ANDHRA KESARI UNIVERSITY

University COLLEGE OF AKU

DEPARTMENT OF MICROBIOLOGY

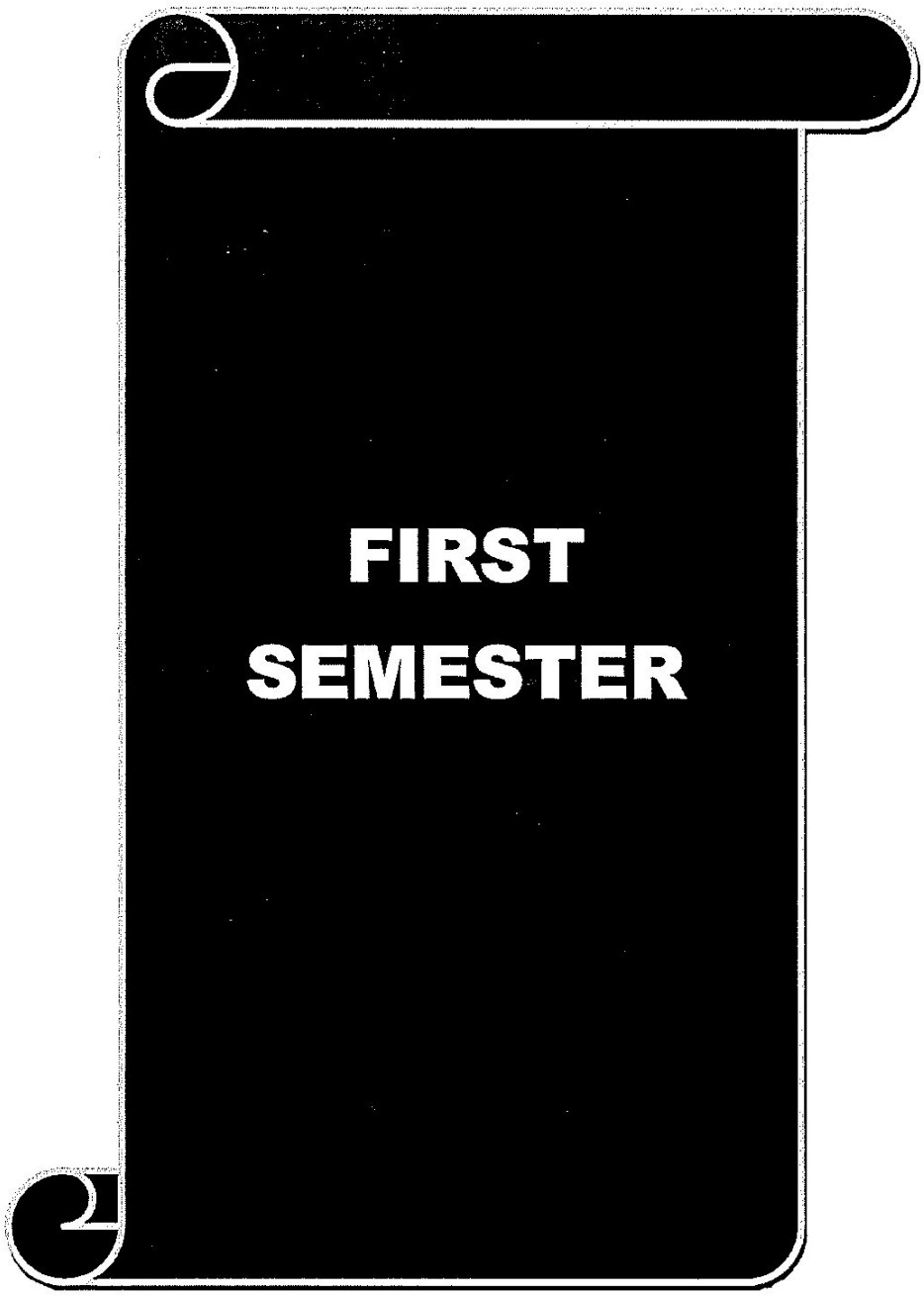
M.Sc. BOTANY: 2026-2027

Course Structure

Course code	M.Sc. BOTANY							
		L	P	S/M/P	C	CIA	ESE	Total
SEMESTER I								
BOT 1.1	Core - Plant Systematics	4			4	30	70	100
BOT 1.2	Core - Reproductive Biology of Angiosperms	4			4	30	70	100
BOT 1.3	Compulsory Foundation - Biology and Diversity of Viruses, Bacteria, Algae and Fungi	4			4	30	70	100
BOT 1.4 A/B/C	(A) Elective Foundation - Outlines of Bryophytes, Pteridophytes, Gymnosperms and Plant Fossils (B) Elective Foundation– Phycology (C) Elective Foundation - Evolutionary Biology	4			4	30	70	100
BOT PI	1.1 + 1.2		6		4	30	70	100
BOT PII	1.3 + 1.4		6		4	30	70	100
	Audit Course		2	6	2	50	-	-
	Sub-Total:				24			600
SEMESTER II								
BOT 2.1	Plant Ecology and Biodiversity	4			4	30	70	100
BOT 2.2	Plant Physiology	4			4	30	70	100
BOT 2.3	Compulsory Foundation – Cell Biology	4			4	30	70	100
BOT 2.4 A/B/C	(A) Elective Foundation - Plant Structure and Development (B) Elective Foundation – Principles of Forestry (C) Elective Foundation - Microorganisms in Health and Environmental Alleviation	4			4	30	70	100
BOT PI	2.1 + 2.2		6		4	30	70	100
BOT PII	2.3 + 2.4		6		4	30	70	100
Skill Development Course	MOOCS	2		6	2	50	-	-
	Sub-Total:				24			600

SEMESTER III								
BOT 3.1	Plant Pathology	4			4	30	70	100
BOT 3.2	Plant Metabolism	4			4	30	70	100
BOT 3.3 A/B/C	(A) Elective-I - Ethnobotany and Ethnomedicine (B) Elective-I – Principles and Methods of Plant Propagation (C) Elective-I – Mushroom Cultivation and Single Cell Protein	4			4	30	70	100
BOT 3.4 A/B/C	(A) Elective- II – Molecular Biology of Plants (B) Elective- II – Advanced Molecular Tools (C) Elective- II – Phytoremediation	4			4	30	70	100
BOT PI	3.1 + 3.2		**6**		4	30	70	100
BOT PII	3.3 + 3.4		**6**		4	30	70	100
Skill Enhancement Course	Through MOOCS			6				
	Sub-Total:				24			600
SEMESTER IV								
BOT 4.1	Plant cell, Tissue and Organ Culture	4			4	30	70	100
BOT 4.2 A/B/C	(A) Elective-I – Cytogenetics and Plant Breeding (B) Elective-I – Genomics, Proteomics and Metabolomics (C) Elective-I – Genetic engineering and Bioinformatics	4			4	30	70	100
BOT 4.3 A/B/C	(A) Elective- II –Horticulture and Landscaping (B) Elective- II – Organic Farming and Vermi Composting (C) Elective- II – Biofertilizer Technology	4			4	30	70	100
BOT PI	4.1 + 4.2			6	4	30	70	100
BOT PI	4.3 + 4.4			6	4	30	70	100
Project work				6	4	-	-	100
	Sub-Total:				24			600
	Grand Total				96			2400

Note: pass in audio course, skill development and skill enhancement courses are mandatory.


FIRST
SEMESTER

ANDHRA KESARI UNIVERSITY UNIVERSITY COLLEGE OF SCIENCES DEPARTMENT OF BOTANY & MICROBIOLOGYM.Sc. BOTANY SEMESTER-I

Semester	BOT 1.1: PLANT SYSTEMATICS	L	T	P	C
1		4	0	6	4

LEARNING OBJECTIVE (LO):

LO1	The aim of the course is to impart knowledge in diversity of plants, their identification, nomenclature and their classification based on various aspects including recent advances in the field.

COURSE OBJECTIVE (CO):

CO1	The student will be able to Learn the hierarchical taxonomic structure and Know the principles and rules of nomenclature for naming the plants.
CO2	The student will be able to understand the recent advances in the classification of plant groups.
CO3	The student will be able to Identify the role of various taxonomic evidences in classification of plants. Know the importance of Botanical Survey of India in Systematic studies.
CO4	The students will be able to Identify the plants by using various methods and get acquaintance on herbarium preparation and preservation of specimens.
CO5	The student able to learn the technique of constructing cladograms by using cladistic methods.

UNIT-I

Systematics: Concepts and basic components; Taxonomic structure; Taxonomic hierarchy-species to division; International Code of Nomenclature (ICN) of algae, fungi and plants - Principles, Rules and Recommendations, Ranks, Principle of Priority, Typification, Author citation, Effective and Valid publication.

UNIT-II

System of classification of Armen Takhtajan and its merits and demerits; Angiosperm Phylogeny Group (APG) classification; A brief account of selective clades like basal angiosperms, Magnolids, Monocots (including Commelinids), Eudicots, Rosids, Asterids.

UNIT-III

Taxonomic evidence: Morphology, Anatomy, Embryology, Palynology and Cytology in relation to taxonomy; Data information systems; Botanical Survey of India (BSI): Objectives, activities, organization and publications.

UNIT-IV

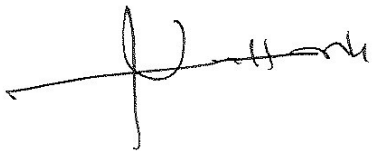
Process of Plant Identification: Construction, types and use of Taxonomic keys; Herbarium methodology: Collection of plants, processing and preservation of specimens; ImportantWorld and Indian herbaria; Major botanical gardens of the World and India; DNA barcoding in plants and its practical implications.

UNIT-V

Chemosystematics: Primary and Secondary metabolites, Semantides and Non-semantides etc. in plants; Phylogenetic Systematics: operational units, characters, coding and construction of cladograms; Serosystematics: Methodology and its applications in systematics; Molecular Systematics: Gene sequences, Phylogenetic analysis, Restriction site analysis, allozymes etc.

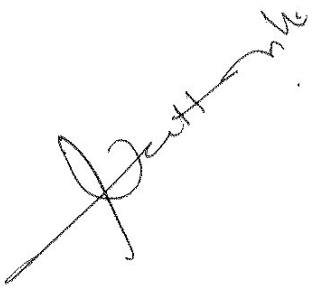
REFERENCE BOOKS:

1) **International Code of Nomenclature for algae, fungi, and plants** (Schenzhen Code), 2018. (online version) adopted by the *Nineteenth International Botanical Congress*, Chenzehen, China.
2) **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.
3) **Judd,W.S. Campbell, C.S.,Kellogg, E.A.,Stevens, P.A. and Donoghue**, M.J.2016. *Plant Systematics: A Phylogetic Approach.* Sinauer Associates, Inc.,Massachusetts.
4) **Simpson, M. G.** 2006. *Plant Systematics*. Elsevier Academic Press, Canada.
5) **Sambamurthy, A. V. S. S.** 2005. *Taxonomy of Angiosperms*. I.K.International Pvt. Ltd, New Delhi.
6) **Crawford, D.J.**2003. Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
7) **Gurcharan Singh**.1999. *Plant Systematics - Theory and Practice*. Oxford & IBH Publishing company Pvt. Ltd., New Delhi.
8) **Radford, A. E.** 1986. *Fundamentals of Plant systematics*. Harper & Row Publisher, New York.
9) **Davis, P. H.** and **Heywood, V. M.**1973. Principles of Angiosperm Taxonomy. Robert. Kereiger Publishers, New York.
10) **Gamble, J. S.** and **Fisher, C. E. C.** 1915-35. *Flora of Presidency of Madras*. 3 Volumes. BSMS, Dehradun.



OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	2	3	1	2	2	2	2	2	2	2	2	1
CO2	3	3	2	2	3	1	1	2	2	2	2	2	2	1	1
CO3	3	3	2	3	3	1	1	2	2	2	2	2	2	2	1
CO4	3	3	2	3	3	1	1	3	2	2	2	2	3	1	1
CO5	3	3	2	1	2	1	2	2	2	1	2	2	3	1	1



Semester	BOT 1.2: REPRODUCTIVE BIOLOGYOF ANGIOSPERMS	L	T	P	C
I		4	0	6	4

LEARNING OBJECTIVE (LO):

LO1	This course is meant to answer that how the innate biology is influenced by variety of developmental and ecological constraints and to impart an insight into the reproduction of the most evolved and advanced group of plants, especially angiosperms.

COURSE OBJECTIVE (CO):

At the end of the course, the student will be able to

CO1	Understand how floral differentiation takes place and what genes responsible for it; to know about factors responsible for the pollen sterility and this phenomenon could be exploited for crop improvement.
CO2	Get insight about pollen-pistil interaction and role of endosperm in embryo development.
CO3	Dnderstand the molecular mechanism and gene expression in embryogenesis and development of dicot and monocot embryos.
CO4	Develop skills about the practical applications of apomixes and get expertise resolving the systematic position of the disputed taxa.
CO5	Become an authority in the subject and develop the strategies to regenerate plants on commercial scale by using embryos and endosperm as explants in order to obtain the intergeneric hybrids and seedless fruits respectively.

UNIT-I

Historical account of Plant Reproduction.

Floral differentiation: Inflorescence and floral meristem, mutations affecting floral differentiation.

Male Gametophyte: Structure of anther, microsporogenesis, role of tapetum; pollen development; formation of vegetative and generative cells; pollen sterility; abnormal features of pollen.

Female gametophyte: Types of ovule, megasporogenesis, special features. Types of female gametophytes and their development, ultra structure of mature embryo sac; haustorialbehaviour of embryo sac, nutrition of embryo sac.

UNIT-II

Pollination: Pollen transfer, pollination mechanisms and vectors. Structure of style and stigma; pollen-pistil interaction.

Fertilization: Pollen germination and pollen-tube growth, path of pollen-tube, pollen tube discharge; double fertilization.

Endosperm: Types of endosperms, cytology and functions of endosperm.

UNIT-III

Embryogenesis: Gene expression during embryogenesis. Embryogenic in dicots and monocots. Underdeveloped and reduced embryos, Nutrition of embryo.

Polyembryony: Causes of polyembryony, experimental induction of polyembryony, classification of polyembryony and its practical applications.

UNIT-IV

Apomixis: Vegetative reproduction, apospory, causes of apomixis, significance of apomixis.

Embryology in relation to Taxonomy: Importance of embryological characters in taxonomic considerations, families with special embryological features. Role of palynology in taxonomy.

UNIT-V

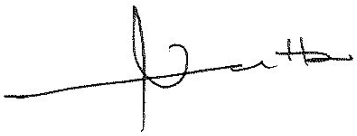
Experimental Embryology: Embryo culture: Embryo rescue, embryo culture, microsurgical experiments and applications. Somatic embryogenesis: Direct and indirect somatic embryogenesis, embryoids, synthetic seeds, practical applications of somatic embryogenesis. Endosperm culture: The technique of endosperm culture, histology and cytology of callus, triploid production and their practical applications.

TEXT BOOKS:

1) Maheswari, P. A. 1950. *Introduction to Embryology of Angiosperms*. McGraw Hill Book
2) company.
3) Shivanna, K.R. and John, B.M. 1989.*The Angiosperm Pollen structure and Function*, WileyEastern Ltd., New Delhi.
4) Johri, B.M., Ambegaokar, K.B. and Srivastava, P.S. *Comparative Embryology of*
5) *Angiosperms*, Vol.I& II, Springer Verlag.
6) Bhojwani, S.S. and Bhatnagar, S.P. 2000. *Embryology of Angiosperms* (revised edition), Vikaspublishing House, New Delhi.
7) Fosket, D.E. 1994. *Plant Growth and Development: A Molecular Approach*. Academic Press, New York.
8) Raghavan, V. 1997. Molecular Embryology of Flowering plants. Cambridge University Press, Cambridge.
9) Khasim, S. M. 2002. *Botanical Microtechnique: Principles and Practice*. Capital Publishing company, New Delhi.

OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
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CO2	3	3	2	2	3	1	1	2	2	2	2	2	2	1	1
CO3	3	3	2	3	3	1	1	2	2	2	2	2	2	2	1
CO4	3	3	2	3	3	1	1	3	2	2	2	2	3	1	1
CO5	3	3	2	1	2	1	2	2	2	1	2	2	3	1	3



Semester	BOT 1.3: BIOLOGY AND DIVERSITYOF VIRUSES, BACTERIA, ALGAE AND FUNGI	L	T	P	C
I		4	0	6	4

LEARNING OBJECTIVE (LO):

LO	This course is designed to enrich the student with knowledge on Distribution, Classification, Structural features and significance of viruses, Bacteria, Algae and Fungi.

COURSE OBJECTIVE (CO):

At the end of the course, the student will be able to

CO1	Acquaint with basic and advanced information on viruses and Comprehend the importance of viruses.
CO2	Understand the structural features, nutritional types and significance of Eubacteria, Archaebacteria, Actinomycetes and Cyanobacteria
CO3	Categorize the algal members and know the importance of algae.
CO4	Realize the distribution, classification and general characters of fungi.
CO5	Identify edible and poisonous mushrooms and can practice the cultivation of mushrooms for self-employment.

UNIT-I

Brief account of discovery of viruses; general properties, structure, cultivation, purification and transmission of viruses; brief account of bacteriophages and plant viruses; Economic importance.

UNIT-II

Morphology and ultra structure of bacteria; Nutritional types (autotrophs and heterotrophs); Growth of Bacteria; Recombination in bacteria (transformation, transduction and conjugation); General characters of Actinomycetes, Archaebacteria, Mycoplasmas and Cyanobacteria; Economic importance.

UNIT-III

Distribution, thallus organization, classification and economic importance of algae; Brief account of Chlorophyceae, Rhodophyceae, Phaeophyceae, and Bacillariophyceae. Algae as primary producers and commercial products. Algae as SCP. Algal blooms and toxins.

UNIT-IV

General characters; Nutrition and reproduction of fungi; classification of Fungi (Ainsworth system); Brief account of Zygomycotina, Ascomycotina, Basidiomycotina and Deteuromycotina.

UNIT-V

Ecto and endomycorrhizal associations; Edible and poisonous mushrooms, Mushroom cultivation; Importance of Fungi in Agriculture and industry. Mycotoxins.

TEXT BOOKS:

1) An Introduction to Fungi: by Webster, J. (1985). Cambridge Univ. Press.
2) Brock Biology of Microorganisms: by Madigan. Mordinko and Parker (2000).
3) Prentice Hall.
4) Introduction to Plant Viruses: by Mandahar. C.I. (1978). Chand & Co., New Delhi.
5) Introductory Phycology by Kumar, H.D. (1988). Affiliated East-West Press. Ltd,
6) New Delhi.
7) An Introduction to the Algae by Morris. J. (1986). Cambridge University' Press,
8) U.K
9) Microbiology: by Prescott, L.M., Harley, J.P. and Klein, D.A. (1992), WCB
10) Publishers.
11) Introductory Mycology: by Alexopoulos, C.J. Mims, C.W. and Blackwell, M.
12) (1996). John Wiley & Sons.
13) The Biology of Algae by Round. F.E. (1986). Cambridge University Press. U.K.

OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	1	1	2	2	2	1	3	3	3	2	1	2	1
CO2	3	3	1	2	3	3	2	1	3	3	3	3	2	3	2
CO3	3	3	2	2	3	3	2	2	3	3	3	2	1	1	2
CO4	3	3	2	3	3	3	2	1	3	3	3	2	1	1	1
CO5	3	3	2	3	3	3	2	2	3	3	3	3	2	2	3

Semester	BOT 1.4 (A) : OUTLINES OF BRYOPHYTES, PTERIDOPHYTES, GYMNOSPERMS AND PLANT FOSSILS	L	T	P	C
I		4	0	6	4

LEARNING OBJECTIVE (LO):

LO1	To acquire the knowledge about general characters, distributional diversity, economic role, model plants, recent trends, evolutionary and ecological importance of Bryophytes, Pteridophytes, Gymnosperms and Fossils.

COURSE OUTCOMES (CO):

At the end of the course, the student will be able to

CO1	Learn about general characters, morphology, evolution of sporophytes and gametophytes of Bryophytes.
CO2	Know the general characters, phylogeny, origin of stele and seed habit of Pteridophytes.
CO3	Appreciate the structure, reproduction and economic uses of Gymnosperms.
CO4	Gain information about geological time scale, types of fossil, process of fossilization and fossils of various plant groups.
CO5	Understand the environmental and economic importance of above plant groups, recent trends and models plants from lower groups.

UNIT-I

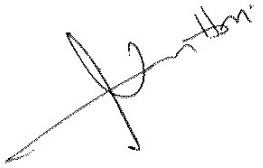
Classification, general characters, range of thallus organization and reproduction in Hepaticopsida, Anthocerotopsida and Bryopsida. Evolutionary trends in gametophytes and sporophytes of Bryophytes.

UNIT-II

General characteristics and classification of pteridophytes; Study of morphology, anatomy and reproduction of Psilopsida, Psilotopsida, Lycopsida, Sphenopsida and Pteropsida. Origin and phylogeny of pteridophytes.Evolution of stele in Pteridophytes. Heterospory and seed habit in pteridophytes.

UNIT-III

Classification, distribution and economic importance of Gymnosperms.Structure and reproduction in living (modern) Cycads, Coniferopsida and Gnetopsida.Wood of gymnosperms; Male and female gametophytes of gymnosperms.



UNIT-IV

Principles of Paleobotany; Geological time scale; determination of age of plant fossils;process of fossilization; types of fossils; a comprehensive account of fossil algae, fossil bryophytes, fossil pteridophytes and gymnosperms.

UNIT-V

Ecological, economic, evolutionary and industrial applications of Bryophytes, Pteridophytes, Gymnosperms and Plant Fossils. Recent trends and model plants from Bryophyte and Pteridophyte plants.

REFERENCE BOOKS:

1) Agashe, S.N. 1995. Palaeobotany. Oxford & IBH, New Delhi
2) Arnold, C.A. 1947. An introduction to Palaeobotany, New York
3) Bhatnagar, S.P. and Moitra, A. 1996. Gymnosperms, New Age Int. Pvt. Ltd. New Delhi.
4) Parihar, N.S. 1991. Bryophytes. Central Book Depot, Allahabad.
5) Parihar, N.S. 1996. The Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad.
6) Puri, P. 1980. Bryophytes.Atma Ram & Sons, New Delhi.
7) Sporne, K.R. 1991. The Morphology of Pteridophytes.B.I.Publication. Pvt. Ltd.
8) Sporne, K.R. 1965. The Morphology of Gymnospermae.B.I.Publications, NewDelhi.

OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	3	2	2	2	2	3	2	1	3	3	3	2	1
CO2	3	2	3	2	2	2	2	3	2	1	3	3	3	2	1
CO3	3	2	3	2	2	2	2	3	2	1	3	3	3	2	1
CO4	3	2	3	2	2	2	2	3	2	1	3	3	3	2	1
CO5	3	2	3	2	2	2	2	3	2	2	3	3	3	2	2

Semester	BOT 1.4 (B): PHYCOLOGY	L	T	P	C
I		4	0	6	4

LEARNING OBJECTIVE (LO):

LO	To impart knowledge to the students on recent cultivation and harvesting practices of algae and make the students cognizant of beneficial and detrimental impact of algae and algal products.

COURSE OBJECTIVE (CO):

At the end of the course, the student will be able to

CO1	Understand the molecular phylogeny approach in classification of algae and algal members of different aquatic habitats and so get familiarity to identify the algal members.
CO2	Become mindful with the requirements and different cultivation methods of micro and macro algae to produce ideal algal cultures.
CO3	Develop awareness on the activities and role of algae in impacting the aquatic life and human health.
CO4	Know the importance of algal members in safeguarding the environment.
CO5	Get awareness about various algal products and their use for the benefit of mankind.

UNIT-I

Contributions of Phycologists. Classification of algae: Classical and Recent developments; Molecular Phylogeny – Polyphasic approach. Algae of Diverse habitats – Fresh water (Lentic & Lotic communities), Marine water and Brackish water. Algal communities of Extreme environments – Thermal hot springs and Cold springs. Fossil algae.

UNIT-II

Algal culture techniques; General Principles; Physical parameters; Culture media; Strain improvement. Different Cultivation and Harvesting methods for Micro algae and Macro algae. Algal cultivation and production in India.

UNIT-III

Algal bloom formation and Eutrophication; Significance of algal blooms and control measures. Toxins produced by different algal groups. Bioaccumulation and Biomagnification of algal toxins. Impact of algal toxins on aquatic life and humans.

UNIT-IV

Role of algae in pollution control, CO_2 sequestration, Bioredemiation, Soil fertility and treatment of waste water plants. Algal Biofuels – bio-diesel, bio-ethanol and biological hydrogen production.

UNIT-V

Algal products as – Nutraceuticals, Biomedical compounds, Biofertilizers, Polysaccharies, Pigments, Dietary fibres, Animal feed, Food colourants and Cosmetics.

TEXT BOOKS:

1) Fritsch, F.E. 1945. The Structure and Reproduction of Algae Vol. I & II. Cambridge Univ. Press, Cambridge, London.
2) Sharma O.P. 2011. Algae. TATA McGraw-Hill, India.
3) South G.R. and Whittick A. 1987. Introduction to Phycology. Blackwell Scientific Publications, London.
4) Lee R.E. 1989. Phycology Vol. II. Cambridge Univ. Press. Cambridge, London.
5) Anderson R.A. 2005. Algal Culturing Techniques. Physiological Society of America, Elsevier Academic Press, USA.
6) Sahoo D. and Qasim S.Z. (Eds). 2002. Sustainable Aquaculture. APH Publishing Corporation, New Delhi, India.
7) Murthy A.V.S.S. 2005. A text book of algae. I.K. International Pvt., Ltd., New Delhi.
8) Southcott G.R. and Whittick A. 1987. Introduction to Phycology. Blackwell Scientific Publication, UK.
9) Venkataraman, G.S. 1974. Algae form and function. Today and Tomorrow's Pub., New Delhi.
10) Bux et al. (eds). 2016. Algae Biotechnology: Products and Processes, Springer.
11) Chu W. 2012. Biotechnological Applications of Microalgae. IeJSME 6(1): S24-S37.
12) Lee R.L. 2008. Phycology (4th edition). Cambridge University Press.
13) Richmond A. (ed) 2003. Hand Book of Microalgal culture. Blackwell Publishing House.
14) Barsanti L. and Gualtieri P. 2006. Algae – Anatomy, Biochemistry and Biotechnology. Taylor & Francis.

OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	1	1	2	3	2	2	1	3	3	1	1	1	1
CO2	3	3	3	2	2	3	2	2	3	3	3	2	1	1	1
CO3	3	3	1	1	3	2	2	2	3	3	3	1	1	1	1
CO4	3	3	1	1	3	2	2	2	3	3	3	2	2	1	1
CO5	3	3	1	2	3	2	2	3	3	3	3	1	2	1	3

Semester	BOT 1.4 (C): EVOLUTIONARY BIOLOGY	L	T	P	C
I		4	0	6	4

LEARNING OBJECTIVE (LO):

LO1	To provide a comprehensive overview of concept of evolution and origin of life, theories of evolution, population genetics, genetic drift, natural selection, micro-evolution, speciation and phylogenetic tree.

COURSE OUTCOMES (CO):

At the end of the course, the student will be able to

CO1	Appreciate the concept of evolution, origin of life and different theories of evolution.
CO2	Gain information about the embryological, paleontological and molecular phylogeny evidences of evolutionary processes.
CO3	Get the good knowledge about variations in population, population genetics, genetic drift and natural selection.
CO4	Will gain knowledge on microevolution, species and speciation and adaptive radiation.
CO5	Construct the phylogenetic trees basing on morphology, phytochemistry and molecular sequences with the aid of relevant software's. Analyze the same forsolving other biology related practical problems with potential applications.

UNIT-I

Origin of life and Historical Review of Evolutionary Concept

Concept of Evolution, Origin of Life, Prokaryotes and Eukaryotes. Explanation of various theories of evolution comprising of Lamarckism, Darwinism and Neo-Darwinism.

UNIT- II

Evidences of Evolution

Analogy and Homology, Embryological Evidences of Evolution, Evolutionary, Paleontological and Molecular Phylogeny evidences.

UNIT- III

Sources of Variations and Population Genetics

Variations and Mutations, Hardy-Weinberg Law, factors influencing equilibrium and gene frequencies and Genetic Drift.Types of Natural Selection.

UNIT- IV

Product of Evolution

Micro-evolutionary Changes, Concept of Species, Types of speciation, models of speciation, pattern of speciation, species formation, signification of speciation; Adaptive Radiation.

UNIT- V

Phylogenetic Trees

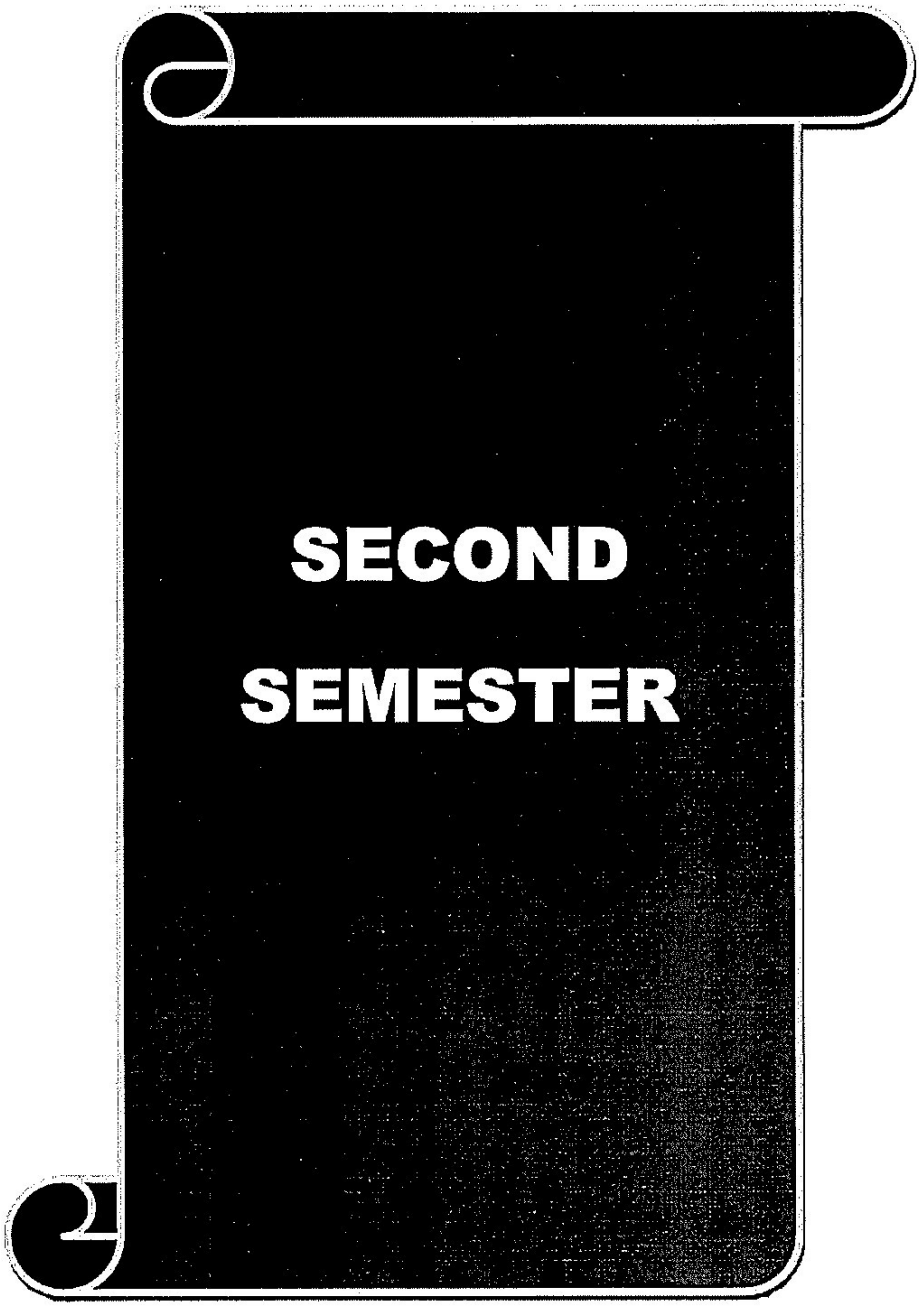
Types of phylogenetic trees based on morphology, chemistry and molecules. Construction of molecular phylogenetic trees.Various software's used for construction of phylogenetic trees. Implications of Phylogenetic Trees in other fields of biology. Tracing ancestor-descendant relationships. Phenetics and cladistics.

REFERENCE BOOKS:

1) Bishop, B. A., & Anderson, C. W. (1990). Students' conceptions of natural selection and its role in evolution. *Journal of Research in Science Teaching, 27,* 415-427.
2) Hafner, M.S. (1994). *Evolution laboratory: Laboratory exercises and discussions in evolutionary biology.* Baton Rouge, LA: Louisiana State University.
3) Hartl, D. L. (1988). *A primer of population genetics* (2nd edition). Sunderland, MA: Sinauer Associates.
4) Minkoff, E. C. (1983). *Evolutionary biology.* Reading, MA: Addison-Wesley Publishing Company.
5) Sober, E. (1994). *Conceptual issues in evolutionary biology.* Cambridge, MA: MIT Press.
6) Mark Ridley. Evolution. 3rd Edition. Blackwell Pubishing. (2004).
7) Mohan P. Arora. Evolutionary Biology, Himalaya Publishing House, Bombay.
8) P. S. Verma and V. K. Agarwal. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, Revised Edition. S. Chand Publication (2004).
9) Strickberger. Evolution.Prentic Hall. (2002).
10) Theodore H., Jr Eaton.Evolution.1st Edition. W. W. Norton Publication. (1970).

OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	2	2	1	2	2	2	1	3	3	1	1	1
CO2	3	3	2	2	2	1	2	2	2	1	3	3	1	1	1
CO3	3	3	2	2	2	1	2	2	2	1	3	3	1	1	1
CO4	3	3	2	2	2	1	2	2	2	1	3	3	1	1	1
CO5	3	3	2	2	2	2	2	2	2	1	3	3	1	1	1


SECOND
SEMESTER

DEPARTMENT OF BOTANY & MICROBIOLOGY

M.Sc. BOTANY

SEMESTER-II

Semester	BOT 2.1: PLANT ECOLOGY AND BIODIVERSITY	L	T	P	C
II		4	0	6	4

LEARNING OBJECTIVE (LO):

LO1	The aim of the course is to impart knowledge of concepts and principles of ecology, ecosystem function, nutrient cycling, biodiversity conservation and sustainable development, and application of these concepts to solve environmental problems.

COURSE OBJECTIVE (CO):

At the end of the course, the student will be able to

CO1	Identify the factors controlling the equilibrium of ecosystem.
CO2	Understand the theory of continental drift for the evolution of floras of the various regions of the world.
CO3	Identify the biodiversity hot spots of the world and to understand the various measures to be taken to conserve them effectively.
CO4	Gain the knowledge about the *in situ* and *ex situ* conservation of natural resources.
CO5	Understand the sustainable development, Phytoremediation and the role of Remote sensing and GIS in biodiversity management.

UNIT-I

Levels of Ecological Organization; Population characteristics and dynamics; Communities characteristics and their analysis; Structure and function of ecosystem; Energy flow in ecosystem; Homeostasis of ecosystem; Biomes and their types.

UNIT-II

Soils: Soil properties and types of soils; Global biogeochemical cycles of Carbon and Sulfur; Dynamic Phytogeography: Basic principles, Age and area theory; Centre of origin; Endemism, Migration and Continental drift.

UNIT-III

Biodiversity: Current concepts, Levels of Biodiversity like Species, Ecosystem and Genetic diversities, IUCN categories of threat; Causes of biodiversity loss; Keystone species; Biodiversity hotspots of India and world; Organizations involved in biodiversity conservation: IUCN, WWF,UNEP and UNESCO.

UNIT-IV

Strategies for *in situ* conservation: Protected areas: Sanctuaries, National Parks, Biosphere Reserves and Mangroves; Strategies for *ex situ* conservation: Botanical Gardens, Seed Banks, Field Banks, Gene Banks, *in vitro* preservation;

UNIT-V

Air pollution and climate change; Sustainable development; Phytoremediation; Application of Remote sensing and Geographical Information System (GIS) in biodiversity studies.

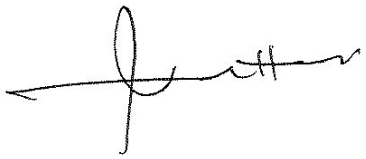
TEXT BOOKS:

1) **Marchese, C**, 2014. *Biodiversity hot spots: A shortcut for more complicated concept.Global Ecology and conservation.* http://dx.doi.org/10.10.16/j.gecco.2014.12.008.
2) **Odum, E.P.** and **Gary W. Barrett**, 2011. *Fundamentals of Ecology* (5th Edition), Saunders ISBN.
3) **Russel, P.J., Wolfe,S. L.,Hertz, P. E., Starr, C.** and **Mc Million B.**, 2008. *Ecology*, Cengage Learning India PvtLtd.,New Delhi.
4) **Wilkinson, D.A.** 2007. *Fundamental Processes in Ecology: An Earth system Approach.* Oxford.
5) **Chapman, J.L.** and **Reiss, M.J.**, 2003. *Ecology: Principles and Applications*, (2nd Edition) Cambridge University Press, UK.
6) **Ambasht, R.S.** and **Ambasht, N.K.**, 1999. *A Text Book of Ecology*, CBS Publishers and Distributers, New Delhi.
7) *IUCN Red List of threatened species* Version 2019.1.
8) **Chauhan, S.S.** 2014. *Status of Biodiversity in India: Issues and Challenges.* Indian Journal of Plant Sciences 3(1): 35-42.
9) **Wood,A.,Pamela,S.E.** and **Johanna,M.** 2000. *The root causes of biodiversity loss.* United Kingdom: Early-Scan Publications.
10) **Richard B. Primack**, 1993. *Essentials of Conservation Biology* (6th Edition) Oxford University Press.
11) **Heywood, V.M.** and **Watson,R.T.** 1985. Global Biodiversity Assessment, Cambridge University Press, Cambridge.
12) **Swaminathan M.N. & Jam R.S.**, 1982. *Biodiversity: Implications for Global Security*, Macmillan.



OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
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CO2	3	3	2	2	2	1	2	2	2	1	3	3	1	1	1
CO3	3	3	2	2	2	1	2	2	2	1	3	3	1	1	1
CO4	3	3	2	2	2	1	2	2	2	1	3	3	1	1	1
CO5	3	3	2	2	2	2	2	2	2	1	3	3	1	1	1



Semester	BOT 2.2: PLANT PHYSIOLOGY	L	T	P	C
II		4	0	6	4

LEARNING OBJECTIVE (LO):

LO1	To study the photobiology of plants and its role in flowering and photo morphogenesis. To study the growth regulators in growth and development of plants To study the effects and responses of plats to abiotic stresses.

COURSE OBJECTIVE (CO):

CO1	Understand the mechanism of transport of water and solutes. Basic principles on ionic transport facilitate the student to understand the gas exchange mechanism of plants with surrounding environment.
CO2	The student is able to understand the sensory photobiology which helps acquire knowledge on floriculture.
CO3	Student able to learn the importance of growth regulators in plant growth and development
CO4	Student acquire knowledge on analytical techniques involved in isolation, purification and assays on Biomolecules. Student fit to work-in in scientific laboratories
CO5	Student gain the knowledge on plant adaptations to different abiotic stresses

UNIT - I

Membrane transport and translocation of water and solutes: The structure and properties of water; water transport processes (diffusion, bulk flow, osmosis, water potential, components of water potential); Mechanism of water transport through xylem; Solute transport by active and passive mechanisms. Structure and properties of membrane transport proteins.

UNIT - II

Water loss by transpiration; Mechanism of stomatal movements; antitranspirants. Sensory Photobiology: Historical discovery of phytochromes, structure and functions of phytochrome, photochemical and biochemical properties of phytochrome, phytochrome induced plant responses, molecular mechanism of action of phytochrome in gene expression, Cryptochrome and its role in photomorphogenesis.

UNIT - III

The flowering process- Photoperiodism and its significance, initiation of flower primordia, flowering stimulus, vernalization, endogenous clock and its regulation. Plant growth regulators: Physiological effects and mode of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid, brassinosteroids, jasmonic acid and salicylic acid.

UNIT-IV

Signal transduction: Over view, receptors and G proteins, second messengers, two component sensor regulator system in bacteria and plants, signal transduction and gene expression. Essential nutrients, deficiencies and plant disorders.

UNIT - V

Stress Physiology: Water stress, salt stress, temperature stress (HSP), biotic stress (HR and SAR), heavy metal stress; Stress avoidance and tolerance mechanisms; Structural, physiological, biochemical and molecular responses of plants to environmental stresses; Reclamation of saline and heavy metal contaminated soils.

REFERENCE BOOKS:

1) Devline and Witham, 1986. Plant Physiology.CBS Pubis and Distributors. New Delhi.
2) Hopkins, W.G. 1995. Introduction to Plant Physiology, John Wiley & Sons. Inc., New York, USA.
3) Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones. Springer Verlag, New York, USA.
4) Singhal *et al.* 1999. Concepts in Photobiology. Photosynthesis and Photo-morphogenesis, Narosa Pub. House. New Delhi.
5) Taiz and Zeiger, 1998. Plant Physiology. Sinauer Associates Inc., Publishers, Sunderland.
6) Salisbury F.B & C. W. Ross, 1992. Plant Physiology, 4th Edition. Wadsworth Publishing Co., Belmount, California.

OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
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CO2	3	3	3	3	3	2	1	2	3	3	3	2	1	1	1
CO3	3	3	2	2	3	2	2	2	3	3	3	2	1	2	1
CO4	3	3	2	2	1	1	1	1	3	3	2	2	1	2	1
CO5	3	3	2	3	2	1	1	2	3	3	2	2	1	2	1

Semester	BOT 2.3: CELL BIOLOGY	L	T	P	C
II		4	0	6	4

LEARNING OBJECTIVE (LO):

LO	The aim of the course is to impart knowledge on structure and functions of cell and cell organelles, chromosome types and their alterations, cell cycle based on various aspects including recent advances in this field.

COURSE OBJECTIVE (CO):

At the end of the course, the student will be able to

CO1	Understand structural organization and functions of the cell organelles.
CO2	Know the fine structure and organization of chromosomes, chromatin types and special types of chromosomes
CO3	Understand the mechanism of cell division, cell cycle phases and the role of check points, cyclins and cyclin dependent kinases.
CO4	Gain knowledge about Apoptosis, oncogene and tumor suppression genes.
CO5	Apprehend different aspects of structural and numerical alterations in chromosomes.

UNIT- I

Eukaryotic cell: Organelles – Chloroplast, Mitochondria, Ribosomes, Endoplasmic reticulum, Peroxisomes, Golgi apparatus, Lysosomes and plant vacuoles and Cytoskeleton.

UNIT- II

Nucleus; Ultrastructure of prokaryotic and eukaryotic chromosome; chromosome banding; Karyotype; Euchromatin and heterochromatin. Special types of Chromosomes: Polytene, Lamp-brush, B-chromosomes, and Sex- chromosomes,

UNIT- III

Phases of Cell cycle: G1, S, G2 and M phases, Check points in cell cycle - Role of cyclins; Cyclin dependent kinases; Cell division; significance of meiosis.

UNIT- IV

Apoptosis –mechanism and significance, oncogene and tumour suppressor genes. Genomes of mitochondria and chloroplasts. Endosymbiotic theory.

UNIT-V

Structural alteration in chromosomes - Origin, Duplications, Deletions, Inversions and Translocations.Numerical alteration in chromosomes: Origin, Occurrence of haploids, polyploids and aneuploids.

TEXT BOOKS:

1) **Arun Kumar Sharma**and **Archana Sharma**, 1980. *Chromosome Techniques. Theory and Practice.*Third Edition, Butterworth -Heinemann, London.
2) **Brown, W.V.**and **Berke,E. M.** 1975.*Text Book of Cytology*, Saint Louis: C V Mosby Company, USA.
3) **Darlington, C.D**. 1903. *Recent Advances in Cytology*, Blakiston`s Son & Co., Philadelphia.
4) **De Robertis, E. D. P.** and **De Robertis, E. M. F**. 2010.*Cell and Molecular Biology,* 8th Edition, Wolters Kluwer, USA.
5) **Jean Brachet** and Mirsky, **Alfred E.** (Eds.): **The Cell**, Academic Press, Inc. New York, USA.
6) **Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick,** 2018. Lewin1s, B. 2018.
7) *Genes*. 12th Edition, Jones& Bartlett Learning, Burlington, MA 01803.
8) **Stebbins, G.L.,** *Chromosomal Evolution in Higher Plants*, Edward Arnold Publications, London.
9) **Roy, S.C.** and **Kalyan Kumar De.,** 1977. *Cell Biology*, New Central Book Agency, Calcutta.
10) **Wolfe, Stephen L.** 1993. *Molecular and Cellular Biology*. Wordsworth Publishing Company, California. USA.

OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
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CO3	3	3	1	2	2	2	2	1	2	3	3	2	1	2	1
CO4	3	3	1	2	3	1	2	1	1	3	3	2	1	2	1
CO5	3	3	2	1	3	1	1	1	3	3	3	1	3	1	1

Semester	BOT 2.4 (A): PLANT STRUCTURE AND DEVELOPMENT	L	T	P	C
II		4	0	6	4

LEARNING OBJECTIVE (LO):

LO1	To gain knowledge on the development and regulation of shoot apex, root apex, leaf, and cambium; secondary growth and abnormal secondary growth; and leaf senescence in plants.

COURSE OUTCOMES (CO):

At the end of the course, the student will be able to

CO1	Understand the role of meristems in plant development; organization and regulation at the shoot and root apices.
CO2	Learn about nature and function of cambia and wood; normal and anomalous secondary growth; different tissue types.
CO3	Appreciate the structure and development of leaves and nodes, and significance of CAM and Kranz anatomy.
CO4	Understand embryo structure and pattern of its development; factors influencing the seed germination and seedling growth.
CO5	Know the factors inducing the dormancy; methods of breaking dormancy;senescence and their significance in plant development; and applications of anatomy in taxonomy and pharmacognosy.

UNIT-I

Types and functions of meristems, organization and regulation of Shoot Apical Meristem (SAM) and Root Apical Meristem (RAM), floral meristems and MADS-Box genes.

UNIT-II

Structure and function of vascular cambium; wood- heart wood and sap wood, porous and nonporous wood, reaction wood; secondary growth in Dicots and Monocots; Anomalous secondary growth in Dicots and Monocots; structure and functions of simple and complex tissues.

UNIT-III

Structure and development of leaf, stomata, nodes their and evolution; special anatomical adaptations of Kranz and CAM anatomy features.

UNIT–IV

Plant embryo development, stages, cell division and pattern formation in embryo, cell polarity In embryo, genetic and hormonal regulation of embryo development. Seed germination and factors influencing the germination and seedling growth.

UNIT- V

Seed Dormancy- types, factors causing seed dormancy, mechanism of breaking seed dormancy, Programmed Cell Death (PCD); Senescence types and biochemical changes associated with leaf senescence; applications of anatomy in taxonomy and pharmacognosy.

REFERENCE BOOKS:

1) Atwell, B.J. Kriederusann, P.E. and Jumbull, C.G.N. (Eds.), 1999. **Plant in action**:
2) **Adaptation in nature, Performance in cultivation,** MacMillan Education. Sydney.
3) Bewley, J. D. and Black, M. 1994. **Seeds: Physiology of Development and Germination**, Plenum Press, New York.
4) Burgess, J. 1985. **An Introduction to Plant Cell Development**, Cambridge University Press, Oxford.
5) Fahn, A. 1982. **Plant Anatomy** (3Td Ed.), Pergamon Press, Oxford.
6) 5.Fosket, D.E. 1994. **Plant Growth and Development** - A Molecular approach, Academic Press, Oxford.
7) Lyndon, R.F. 1990. **Plant Development-The Cellular basis**, Unnin Hyman, London.
8) Raghavan, V. 1999. **Developmental Biology of Flowering Plants**, Springer-Verlag, NY.
9) Steeve, T.A. and Sussex, I.M. Patterns in Plant Development (2r Ed.), Cambridge University Press, Cambridge.
10) Singh, V., Pande, P.C and D.K.Jain (2ed.). Anatomy of Seed Plants. Rastogi Publications, Meerut, India.

OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
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CO3	3	3	2	2	2	2	2	3	2	2	3	3	3	2	1
CO4	3	3	2	2	2	2	2	2	2	2	3	3	3	2	1
CO5	3	3	2	2	2	2	2	3	2	2	3	3	3	3	1

Semester	BOT 2.4 (B): PRINCIPLES OF FORESTRY	L	T	P	C
II		4	0	6	4

LEARNING OBJECTIVE (LO):

LO1	To gain information on various aspects of forest types, composition, and their sustainable management; and usage of all the forest natural resources and biodiversity.

COURSE OUTCOMES (CO):

At the end of the course, the student will be able to

CO1	Appreciate the different forest types and their uses.
CO2	Understand the potential uses of allied branches of forestry, acts related to forests, and the role of forests in reducing global warming.
CO3	Enrich information related to world forests distribution, classification, practices and resources productivity.
CO4	Unravel the role of dendrology, ICBN and other systems of classification in tree identification and classification.
CO5	Will come to know about general problems of forest development and economy; and National and International organizations involved in Forest management.

UNIT-I

Forests; definitions, role, benefits-direct and indirect. History of forestry-definitions- divisions and interrelationships. Classification of forests-high forests, coppice forests, virgin forest and second growth forests, pure and mixed forests-even and uneven aged stands. Foresttypes of India-classification.

UNIT-II

Agroforestry-farm forestry, social forestry, joint forest management-concepts, programmes and objectives. Important acts and polices related to Indian Forests. Global warming –forestry options for mitigation and adaptation-carbon sequestration. Important events/dates related to forests and environment-themes and philosophy.

UNIT-III

Introduction to world forests-geographical distribution, and their classification, factors influencing global forests distribution, productivity and increment of world forests. Forest resources and forestry practices in different regions of the world. Western Europe, North America, Central Africa, Australia, Central America, Russia, Japan and China.

UNIT-IV

Introduction to dendrology-history, significance of dendrological studies, and applications in tree identification; Botanical nomenclature, ICBN rules and codes, binomial and polynomials, systems of classification-natural, artificial, and phylogenetic classification. Principles of systematics.

UNIT-V

General problems of forest development and economy. Forest based industries in the developed and developing countries. Trade patterns of forest based raw materials. Recent trends in forestry development in the world. National and international organizations inForestry.

REFERENCE BOOKS:

1) Beazley, M. 1981. The international book of Forestry. London Champion and Seth. 1968. Forest types of India.
2) Grebner, D.l., Bettinger, P and Siry, J.P. 2012. Introduction to Forestry and Natural Resources. Academic Press. 508p (Google e book).
3) Khanna, L.S. 1989. Principles and practice of Silviculture. Khanna Bandu, New Delhi.
4) Mather, A.S. 1990.Global forest resources. Belhaven. London, Pearssson,R.
5) World Forest resources. 1992. Periodical experts. New Delhi.
6) Westuby, J. 1991. Introduction to world forestry. Wiley, 240 9.
7) Indian Forestry by K. Manikandan, S. Prabhu.
8) Introduction to Forestry Science by De Vere Burton.
9) Forest Resources and Sustainable Development by Kailash Chandra Bebarta.
10) Forestry: Principles and Applications by Antony Joseph Raj, S.B. Lai.

OUTCOME MAPPING:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	2	2	2	2	3	3	2	2	2	3	3	2
CO2	3	3	3	2	2	2	2	3	3	2	2	2	3	3	2
CO3	3	3	3	2	2	2	2	3	3	2	2	2	3	3	2
CO4	3	3	3	2	2	2	2	3	3	2	2	2	3	3	2
CO5	3	3	3	2	2	2	2	3	3	2	2	2	3	3	2

Semester	BOT 2.4 (C): MICROORGANISMS IN HEALTH AND ENVIRONMENTAL ALLEVIATION	L	T	P	C
II		4	0	6	4

LEARNING OBJECTIVE (LO):

LO	This course explains the concept, significant role and impact of microbes on different environments and particularly human health with the focus on important bacterial, viral and fungal pathogens.

COURSE OBJECTIVE (CO):

At the end of the course, the student will be able to

CO1	Gain knowledge on important human diseases.
CO2	Acquire useful information regarding the diagnosis of diseases
CO3	Improve the knowledge on different drugs and their mode of action.
CO4	Have awareness of microbes in different environments and understand the types of allergies and their control.
CO5	Gain adequate knowledge on the role of microbes as cleaners of pollution.

UNIT- I

Important developments in Medical Microbiology. Normal microbial flora of human body. Outlines on the role of microbes in human health – Study of the pathogen, pathogenesis, symptoms, epidemiology of diseases- Hepatitis and HIV: Typhoid and Cholera; fungal skin diseases and Amoebic dysentery, Malaria.

UNIT- II

Measures to control microbial infections- Diagnosis of the disease – collections of specimens, microscopic, biochemical and serological methods of diagnosis of bacterial infections-

UNIT- III

Outlines of Chemotherapy. Clinical use and mode of action of the following drugs.

Antibacterial drugs : Sulpha drugs, penicillin, Tetracyclines

Antiviral drugs : Amantadine, Acyclovir

Anti fungal drugs : Imidazoles, Nystatin

UNIT- IV

Brief account on microbes present in aerial, aquatic and soil environments. Study on allergy causing agents, types of allergies and control. Tests for water quality- Treatment of water for drinking purpose- Study on beneficial microbes present in soil.

UNIT- V

Outline on role of microbes in water and soil pollution- Control of polluted environments – role of microbes in cleaning of oil spills, degradation of pesticides, sewage water treatment – Solid waste treatment.

TEXT BOOKS:

1) Ananthanarayana, R. and Panicker, C.K.J. 2000. Text book of Microbiology, Oriental Longman publications
2) Jawetz *et al.* 1998. Medical Microbiology 21st Edn. Prentice Hall International Inc.
3) Bailey and Scott 1998 Diagnostic Microbiology (10th Edn.) Published by Mosby.
4) Madigan *et al.* 1997. Brock's Biology of Microorganisms 8th Edn. Prentice Hall International Inc.
5) Presscott *et al.* 2005. Microbiology 3rd. edition.
6) Raplh Mitchell 1978. Environmental Microbiology
7) Lynch & Poole 1979. Microbial Ecology: A conceptual approach
8) Paul & Clark 1989. Soil Microbiology & Biochemistry
9) Rheinheimer 1974. Aquatic Microbiology
10) Tilak. Aerobiology
11) Subba Rao 1995. Soil Microorganisms and Plant Growth
12) Subba Rao 199. Soil Microbiology
13) Atlas & Bartha 1997. Microbial Ecology
14) Maier, Peper & Gerba 2000. Environmental Microbiology

OUTCOME MAPPING:

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CO4	3	3	2	2	3	2	2	1	3	3	3	1	1	2	2
CO5	3	3	2	2	3	2	2	3	3	3	3	1	1	2	1