesticides [1P]

13. Study of Mycoherbicides-*Aspergillus*, *Penicillium* to control *Alternanthera*, *Fusarium* to control water hyacinth. [1P]
14. Study of Mycofungicides-Mycorrhizal fungi to control soil borne pathogens- *Trichoderma* to control soil borne pathogens. [1P]
15. Study of Nutrient profiling and Medicinal value of mushrooms. [1P]

Note: Visit to mushroom industry and report preparation.

ESSENTIAL/ RECOMMENDED READINGS:

1. Practical Manual Mushroom Production (NIOS).
2. Training Manual on Mushroom Cultivation Technology (APCAEM)
3. Mushroom Growing Practical Manual by R. L. O Jackson.
4. Nita Bahl 2000, Handbook On Mushroom Cultivation

**MAJOR ELECTIVE CORE COURSE [BO-ME-525(B)T]: Floriculture
and Nursery Management**

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-ME-525(B)T - Floriculture and Nursery Management	2	2	---

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. Introduction to Floriculture and Nursery Management.
2. Identify the various sectors and subfields within floriculture and nursery management.
3. Explain the historical and cultural significance of ornamental plants in different societies.
4. To understand harvesting technique.
5. Identify suitable soil types and growing media for different ornamental plant species.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Understand the fundamental concepts of floriculture, including plant growth and development and propagation techniques.

CO-2: Stay updated on current industry trends, emerging technologies, and new plant varieties within the field of floriculture.

CO-3: Demonstrate proficiency in a range of plant propagation methods, including seed germination, cutting preparation, grafting, and division.

SYLLABUS OF BO-ME-525(B)T :**[30 Hours]****FLORICULTURE****[15 Hours]****Unit-I: INTRODUCTION****[2 Hours]**

1. Floriculture: Concept, definition, Scope and Importance of floriculture.
2. Global scenario of flowers, scope of floriculture in India.

Unit-II: PRE-REQUISITES OF COMMERCIAL FLORICULTURE**[3 Hours]**

1. Soil and climate requirements, field preparation, systems of planting, water and nutrient management, weed management.
2. Training and pruning, pinching and disbudding.
3. Special horticultural practices.
4. Use of growth regulators.

Unit-III: HARVESTING AND PROCESSING OF FLOWERS	[5 Hours]
1. Introduction, harvesting techniques.	
2. Postharvest handling and grading, pre-cooling, packing and storage.	
3. drying techniques – air drying, sun drying, press drying, essentialoil extraction.	
4. Transportation and marketing, export potential.	
Unit-IV: COMMERCIAL PRODUCTION OF FLOWERS	[5 Hours]
1. Varietal wealth and diversity, manuring.	
2. Important pests and diseases, control measures.	
3. Storage and transport.	
4. Export potential of cut flowers: Chrysanthemum, Gerbera, Tuberose, Anthurium;	
5. Loose flowers- Scented Rose and Jasmine.	
NURSERY MANAGEMENT	[15 Hours]
Unit-I: INTRODUCTION	[1 Hours]
1. Introduction and Definition.	
2. Scope and importance of Nursery Management.	
Unit-II: NURSERY SITE AND PREPARATION OF THE SITE	[3 Hours]
1. Types of Nurseries, Water, Location, Topography, Size of Nursery.	
2. Soil clearing of surface, Removal of Top Soil, Erosion Control.	
3. Wind Damage, Surface Dressing, Shape, Fencing.	
Unit-III: DESIGN AND LAYOUT OF NURSERY	[2 Hours]
1. Administration Area, Operations Area, Production Areas.	
2. Germination Section, Transplanting Area.	
Unit-IV: PRODUCING PLANTS FROM SEED	[4 Hours]
1. Seed Handling, Seed Procurement and Storage.	
2. Seed Dormancy and Pre-Treatment, Germination Process, Time of Sowing, Method of Sowing.	
3. Transplanting the Young Seedlings, Regeneration Seedlings, Tending the Seedlings.	
4. Watering, Germination Bedsand Transplants, Weed Control.	
Unit-V: METHODS OF VEGETATIVE PROPAGATION	[3 Hours]
1. Cuttings.	
2. Layering.	
3. Grafting	
4. Budding.	
Unit-VI: GROWING MEDIA	[2 Hours]
1. Growing Media for Propagation and Germination Beds.	

2. Growing Media for Transplant Beds.
3. Growing Media for Container Seedlings.
4. Organic Material, Compost.
5. Mixing the Growing Media, Media Compaction in Pots, Mulching.

ESSENTIAL/ RECOMMENDED READINGS:

1. Arora JS. 2020. Introductory Ornamental horticulture 9th Edition. *Kalyani Publishers*.
2. Bhattacharjee SK. 2018. Advances in Ornamental Horticulture. Vols. I-VI. *Pointer Publishers*.
3. Bose TK & Yadav LP. 2002. Commercial Flowers. Revised 2nd Edition. *NayaProkash*.
4. Bose TK, Maiti RG, Dhua RS & Das P. 2012. Floriculture and Landscaping. 2nd Edition *NayaProkash*.
5. Chadha KL & Choudhury B. 2014. Ornamental Horticulture in India. *ICAR*.
6. Chadha KL. 1995. Advances in Horticulture. Vol. XII. *Malhotra Publishing House*.
7. Chaudhary RC. 2008. Introduction to Plant Breeding. *Oxford & IBH*.
8. Singh BD. 2018. Plant Breeding. *Kalyani Publishers*.
9. Lauria A & Ries VH. 2021. Floriculture – Fundamentals and Practices. *Agrobios (India)*.
10. Prasad S & Kumar U. 2012. Commercial Floriculture. *Agrobios (India)*.
11. Keats C. Hall 2003. Manual on Nursery Practices, Forestry Department, 173 Constant Spring Road, Kingston 8, Jamaica.
12. Evans Julian 2004. Plantation Forestry in the Tropics, 3rd Edition Ch 10. Clarendon Press. Oxford.
13. Jaenicke, H. 1999. Practical Guidelines for Research Nurseries. *International Centre for Research in Agroforestry*. Nairobi, Kenya.
14. Mc.Donald, B. 1986. Practical Plant Propagation for Nursery Growers, Timber Press, New York
15. Schmidt, L. 2000. Guide to Handling of Tropical and Subtropical Forest Seed. DANIDA Forest Seed Centre

**MAJOR ELECTIVE CORE COURSE [BO-ME-526 (B)P]: Practical Based
On BO-ME-525(B)T**

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-ME-526(B)P - Practical Based On BO-ME-525(B)T	2	---	2

LEARNING OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To provide the unit with appropriately trained personnel for the promotion of Plant production in the country.
2. To increase the interest of students in the cultivation and conservation of plant.
3. To provide thorough knowledge about how to propagate and grow plants for sale to public.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Understand the importance of a plant nursery and basic infrastructure to establish it.

CO-2: Explain the basic material, tools and techniques required for nursery.

CO-3: Demonstrate expertise related to various practices in a nursery. Comprehend knowledge and skills to get an employment or to become an entrepreneur in plant.

CO-4: Identify climatic requirements of nursery plant cultivation.

CO-5: Learn value of nursery plant.

SYLLABUS OF BO-ME- 526 (B)P:

PRACTICALS:

[60 Hours]

1. Study of special cultural practices for flower crops under protected structure. [1 P]
2. Gerbera – identification and description of species/varieties, propagation, planting and pruning management. [1 P]
3. Study of garden tools and implements – Sprayer, Duster, Pruning knife, Sprinkler, Micro-irrigation system. [1 P]
4. Preparation of growing media for propagation and germination beds. [1 P]
5. Preparation of Bed for nursery and seed sowing. [1 P]
6. Study of different method of seed germination. [1 P]
7. Study of methods for breaking seed dormancy [1 P]
8. Preparation of growing media for Container Seedlings [1 P]
9. Study of Cutting and Budding method used for plant propagation. [1 P]
10. Study of Air Layering method for plant propagation. [1 P]
11. Study of plant propagation method by Grafting. [1 P]
12. Study of important pest and diseases of flowering plants with their control measure [1 P]

13. Method of harvesting of cut flower and their preservation method. [1 P]
14. Study of methods of post-harvest technology for cut flowers. [1 P]
15. Methods of making dry flower. [1 P]

ESSENTIAL/ RECOMMENDED READINGS:

1. Adam C.R. (2004). Principles of Horticulture. Elsevier Butterworth-Heinemann.
2. Peter K. V. (2015). Basics of Horticulture. New India Publishing Agency, New Delhi.
3. Gupta S.N. (2016). Instant Horticulture. Jain Brothers, New Delhi.
4. Tiwari A.K. and R. Kumar (2012). Fundamentals of Ornamentals, Horticulture and Landscape Gardening. New India Publishing Agency, New Delhi.
5. Acharya, N.K., (2001) Textbook on intellectual property rights, Asia Law House.(Unit I)
6. Bose, T.K., Mukherjee, D., (1972) Gardening in India. Oxford & IBH Publishing Co.,New Delhi. (Unit IV)
7. Dawson, C. (2002) Practical research methods. UBS Publishers, New Delhi. (Unit II)
8. Edmond, M., Andres, Fundamentals of Horticulture. McGraw Hill Book Co., New Delhi. (Unit III)
9. Ganguli, P., (2001) Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill. (Unit I)
10. Guru, M., Rao, M.B., (2003) Understanding Trips:Managing Knowledge in Developing Countries, Sage Publications. (Unit I)
11. Kumar, N., (1997) Introduction to Horticulture, Rajalakshmi Publications, Nagercoil.(Unit III).
12. Lancaster, P., (1997) Gardening in India. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. (Unit IV)
9. Laurie, A., Ries, V.C., (2003) Floriculture: Fundamentals & Practices. (Unit III)
- Miller, A.R., Davis, M.H., (2000) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers. (Unit I)
13. Randhawa, G.S., Mukhopadhyay, A., (1986) Floriculture in India. Allied Publishers. (Unit III)
12. Sandhu, M.K., (1989) Plant Propagation. Wile Eastern Ltd., Bangalore. (Unit IV)
14. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong. (Unit II)

ON JOB TRAINING COURSE (BO-OJT-427)

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
BO-OJT-427	4	---	4

LEARNING OBJECTIVES:

Upon completion of the on-the-job training program, students will be able to:

1. To apply theoretical knowledge of Botany to practical scenarios.
2. To develop practical and Technical skills.
3. To gain proficiency in using scientific instruments and techniques for botanical analysis.
4. To provide a general work experience so that student can apply skills and knowledge in College and industry.
5. To analyze and interpret data obtained from fieldwork and laboratory experiments.
6. To enhance communication and collaboration skills within a professional botanical setting.
7. To provide hands-on knowledge about a particular topic so that it becomes easy for the trainee to understand it practically and it can be implemented effectively.

COURSE OUTCOMES:

After completion of this course student will able to;

CO-1: Apply theoretical knowledge of botany to solve practical problems in various aspects of the field and industry.

CO-2: Proficiency in plant collection, preservation, and identification techniques, ensuring the accuracy and reliability of data. This knowledge can be applicable in seed, herbal and agricultural industries.

CO-3: Will be able for skillful utilization of scientific instruments and techniques for conducting botanical analyses and experiments.

CO-4: Competence in analyzing and interpreting data acquired from fieldwork and laboratory experiments using appropriate statistical methods.

CO-5: Will have effective communication and collaboration skills within a professional botanical setting, fostering teamwork and sharing of knowledge.

CO-6: The training will be effective for new employees to develop or sharpen their skills and gain real-time expertise and knowledge in their field of interest.

CO-7: The training of certification course will enhance the chances of students to get entrepreneurial and job opportunities and can withstand the competition.

COURSE OVERVIEW:

This on-the-job training program in Botany is designed to provide practical experience and skill development in various aspects of botany, aligning with the objectives outlined in the National

Education Policy (NEP) 2020. Students will have the opportunity to apply theoretical knowledge gained in the classroom to real-world scenarios and enhance their understanding of botanical concepts through hands-on training. The program aims to foster critical thinking, problem-solving, and practical skills essential for a career in botany and botany related fields like seed industry, herbal industry, agriculture-based industries.

Course Duration: 6 months