

**Proposed Broad Structure of Syllabus under CBCS for the P.G.
Department of Botany, BU**

Semester I

Course				Lect. Hour/Week	Duration of Exam (in Hour)	Marks			Credit
Course Code	Type	T/P	Name			I.A.	E.T	Total	
MSBO101	Core	T	Microbiology	4T	2	10	40	50	4
MSBO102	Core	T	Phycology	4T	2	10	40	50	4
MSBO103	Core	T	Unit I : Mycology & Unit II : Plant Pathology	4T	2	10	40	50	4
MSBO104	Core	T	Unit I : Bryology Unit II : Pteridology	4T	2	10	40	50	4
MSBO105	Core	P	Unit I : Microbiology Unit II: Phycology	8P	4	10	40	50	4
MSBO106	Core	P	Unit I :Mycology & Plant Pathology Unit II : Bryology & Pteridology	8P	4	10	40	50	4
Total Credit									24

Semester II

Course				Lect. Hour/Week	Duration of Exam (in Hour)	Marks			Credit
Course Code	Type	T/P	Name			I.A.	E.T	Total	
MSBO201	Core	T	Plant Physiology	4T	2	10	40	50	4
MSBO202	Core	T	Plant Biochemistry	4T	2	10	40	50	4
MSBO203	Core	T	Unit I : Taxonomy of Angiosperm Unit II : Phytogeography	4T	2	10	40	50	4
MSBO204	Core	T	Gymnosperm, Paleobotany & Palynology	4T	2	10	40	50	4
MSBO205	Core	P	Unit I : Plant Physiology Unit II : Plant Biochemistry	8P	4	10	40	50	4
MSBO206	Core	P	Unit I : Taxonomy of Angiosperm & Phytogeography Unit II : Gymnosperm, Paleobotany & Palynology	8P	4	10	40	50	4
Total Credit									24

Semester III

Course				Lect. Hour/Week	Duration of Exam (in Hour)	Marks			Credit
Course Code	Type	T/P	Name			I.A.	E.T	Total	
MSBO301	Core	T	Ecology & Plant Anatomy	4T	2	10	40	50	4
MSBO302	Core	T	Pharmacognosy & Instrumentation	4T	2	10	40	50	4
MSBO303	Core	P	Unit I : Ecology & Plant Anatomy Unit II : Pharmacognosy & Instrumentation	8P	4	10	40	50	4
MSBO 304-1 / 304-2	GE	T	Plant System and Function Plant Diversity and Evolution	2T	2	05	20	25	2
MSBO 305-1, 305-2, 305-3, 305-4, 305-5, 306-6	DE	T	Plant Physiology and Biochemistry Molecular Plant Pathology and Fungal Biotechnology Microbiology Plant Genetics and Biotechnology Taxonomy of Angiosperms and Biosystematics Phycology	4P	4	10	40	50	4
MSBO 306-1, 306-2, 306-3, 306-4, 306-5, 306-6	DE	P	Plant Physiology and Biochemistry Molecular Plant Pathology and Fungal Biotechnology Microbiology Plant Genetics and Biotechnology Taxonomy of Angiosperms and Biosystematics Phycology	8P	4	10	40	50	4
MSBO307	CE		Workshops on Awareness campaign on preservation of Biodiversity, agrobiodiversity, medicinal plants etc.			05	20	25	02
Total Credit									24

Semester IV

Course				Lect. Hour/Week	Duration of Exam (in Hour)	Marks			Credit
Course Code	Type	T/P	Name			I.A.	E.T	Total	
MSBO401	Core	T	Genetics, Plant Breeding & Biostatistics	4T	2	10	40	50	4
MSBO402	Core	T	Cell Biology & Bioinformatics	4T	2	10	40	50	4
MSBO403	Core (floating)	P	Unit I : Genetics, Plant Breeding & Biostatistics Unit II : Cell Biology & Bioinformatics	4T	2	10	40	50	4
MSBO 404-1, 404-2, 404-3 404-4, 404-5, 404-6	DE	T	Plant Physiology and Biochemistry Molecular Plant Pathology and Fungal Biotechnology Microbiology Plant Genetics and Biotechnology Taxonomy of Angiosperms and Biosystematics Phycology	4T	2	10	40	50	4
MSBO 405-1 405-2 405-3 405-4 405-5 405-6	DE	P	Plant Physiology and Biochemistry Molecular Plant Pathology and Fungal Biotechnology Microbiology Plant Genetics and Biotechnology Taxonomy of Angiosperms and Biosystematics Phycology	4P	4	10	40	50	4
MSBO406	PROJECT/TERM PAPER	NA	(Based on DE)	4P	50	50	4
Total Credit									24

SEMESTER- I

CORE COURSE MSBO101: Microbiology (Theory) Credit – 4

Sl. no.	Chapter	No. of lectures
1.	History of Microbiology and bacterial classification: - Early history and milestone discoveries in Microbiology.	4T/W
2.	Bacterial Taxonomy:- Brief idea about the modern approach of bacterial taxonomy.	
3.	Ultrastructure of prokaryotic cell:- Cell wall and cell membrane of bacteria and archaea; Muerin biosynthesis; Mechanism of flageller movement and chemotaxis Gliding movement.	
4.	Bacterial genetic material: – Structure and replication of bacterial chromosome; Plasmid – structure type and properties, episome, plamid vector and their applications; spontaneous and induced mutation of bacteria, Fluctuation test.	
5.	Bacterial growth and nutrition :- CFU, Growth curve, growth factor, growth kinetics ; batch and continuous culture; synchronous culture , enrichment culture, diauxic growth; Microbial growth control by disinfectant, antiseptic and chemotherapeutic agents – a brief account of their types and mode of action. Brief idea about Autotrophy, heterotrophy and Mixotrophy.	
6.	Genetic recombination in bacteria: – Molecular mechanism of Transformation, Conjugation, Transduction, Gene mapping and Complementation test.	
7.	Gene regulation and metabolic inhibition in bacteria: - Operon concept; <i>lac</i> and <i>trp</i> operon, arabinose operon; catabolic repression, attenuation and riboswitch; allosteric control, types of feedback inhibition and isozyme.	
8.	Microbes in N₂Cycle:- Nitrification, Denitrification, Ammonification; Mechanism of biological N ₂ fixation; nitrogenase and alternative nitrogenase system; nif gene structure and regulation.	
9.	Virus: - Organization and structure of Capsid, and viral genome.Lytic and lysogenic cycle of bacteriophage ,molecular mechanism of regulation of lysogeny , induction of lysogeny and significance of lysogeny; COVID19, genetic material, epidemiology; Viroid and Prion.	
10.	Fundamentals of Immunology:- Innate and acquired immunity, T-cell, B-cell, MHC, Cytokines, Antigen- types and characteristics; Structure and functions of immunogloblins, Cell mediated and Humoral Immunity; Ag-Ab reactions and Immunological techniques – RIA, ELISA .	
11.	Applied Microbiology: Application of microbes in agriculture (biofertilizer, biocontrolling agents), Industry (fermentation and Food), environment (bioremediation) and medicine (sources of antibiotics)	

Suggested readings:

Alexander, M. (1977).*Introduction to Soil Microbiology* .New York: John Wiley & Sons.

Atlas, R. M. (1984). *Microbiology, Fundamentals and Applications*. Macmillan.

Atlas, R. M. & Bartha, R. (1997). *Microbial Ecology: Fundamentals and Applications*, 4th ed. Benjamin/ Cummings.

Black, J. G. (2001). *Microbiology: Principles and Explorations*, 5th ed. John Wiley & Sons, New York.

Campbell, R. (1983). *Microbial Ecology*. 2nd ed. Oxford, Blackwell.

Brocks et al *Biology of Microorganisms*

Davis, B. D., Dulbecco, R., Eisen, H.N. & Ginsberg, H.S. (1990). *Microbiology*, 4th ed. Harper and Row.

Dimmock, N. J. & Primrose, S. B. (1994). *Introduction to Modern Virology*. 4th ed. Blackwell Scientific Publications. London.

Holt, J.G., Krieg, N.R., Sneath, P.H.A. Staley, J.T. & Williams, S.T. *Bergey's Manual of Determinative Bacteriology*. Lippincott Williams & Wilkins.

Maloy, S. R., Cronan, E. J. & Freifelder, D. (1994). *Microbial Genetics*, 2nd ed. Jones and Bartlett.

Pelczar, M. J., Reid, R. D. & Chan, E. C. (1993). *Microbiology*, 5th ed. Macmillan. London.

Pinehuk, G. (2003). *Schaum's outline Series: Theory and Problems of Immunology*. McGrawHill.

Presscott, L. M., Harley, J. P. & Klein, D. A. (1999). *Microbiology*, 4th ed. McGrawHill, New York.

Schlegel, H. G. (1993). *General Microbiology*. 7th ed. Cambridge University Press.

Slonczewski, J.L. & Foster, J.W. (2009). *Microbiology- An Evolving Science*. Norton.

Stanier, R. Y., Adelberg, E. A. & Ingraham, J. L. (1986). *General Microbiology*. 5th ed. Macmillan.

Talaro, K. & Talaro, A. (1999). *Foundations in Microbiology* 3rd ed. Dubuque, McGraw Hill.

Tortora, G. J., Funke, B. R., & Case. C. L. (1999). *Microbiology. An Introduction*. 6th ed. Benjamin/Cummings Publishing. Menlo Park Calif.

Voyleys, B. A. (2002). *The biology of viruses*, 2nd ed. McGraw-Hill.

Abbas, A. K., Lichtman, A. H. & Pillai, S. (2006). *Cellular and molecular Immunology*. 6th ed. Saunders.

Abbas, A. K. & Lichtman, A. H. (2006). *Basic Immunology*. 2nd ed. Elsevier.

Chakraborty, A. K. (2003). *Immunology II*. 2nd ed. N. L. Publishers Siliguri.

Coico R, Sunshine, G., Benjamini, E. (2003). *Immunology: A short Course*. 5th ed. Wiley-Liss: New Jersey.

English, L. S. (1994). *Technological Applications of Immunochemicals (BIOTOL)*. Butterworth- Heinemann, Oxford Freeman & Co.

Goldsby, R. A., Kindt, T. J., Kuby, J. & Osborne, B. A. (2003). *Immunology*. 5th ed. W. H. Freeman & Co.

Khan F. H. (2009) *The Elements of Immunology*. Pearson.

Kindt, T., Goldsby, R. Osborne, B. (2007). *Kuby Immunology*. 6th ed. W.H. Freeman & Co.

Male, D., Brostaff, J., Roth, D. & Roitt, I. (2006). *Immunology*. 7th ed. Mosby.

Rao, C. V. (2002). *Immunology*. Narosa Publishing House, New Delhi.

Roitt, I. M. & Delves, P. J. (2001). *Roitt's Essential Immunology*. 10th ed. Blackwell Science.Ltd.

SEMESTER- I

CORE COURSE MSBO102: Phycology (Theory) Credit – 4

Sl. no.	Chapter	No. of lectures
1.	Modern criteria of algal classification with special emphasis on chloroplast ultrastructure, flagella, molecular data and pigments.	4T/W
2.	Endosymbiosis and its significance in algae.	
3.	Cyanophyta: General features & ecology; genetic recombination; heterocyst structure and function; affinities, economic aspects.	
4.	Rhodophyta: General features; specialities in sexual reproduction and post-fertilization changes, economic aspects.	
5.	Chlorophyta: Characteristic features of different classes highlighting distinctive features of different orders; evolutionary trends in light of modern findings; origin of land plants from algae.	
6.	Photosynthetic Stramenopiles: distinctive features a) Diatoms: Features and ecology, applications in forensic science. b) Xanthophyceans: General features, parallelism with green algae & affinities. c) Phaeophyceans: General features & ecology; lifecycle patterns, economic aspects.	
7.	Algal biotechnology: aquaculture, bioremediation, biodiesel, bioethanol and hydrogen production by algae, carbon sequestration by algae, algae as health food; Industrial use of algae, photobioreactors and raceway ponds, modern trends.	

Suggested Books for Phycology

1. Phycology by **Robert Edward Lee, 5th Edition**
2. Algae by **James E. Graham , Linda E. Graham, Lee W. Wilcox , M.E. Cook, 3rd Edition**
3. Freshwater Algae: Identification, Enumeration and Use as Bioindicators by **Edward G. Bellinger, David C. Sigeo, 2nd Edition**
4. Algae: Anatomy, Biochemistry, and Biotechnology, **By Laura Barsanti, Paolo Gualtieri, 2nd Edition.**
5. The Algae World, **by Dinabandhu Sahoo and Joseph Seckbach.**
6. A beginner's guide to freshwater algae, **by Hilary Belcher , Erica Swale.**
7. Freshwater Algae of North America, **by John Wehr Robert Sheath, J. Patrick Kociolek, 2nd Edition.**

SEMESTER- I

CORE COURSE MSBO103: Mycology and Plant Pathology (Theory) Credit – 4

Unit-I (Mycology)

Sl. no.	Chapter	No. of lectures
1.	Position of fungi in modern systematic: Modern approaches towards classification of fungi. Classification of the kingdom Mycota beyond G. C. Ainsworth (1973) system; Phylogeny and evolution of fungi. Mechanisms behind the spore dispersal in different groups of fungi like, Ascomycetes and Basidiomycetes . Deuteromycotina: A general account of the asexual fruitbodies and sporulating structures of the members, classification of this group with special reference to conidial ontogeny.	4T/W
2.	Life cycle patterns: Basic pattern of sexuality, sexual mechanisms and their correlations in different groups of fungi. Parasexual cycle and its significance.	
3.	Ultra-structural features of fungal cell structures- Fungal cytology and genetics: Fungal cell wall and its biochemical composition and classification of fungi on the basis of cell wall composition. Fungal Nucleus and its division.	
4.	Fungal symbionts: Mycorrhizae-basic concept, types and their applications. Lichen-Phycobiont and mycobiont, histology, biology and physiology of lichen thallus, economic importance of lichen.	
5.	Beneficial uses of fungi: Fungi producing medicines, alcohol and organic acids; industrial production of ethyl alcohol and penicillin. Cultivation of edible mushroom (Oyster mushroom and Button mushrooms); nutritional and medicinal properties of mushrooms.	
6.	Fungi as Human and Animal parasites: Mycoses of vertebrates- types, symptoms and clinical measures, insect fungus association.	

Unit-II (Plant Pathology)

Sl. no.	Chapter	No. of lectures
1.	Plant diseases: Basic concept and Classification of plant diseases. Pathogenesis- Contact, entry and penetration, establishment of the plant pathogens inside the host plant. Plant pathogens in offence: enzymes and toxins.	4T/W
2.	Host plants in defense: Plant defense responses- structural and biochemical defense and host plant's resistance - horizontal and vertical resistance-basic concept.	
3.	Plant disease epidemiology: Factors responsible for development of plant disease epidemic; Disease forecasting and Remote Sensing; Computer simulation technique.	

4.	Strategies of plant disease management: Cultural, Chemical, Biological and Integrated Management of Plant Diseases; Modern approaches of Biocontrol for Insect Pest management. Biopesticides and their applications in management of plant diseases.
5.	Seed deterioration: Factors responsible for seed deterioration, effect of fungal deterioration of seeds and grains and Mycotoxin contamination in seeds and grains.
6.	Mycotoxins- production with special reference to aflatoxins– effects of mycotoxin contaminations in food and feed. Control of seed deterioration.
7.	Study of plant diseases: Symptoms, etiology, disease cycles and control measures of some important diseases of the following crops: Rice, Wheat, Potato, Sugarcane and Tea.

Suggested Readings:

1. Introduction to Fungi- John Webster and Roland W.S. Weber
2. Introductory Mycology -Alexopoulos C.J., C.W. Mims and M. Blackwell
3. The Mycota- Esser, K. and Bennet J. W. (Eds.)
4. An Introduction to Mycology - Mehrotra, R.S. and Aneja, K.R.
5. Fundamentals of Mycology -Burnett, J. H.
6. Chemical fungal taxonomy -Frisvad, J.C. Bridge, P.D. and Arora, D.K.
7. The Filamentous Fungi - Smith, J.E.
8. Fungal Nutrition and Physiology - Garraway, M. O. and Evans, R. C.
9. Mushroom Biology - Miles, P.G. and Chang, S.T.
10. Mycorrhizae Verma - A. and Hock, B.
11. Ectomycorrhizal Fungi - Cairney, J.W.G. and Chambers, S.M.
12. Industrial mycology -Berry, R.
13. Plant Pathology - Agrios, G.N.
14. Plant Pathology -Mehrotra, R.S.
15. Annual Review of Phytopathology - APS Press
16. Biotechnology in Plant Disease Control- Cheet, I.
17. Postinfectious defense mechanisms - Mahadevan, A.
18. Pathogenesis and host specificity in plant diseases. Vol. III.-Rudra P. Singh, Uma S. Singh
19. Keiisuke Kohmoto (eds.) 1995.
20. The nature of disease in plants - Scheffer, R.P.
21. Principles of Plant Pathology -Tarr, S.A.J .

SEMESTER- I

CORE COURSE MSBO104: Bryology and Pteridology (Theory) Credit – 4

Unit-I (Bryology) Credit – 2

Sl. no.	Chapter	No. of lectures
1.	Introduction: Diversity in forms, habitats, economic importance and ecological values.	4T/W
2.	Classification of Bryophytes – traditional and modern systems.	
3.	Idea about different classes and orders of Bryophytes	
4.	Origin & evolution of Bryophytes: Basic ideas	
5.	Peristome characteristics and their importance	
6.	Indicator Bryophytes	

Unit-II (Pteridology) Credit – 2

Sl. no.	Chapter	No. of lectures
1.	Introduction about pteridophytes.	4T/W
2.	A general account and outline of recent system of classification of Pteridophytes (upto order level).	
3.	Comparative studies on the vegetative and reproductive organographies, evolutionary tendencies and affinities of the members belonging to different groups of Zosterophyllopsida, Trimerophytopsida, Lycopsida (Drepanophycales, Protolpidodendrales, Lycopodiales, Selaginellales, Lepidodendrales and Isoetales) and Sphenopsida (Hyeniales, Sphenophyllales, Calamitales and Equisetales).	
4.	A comparative study of the members belonging to the following taxonomic groups and evolutionary tendencies and affinities: (a) Coenopteridales, (b) Marattiales, (c) Ophioglossales, (d) Filicales (Schizaeaceae, Gleicheniaceae, Cyatheaceae, Polypodiaceae), (e) Salviniales, (f) Marsileales.	
5.	Stelar concept, types and evolution	
6.	Soral evolution in ferns	
7.	Spores: Types, germination pattern, gametophyte development and types.	
8.	Mating systems in ferns, control of sexuality in homosporous pteridophytes by Antheridogen activity, Apogamy and Apospory, polyploidy.	

SEMESTER- I

CORE COURSE MSBO105: Microbiology and Phycology (Practical) Credit – 4

Unit-I (Microbiology)

Sl. no.	Chapter	No. of lectures
1.	Aseptic method:- Autoclave, hot air oven, Incubator, bacterial filter and Laminar air flow.	8P/W
2.	Preparation and sterilization of culture media :- Idea about different kinds of bacterial media, preparation of media, slants, stabs and pouring of plates.	
3.	Methods of isolation of pure culture by streak plate and pour plate method.	
4.	Morphological characteristics of bacteria and microscopic examination of stained cell preparation - Simple staining, Gram staining, Endospore staining.	
5.	5. Direct examination of root nodule bacteria in microscope and isolation of Rhizobium from root nodule.	
6.	Measurement of bacterial growth by turbidimetry and by direct cell count by Haemocytometer method.	
7.	Isolation and enumeration of microorganisms from natural samples (soil and water) by agar plate technique.	
8.	Physio-biochemical test for identification of bacteria:- a) Catalase b) Protease, c) Amylase e) Indole production	
9.	Determination of antibiotic sensitivity of some bacteria by disc diffusion method.	
10.	Demonstration of the following experiments:- a) Replica plating technique for isolation of auxotrophic mutants. b) Isolation of pure culture from streak plate method c) Agarose gel electrophoresis, d) SDS-PAGE, e) Atomic Absorption Spectrophotometer ..	
11.	Blood grouping by Ag-Ab reaction (Kit based method).	

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Dimmock, N. J. & Primrose, S. B. (1994). Introduction to Modern Virology. 4th ed. Blackwell Scientific Publications. London.

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Determinative Bacteriology. Lippincott Williams & Wilkins.

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Khan F. H. (2009) The Elements of Immunology. Pearson.

Kindt, T., Goldsby, R. Osborne, B. (2007). Kuby Immunology. 6th ed. W.H. Freeman & Co.

Male, D., Brostaff, J., Roth, D. & Roitt, I. (2006). Immunology. 7th ed. Mosby.

Rao, C. V. (2002). Immunology. Narosa Publishing House, New Delhi.

Roitt, I. M. & Delves, P. J. (2001). Roitt's Essential Immunology. 10th ed. Blackwell Science.Ltd.

Unit-II (Phycology)

Sl. no.	Chapter	No. of lectures
1.	Collection & identification of local algae of West Bengal.	8P/W
2.	Study of common phytoplankton and its method of collection.	
3.	Study of representative marine algae.	

SEMESTER- I

CORE COURSE MSBO106: Mycology & Plant Pathology, Bryology & Pteridology (Practical) Credit – 4

Unit-I (Mycology and Plant Pathology)

Sl. no.	Chapter	No. of lectures
1.	Methods of sterilization: Autoclave, hot air oven, incubator, laminar air flow; principles and methods of sterilization.	8P/W
2.	Preparation of fungal culture media; Basic idea about different types of fungal culture media, media preparation and preparation of slants, stabs and petri-plates.	
3.	Demonstration on sub culturing-- fungal and bacterial sub culture techniques.	
4.	Methods of isolation of fungi and bacteria and establishment of pure culture by dilution plate and streak plate technique.	
5.	Study of fungal tissue organisation from fruit bodies and study of different spore forms.	
6.	Study of the vegetative and reproductive structures of members of the following groups – a) Phycomycetes b) Ascomycetes c) Basidiomycetes and d) Deuteromycetes. [Students are required to submit field and laboratory records, preserved and dried specimens and permanent slides]	

Unit-II (Bryology)

Sl. no.	Chapter	No. of lectures
1.	Methods of collection and preservation of Bryophytes	8P/W
2.	Identification of unknown bryological specimen up to genus level using a suitable artificial key.	
3.	Methods of preparation of permanent slides. [Students are required to submit field and laboratory records, preserved, dried specimens and permanent slides].	

Unit-II (Pteridology)

Sl. no.	Chapter	No. of lectures
1.	Anatomical, morphological and palynological studies of some members of Pteridophytes occurring in West Bengal, Identification up to the genus.	8P/W
2.	Study of some fossils (slide and megafossils).	
3.	Field work including submission of field and laboratory records.	

SEMESTER- II

CORE COURSE MSBO201: Plant Physiology (Theory) Credit – 4

Sl. no.	Chapter	No. of lectures
1.	Hormone physiology: General concept of phytohormones and plant growth regulators; Phytohormone families and members of each family; growth promoting and retarding chemicals; general mode of phytohormone action; hormone binding proteins; second messengers; gene activation; examples of target cells for hormone action; Modern techniques for hormone assay.	4T/W
2.	Physiology of Auxins: Chemistry, mode of action, auxin mutants and signaling.	
3.	Gibberellins: Chemistry, mode of action, mutants and signaling.	
4.	Physiology of Cytokinins: Chemistry, mode of action, mutants and signaling.	
5.	Physiology of Abscisic acid: Chemistry, mode of action, ABA mutants and signaling.	
6.	Physiology of Ethylene: Chemistry, mode of action, mutants and signaling.	
7.	Photophysiology: Photosynthesis - Light harvesting complexes & mechanisms of electron transport; CO ₂ fixation-C ₃ , C ₄ and CAM pathways, their energetics and significance. C ₂ pathway- Compartmentalized reactions, regulation, energetics and significance. Photosensory mechanisms: Basic concept.	
8.	Solute transport and photoassimilates translocation: uptake, transport and translocation of water, ions, solutes and macromolecules, mechanisms of loading and unloading of photoassimilates.	
9.	Seed Biology: Dormancy - Types, control mechanism, chemical and physical manipulative methods of breaking seed dormancy; biological significance of dormancy. Seed aging.	
10.	Flowering Biology: Photoperiodic control, hormonal regulation; nature of floral stimulus; experimental evidence to prove the mobile nature of floral stimulus, gene-induced regulation floral development, ABC model, second messengers and flowering.	
11.	Senescence Biology: Types of senescence, biochemical indices of senescence, biochemical changes occurring during leaf senescence, senescence regulatory genes, Regulation of Senescence.	
12.	Stress Physiology: Basic concepts of plant responses to abiotic and biotic stress. Tolerance mechanisms, Concept of Oxidative stress, Genes in stress tolerance.	

Reference Books for CORE COURSE MSBO201: Plant Physiology (Theory)

1. Biochemistry and Molecular Biology of Plants Buchanan B, Gruissem W, Jones R, ASPP, Maryland; First Edition 2.
2. Plant Biochemistry Hans-Walter Heldt; New Edition
3. Plant Biochemistry and Molecular Biology Lea PJ, Leegood RC; New Edition 1999 John Wiley & Sons
4. Plant Physiology Taiz L and Zeiger E; New Edition, Sinauer Associates, INC Massachusetts, USA
5. Plant Biochemistry by P.M. Dey & J. B. Harborne, Indian Edition, Academic Press
6. Natural Products from Plants (2006) by Leland J. Cseke, CRC

SEMESTER- II
CORE COURSE MSBO202: Plant Biochemistry (Theory) Credit – 4

Sl. no.	Chapter	No. of lectures
1.	Principles of biophysical chemistry (pH, buffer, reaction kinetics, general concept of thermodynamics, colligative properties).	4T/W
2.	Carbohydrate metabolism: Glycolysis & TCA cycle and their control mechanisms; Oxidative Phosphorylation; Pentose phosphate pathway and its control and significance; biological energy transducers. Gluconeogenesis and Glyoxalate cycle and their control and significance.	
3.	Lipid metabolism: biosynthesis and oxidation of fatty acids.	
4.	Protein chemistry: Amino acids and peptide bonds, determination of amino acid sequence in a polypeptide; Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds) Post translational modification of protein, chaperone and protein folding, protein targeting.	
5.	Nucleic acids: Conformation of helix (A, B, Z), t-RNA, micro-RNA). Stability of proteins and nucleic acids.	
6.	Enzyme kinetics: Deduction of Michaelis-Menten equation, Lineweaver-Burk plot; enzyme inhibition, isozymes, allosteric enzymes, ribozymes and abzymes.	
7.	Secondary metabolites and chemical defense: Plant natural products (secondary metabolites), their range and eco-physiological functions.	
8.	Overview, second messengers, receptors and G-proteins, phospholipid signaling, role of cyclic nucleotides, calcium-calmodulin cascade, diversity in protein kinases and phosphatases, specific signaling mechanisms and their regulation.	
9.	Biochemical genetics: Chemistry of nucleic acids, genetic methods, Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels. Protein sequencing methods, detection of post translation modification of proteins. DNA sequencing methods, strategies for genome sequencing, gene therapy.	

Reference Books for CORE COURSE MSBO202: Plant Biochemistry(Theory)

1. Biochemistry and Molecular Biology of Plants Buchanan B, Gruissem W, Jones R, ASPP, Maryland; First Edition 2.
2. Plant Biochemistry Hans-Walter Heldt; New Edition
3. Plant Biochemistry and Molecular Biology Lea PJ, Leegood RC; New Edition 1999 John Wiley & Sons
4. Plant Physiology Taiz L and Zeiger E; Fourth Edition, Sinauer Associates, INC 5, Massachusetts, USA
5. Plant Biochemistry by P.M. Dey & J. B. Harborne, Indian Edition, Academic Press
6. Natural Products from Plants (2006) by Leland J. Cseke, CRC

SEMESTER- II
CORE COURSE MSBO 203: Taxonomy and Biogeography of Angiosperms (Theory)
Credit – 4

Sl. no.	Chapter	No. of lectures
1.	Principles and practices in plant taxonomy, systematic and biosystematics: concepts, components and importance; brief history of Taxonomy(Theophrastus to recent);character concept; evolution of system of classifications (herbalists, artificial system, natural system, phylogenetic system, phenetic concept, cladistic concept); concepts, categories, methods and limitation of biosystematics.	4T/W
2.	Plant nomenclature: History; pre-Linnean concept; Linnean concept; de Candolle rules; Kew Rule; Paris code to Shenzhen code; Important dates of ICN; Principles of Botanical Code; Rules & Recommendations- Rank of taxa, Author citation, Effective and Valid publication, Type concepts, Rejection of names, Conservation of names, Orthography and Gender of name; Important terminologies.	
3.	Species concept and speciation: different species concepts- Biological Species Concept (BSC), Evolutionary Species Concept (ESC), Morphological Species Concept (MSC), Phylogenetic Species Concept (PSC), Recognition Species Concept (RSC), Successional Species Concept (SSC), Taxonomic Species Concept (TSC) etc.; speciation- variation and source of variation in plant population, reproductive isolation barriers, speciation types- allopatric, sympatric, parapatric and genic view of speciation.	
4.	Taxonomic literature and e-taxonomy- flora, monograph, revision, manual, journal & periodicals, bibliography, icon or illustrated book, dictionaries, indices, catalogues, identification keys, Index Herbariorum; e-flora, e-catalogue, e-index, GBIF, BHL, WCSP, POWO, Jstor-Global Plants, virtual herbaria and other web resources of taxonomy.	
5.	Phenetics & cladistics- principles & methods.	
6.	APG classification: principles & salient features; major angiosperm clades- ANA grade, Magnoliids, Commelinids, Monocots, Eudicots, Core-eudicots, Rosid I / Fabids, Rosid II / Malvids, Asterids / Lamiids, Asterid I / Campanulids, Asterid II / Campanulids, interrelationships among the clades, apomorphies of the major clades.	
7.	Plant identification: methods of plant identification, traditional versus modern approach.	
8.	Biodiversity and Conservation: components, levels, values of biodiversity; types of conservation; concept of hotspots and hottest hotspots, role in conservation.	
9.	Concept of plant biogeography: Endemism- causes, types, levels, endemism in relation to chromosome number, endemism in India; Plant migration as a process- concept of 'front' and 'jump', long distance migration, basic components of plant migration- Fecundity, dispersal, establishment and growth to reproductive maturity; Disjunction and Vicariance.	
10.	Major phytochoria of the world and India: basic principles, four 'realms' classification, A. Takhtajan's (1986) six kingdom classification, levels of Takhtajan's phytochoria, levels of endemism in Takhtajan's kingdom, Indian phytochoria.	
11.	Evolution of flowering plants: Floral diversification- reproductive innovations & radiation (floral phyllotaxy, floral symmetry, floral merism, perianth, androecium, gynoecium, ovule, fruit, seed, pollination syndromes), evolution and diversification of major angiosperm groups; parallel and convergent evolution (parasitism, carnivory, halophytes).	

Suggested readings for Taxonomy and Biogeography of Angiosperms

1. Angiosperm Phylogeny Group (2016) An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society* 181: 1-20.
2. Armen Takhtajan (1991) *Evolutionary Trends in Flowering Plants*-Columbia University Press.
3. Briggs David 2009. *Plant microevolution and Conservation in Human-influenced Ecosystems*.Cambridge University Press.
4. Cronquist, A. 1981 .*An Integrated System of Classification of Flowering Plants* Columbia University Press, New York.
5. Cronquist, A. 1988. *The Evolution and Classification of Flowering Plants* (2nded.) Allen Press, U.S.A.
6. Davis, P. H. and V. H. Heywood 1991. *Principles of Angiosperm Taxonomy*. Today and Tomorrow Publications, New Delhi.
7. Devis, P.H. and Heywood, V. H. 1973.*Principles of angiosperms taxonomy*. Robert E. Kreiger Pub. Co. Newyork.
8. Grant W. F. 1984. *Plant Biosystematics*.Academic press, London.
9. Heywood, V. H. and Moore, D. M. 1984. *Current concepts in Plant Taxonomy*. Academic Press, London.
10. Hislop-Harisson, J. 1967.*Plant Taxonomy*.English Language Book Sco.And Edward Arnold Pub.Ltd, UK.
11. Jones, S. B., Jr.and Luchsinger, A. E. 1986. *Plant Systematics* (gd edition). McGraw -Hill Book Co., New York.
12. Judd W. S., Campbell, C. S., Kellogg, E. A., Stevens P. F. and M. J. Donoghue 2008. *Plant Systematics: A phylogenetic Approach*.Sunderland, Massachusetts, USA.
13. Judd, W.S., Campbell, C.S, Kellogg, E.A., Stevens, P.A. and Donoghue, M.J. 2016. *Plant Systematics: A Phylogenetic Approach*. Sinauer Associaes, Inc., Massachusetts.
14. Lawrence George H. M. 1951. *Taxonomy of Vascular Plants*.Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.
15. Leadlay E. and S. Jury (ed.) 2006. *Taxonomy and Plant conservation*.Cambridge University Press.
16. Manilal, K. S. and M. S. Muktesh Kumar [ed.] 1998. *A Handbook of Taxonomic Training*. DST, New Delhi.
17. Nordentam, B., El Gazaly, G. and kassas, M. 2000.*Plant systematic for 21st century*.Portland press.Ltd, London.
18. Pamela S. Soltis et al. (2005) *Phylogeny & Evolution of Angiosperms*, Sinauer Associates.
19. Quicke, Donald, L. J. 1993. *Principles and Techniques of Contemporary Taxonomy*.Blakie Academic & Professional, London
20. Radford, A. E. 1986. *Fundamentals of plant systematic*. Harper and Raw publication, USA.
21. Simpson M. G. 2006. *Plant systematics* (Second Edition) Elsevier.
22. Simpson, M.G. 2010. *Plant Systematics*. Elsevier, Amsterdam.
23. Stuessy TF 2009. *Plant Taxonomy: The systematic Evaluation of Comparative Data*. Columbia University Press, New York.
24. Stuessy, T.F., Crawford, D.J., Soltis, D.E. and Soltis, P.S. 2014. *Plant Systematics: The origin, interpretation, and ordering, of plant biodiversity*. Koeltz Scientific Books, Konigstein, Germany.

25. Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.
26. Woodland, D. W. 1991. Contemporary Plant Systematics, Pentice Hall, New Jersey.
27. Hennig, W. 1966. Phylogenetic Systematics. Urbana: Univ. Illinois Press (an English translation of a book published earlier in German).
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On line Journals available on UGC website

SEMESTER- II

CORE COURSE MSBO 204: Gymnosperm, Paleobotany, Palynology (Theory) Credit: 4 (Gymnosperm)

Credit: 2

Sl. no.	Chapter	No. of lectures
1.	Introduction to gymnosperms: general features of gymnosperms; economic importance of gymnosperms; general idea of endangered and endemic taxa of gymnosperms.	4T/W
2.	Origin of seed-habit: Origin and evolution of nucellus and integument; switchover from zooidogamy to siphonogamy - hydrasperman reproduction, prepollen and evolution of typical gymnospermous pollen grains.	
3.	Progymnospermopsida: Geologic distribution, characteristic features, range of vegetative morphology and reproductive structures and classification; evolutionary significance.	
4.	Classification of gymnosperms: Andrew (1961), Sporne (1974), Steward (1983), Gifford & Foster (1989), Bhatnagar&Moitra (1996), Linear Sequence of Extant Gymnosperm.	
5.	Biogeography, distribution and phylogeny of Extant Gymnosperm: disjunctive distribution in two hemisphere- Northern hemisphere & Southern hemisphere; major clades of gymnosperm and their interrelationship, Anthophyte hypothesis, Gnetales-other seed plant hypothesis, Gnetifer hypothesis, Gnepine hypothesis, Gnecup hypothesis.	
6.	Development of female gametophytes among extant gymnosperms.	

(Palaeobotany)

Credit: 1

Sl. no.	Chapter	No. of lectures
1.	Fossil: Definition, types and mode of preservation. Principles of correlation and stratigraphy; dating of rocks; outline of Standard Geologic Time Scale.	4T/W
2.	Chemical evolution and origin of life; early life forms as known from Precambrians; origin of eukaryotes.	
3.	Basic concepts of continental drift and plate tectonics; importance of fossil plants in palaeoecological studies.	

Suggested Readings for Gymnosperms and Palaeobotany

1. Stewart, W.N. and Rothwell G.W. (1993), Palaeobotany and the Evolution of Plants, Cambridge University Press.
2. Foster A.S. & Gifford F.M. (1967): Comparative morphology of vascular plants, Freeman Publishers, San Francisco.
3. Eames, A.J.(1974): Morphology of Vascular Plants-lower groups, Tata Mc-Graw Hill publishing Co., New Delhi.
4. Arnold, C.A. (1947): Introduction to Palaeobotany, Mc-Graw Hill Book Co. Inc., New York and London.
5. Kubitzki K. (1990), The families and genera of vascular plants Pteridophytes and Gymnosperms, Springer Verlag, New York
6. Agashe, S.N. (1995), Palaeobotany, Oxford & IBH, New Delhi.
7. Biswas, C & Johri, B.N. (2004), The Gymnosperms, Narosa Publishing House, New Delhi.
8. Coulter J.M. & Chamberlain C.J.(1978): Morphology of Gymnosperms, Central Book Depot, Allahabad.
9. Kakkar, R.K.and Kakkar, B.R. (1995), The Gymnosperms (Fossils & Living), Central Publishing House, Allahabad.
10. Sharma O.P. (2002) Gymnosperms, Pragati Prakashan, Meerut.
11. Siddiqui, K.A. (2002) Elements of Palaeobotany, Kitab Mahal, Allahabad.
12. Bhatnagar, S.P. and Moitra A. (1996), Gymnosperms, New Age International Pvt. Ltd., New Delhi.
13. Singh, H. (1978), Embryology of Gymnosperms, Encyclopedia of Plant Anatomy X, Gebryder, Bortragear, Berlin.
14. Pant, D.D. (2003): Cycas and allied Cycadophytes, BSIP, Publications.
15. Bierhorst D.W. (1971): Morphology of vascular plants McMillan, New York.
16. Thomas, B.A. & Spicer R.A. (1987): The Evolution and Palaeobiology of land plants. Discordies Press, Fortland, USA.
17. Spicer, R.A. & Thomas, B.A. (1986) Systematic and taxonomic approaches in Palaeobotany. Systematic Association Special Volume.
18. Chamberlain C.J. (1986); Gymnosperms, structure and Evolution, CBS publishers and distributors, New Delhi.
19. On line Journals available on UGC –VSAT

(Palynology)

Credit: 1

Sl. no.	Chapter	No. of lectures
1.	Spore-pollen morphology: polarity, symmetry, shape, size, aperture patterns, NPC system for numerical expression of apertural details; exine stratification, surface structure and sculptures of sporoderms; LO analysis; sporopollenin- chemical nature, biological significance; development of pollen wall-Ubisch body; viscin threads, pollen kitt.	4T/W
2.	Pollen dispersal units, concept of anthesis, pollination modes, floral construction, pollination syndromes with special reference to melittophilous, miophilous, sapromyophilous, lepidophilous flowers.	
3.	Application of palynology & paleopalynology: forensic palynology, aeropalynology with reference to allergy; Melissopalynology; exploration of fossil fuel.	

Suggested Readings for Palynology

1. Fageri, K and J Inversen, 1964: Text book of pollen analysis.
2. Nair, P K K1964 : Advances in Palynology.
3. Nair, P K K1966 : Essentials of Palynology.
4. Heslop-Harrison, Y. 1971: Pollen development and physiology.
5. Gregory, P H, 1973: Microbiology of atmosphere.
6. Erdtman, G.1988 : Pollen morphology and plant taxonomy.
7. Tilak, S T. 1989 : Airborne pollen and fungal spores.
8. Shivanna K R and N S Rangaswami 1992 : Pollen Biology, A Laboratory manual.
9. Bhattacharya, K., M R Majumdar and S G Bhattacharya 2006: A Text book of Palynology.

SEMESTER- II

CORE COURSE MSBO205: Plant Physiology & Biochemistry (Practical)

Credit 4

Unit – I: Plant Physiology

Sl. no.	Chapter	No. of lectures
1.	Determination of chlorophyll, carotenoids, anthocyanins from normal and stressed plants	8P/W
2.	Effect of high temperature stress on membrane deterioration of plants.	
3.	Effect of drought stress on Root metabolic activity of seedling	
4.	Determination of water potential of plant samples by Chardakov's method.	
5.	Isolation of chloroplast and Study of photolysis of water by Hill reaction.	
6.	Demonstration of cytokinin-induced deferral of senescence by chlorophyll retention test in leaves of different chronological ages.	
7.	Assessment of viability status of aged and fresh seed lots by standard physiological test.	

Unit – II : Plant Biochemistry

Sl. no.	Chapter	No. of lectures
1.	Assay and compare activity of an antioxidant enzyme (catalase) from drought stressed and untreated control supplied experimental seedling	8P/W
2.	Assay and compare activity of a hydrolytic enzyme (protease) from drought stressed and untreated control experimental seedling	
3.	Estimate Reducing sugar, amino acids, Protein, phenolics present in supplied unknown solutions by Spectrophotometric methods	
4.	Purify and quantify proteins present in a supplied plant tissue.	

5.	Demonstration of Biochemistry tools: Different Centrifuges, Spectrophotometry, Chromatography (Paper & Thin layer), 1D SDS-PAGE (Demonstration), 2 DE, RT-PCR, GC-MS .	
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SEMESTER- II

CORE COURSE MSBO 206: Taxonomy and Biogeography of Angiosperms, Gymnosperm, Palaeobotany and Palynology (Practical)

Credit: 4

Unit- I: Taxonomy and Biogeography of Angiosperms (Practical)

Credit: 2

Sl. no.	Chapter	No. of lectures
1.	Application of taxonomic methods for identification of locally available Species according theory syllabus: Workout, descriptions, illustration (drawing with analysis), photography (plate to be prepared) and identification of the members of the following angiosperm taxonomic groups: MONOCOTS (Poaceae, Cyperaceae); COMMELINIDS (Commelinaceae); EUDICOTS (Menispermaceae, Ranunculaceae, Nelumbonaceae); CORE EUDICOTS (Nyctaginaceae, Portulacaceae, Polygonaceae, Loranthaceae, Santalaceae); ROSIDS (Vitaceae, Zygophyllaceae, Oxalidaceae, Euphorbiaceae, Rhizophoraceae, Passifloraceae, Polygalaceae); ASTERIDS (Lamiaceae, Rubiaceae, Apiaceae, Asteraceae) and other locally available plants according to theory syllabus.	8P/W
2.	Acquaintance with different types of Taxonomic Literature–Flora, Manual, Monograph, Glossary, Index, Dictionary, Keys and Periodicals etc.	
3.	Acquaintance with different types of e-taxonomic resources- e-Flora, e-Catalogue, e-Index, BHL, Jstor Global Plant.	
4.	Study of inter- and infra- specific variation of locally available taxa. Determination of polarity of character states according to evolutionary concepts.	
5.	Preparation of Artificial keys: Artificial key to be prepared at the family, genus, species and infra-specific level on the basis of worked out specimens.	
6.	Students are to submit herbarium specimens (at least 25).	

Unit- II: Gymnosperm, Palaeobotany and Palynology (Practical)

Credit: 2

Sl. no.	Chapter	No. of lectures
1.	Spore and pollen morphological study: selected pteridophytes, gymnosperms, and angiosperms using acetolysis/alkali maceration method; preparation of key to pollen sample.	8P/W
2.	Extraction of pollen grains from honey sample and qualitative and quantitative analyses of pollen morpho-types.	
3.	Study of the vegetative and reproductive parts of extinct gymnosperms.	
4.	A comparative study of the vegetative and reproductive parts of extant cycads and conifers.	

** (Submission of laboratory records including permanent slides)

Sl. no.	Chapter	No. of lectures
1.	The Environment: Physical environment; biotic environment; biotic and abiotic interactions; plant adaptations to the environment.	4T/W
2.	Ecosystem: Structure and function; energy flow and mineral cycling (Carbon, Nitrogen, sulphur); Gross & Net primary productivity and decomposition.	
3.	Habitat and niche: Concept; niche width and niche overlap; fundamental and realized niche; resource partitioning; character displacement.	
4.	Population ecology: Characteristics of a population; population growth curves; population regulation; life history- Trade-offs, strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.	
5.	Species interactions: Types of interactions, interspecific competition, predation, keystone species.	
6.	Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.	
7.	Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.	
8.	Applied ecology: Environmental pollution; global environmental change.	
9.	Conservation of Biodiversity: Brief idea about In-situ (Biosphere Reserves, National Parks, Sanctuaries and Sacred Groves) and Ex-situ (Botanical Gardens, Cryopreservation, Gene Banks, Seed Banks, Pollen Banks, Sperms Banks, DNA Banks, Tissue Culture and Biotechnological Strategies); Afforestation, Social Forestry, Agro forestry, ecorestoration, environmental education.	

Suggested Readings for Ecology

1. Patterns of primary production in the biosphere. H.F.W. Lieth (1978).
2. Fundamentals of Ecology. Agarwal S. K. (1992).
3. The Biosphere. Bradbury I. K. (1990)
4. Handbook of Limnology and water pollution with practical methodology Das S. M. (1989).
5. Environment and Plant Ecology. Etherington J. R. (1975).
6. Deterministic mathematical models in population ecology. Freedman H. I.(1980).
7. Quantitative Plant Ecology. Greig Smith P. (1983).
8. Comparative Plant Ecology. Grisms J. P. et .al (1988).
9. Quantitative and dynamic ecology. Kershaw K. S. (1964).
10. Concept of ecology. Kormondy E. J. (1966).
11. Ecology. Krebs C. J. (1978).
12. Manual of plant Ecology. Misra K. C. (1989).
13. Proceedings of the school of plant ecology. Misra R. and Das R. R. (1971).
14. Ecology. Odum E. P. (1971).
15. Fundamentals of Ecology. Odum E. P. (3rd ed. 1996).
16. Fundamentals of Ecology. Odum E. P. and Gary W. Barrett (6th ed. 2010).

17. Principles of Environment Sciences. Pandeya S. C. et al (1963).
18. on the Origin of Species. London: John Murray (always seek out the first edition, facsimile version, and avoid later editions). Darwin, C. 1859
19. Genetics and the Origin of Species. New York: Columbia Univ. Press (there are several later editions, and the title changed in the last). Dobzhansky, T. 1937.
20. The Genetical Theory of Natural Selection. Oxford: Oxford Univ. Press (there is a later edition). Fisher, R. A. 1930.

UNIT II: Plant Anatomy

1 CREDIT

Sl. no.	Chapter	No. of lectures
1.	Organization of shoot and root apical meristems. Changes in shoot apex during transition to flowering.	4T/W
2.	Development and differentiation: Polarity, symmetry, pattern formation (brief idea of genetic control of differentiation and organogenesis).	
3.	Origin, differentiation and phylogeny of xylem and phloem.	
4.	Leaf morphogenesis (brief idea of genetic control of differentiation and organogenesis).	
5.	Xylotomy and its importance.	
6.	Ultra structural features of sieve tube elements and their importance.	

Suggested Readings for Anatomy

1. Barnova, M A. 1987: Historical developments of the present classification of morphological types of stomata. Bot.Res.53:53-79.
2. Cutter, E G 1971 Plant Anatomy
3. Dilcher, D D 1974: Approaches to the identification of angiosperms leaf remains. Bot.Rev. 40:2- 157
4. Emmes, E J. and M C Danials, 1947: An introduction to plant anatomy.
5. Easau, K. 1962: Plant anatomy –anatomy of seed plants.
6. Fahn, A.1969: Secretary Tissue system
7. Foster, A S 1942: Practical plant anatomy
8. Haberland, G.1965: Physiological
9. Masueth, J D. 1936 : Plant anatomy
10. Metcalfe, C R and L Chalk, 1950: Anatomy of the dicotyledons
11. Solender, H. 1908 : Systematics anatomy of the dicots
12. Tomlinson, P S 1961: Anatomy of the monocotyledons.

SEMESTER- III

CORE COURSE MSBO302: Pharmacognosy and Instrumentation (Theory)

Credit 4

UNIT I: Pharmacognosy 2 CREDITS

Sl. no.	Chapter	No. of lectures
1.	Definition. History and scope of Pharmacognosy.	4T/W
2.	Drugs: Various systems of classification of drugs of natural origin, Morphological and microscopic examination of drugs.	
3.	Extraction and purification of natural products; Chromatographic study of drugs; Spectroscopic techniques; Methods of identification and analysis of results; Applications of phytochemical analysis.	
4.	Importance of Crude drug; Preparation of drugs for commercial market: a) Collection, Harvesting, Drying, Garbling, Packaging, storage and preservation. b) General idea of drug evaluation, pharmacopoeial standards, Adulteration, contamination and substitution.	
5.	Pharmacological activities of natural products, its' importance in pharmaceutical industries.	
6.	Silviculture: Definition, scope and objective; Farm forestry, social forestry and agro Forestry.	
7.	Plants as a source of petroleum substitute.	

UNIT I: Instrumentation

Sl. no.	Chapter	No. of lectures
1.	Isolation and purification of Protein, RNA, DNA (genomic and plasmid); Analysis of and proteins, RNA and DNA by one and two dimensional gel electrophoresis, isoelectric focusing gels;	4T/W
2.	Protein sequencing methods, detection of post-translation modification of proteins; Isolation, separation and analysis of carbohydrate and lipid molecules	
3.	DNA sequencing methods, strategies for genome sequencing; Methods for analysis of gene expression at RNA and protein level, Micro array based techniques;	
4.	Molecular cloning of DNA or RNA fragments in bacterial; expression of recombinant 23	
5.	Proteins using bacterial and plant vectors; Isolation of specific nucleic acid sequences; generation of genomic and cDNA libraries in plasmid BAC and YAC vectors;	
6.	RFLP, RAPD and AFLP techniques	

7.	Analysis of biomolecules using UV/visible, fluorescence, NMR; Structure determination using X-ray diffraction	
8.	Different Radiolabeling techniques, Incorporation of radioisotopes in biological samples, molecular imaging of radioactive material.	

SEMESTER- III

CORE COURSE MSBO303: Ecology and Plant Anatomy, Pharmacognosy and Instrumentation(Practical)
Credit 4

UNIT I: Ecology 1 CREDIT

Sl. no.	Chapter	No. of lectures
1.	Application of quadrat method in determination: Species-area relationship Relative frequency Relative density Relative dominance Importance value index	8P/W
2.	Determination of species diversity: Simpson index, Shannon index etc.	
3.	Estimation of Organic matter, Nitrogen and phosphate of soil.	
4.	Determination of total soluble salts in soil/water.	
5.	Determination of soil texture.	
6.	Determination of DO in polluted and non-polluted water.	
7.	Ecological observation during field study.	

UNIT I: Plant Anatomy

Credit: 1

Sl. no.	Chapter	No. of lectures
1.	Study of stomatal index, palisade ratio, vein-islet number.	8P/W
2.	Comparative study of nodal vascular: Unilacunar, Trilacunar, Multilacunar.	
3.	Comparative study of laticifers.	
4.	Structural analysis of secondary xylem and secondary phloem in section.	
5.	Study of sieve elements in Angiosperms and Gymnosperms. [Submission of laboratory records including permanent slides]	

UNIT II: Pharmacognosy**Credit: 1**

Sl. no.	Chapter	No. of lectures
1.	Organoleptic and microscopic studies in crude drug materials of plant origin in form of intact (fresh) and powdered samples: leaf, stem, rhizome, root, fruit and seeds – drugs.	8P/W
2.	Study of unorganized drugs - grains, resins, latex, oils etc.	
3.	The fluorescence characteristics of powdered drug samples treated with inorganic acids and solvents under ordinary light and UV light.	

UNIT II: Instrumentation**Credit: 1**

Sl. no.	Chapter	No. of lectures
1.	Demonstration of instruments; Electrophoretic techniques (1D, 2D); Chromatographic Techniques (Paper, Thin Layer, HPLC, GC), Restriction Mapping, RAPD, Transformation, PCR, SEM, Confocal and TEM.	8P/W
2.	Microscopy: Principles of light and electron microscopy; Light, Fluorescence, Confocal, SEM, TEM and AFM.	
3.	Demonstration of immune-fluorescent technique like ELISA.	

SEMESTER- III**CORE COURSE MSBO304-1: Plant System and Function (Theory)****Credit 2**

Sl. No.	Chapter	No. of lectures
1.	Central dogma and its role.	4T/W
2.	The proteins –the control molecules of metabolic orchestra	
3.	Photosynthesis as only mechanism for fixing radiant energy	
4.	Plant Secondary metabolism & its role	
5.	Plant System Biology	

SEMESTER- III

CORE COURSE MSBO 304-2: Plant Diversity and Evolution (Theory) Credit 2

Sl. No.	Chapter	No. of lectures
1.	Origin and diversity of unicellular protists.	4T/W
2.	Adaptation of plants for migration to land	
3.	Early diversification for greening of land.	
4.	Origin of bifacial cambium and phanerogamic mode of reproduction in the development of higher forest canopy.	
5.	Origin and advantage of angiosperms reproductive mode. Early diversification of angiosperms.	
6.	Diversification of floral construction with special reference to plant animal interaction.	
7.	Significance of rhizospheric microorganisms & mycorrhizal fungi in mobilization of nutrients for plants in terrestrial habits.	
8.	Plant diversity with reference to biodiversity hotspots.	

SEMESTER- III

CORE COURSE MSBO305-1: Plant Physiology & Biochemistry (Theory)Credit 4

Sl. no.	Chapter	No. of lectures
1.	Stress physiology: Responses of plants to abiotic (water, temperature and salt) and biotic (pathogen) stresses, mechanisms of stress tolerance and avoidance, stress inducible genes and stress proteins (HSPs, cold acclimation proteins, osmotin and phytochelatin).	4T/W
2.	Hormone Signaling: A general account of polyamines, brassinosteroids, jasmonic and salicylic acid with reference to their chemistry, physiological roles and signaling	
3.	Crop Physiology: physiological basis of crop yield with special reference source- sink relationship; designer crops, Prospects and controversial aspect of GM crops, role of contributory and noncontributory leaves on productivity, ideotypic characters of rice and sunflower.	
4.	Seed Biology: Physiology of seed development, maturation, dormancy and germination: Propagules and seeds: microbotic, mesobiotic and macrobotic; orthodox, recalcitrant and synthetic seeds; seed vigour and viability Hormonal regulation of seed development, events associated with seed maturation, factors regulating seed dormancy, mechanisms of mobilization of food reserves during seed germination, Harrington's thumb rule for seed deterioration, physiological and biochemical changes during seed deterioration.	
5.	Fruit development and ripening: Stages of fruit development and their regulation, biochemical and related events during fruit ripening in climacteric and non-climacteric fruits, physiology and biochemistry of fruit abscission, post-harvest changes, production of transgenic fruits	
6.	Senescence Biology: Senescence, abscission and programmed cell death and their characteristics, Leaf and flower senescence, altered metabolism during senescence and its regulation. Hormonal modulations. Environmental, genetic and molecular regulations. Senescence associated and senescence down- regulated genes.	
7.	Oxidative stress and antioxidative strategies: Redox system, Oxidative stress - causes and effects, Defense mechanisms involving diverse enzymatic and non-enzymatic antioxidants.	
8.	Plant Natural compounds and secondary metabolites: Secondary metabolites and chemical defence: Natural products (secondary metabolites), their range and ecophysiological functions. Overview of terpenoidal, alkaloidal, and phenolic metabolites and their biosynthesis. Biochemical mechanisms of plants' chemical war against other plants and animals.	
9.	Biochemtry and Molecular biology of Reproduction & Circadian rhythms: Floral meristems, Floral induction, evocation and development. Regulation of flowering by light and temperature, genes. Involvement of hormones and long distance signaling in rhythms.	

Reference Books CORE COURSE for MSBO305-1: Plant Physiology & Biochemistry

1. Lehninger Principles of Biochemistry, Seventh Edition | ©2017 David L. Nelson; Michael M. Cox
2. Biochemistry and Molecular Biology of Plants Buchanan B, Gruissem W, Jones R, ASPP, Maryland; First Edition
3. Plant Biochemistry Hans-Walter Heldt; New Edition
4. Plant Biochemistry and Molecular Biology Lea PJ, Leegood RC; Second Edition, John Wiley & Sons
5. Plant Physiology Taiz L and Zeiger E; Fourth Edition 2006, Sinauer Associates, INC 5.
6. Plant Biochemistry by P.M. Dey & J. B. Harborne, Indian Edition, Academic Press
7. Natural Products from Plant by Leland J. Cseke, CRC
8. The molecular life of plants by Jones et al Wiley
9. Chemicals from Plants: Perspectives on Plant Secondary Products by N.J. Walton, Diane E. Brown, Imperial College Press and World Scientific Publishing Co. Ltd.
10. ROS in Plant Biology, Bhattacharjee, S, 2019, Springer Nature
11. Drought Stress tolerance in plants. HOSSAIN ET AL 2016, Springer International
12. Introduction to Plant Physiology, John Wiley & Sons, Inc., N.Y., USA, 1999
12. Plant Abiotic Stress Tolerance: Agronomic, Molecular and Biotechnological Approaches Mirza Hasanuzzaman (Editor), Khalid Rehman Hakeem (Editor), Kamrun Nahar (Editor), Hesham F. Alharby (Editor)

SEMESTER- III

CORE COURSE MSBO 305-2: Applied and Molecular Mycology and Plant Pathology (Theory)

Credit 4

Sl. no.	Chapter	No. of lectures
1.	Medical mycology: Human diseases caused by fungi; Mycoses – types- superficial and deep seated mycoses, symptoms and clinical measures.	4T/W
2.	Mycotoxins: Definition, different mycotoxins with special emphasis on Aflatoxin -Biosynthesis of aflatoxin; Effects of mycotoxin contamination in food and feed and its consequences in human health. Candida infection - symptoms and clinical measures.	
3.	Fungi in industry and medicine: A General account on role of fungi producing Antibiotics and Organic acids. Industrial production of Antibiotics- Penicillin , Organic acids- citric acid and Plant growth regulators- Gibberellin , - biosynthetic pathway of their production. Fungi as a source of enzymes in industry. – paper industry, Textile industry, jute rating, tannery. Roles of Mushrooms as nutraceuticals .	
4.	Wood decay: Decay of wood and wood products by wood rotting fungi; Structural and Biochemical changes of wood as a result of decay. Method of wood preservation against fungal decay.	
5.	Genetic recombination in fungi: Heterothallism; Heterokaryosis and Parasexual cycle- events and significance. Extra- chromosomal and transposable genetic elements in fungi. Extra-chromosomal inheritance in fungi.	
6.	Cell cycle in Yeast: Cell cycle organization in yeast; cell cycle genetics in yeast; cyclins and cyclin dependent kinases; regulation of cell cycle in yeast. Genetic manipulation of brewing yeast.	
7.	Genomic organization and Protein secretion in yeast, genomic structure and organization in yeast. Protein secretory pathway in yeast; Protein folding- heat shock proteins and chaperons. Regulation of protein synthesis in yeast.	
8.	Industrial Strain Improvement: Genetic manipulation of industrially important fungi for fungal strain improvement. Recombinant DNA technology for improving industrially important fungal strains- protoplast fusion and hybrid strain development for improvement.	
9.	Fungi in Biotechnology- Role of fungi in biotechnology and fungi as biotechnological tools.	
10.	Lichen- Mycobiont – phycobiont relationship. Histoogy, Biology, physiology of lichen thallus, reproduction of lichen thallus. Ecological importance and economical benevolence of lichen.	

SEMESTER- III

CORE COURSE MSBO 305-3: Microbiology (Theory) Credit 4

Sl. no.	Chapter	No. of lectures
1.	Modern concept of bacterial Taxonomy: Classical and Molecular taxonomy, Numerical taxonomy, Bergey's manual of Determinative & Systematic Bacteriology, Type culture collection centre.	4T/W
2.	Concise account of the following groups: a) Mycoplasmatales b) Myxobacteria c) Bdellovibrio d) Actinobacteria	
3.	Bacterial photosynthesis:- Photosynthetic bacteria and mechanism of bacterial photosynthesis.	
4.	Chemolithotrophic bacteria: - types, modes of metabolism and energy transfer; heterotrophic CO ₂ fixation.	
5.	Membrane Transport system of bacteria :- Active and passive transport, facilitated diffusion, group translocation, ion transport through ionophores and protein transport.	
6.	Aerobic, Anaerobic respiration in bacteria & Bacterial Fermentation: - EMP pathway, HMP pathway, ED pathway, Phosphoketolase pathway, Bifidumpathway, TCA Cycle, Glyoxalate Cycle, ETC, Proton motive force, Chemiosmotic theory; Denitrification, Alcohol Fermentation, Lactate Fermentation	
7.	Biosynthesis of Amino acids & Nucleic acids in Bacteria: Glutamate and Aspartate families of amino acids and their regulation.	
8.	Industrial Microbiology and Biotechnology:- Fermenter – Basic principles, types, operation, sterilization, aeration, control of temperature, surfactant; Microbial fermentation of industrial enzymes (e.g. amylase), antibiotics (e.g. penicillin), amino acids (e.g. lysine). Fermented foods :- dairy products (e.g. Cheese), alcoholic beverages (e.g. Beer, wine), microbial cells as food e.g. Probiotics, Food borne disease; Microbial contamination and spoilage of food, methods of food preservation (physical and chemical).	
9.	Agricultural Microbiology: Biofertilizers (mass production of Rhizobium and Azotobacter); Microbial control of insects. Use of viruses in agriculture. PGPR: - Types, production and importance in Agriculture	
10.	Advanced approaches in Microbiology: Genomics, Proteomics, Metagenomics, Microarray, Bioinformatics	

Suggested readings:

- Alexander, M. (1977). *Introduction to Soil Microbiology*. New York: John Wiley & Sons.
- Atlas, R. M. (1984). *Microbiology, Fundamentals and Applications*. Macmillan.
- Atlas, R. M. & Bartha, R. (1997). *Microbial Ecology: Fundamentals and Applications*, 4th ed. Benjamin/ Cummings.
- Black, J. G. (2001). *Microbiology: Principles and Explorations*, 5th ed. John Wiley & Sons, New York.
- Campbell, R. (1983). *Microbial Ecology*. 2nd ed. Oxford, Blackwell.
- Brocks et al *Biology of Microorganisms*

Davis, B. D., Dulbecco, R., Eisen, H.N. & Ginsberg, H.S. (1990). *Microbiology*, 4th ed. Harper and Row.

Dimmock, N. J. & Primrose, S. B. (1994). *Introduction to Modern Virology*. 4th ed. Blackwell Scientific Publications. London.

Holt, J.G., Krieg, N.R., Sneath, P.H.A. Staley, J.T. & Williams, S.T. *Bergey's Manual of Determinative Bacteriology*. Lippincott Williams & Wilkins.

Maloy, S. R., Cronan, E. J. & Freifelder, D. (1994). *Microbial Genetics*, 2nd ed. Jones and Bartlett.

Pelczar, M. J., Reid, R. D. & Chan, E. C. (1993). *Microbiology*, 5th ed. Macmillan. London.

Pinehuk, G. (2003). *Schaum's outline Series: Theory and Problems of Immunology*. McGrawHill.

Presscott, L. M., Harley, J. P. & Klein, D. A. (1999). *Microbiology*, 4th ed. McGrawHill, New York.

Schlegel, H. G. (1993). *General Microbiology* .7th ed. Cambridge University Press.

Slonczewski, J.L. & Foster, J.W. (2009). *Microbiology- An Evolving Science*. Norton.

Stanier, R. Y., Adelberg, E. A. & Ingraham, J. L. (1986). *General Microbiology*. 5th ed. Macmillan.

Talaro, K. & Talaro, A. (1999). *Foundations in Microbiology* 3rd ed. Dubuque, McGraw Hill.

Tortora, G. J., Funke, B. R., & Case. C. L. (1999). *Microbiology. An Introduction*. 6th ed. Benjamin/Cummings Publishing. Menlo Park Calif.

Voyleys, B. A. (2002). *The biology of viruses*, 2nd ed. McGraw-Hill.

Abbas, A. K., Lichtman, A. H. & Pillai, S. (2006). *Cellular and molecular Immunology*. 6th ed. Saunders.

Abbas, A. K. & Lichtman, A. H. (2006). *Basic Immunology*. 2nd ed. Elsevier.

Chakraborty, A. K. (2003). *Immunology II*. 2nd ed. N. L. Publishers Siliguri.

Coico R, Sunshine, G., Benjamini, E. (2003). *Immunology: A short Course*. 5th ed. Wiley-Liss: New Jersey.

English, L. S. (1994). *Technological Applications of Immunochemicals (BIOTOL)*. Butterworth- Heinemann, Oxford Freeman & Co.

Goldsby, R. A., Kindt, T. J., Kuby, J. & Osborne, B. A. (2003). *Immunology*. 5th ed. W. H. Freeman & Co.

Khan F. H. (2009) *The Elements of Immunology*. Pearson.

Kindt, T., Goldsby, R. Osborne, B. (2007). *Kuby Immunology*. 6th ed. W.H. Freeman & Co.

Male, D., Brostaff, J., Roth, D. & Roitt, I. (2006). *Immunology*. 7th ed. Mosby.

Rao, C. V. (2002). *Immunology*. Narosa Publishing House, New Delhi.

Roitt, I. M. & Delves, P. J. (2001). *Roitt's Essential Immunology*. 10th ed. Blackwell Science.Ltd.

SEMESTER- III

CORE COURSE MSBO 305-4: Plant Genetics and Biotechnology (Theory) Credit 4

Sl. no.	Chapter	No. of lectures
	1. Concept on gene structure and function: Evolution of gene concept; Fundamental ideas on Mendelian genetics and extension of Mendelian analysis; complexity of gene action; genetic analysis pathway – forward and reverse genetic approaches; fine structure of gene.	4T/W
	2. Structural organization of chromosome and gene expression: Dynamic structure of chromatin and remodeling activity in gene regulation; DNA-protein interaction during transcription; Modes of mRNA, tRNA splicing, snRNPS, capping, polyadenylation and other processing events, Rbozyme; RNA editing, small regulatory RNA (SiRNA and miRNA), RNA interference.	
	3. Quantitative traits and Molecular Breeding: Combining ability, hybrids production by cytoplasmic male sterility system, Molecular marker- types, detection of polymorphism, mapping of molecular loci, QTL mapping and marker assisted selection; gene pyramiding.	
	4. Developmental genetics: Concept on genetic regulation of development – model system: <i>Drosophila melanogaster</i> and <i>Arabidopsis thaliana</i> ; molecular genetic aspects of plant nodulation and N ₂ fixation; floral organ identity genes and MADS box genes; Host pathogen interaction, signaling pathway related to <i>Agro</i> -infection and Crown-Gall Tumor formation; epigenetic regulation of development in plant.	
	5. Transposons and retro-elements: DNA and RNA transposons; Ac/Ds elements in maize, molecular feature of maize Ac/Ds system, cloning of maize Ac/Ds element; Transposon tagging- cloning of <i>cf-9</i> gene in tomato, genetic and evolutionary significance of transposon.	

SEMESTER- III

CORE COURSE MSBO 305-5: (Systematics and Biosystematics of Angiosperms) Theory

Credit 4

Sl. no.	Chapter	No. of lectures
1.	Biosystematics: Principles, aims, steps in Biosystematic study, dynamic units of Biosystematics study (after Clausen 1951, Grant, 1981, Chung-I Wu, 2001), concept of ecotype (ecological races), cline and Good species, role of ecotype in speciation, methods in Biosystematic studies, ecotypic variations and taxonomy; scope and limitations of Biosystematic studies.	4T/W
2.	Phenotypic plasticity and Epigenetics: Concept and role in adaptation, speciation and conservation.	
3.	Endemism: General concept; Distribution of endemic plant families in the globe; Brief account on endemic and threatened Angiosperms taxa of India.	
4.	Biodiversity and Conservation: Inventorying and monitoring of biodiversity, collection and assessment methods of different levels of biodiversity; different conservation strategies; IUCN criteria and categories of threatened plants.	
5.	Systematics of specially adaptive angiosperm groups: parasites, myco-heterotrophs, insectivorous plants and mangroves; taxonomic distribution, biogeography, eco-physiological attributes.	
6.	Plant domestication: Vavilov concept, centre of plant domestication of major crops; dispersal and distribution of major crops; causes and consequences, primary & secondary genetic diversity and regulation of domestication syndrome.	
7.	Morphometrics and statistics in plant systematics: concept on continuous and discontinuous characters, mapping of morphological data, measurement of continuous characters- traditional morphometrics, landmark morphometrics, geometric morphometrics, ordination method to study taxonomic relations, application in angiosperm taxonomy.	

Suggested readings for Systematics and Biosystematics of Angiosperms

1. Angiosperm Phylogeny Group (2016) An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnaean Society* 181: 1-20.
2. Armen Takhtajan (1991) *Evolutionary Trends in Flowering Plants*-Columbia University Press.
3. Briggs David 2009. *Plant microevolution and Conservation in Human-influenced Ecosystems*.Cambridge University Press.
4. Crawford, D.J. 2003. *Plant Molecular Systematics*. Cambridge University Press, Cambridge, UK.
5. Cronquist, A. 1981 .*An Integrated System of Classification of Flowering Plants* Columbia University Press, New York.
6. Cronquist, A. 1988. *The Evolution and Classification of Flowering Plants (2nded.)* Allen Press, U.S.A.
7. Davis, P. H. and V. H. Heywood 1991. *Principles of Angiosperm Taxonomy. Today and Tomorrow Publications, New Delhi.*
8. Devis, P.H. and Heywood, V. H. 1973.*Principles of angiosperms taxonomy*. Robert E. Kreiger Pub. Co. Newyork.
9. Grant W. F. 1984. *Plant Biosystematics*.Academic press, London.
10. Grant, V. 1971.*Plant Speciation*, Columbia University press, London.
Harisson, H.J. 1971. *New concept in flowering plant Taxonomy*. Hickman educational books Ltd. London.
11. Heywood, V. H. and Moore, D. M. 1984. *Current concepts in Plant Taxonomy*. Academic Press, London.
12. Heslop-Harisson, J. 1967.*Plant Taxonomy*.English Language Book Sco.And Edward Arnold Pub.Ltd, UK.
13. Jones, A. D. and Wibins, A. D. 1971. *Variation and adaptation in Plant species* Hickman and Co.
14. Jones, S. B., Jr.and Luchsinger, A. E. 1986. *Plant Systematics (gd edition)*. McGraw -Hill Book Co., New York.
15. Judd W. S., Campbell, C. S., Kellogg, E. A., Stevens P. F. and M. J. Donoghue 2008. *Plant Systematics: A phylogenetic Approach*.Sunderland, Massachusetts, USA.
16. Judd, W.S., Campbell, C.S, Kellogg, E.A., Stevens, P.A. and Donoghue, M.J. 2016. *Plant Systematics: A Phylogenetic Approach*. Sinauer Associaes, Inc., Massachusetts.
17. Lawrence George H. M. 1951. *Taxonomy of Vascular Plants*.Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.
18. Leadlay E. and S. Jury (ed.) 2006. *Taxonomy and Plant conservation*.Cambridge University Press.
19. Manilal, K. S. and M. S. Muktesh Kumar [ed.] 1998. *A Handbook of Taxonomic Training*. DST, New Delhi.
20. Naik, V. N. 1984. *Taxonomy of Angiosperms*. Tata McGraw-Hill Publication Com. Ltd. New Delhi
21. Nordentam, B., El Gazaly, G. and kassas, M. 2000.*Plant systematic for 21st century*.Portland press.Ltd, London.
22. Pamela S. Soltis et al. (2005) *Phylogeny & Evolution of Angiosperms*, Sinauer Associates.
23. Quicke, Donald, L. J. 1993. *Principles and Techniques of Contemporary Taxonomy*.Blakie Academic & Professional, London
24. Radford, A. E. 1986. *Fundamentals of plant systematic*.Harper and Raw publication, USA.
25. Simpson M. G. 2006. *Plant systematics (Second Edition)* Elsevier.
26. Simpson, M.G. 2010. *Plant Systematics*. Elsevier, Amsterdam.

27. Solbrig, O.T. 1970. Principles and methods of plant Sytematics. The Macmillan Co. Publication Co. Inc., USA.
 28. Stebbins, G. L. 1974. Flowering Plants-evolution Above species Level. Edvard Arnold Ltd, London.
 29. Stuessy TF 2009. Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.
 30. Stuessy, T.F., Crawford, D.J., Soltis, D.E. and Soltis, P.S. 2014. Plant Systematics: The origin, interpretation, and ordering, of plant biodiversity. Koeltz Scientific Books, Konigstein, Germany.
 31. Takhtajan, A. 1962. Flowering plants- Origin and Dispersal. Taylor, D. V. and L. J. Hickey 1997. Flowering Plants: Origin, Evolution and Phylogeny.CBS Publishers & Distributers, New Delhi.
 32. Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.
 33. Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.
 34. Woodland, D. W. 1991. Contemporary Plant Syatematics, Pentice Hall, New Jersery.
 35. Hennig, W. 1966. Phylogenetic Systematics. Urbana: Univ. Illinois Press (an English translation of a book published earlier in German).
- On line Journals available on UGC website

SEMESTER- III

CORE COURSE MSBO 305-6: Phycology(Theory) Credit 4

Sl. no.	Chapter	No. of lectures
1.	Work done on freshwater algae with special reference to India & Contributions of Prof. M. O. P. Iyengar.	4T/W
2.	Distribution pattern of Marine algae in Indian coasts.	
3.	Biochemical taxonomy of algae.	
4.	Ultrastructure of flagella and its taxonomic importance.	
5.	Endosymbiosis and origin of Eukaryotic algae	
6.	Phylogeny of algal plastids.	
7.	Green cyanobacteria: their taxonomic status.	
8.	Charophytes & origin of land plants.	
9.	Dinoflagellates: distinctive features, ecology & importance.	

10.	Desmids: taxonomy & importance.	
11.	A brief study of the following classes of algae: a) Prymnesiophyceae b) Raphidophyceae c) Chrysophyceae d) Euglenophyceae e) Chlorarachniophyceae f) Synurophyceae	

SEMESTER- III

CORE COURSE MSBO 306-1: PLANT PHYSIOLOGY & BIOCHEMISTRY (PRACTICAL)

Credit 4

Sl. no.	Chapter	No. of lectures
1.	To extract, estimate and compare total ascorbate and glutathione present in drought stressed and untreated control experimental seedlings	8P/W
2.	To extract, estimate and compare proline present in drought stressed and untreated control experimental seedlings	
3.	To investigate the impact of moderate high temperature stress on the level of soluble protein in germinating seeds.	
4.	Extraction and estimation of nucleic acids from plant samples.	
5.	Extraction and estimation of the enzyme ascorbate peroxidase from stressed and untreated plant sample	
6.	Extraction and estimation of the enzyme α -amylase from germinating seeds.	

7.	To compare total dehydrogenase activity from seeds of different storage duration.	
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SEMESTER- III

CORE COURSE MSBO 306-2: Applied and Molecular Mycology and Plant Pathology (Practical)

Credit 4

Sl. no.	Chapter	No. of lectures
1.	Principle of sterilization, preparation of fungal and bacterial culture media, methods of sterilization, preparation of slants, stabs, petri plates etc.	8P/W
2.	Method of subculturing, isolation of fungal and bacterial pathogens from plant tissue, establishment of pure culture, their maintenance and preservation. Inoculation technique.	
3.	Identification of fungi by microscopic examination: i) members of Phycomycotina of particular interest ii) members of Ascomycotina of particular interest iii) members of Basidiomycotina of particular interest iv) members of Deuteromycotina of particular interest.	
4.	Study of hyphal types in fungal sporocarps.	
5.	Study of mycorrhizal association on root samples of some common plants using standard protocol, Study of the mycorrhizal structures like, mycorrhizal hyphae, arbuscules and vesicles.	

6.	Microscopy:- Light and simple microscope, Bright field microscopy, SEM, TEM and applications of these techniques in plant pathology	
7.	Preparation of spawn for mushroom culture and demonstration on mushroom culture technique.	

SEMESTER- III

CORE COURSE MSBO 306-3: Microbiology (Practical)

Credit 4

Sl. no.	Chapter	No. of lectures
1.	Quantitative estimation of Sugar, Protein, DNA and RNA by colorimetric method.	8P/W
2.	Microbial growth measurement by turbidity, total count, construction of growth curve, determination of generation time.	
3.	Enrichment culture Aerobic N ₂ fixing bacteria b) Nitrifying bacteria c) Photosynthetic bacteria Endospore forming bacteria e) Cellulase producing bacteria, f) Phosphate solubilizing bacteria.	
4.	Effect of pH, temperature and substrate concentration on bacterial amylase activity.	
5.	Determination of quality of milk by methylene blue reductase test method	
6.	Physio-biochemical test for identification of bacteria:- Catalase b) Protease, c) Amylase d) Acid & Gas Production, e) Indole production f) V-P Test, g) Lysine decarboxylase, h) Citrate utilization test.	
7.	Uses of Bioinformatics tools for bacterial gene sequences and protein sequences.	
8.	Protein structure determination using Bioinformatics tool	

9.	Demonstration of the operation of following Instruments a) Spectrophotometer UV-Vis, b) Lyophilizer c) Sonicator d) Fraction collector e) GC-MS f) Laboratory fermenter g) Chemostat h) Centrifuge	
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SEMESTER- III

CORE COURSE MSBO 306-4: Plant Genetics and Biotechnology (Practical) Credit 4

Sl. no.	Chapter	No. of lectures
1.	Solving problems related to (a) Mendelian analysis. (b) Gene interactions. (c) Chromosomal basis of inheritance, (d) Linkage and crossing over. (e) Tetrad analysis, (f) Qualitative genetics, (g) Heritability (h) Non-Mendelian Genetics (extra-nuclear inheritance).	8P/W
2.	Methods in cytological studies; Chromosome morphology study in plants, analysis of karyotype and ideogram.	
3.	Special staining technique: Feulgen staining, Chromosome banding: Orcein-banding	
4.	UV mutagenesis assay using cultured <i>E.coli</i> cells.	
5.	Genotoxicity assessment: Studies on effect of genotoxin and mutagen on mitotic chromosomes, determination of mitotic and abnormality index.	
6.	Study of meiotic chromosomes and meiotic abnormalities.	

7.	Assay for chromosomal fragmentation and micronuclei test.	
8.	Isolation of nuclei from leaf tissues and DNA fragmentation and comet assay.	

SEMESTER- III

CORE COURSE MSBO 306-5: (Systematics and Biosystematics of Angiosperms) Practical Credit: 4

Sl. no.	Chapter	No. of lectures
1.	Study of intra- and inter- specific variation of Angiosperms taxa (both from fresh and preserved specimens) from substances mentioned in theory syllabus. Preparation of artificial keys.	8P/W
2.	Comparative studies of species/taxa to understand character polarization, apomorphy and plesiomorphy.	
3.	Application of ICN rules in solving nomenclature problems.	
4.	Searching of the original materials and the protologue of the names of the studied species and accurate typification.	
5.	Preparation of check lists using e-taxonomic resources.	
6.	Excursion to different phyto-geographic regions to study floristic composition.	
7.	Preparation of herbarium specimens following standard methods and relevant documents.	

SEMESTER- III

CORE COURSE MSBO 306-6: Phycology (Practical) Credit 4

Sl. no.	Chapter	No. of lectures
1.	Collection, fixation & preservation techniques for different types of algae for different purposes.	8P/W
2.	How to study, describe & prepare key up to genus level using standard characters.	
3.	Determination of plankton; species diversity index and algal pollution index of a water body using phytoplankton	
4.	Identification of common phytoplankton	
5.	Culture of algae. Students are required to submit a pure culture in next semester	

SEMESTER- III

CORE COURSE MSBO 307: Workshop on awareness campaign on preservation of Biodiversity, agrobiodiversity, medicinal plants etc. Credit 2

SEMESTER- IV

CORE COURSE MSBO401:Genetics, Plant Breeding and Biostatistics (Theory) Credit 4

Sl. no.	Chapter	No. of lectures
1.	Introduction to Plant Genetics: Brief history of classical and molecular genetics; Extension of Mendelism; Allelism; Gene action, Interaction with environment, Penetrance and expressivity; Gene interaction – epistasis, pleiotropy, <u>Pedigree analysis, lod score for linkage testing, genetic disorders.</u>	4T/W
2.	Linkage, Crossing over and Chromosome Mapping: Physical basis of crossing over; Recombination and gene mapping; Construction of genetic and physical mapping. <u>Chromosome banding patterns: Linear differentiation of chromosome segments, types of chromosome banding, uses of chromosome banding in cytogenetics. Mutations and mutagenesis: TILLING; Detection, Molecular basis and Applications.</u>	
3.	Genome Organization in Eukaryotes: Genome types; Eukaryote nuclear genome; gene concept; Organization of structural and functional components of chromosome-centromere, telomere, NOR; Sex chromosome in plants; Genome duplication, alteration and their evolutionary role; Genes and gene number, content and C-value paradox, <u>DNA content and adaptability, repetitive DNA, split genes, overlapping genes.</u>	
4.	Structural and Numerical Alterations of Chromosomes: Deficiency, Duplication, Inversion, Translocation and their meiotic behavior; Origin and significance of haploids, aneuploids, euploids, autopolyploids and allopolyploids.	
5.	Genetic Integrity and Diversity: Basis of chromosome separation; Recombination mechanism; Evolutionary significance, genetic control; Structure and function of Transposable elements and their role in evolution; Repair and retrieval system of genes; Gene expression regulation during differentiation and growth: <u>Heterochromatization in human beings, <i>Drosophila</i> and Yeast, position effect: Dosage compensation mechanism, sex chromatin and sex chromosomal linked inheritance. Non-Mendelian inheritance and maternal effects.</u>	
6.	Genomes, Genomics and Proteomics: Basic concept of genome sequencing- <i>Arabidopsis</i> , Rice and Human Genome; Genome annotation, Synteny, Gene Search and Comparative Genetic data; <u>Microarrays, DNA Chips</u> ; Proteomics – Application, Protein expression profiling.	

7.	Population Genetics and Plant Breeding: Definition, Gene Frequency in population; Genetic Equilibrium; Hardy-Weinberg Law; Speciation Mechanism; Breeding system and genetic consequences in plants; <u>Quantitative genetics: Qualitative and quantitative traits</u> ; Polygenic inheritance, heritability and its measurements, <u>QTL mapping</u> ; Marker Assisted Breeding for agronomic importance.	
1.	Statistics Variable and attribute, primary and secondary data.	
2.	Sampling and sample designs: Classification and tabulation of data; Frequency distribution; Diagrammatic and graphical presentation	
3.	Central tendency: Arithmetic, geometric and harmonic mean; Median; Mode.	
4.	Measures of dispersion: Variance; Mean deviation; Standard deviation and error; Moment; Skewness and kurtosis.	
5.	Correlation and regression analysis: Bivariate and multivariate.	
6.	Normal, binomial and poisson distribution.	
7.	Test of hypothesis: t, u and Chi square test.	
8.	8. Analysis of variances and covariance: Bivariate and multivariate.	

SEMESTER- IV

CORE COURSE MSBO 402: Cell Biology and Bioinformatics (Theory) Credit 4

Sl. no.	Chapter	No. of lectures
1.	Introduction: Cellular organization – its origin and evolution	4T/W
2.	Biomembranes: Structural models, composition and dynamics, biogenesis and assembly, transport of macromolecules and ions.	
3.	Mitochondria: Biogenesis, origin and evolution, mitochondrial genome.	

4.	Chloroplast: Biogenesis, origin and evolution, chloroplast genome.
5.	Nucleus: Chromatin organization and activation, packaging and its higher order structure, chromosome, basic nucleolar structure structures and dynamics.
6.	Cytoskeletons: Nature, intermediate filaments, microtubules, actin-binding filaments.
7.	Cell signaling and interaction: Signal transduction, its basic components and types, Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two component systems, light signaling in plants, bacterial chemotaxis and quorum sensing.
8.	Cellular communication: General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. intercellular junctions and adhesions.
9.	Cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle Cancer – molecular events, protooncogenes, oncogenes, tumor-suppressor genes and their inter-play, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic aspects of uncontrolled cell growth.
10.	Bioinformatics: Genome and protein information resources, sequence analysis, multiple sequence alignment, homology and analogy, pattern recognition, analysis package, application and prospects in medicine and agriculture.

SEMESTER- IV

CORE COURSE MSBO 403: Unit-I: Genetics, Plant Breeding and Biostatistics (Practical)

Credit 2

Sl. no.	Chapter	No. of lectures
1.	Solving problems related to (i) Mendelian inheritance (ii) Gene interactions (iii) Linkage and crossing over (iv) Tetrad analysis.	8P/W
2.	Analysis of genotype – Environment interaction, Correlation coefficient and Yield component analysis.	

3.	Analysis of genetic polymorphism – Cytogenetic biomarker in mutagenesis, Isozymes and other molecular markers (RAPD) – Demonstration.	
1.	Biostatistics Calculations of mean, variance, standard deviation, standard error, coefficient of variance, Use of t-test for comparing two means.	
2.	Determination of the relationship between variables using correlation and regression analysis.	
3.	Analysis of variance: ANOVA, ANCOVA, <i>U</i> -test.	
4.	4. Use of Chi-square test for goodness of fit. ** (Submission of laboratory records)	

Unit-II: Cell Biology and Bioinformatics (Practical)

Credit 2

Sl. no.	Chapter	No. of lectures
1.	Study of different phase of cell cycle, analysis of mitotic and meiotic chromosomal behavior in different phase of cell division.	8P/W
2.	Determination of mitotic chromosomal abnormality index and types of chromosomal/nuclear abnormalities in root tip meristem.	
3.	Isolation of nuclei from plant leaf tissue and staining of nuclei.	
4.	Nucleolar staining and determination of nucleolar frequency.	
5.	Study of chromosome banding pattern for detection of euchromatic and heterochromatic regions: Orcein banding.	
6.	Bioinformatics: Data base, sequence analysis, phylogenetic inference package. ** (Submission of laboratory records)	

SEMESTER- IV**DISCIPLINE CENTRIC ELECTIVE, MSBO 404-1: Plant Physiology & Biochemistry (Theory)****Credit – 4**

Sl. no.	Chapter	No. of lectures
1.	Fundamental concepts of Chemistry for explaining the properties of Biomolecules: Chemical bonds, stabilizing interactions (Vander walls, electrostatic, H-bonding, hydrophobic interactions), biophysical chemistry(p^H , buffer, reaction kinetics, colligative properties), Conformation of Protein (Secondary, tertiary, quaternary structures, domains, Motifs, Folds, Ramachandran Plot, Chaperonin and Protein folding), Nucleic acids (A,B,Z-DNA, tRNA, Micro RNA).	4T/W
2.	Bioenergetics : Laws of Thermodynamics, concepts of entropy, enthalpy and free energy, Oxidative reactions, group transfer, Biological energy transducers	
3.	Membrane Chemistry & Function: Structure of model Membrane, Lipid bilayer and membrane protein diffusion, Membrane transport (pumps, carriers, channels, mechanism of sorting, intracellular transport), electrical properties of membrane, membrane raft.	
4.	Cell signaling: Hormones and receptors, Cell surface receptors, Signaling through G-protein coupled receptors, Signal transduction pathways, Second messengers, Regulation of Signaling pathways, Plant two-component signaling systems.	
5.	Photophysiology: Photosynthesis- LHCPs, Z-scheme, photophosphorylation, Management of light energy & photoprotective mechanisms, PCRC, Rubisco & its regulation. Photomorphogenesis – Different classes of photoreceptors, photochemical and biochemical properties of Phytochrome, Cryptochrome and Phototropin; Phytochrome and phototropin signaling, PHY genes, blue light and stomatal movement.	
6.	Respiration and Photorespiration: Oxidative reactions, electron transport, ATP synthesis, alternate oxidase, photorespiratory pathway and its regulation and energetics.	
7.	Omic sciences in plant Biology: Basic concepts of Proteomics, Transcriptomics, Genomics and their application in Plant Biology & agriculture	
8.	Applied Biochemistry: Fundamentals of Proteomics, metabolomics and genomics and their application in agriculture. Principle and application of biochemical and biophysical methods - Electrophoresis (ID, 2D, capillary electrophoresis), Chromatography (HPLC, GLC, Affinity chromatography, Ion exchange chromatography, Spectroscopy (UV-VIS, fluorescence, NMR), X-ray diffraction, Mass spectrometry, Radio labeling techniques, Blotting techniques.	

Reference Books for MSBO 404-1: Plant Physiology & Biochemistry (Theory)

1. Lehninger Principles of Biochemistry, Seventh Edition | ©2017 David L. Nelson; Michael M. Cox
2. Biochemistry and Molecular Biology of Plants Buchannan B, Gruissem W, Jones R, ASPP, Maryland; First Edition
3. Plant Biochemistry Hans-Walter Heldt; 2006 Edition
4. Plant Biochemistry and Molecular Biology Lea PJ, Leegood RC; Second Edition 1999 John Wiley & Sons

5. Plant Physiology Taiz L and Zeiger E; Fourth Edition 2006, Sinauer Associates, INC 5.
6. Plant Biochemistry (2000)by P.M. Dey& J. B. Haroborne, Indian Edition, Academic Press
7. Natural Products from Plants (2006)by Leland J. Cseke, CRC
8. The molecular life of plants by Jones et al Wiley
9. Chemicals from Plants: Perspectives on Plant Secondary Products (1999)by N.J. Walton, Diane E. Brown, Imperial College Press and World Scientific Publishing Co. Ltd.
10. ROS in Plant Biology , Bhattacharjee, S, 2019, Springer Nature
11. Introduction to Plant Physiology, John Wiley & Sons, Inc., N.Y., USA, 1999
12. Plant Abiotic Stress Tolerance: Agronomic, Molecular and Biotechnological Approaches Mirza Hasanuzzaman (Editor), Khalid Rehman Hakeem (Editor), Kamrun Nahar (Editor), Hesham F. Alharby (Editor)

SEMESTER- IV

CORE COURSE MSBO 404-2: Applied and Molecular Mycology and Plant Pathology(Theory)

Credit 4

Sl. no.	Chapter	No. of lectures
1.	Disease incidence: Pre-penetration phase-Molecular basis of plant-pathogen interaction- physiology and genetics of plant- pathogen interaction; Genetics of pathogenicity; Resistant genes and avirulent genes. Gene for gene hypothesis and its molecular- genetical explanation; Molecular basis of appressorium formation and its role in plant disease development.	4T/W
2.	Stress Biology: Plant responses to different biotic and abiotic stresses: Stress tolerance and mechanism of Biotic and Abiotic stress tolerance; Hypersensitive response (HR)- Hypersensitive reactions- the mechanism elicitor-receptor complex formation. Structural and Biochemical defenses.	
3.	Molecular biology of plant disease resistance: Genetical and biochemical basis of plant disease resistance; Systemic Acquired Resistance (SAR), Induced Systemic Resistance (ISR) – Induction of resistance in host plants. Molecular aspect of plant disease resistance- role of phenolics, phytoalexins and phytoanticipins, Reactive oxygen species (ROS) and Oxidative stress- Ion-Flux Cascade and Programmed Cell Death (PCD), Lipoxigenase, PR- proteins- their classes and roles in plant disease resistance. PR-gene expression and their regulation. Basic knowledge about the defense enzymes of host plants, alarm signal and signal transduction mechanism.	
4.	Mycorrhizae and its molecular biology: Types, co-evolution, applications of mycorrhizae in agriculture and forestry and their possible use as biofertilizers. Molecular aspects of mycorrhization-molecular mechanism involved in signaling for mycorrhization and signal transduction pathway. Mass inoculum production of mycorrhizal biofertilizers-conventional methods and root organ culture (ROC).	
5.	Molecular diagnostic Techniques and tools for diagnosis of phytopathogens: Detection of plant pathogens from plant tissues using ELISA immunoassay techniques, immunofluorescent technique, DNA-DNA hybridization; DNA-RNA hybridization, PCR amplification, protein profiling by gel electrophoresis (SDS-PAGE).	

6.	Biotechnology and crop improvement: Development of disease resistant crop varieties by application of tissue culture, mutation breeding and recombinant DNA technology.	
7.	Phytoalexins: Definition, types and roles. Phytoalexins biosynthesis, Elicitors of phytoalexins synthesis; degradation of phytoalexins manipulation of phytoalexin biosynthesis in plants.	
8.	Toxins: Host specific and non host specific toxins, their role in pathogenicity and mode of action.	
9.	Plant disease control: Modern approaches Biological control of phytopathogens, insect pest management. Application of avirulent genes in control of plant pathogens, Integrated pest and disease Management (IPM/IDPM). Mass inoculums production and commercialization of biocontrol fungi and entomopathogenic fungi.	

SEMESTER- IV

CORE COURSE MSBO 404-3: Microbiology (Theory) Credit 4

Sl. no.	Chapter	No. of lectures
1.	Concise account of the following groups:- Rickettsiales b) Chlamydiae c) Extremophiles (Thermophiles Halophiles, Psychrophiles)	4T/W
2.	Plasmid- Types, Compatibility, Copy numbers, maintenance & amplification; Ti & Ri plasmid & its, application in biotechnology	
3.	Transposon and Retroposon;- Prokaryotic and Eukaryotic transposable elements, mechanism of transposition, transposon mutagenesis and their role in evolution	
4.	Prokaryotic DNA Replication, Transcription, Translation and their regulation	
5.	DNA damage and repair: - DNA damage & repair mechanisms in bacteria, RNAi, miRNA, siRNA and antisense RNA	
6.	Recombinant DNA Technology- Principles, Enzymes, Vectors, Methods, application of Recombinant DNA Technology.	
7.	Virology , Cultivation of viruses, methods for detection and assay, phage typing, major human viruses: HIV, Hepatitis B and COVID-19, their salient properties, diagnosis, prevention and treatment. Viral vaccines, interferon and antiviral drugs.	
8.	Environmental Microbiology: Biological treatment of wastes and pollutants: solid wastes disposal, treatment of liquid wastes; Biodegradation of environmental pollutants: petroleum hydrocarbons and xenobiotics. Bioremediation of heavy metals; Bioleaching and recovery of metals.	
9.	Medical microbiology:- Chemotherapy, Sulfa drug and their mode of action, Antibiotics – classification, mode of actions, antibiotic assay and sensitivity test, non-medical uses of antibiotics. Antiviral drugs and their mode of action; Drug resistance- origin, causes and clinical implications. Interferon – Chemical nature, mechanism of action, production and application. Pathogenicity due to invasiveness, exotoxin, endotoxin , toxoid and their practical application; Epidemiology, Symptoms, prevention and control of a) Tuberculosis b) AIDS	
10.	Immunology- Innate & Adaptive immunity; Cell mediated and Humoral immunity; MHC types and function; Cytokines; Complement – types, pathways of fixation; Antibody diversity and Class switching; Hypersensitivity- and their types; Monoclonal antibody production and application; Ag-Ab reaction;	
11.	Techniques- ELISA, RIA, RIST, RAST, FACS, FRET, FISH, EMSA, DNase I footprinting, Immunofluorescent	

Suggested readings:

- Alexander, M. (1977). *Introduction to Soil Microbiology*. New York: John Wiley & Sons.
- Atlas, R. M. (1984). *Microbiology, Fundamentals and Applications*. Macmillan.
- Atlas, R. M. & Bartha, R. (1997). *Microbial Ecology: Fundamentals and Applications*, 4th ed. Benjamin/ Cummings.
- Black, J. G. (2001). *Microbiology: Principles and Explorations*, 5th ed. John Wiley & Sons, New York.
- Campbell, R. (1983). *Microbial Ecology*. 2nd ed. Oxford, Blackwell.
- Brocks et al *Biology of Microorganisms*
- Davis, B. D., Dulbecco, R., Eisen, H.N. & Ginsberg, H.S. (1990). *Microbiology*, 4th ed. Harper and Row.
- Dimmock, N. J. & Primrose, S. B. (1994). *Introduction to Modern Virology*. 4th ed. Blackwell Scientific Publications. London.
- Holt, J.G., Krieg, N.R., Sneath, P.H.A. Staley, J.T. & Williams, S.T. *Bergey's Manual of Determinative Bacteriology*. Lippincott Williams & Wilkins.
- Maloy, S. R., Cronan, E. J. & Freifelder, D. (1994). *Microbial Genetics*, 2nd ed. Jones and Bartlett.
- Pelczar, M. J., Reid, R. D. & Chan, E. C. (1993). *Microbiology*, 5th ed. Macmillan. London.
- Pinehuk, G. (2003). *Schaum's outline Series: Theory and Problems of Immunology*. McGrawHill.
- Presscott, L. M., Harley, J. P. & Klein, D. A. (1999). *Microbiology*, 4th ed. McGrawHill, New York.
- Schlegel, H. G. (1993). *General Microbiology*. 7th ed. Cambridge University Press.
- Slonczewski, J.L. & Foster, J.W. (2009). *Microbiology- An Evolving Science*. Norton.
- Stanier, R. Y., Adelberg, E. A. & Ingraham, J. L. (1986). *General Microbiology*. 5th ed. Macmillan.
- Talaro, K. & Talaro, A. (1999). *Foundations in Microbiology* 3rd ed. Dubuque, McGraw Hill.
- Tortora, G. J., Funke, B. R., & Case. C. L. (1999). *Microbiology. An Introduction*. 6th ed. Benjamin/Cummings Publishing. Menlo Park Calif.
- Voyleys, B. A. (2002). *The biology of viruses*, 2nd ed. McGraw-Hill.
- Abbas, A. K., Lichtman, A. H. & Pillai, S. (2006). *Cellular and molecular Immunology*. 6th ed. Saunders.
- Abbas, A. K. & Lichtman, A. H. (2006). *Basic Immunology*. 2nd ed. Elsevier.
- Chakraborty, A. K. (2003). *Immunology II*. 2nd ed. N. L. Publishers Siliguri.
- Coico R, Sunshine, G., Benjamini, E. (2003). *Immunology: A short Course*. 5th ed. Wiley-Liss: New Jersey.
- English, L. S. (1994). *Technological Applications of Immunochemicals (BIOTOL)*. Butterworth- Heinemann, Oxford Freeman & Co.
- Goldsby, R. A., Kindt, T. J., Kuby, J. & Osborne, B. A. (2003). *Immunology*. 5th ed. W. H. Freeman & Co.
- Khan F. H. (2009) *The Elements of Immunology*. Pearson.
- Kindt, T., Goldsby, R. Osborne, B. (2007). *Kuby Immunology*. 6th ed. W.H. Freeman & Co.
- Male, D., Brostaff, J., Roth, D. & Roitt, I. (2006). *Immunology*. 7th ed. Mosby.
- Rao, C. V. (2002). *Immunology*. Narosa Publishing House, New Delhi.
- Roitt, I. M. & Delves, P. J. (2001). *Roitt's Essential Immunology*. 10th ed. Blackwell Science.Ltd.

SEMESTER- IV

CORE COURSE MSBO 404-4: Plant Genetics and Biotechnology(Theory) Credit 4

Sl. no.	Chapter	No. of lectures
1.	Evolutionary Genetics: Evolutionary forces, RNA world, DNA world and major evolutionary events, Genome evolution - gene duplication, protein domains, introns, lateral-horizontal gene transfer, molecular evolution and molecular clock.	4T/W
2.	Plant In Vitro Technology: History, basic idea and techniques, medium components, medium preparation, differentiation and regeneration, organogenesis and morphogenesis, genetic control; Embryogenesis and its physiological and biochemical aspects, synthetic seeds and embryo rescue; Haploid and triploid culture; Protoplast culture and somatic hybridization – principle, scope, isolation, purification and culture of protoplast, Nuclear and cytoplasmic hybrids, applications; Micropropagation – Principle, methods of clonal propagation, virus free plant production, Genetic assessment by RAPD, ISSR markers, Evaluation of germplasm preservation, In <i>Situ/Ex Situ</i> conservation of germplasm; Cryopreservation – Principle, techniques and applications.	
3.	Components of genetic transformations in plants: Strategies and methods of genetic manipulations, characterization of plant promoters; concepts on tissue specific and inducible and constitutive promoters; <i>Agrobacterium</i> mediated gene transfer, characteristics of Ti/Ri plasmids; co-integrative and binary vectors, Direct or physical DNA delivery methods – electroporation, biolistics; Chloroplast transformation; Functional genomics: validation of transgene stability and function; Concepts on genome editing tools: Zinc finger nucleases (ZFNs), transcription activators like effector nucleases (TALENs) and clustered regulatory interspaced short palindromic repeats (CRISPR/Cas); Application of transgenic plants for productivity and performance; Molecular pharming - benefits and risks; biopolymer production through transgenic approach; Biosafety, bioethics and plant biotechnology.	
4.	Strategy for Crop Improvements: Basic idea and principle of crop improvement through transgene technology; developing herbicide tolerance in crops; target of herbicide action and detoxification of herbicides; Genetic engineering of plants for insect resistance: Bt toxin and use of protease inhibitors; Engineering plants for abiotic stress tolerance, including salt and drought tolerance; Production of secondary metabolites - Biotransformation and metabolic engineering for secondary metabolite production.	

SEMESTER- IV

CORE COURSE MSBO 404-5: (Systematics and Biosystematics of Angiosperms) Theory

Credit: 4

Sl. no.	Chapter	No. of lectures
1.	Methods and principles of biological systematics: evolutionary principles and methods, character mapping, phylogenetic classification, comparison between phylogenetic classifications with those derived from other taxonomic methods.	4T/W
2.	Phylogenomics&Phylogeography: Principles, methods & outcomes.	
3.	Phenetic: Principles, Clustering method- OTU selection, concept of character(s), unit characters selection, OUT X character matrix, character coding matrix, similarity coefficient matrix, clustering (UPGMA method), phenogram construction and analysis; application in Taxonomy & Agronomy.	
4.	Cladistics: Principles; concepts on monophyly, monophyletic group, paraphyletic group, polyphyletic group, apomorphy, synapomorphy, plesiomorphy, homoplasy, analogy, clade, cladogram, phylogram, phylogenetic tree, anagenesis, cladogenesis, outgroup, ingroup, morphocline/ transformation series, character evolution, terminal taxon, principle of parsimony, principle of maximum likelihood, Bayesian principle, rooted tree, unrooted tree, consensus tree, cladogram robustness, phylogenetic software, exhaustive search of tree, heuristic search of tree, bootstrap analysis, Jackknife Analysis, biogeographic analysis; taxon selection; character analysis; cladogram construction; cladogram analysis.	
5.	Journey from Alpha Taxonomy to Phylogenetics in India: contribution of VanRheede, Botanical Collections in India, Recent Trends in Capturing Specimen Data and Images, Species Discovery, Catalogue of Taxa into Floras, Adoption of Molecular Data, National Priorities on Plant taxonomy and Biodiversity Studies, role of BSI and other institutes in Indian taxonomy.	
6.	Molecular Systematics: History, Concept and methods; Molecular Taxonomy and the need for accelerated pace of species discovery, strengths and limitations of molecular taxonomy; molecular markers in plant phylogenetic analysis.	
7.	Chemotaxonomy in Angiosperm Phylogeny: History, primary and secondary metabolites, semantides, their significance in Angiosperms Systematics; Chemotaxonomic markers in APG; tools and techniques in chemotaxonomy.	
8.	Barcoding concept: Importance; standard molecular barcodes, nrDNA, cpDNA and mtDNA.	
9.	The New Global Taxonomy Initiatives and collection based systematic: Biodiversity strategy and systematics Agenda for 2020 (SA2K); Building the Biodiversity Cyber Bank— an ambitious global community-wide cyber infrastructure.	

Suggested readings for Systematics and Biosystematics of Angiosperms

1. Angiosperm Phylogeny Group (2016) An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
2. Armen Takhtajan (1991) Evolutionary Trends in Flowering Plants-Columbia University Press.
3. Briggs David 2009. Plant microevolution and Conservation in Human-influenced Ecosystems. Cambridge University Press.
4. Crawford, D.J. 2003. Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.

5. Cronquist, A. 1981 .An Integrated System of Classification of Flowering Plants Columbia University Press, New York.
6. Cronquist, A. 1988. The Evolution and Classification of Flowering Plants (2nded.) Allen Press, U.S.A.
7. Davis, P. H. and V. H. Heywood 1991. Principles of Angiosperm Taxonomy. Today and Tomorrow Publications, New Delhi.
8. Devis, P.H. and Heywood, V. H. 1973.Principles of angiosperms taxonomy. Robert E. Kreiger Pub. Co. Newyork.
9. Grant W. F. 1984. Plant Biosystematics.Academic press, London.
10. Grant, V. 1971.Plant Speciation, Columbia University press, London.
Harisson, H.J. 1971. New concept in flowering plant Taxonomy. Hickman educational books Ltd. London.
11. Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.
12. Heslop-Harisson, J. 1967.Plant Taxonomy.English Language Book Sco.And Edward Arnold Pub.Ltd, UK.
13. Jones, A. D. and Wibins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co.
14. Jones, S. B., Jr.and Luchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw -Hill Book Co., New York.
15. Judd W. S., Campbell, C. S., Kellogg, E. A., Stevens P. F. and M. J. Donoghue 2008. Plant Systematics: A phylogenetic Approach.Sunderland, Massachusetts, USA.
16. Judd, W.S., Campbell, C.S, Kellogg, E.A., Stevens, P.A. and Donoghue, M.J. 2016. Plant Systematics: A Phylogenetic Approach. Sinauer Associaes, Inc., Massachusetts.
17. Lawrence George H. M. 1951. Taxonomy of Vascular Plants.Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.
18. Leadlay E. and S. Jury (ed.) 2006. Taxonomy and Plant conservation.Cambridge University Press.
19. Manilal, K. S. and M. S. Muktesh Kumar [ed.] 1998. A Handbook of Taxonomic Training. DST, New Delhi.
20. Naik, V. N. 1984. Taxonomy of Angiosperms. Tata McGraw-Hill Publication Com. Ltd. New Delhi
21. Nordentam, B., El Gazaly, G. and kassas, M. 2000.Plant systematic for 21st century.Portland press.Ltd, London.
22. Pamela S. Soltis et al. (2005) Phylogeny & Evolution of Angiosperms, Sinauer Associates.
23. Quicke, Donald, L. J. 1993. Principles and Techniques of Contemporary Taxonomy.Blakie Academic & Professional, London
24. Radford, A. E. 1986. Fundamentals of plant systematic.Harper and Raw publication, USA.
25. Simpson M. G. 2006. Plant systematics (Second Edition) Elsevier.
26. Simpson, M.G. 2010. Plant Systematics. Elsevier, Amsterdam.
27. Solbrig, O.T. 1970. Principles and methods of plant Sytematics. The Macmillan Co. Publication Co. Inc., USA.
28. Stebbins, G. L. 1974. Flowering Plants-evolution Above species Level. Edvard Arnold Ltd, London.
29. Stuessy TF 2009. Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.
30. Stuessy, T.F., Crawford, D.J., Soltis, D.E. and Soltis, P.S. 2014. Plant Systematics: The origin, interpretation, and ordering, of plant biodiversity. Koeltz Scientific Books, Konigstein, Germany.

31. Takhtajan, A. 1962. Flowering plants- Origin and Dispersal. Taylor, D. V. and L. J. Hickey 1997. Flowering Plants: Origin, Evolution and Phylogeny. CBS Publishers & Distributors, New Delhi.
32. Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.
33. Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.
34. Woodland, D. W. 1991. Contemporary Plant Systematics, Pentice Hall, New Jersey.
35. Hennig, W. 1966. Phylogenetic Systematics. Urbana: Univ. Illinois Press (an English translation of a book published earlier in German).

On line Journals available on UGC website

SEMESTER- IV

CORE COURSE MSBO 404-6: Phycology (Theory) Credit 4

Sl. no.	Chapter	No. of lectures
1.	Fossil algae & their importance.	4T/W
2.	Carbon dioxide concentrating mechanism (CCM) in algae.	
3.	Phytoplankton Ecology: factors (light, temperature, chemical & current) and distribution.	
4.	Terrestrial algal ecology: soil algae, cryoalgae and subaerial algae	
5.	Macroalgal and periphyton ecology: biogeography of seaweeds; influence of biological factors on periphyton	
6.	Algae of unusual habitats: thermal algae, halotolerant forms and their ecology	
7.	Extracellular products of algae & toxic algae.	
8.	Algae in Biotic associations.	

9.	Algal biotechnology with special reference to health food, biocosmetics, medicine, biofuels, biomonitoring and bioremediation.	
10.	Control of aquatic algae.	
11.	Biogeochemical role of algae Isolation, purification & growth characteristics in relation to algal culture; indoor and outdoor cultivation culture; photobioreactors.	

SEMESTER- IV

CORE COURSE MSBO 405-1: PLANT PHYSIOLOGY & BIOCHEMISTRY (PRACTICAL)

Credit 4

Sl. no.	Chapter	No. of lectures
1.	To separate amino acids from a mixture sample by paper chromatographic technique.	8P/W
2.	Protein purification by salting out and isoelectric precipitation.	
3.	Purification of protein by 1-D SDS-PAGE	
4.	To separate flavonoids from a mixture sample by TLC technique	
5.	Soxlet extraction, concentration (vacuum evaporation) and quantification of phenolic compounds from plant sample.	
6.	Demonstration of 2D electrophoretic separation of plant proteins.	
7.	Extraction and estimation of Na ⁺ and K ⁺ ions from salinity stressed and untreated control seedlings	

SEMESTER- IV

CORE COURSE MSBO 405-2: Applied and Molecular Mycology and Plant Pathology(Practical)

Credit 4

Sl. no.	Chapter	No. of lectures
1.	Study of symptomology and histopathology and identification of some common plant diseases caused by fungi, bacteria and viruses.	8P/W
2.	Spectrophotometric Estimation of total phenols in diseased and healthy plant tissue.	
3.	Spectrophotometric Estimation of nucleic acids from healthy and diseased plant tissue -extraction and estimation	
4.	Assay of pectolytic enzymes produced by pathogens during pathogenesis. Assay of cellulolytic enzymes produced by pathogens during pathogenesis.	
5.	Assay of chitinolytic enzymes produced by pathogens during pathogenesis.	
6.	Laboratory testing of fungicides: a) standard procedure for preparation of calibrated spore suspension b) standard procedure for preparation of stock solution of test chemicals c) Fungicidal bioassay using fungal spore germination technique and determination of MIC value.	
7.	Antibiotic bioassay: following bacterial growth and standard protocol.	
8.	Demonstration for operation of the following instruments:- Spectrophotometric studies— UV-VIS spectrophotometer, Atomic Absorption spectrophotometer, ELISA -immunofluorescent assay, Electrophoretic Techniques- SDS-PAGE - GEL electrophoresis, GEL documentation system. Chromatographic techniques- HPLC, GC-MS. Centrifuge- cold centrifuge, Ultra-centrifuge.	
9.	Bioinformatics and its implications in fungal and bacterial protein and gene sequencing.	

SEMESTER- IV

MSBO-405-3 DEMicrobiology (Practical)

Credit-4

50 L

Sl. no.	Chapter	No. of lectures
1.	Determination of MIC and MBC of antibiotic. Assay of antibiotic by agar cup assay and tube dilution method.	8P/W
2.	Determination of phenol co-efficient.	
3.	Determination of thermal death point of bacteria.	
4.	Isolation of Plasmid / genomic DNA from bacteria and Agarose gel Electrophoresis of isolated DNA, Quantification of DNA using Spectrophotometer. Restriction enzyme digestion (kit based), electrophoresis & documentation. Bacterial protein isolation, SDS-PAGE of isolated protein and determination of Mol. wt., Bradford assay	
5.	Standard Quality analysis of water- a) Presumptive test b) Confirmed test c) Completed test d) IMVIC test	
6.	Isolation of <i>Rhizobium</i> from nodule of leguminous plant . Demonstration of production of <i>Rhizobium</i> inoculant in laboratory fermenter.	
7.	Separation of mixture of sugars and amino acids by paper Chromatography and Thin Layer Chromatography method and their identification.	
8.	Demonstration of the operation of following Instruments a) Atomic Absorption b) HPLC c) SEM d) PCR e) RT-PCR, f) qPCR	
9.	Isolation of heavy metal bacteria and detection of bioremediation efficiency by modern approach	
10.	Serological test (agglutination and precipitation-kit based)	
11.	Isolation of bacteriophage from sewage water	

SEMESTER- IV

CORE COURSE MSBO 405-4: Plant Genetics and Biotechnology(Practical)

Credit 4

Sl. no.	Chapter	No. of lectures
1	Preparation of stock solution and MS basal medium.	8P/W
2	Laboratory experiments for callus induction, organogenesis, somatic embryogenesis and plant regeneration.	
3	Preparation of synthetic seed with somatic embryo.	
4.	Isolation of plasmid DNA from cultured <i>E.coli</i> cells; plasmid purification	
5.	Digestion of plasmid DNA using restriction endonucleases, restriction fragments analysis through agarose gel electrophoresis and determination of restriction maps	
6.	Transformation of competent <i>E.coli</i> cell using plasmid DNA, determination of transformation efficiency.	
7.	Isolation, purification and spectrophotometric estimation of plant genomic DNA.	
8.	Principle and applications of polymerase chain reaction, amplification of DNA sequence by PCR, site-directed mutagenesis (demonstration only)	
9.	Isolation protoplast from leaf mesophyll cell, visualization of protoplast.	
10.	Preparation of <i>Agrobacterium</i> culture, <i>Agro</i> -transformation with plant binary vector, transient gene expression assay by Tobacco leaf <i>Agro</i> - infiltration, <i>GUS</i> reporter assay.	

SEMESTER- IV

CORE COURSE MSBO 405-5: (Systematics and Biosystematics of Angiosperms) Practical

Credit 4

1.	Study of some apomorphic floral characters (in comparative manner) in locally available special group of Angiospermic plants.	8P/W
2.	Morphological study of locally available Angiospermic taxa/species and Phenetics analysis of the studied taxa/species by UPGMA method.	
3.	Cladistic analysis of the studied species using PAUP/other software: Characters selection, homology assessment, determination of polarity of characters (morphocline), preparation of taxa X characters metrics, cladogram construction and interpretation of clades.	
4.	Acquisition of molecular markers sequence of the studied species from online databases and Molecular phylogenetic analysis using MEGA and other softwares.	
5.	Extraction and preliminary Phytochemical screening and quantitative estimation of some selective Chemotaxonomic markers.	
6.	Excursion to different phyto-geographic regions to study floristic composition.	
7.	Preparation of herbarium specimens following standard methods and relevant documents.	

SEMESTER- IV

CORE COURSE MSBO 405-6: Phycology (Practical) Credit 4

Sl. no.	Chapter	No. of lectures
1.	How to study, describe & prepare key up to species level using standard characters.	8P/W
2.	Study of Indian marine algae.	
3.	Collection and study of representative diatoms using standard techniques	
4.	Culture of algae (continuation) students are required to submit a pure culture	
5.	Cytology of algae.	

SEMESTER- IV

CORE COURSE MSBO 406: Based on DE (Project/Term paper) Credit 4