Syllabus for M.Sc. in Botany

[Two Years M.Sc course based on Choice Based Credit System (CBCS)]

Four semesters will cover all 25 units of the whole syllabus. One project work or one review paper will be prepared by the students in final semester. Each semester with five units of 50 marks each.

Two years PG course of Botany will be conducted for 1000 marks with 100 credit points.
Semester I & II (BOT /ThGL/101-105 & BOT/ThGL/201-205) is totally based on Core subject.

Semester I : Full marks = 250 with 5 units (25 credit points).

Unit	Topic	Periods per week	Internal Assessment *	Theory	Practical	Full Marks	Credit points (Int.Assmt.+ Th + Pr)
BOT/ThGL/101	Microbiology	5	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/102	Phycology	5	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/103	Mycology	5	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/104	Bryophytes and Pteridophytes	5	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/105	Gymnosperm, Paleobotany, & Palynology	5	10	25	15	50	5 (1+2.5+1.5)
	Five units	25 periods	Marks 50	Marks 125	Marks 75	Total Marks 250	Total credit 25

Internal assessment (10 marks* for each unit) will be evaluated on the basis of attendance, performance in theory and practical classes, submission of practical note book, unit tests, performance in remedial classes etc.

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Semester II : Full marks = 250 with 5 units (25 credit points).

Unit	Topic	Periods per week	Internal Assessment *	Theory	Practical	Full Marks	Credit points (Int.Assmt.+ Th+Pr)
BOT /ThGL/201	Cell Biology	5	10	25	15	50	5 (1+2.5+1.5)
BOT /ThGL/202	Genetics	5	10	25	15	50	5 (1+2.5+1.5)
BOT /ThGL/203	Molecular biology	5	10	25	15	50	5 (1+2.5+1.5)
BOT /ThGL/204	Plant Physiology	5	10	25	15	50	5 (1+2.5+1.5)
BOT /ThGL/205	Biochemistry	5	10	25	15	50	5 (1+2.5+1.5)
	Five units	Total 25	Marks 50	Marks 125	Marks 75	Total Marks 250	Total credit 25

ThGL: Theory (general) + Laboratory

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Semester III

Full marks= 250 with 4units (BOT 301, 302, 303 & 304) from Core topic and BOT 305 (1 unit for CBCS). [25 Credit point including Practical]

One unit CBCS paper BOT/Th(a/b/c/d)/305 from "Section CBCS" (50 Marks; 5 credit points)

Unit	Topic	Periods per week (Th + Pr)	Internal Assessment *	Theory	Practical	Full Marks	Credit points (Int.Assmt.+ Th +Pr.)
BOT/ThGL/301.	**Taxonomy of Angiosperm**	5 (2 Th + 3Pr)	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/302.	**Plant pathology**	5 (2 Th + 3Pr)	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/303.	**Plant Biotechnology**	5 (2 Th + 3Pr)	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/304.	**Plant resources & utilization**	5 (2 Th + 3Pr)	10	25	15	50	5 (1+2.5+1.5)
BOT/Th/305 (a/b/c/d)	CBCS paper***	5 4+1=5	10	40		50	5 (1+4.0)

One practical period = 3 hrs duration in each day. Therefore, one practical for each of 301, 302, 303 & 304. Total 4x3=12 Practical Classes per Week.

***** One topic to be opted from "Section CBCS"**

a. Chemical ecology: Insect-plant interaction; Bio pesticides

b. Biological methods & Instrumentation

c. Bioenergy sources and energy production

d. Horticulture, Aquaculture and Orchard management; Forest Management and Human-Animal conflict.

Units (a/b/c/d) from CBCS will be offered as per existing infrastructural facilities of the concerned department.

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Semester IV

Full marks = 250 with 3 units (unit BOT/ThGL/401, 402, 403) for Core topics,
One Unit BOT/Ths/404 A/B/C/D Special Paper
One unit BOT/PR/405 for Project/Review paper (50 Marks; 5 credit points)
Total 25 Credit points

Unit	Topic	Period per week	Internal Assessment *	Theory	Practical	Full Marks	Credit points (Int. Assmt.+ Th+Pr.)
BOT/ThGL/401	Anatomy & Pharmacognosy	5	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/402	Ecology & Environmental biology	5	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/403	Biostatistics & Bioinformatics	5	10	25	15	50	5 (1+2.5+1.5)
BOT/ThS/404	**404 A/B/C/D****	5 (Th)	10	40	--	50	5 (1+4.0)
BOT/PR/405	**Project Work/ Review work**	**50 Marks; 5 credit points**					

Special Paper Options

**** One topic to be opted from the following:**

404 A. Diversity of Life forms & Conservation

404 B. Industrial & Clinical microbiology

404 C. Developmental Biology and Evolution.

404 D. Ethno botanical knowledge on therapeutics & Immunology.

Units (A/B/C/D) from Special Paper options will be offered as per existing infrastructural facilities of the concerned department.

FIRST SEMESTER
UNIT: BOT/ThGL/101:
Microbiology
(Theory 25 marks + Internal Asst.)

1. **History of Microbiology:** Leeuwenhoek's Animalcules, Cell theory, Spontaneous Generation, Germ theory of Disease, Koch's Postulates.
2. **Microbial taxonomy:** Basis of bacterial classification: polyphasic approaches to bacterial taxonomy. Salient features of major bacterial groups according to Bergey's Manual of Systematic Bacteriology.
3. **Microbial growth, nutrition and control:**

Microscopy, Staining, Culturing Microorganisms: Obtaining a pure Culture, Preservation of microorganisms. Doubling time and growth rate, Phases of growth, Measurement of microbial growth, Continuous cultures of microorganisms, Different types of culture media, Factors affecting microbial growth, Nutritional types of microorganisms. Physical and chemical methods of controlling growth of microorganisms. Antibiotic resistance

4. **Concept on prokaryotic cells:** Structure and chemical composition of Gram + and Gram – bacterial cell wall, Passage of Molecules across microbial cell membrane; Archae: Characteristics, types and differences with eubacteria. Structure and functional characteristics of Actinomycetes and Mycoplasma.
5. **Nutrition and metabolisms of microorganisms**: Heterotrophy, chemoorganotrophy, chemolithotrophy, mixotrophy, and photoautotrophy.
6. **Virology:** Classification of viruses, Replication of viral nucleic acids; one step growth curve; lytic and lysogenic cycle.
7. **Enviromental Microbiology:** a) Soil Microbiology: Rhizosphere & Microbial flora, nitrogen cycle, biological nitrogen fixation-symbiotic and nonsymbiotic; Role of Phosphorus and Sulfur stabilizing bacteria, b)Air Microbiology: Microbial flora of air; c)Water Microbiology: Microbial flora of water, treatment of waste water

8. **Applied and Industrial Microbiology and Clinical Microbiology:**

a) Microbial fermentation and production of small and macro molecules.
b) Microbial diseases: Animal diseases; cholera, AIDS, hepatitis, giardiasis. Plant diseases; tungro virus of rice, potato scab by Streptomyces, Black leg of Potato by bacteria, Downy mildew of Grape.

Practical: (15 marks)

1. Basic microbiological techniques: Light-Microscopy; use of oil-immersion objective, Preparation of media, sterilization, slant and stab preparation.

2. Cultivation of Microorganisms : on agar-slant/agar-plate;

a) Streak culture: Bacteria (Bacillus subtilis, Staphylococcus aureus, Escherichia coli);

b) Pure-culture: by streak-plate/pour plate methods.

3. Characterization of selected pure culture isolates by Gram staining, simple and negative staining, endospore staining and physio-biochemical features (extracellular enzymes, antibiotic sensitivity).

4. Determination of bacterial growth and growth kinetics by turbidometric and cell count method.

5. A) Microbiological examination of water: i) a) Presumptive test b) Confirmatory test c) Completed test: for coliform; ii) IMViC reactions.

B) Microbiological examination of milk by methylene-blue dye reduction test.

6. Isolation of antibiotic producing organism from soil and their sensitivity assay against standard laboratory strains of bacteria.

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FIRST SEMESTER
UNIT: BOT/ThGL/102 :
Phycology
(Theory 25 marks + Internal Asst.)

1. Introduction, Classification, Phylogeny and Evolution:

a. Range in thallus organization; Ultra-structure of algal cells; Reproduction and Phylogeny.

b. Parameters for classifying algae: Salient features of Cyanophyta (Cyanobacteria: classification, Heterocyst-ultra structure and biochemistry, nif gene);

Chlorophyta (Cell division pattern, ultra structure of flagella; classification and phylogeny); Heterokontophyta [Xanthophyceae, Bacillariophyceae : Ultra structure and developmental patterns of diatom frustules, Role of Frustule protein; Phaeophyceae] and Rhodophyta.

c. Glaucophyta : Characteristics features and phylogenetic significance

d. Dinoflagellates: Cell structure.

e. Concept of Streptophyta and algal origin of land plants.

g. Phylogeny & Evolution: Endosymbiotic origin of Chloroplasts; evolution of chloroplast in different algal groups; molecular markers for phylogenetic study.

2. Algal ecology and Economic importance :

a. Algae in diversified habitats-examples with different geographical locations; Eutrophication, Algal Blooms, Red-tides; Algal toxins.

b. Pheromone in algae and ecological implication

c. Mass production for industrial use: nutraceuticals, pharmaceuticals, biofuel, biofertilizer, Phycocolloids - agar-agar, alginic acid, carageenan; Diatomaceous earth; Single cell protein.

d. *Chlamydomonas reinhardtii* as a model system for molecular biology and genetics.

Practical: (15 marks)

(i) Study on algal diversity: Staining, micrometry, microphotography, Identification of the representative specimen from Cyanophyta (Cyanobacteria), Chlorophyta, Phaeophyta and Rhoodophyta.

(ii) Field survey of Phytoplankton in different habitat and seaweed. Each candidate will submit 5 algal specimen with identification.

(iii) Identification with anatomical features of seaweeds.

(iv) Qualitative and Quantitative estimation of phytoplankton of different habitats.

(vi) Algal culture using defined media.

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FIRST SEMESTER

UNIT: BOT/ThGL/103:
Mycology
(Theory 25 marks + Internal Asst.)

1. Fungi in living world:

a. Introduction **:** Diversity of fungi and fungus-like organisms; evolution and phylogeny including systematics.
b. Physiology of Fungi : Growth - Factors affecting growth (Physical and Nutritional); Growth kinetics.
c. Reproduction of Fungi : Spore forms, molecular and biochemical changes accompanying sporulation, spore liberation, spore dispersal, spore dormancy and germination. Sex hormones in fungi; Patterns of life cycle.
d. Genetics of Fungi : Structure and organization of fungal genome, Mitosis and meiosis in fungi. Genetic control of asexual and sexual reproduction; extra- chromosomal inheritance in fungi.
e. Ecology of Fungi : Fungi in different ecosystems : saprophytes, parasites, predators and symbionts – Lichens and Mycorrhizae (A brief over-view)

2. Fungi of Medical Interest :

a. Mycoses ; Allergies of man and animal caused by fungi.

b. Mycotoxins and Mycotoxicoses, with special reference to Aflatoxins and Ergot alkaloids.

3. Applied Mycology :

a. Industrial application : Single cell protein, alcohol production, antibiotic production (penicillin), organic acids, enzymes and alkaloids (general account).

b. Application of Mycorrhizae : Mycorrhizal networking in plant community benefitting agriculture and forestry.

c. Mushrooms and Mushroom Cultivation : Edible and medicinal mushrooms; biological value of mushrooms, bioconversion of lingo-cellulosic wastes; Cultivation practices – pure culture, spawn production, compost and their preparation, techniques of cultivation of oyster and button mushrooms.

MYCOLOGY

Practical: (15 Marks)

1. Sterilization techniques and sterilizers.
2. Preparation of fungal culture medium , slant, stab and pouring of plates
3. Monosporous, Polysporous and fungal tissue culture; subculturing
4. Isolation of fungi from air, water and soil by culture plate technique.
5. Study of different type of spores.
6. Study on the effect of temperature and pH on spore germination and mycelia growth.
7. Studies on the morphological and reproductive structures of macro- and micro fungi : *Plasmodiophora, Albugo, Saccharomyces, Xylaria, Daldenia, Agaricus, Pleurotus, Volvariella, Clavaria, Puccinia, Auricularia, Fusarium, Alternaria, Colletotrichum, Cercospora, Curvularia, Cladosporium*
8. Study of fungal flora during field trip / Visit to Mushroom Cultivation Centre.

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FIRST SEMESTER
UNIT: BOT/ThGL/104 :
Bryophytes & Pteridophytes
(Theory 25 marks + Internal Asst.)

BRYOPHYTES (Marks 10)

1. General habit, habitat, global distribution, biogeography, growth forms, life forms and colonization.

2. Outline of recent classification (Goffinet & Shaw 2009) of bryophytes into three coordinate Phyla: Marchantiophyta (liverworts), Anthocerophyta (hornworts) and Bryophyta (mosses). Origin, evolution and fossil history of bryophytes.

3. Characteristics, affinities and systematic position of Calobryales, Takakiales and Sphagnales. Comparative study of the gametophyte and sporophyte of major groups with special reference to Indian bryodiversity.

4. Role of bryophytes in ecology& ecosystem dynamics :
Poikilohydry, desiccation tolerant, succession dynamicity, as pollution indicator and for biomonitoring; as phytoremediator.

5. Metabolic chemistry of bryophytes.

PTERIDOPHYTES (Marks 15)

1. Origin of land plants, Classification & Evolution : Adaptive features of pteridophytes for early colonization on land habit; Outline of systematic treatment of pteridophytes; molecular systematic and chemosystematic approach; Distribution of extant groups in time and space; evolutionary significance of the members: a) Rhyniopsida, b) Zosterophyllopsida, c) Trimerophytopsida and d) Early Lycopsids and Sphenopsids.

2. Major Fern groups: Distribution; Structure (study of shoot apex, leaf initiation and early leaf ontogeny in ferns, stomatal types and development; evolution of stele); Reproduction (origin and evolution of sporangium); Diversity of ferns in an ecological domain.

Characteristics and affinity of the members from the following orders:
a) Ophioglossales b) Marattiales c) Osmundales d) Filicales (generilsed form of Simplices,
b) Gradatae and Mixtae types) e) Polypodiales; f) Gleichaniales.

3. Ecological Perspective : Diversity of ferns in an ecological domain; Heterospory and seed habit; Soral evolution in ferns, Salviniaceae; insect, microorganism interaction with pteridophyte; Endangered and Endemic pteridophytes and their conservation.

4. Phytochemistry, Cytogenetic of Pteridophytes : Biochemical aspects of gametophyte differentiation; antheridogens-chemical nature and mode of action; Determination of femaleness in free sporing; Heterosporous plants; Polyploidy, Apospory, Apogamy, Apomixis and genetic variability in fern population-genetic load.

Practical: (15 Marks)

BRYOPHYTE (Marks 5)

1. Workout on comparative morphology and anatomy of the gametophytes and sporophytes of different groups of Bryophytes: Marchantiales, Jungermanniales, Anthocerotales, Isobryales, Hypnobryales, Funariales, Pottiacles, Bryales & Dicranales (depending on availability of the specimen).

2. Workout on different types of peristome structure (Nematodonteae and Arthrodonteae) for classification of mosses.

PTERIDOPHYTE (Marks 10)

1. Study of external and internal morphology of vegetative and reproductive structures (spore types, soral anatomy etc.) of the following species (depending on availability of species):

Lycopodium, Selaginella, Equisetum, Drynaria, Lygodium, Diplopterygium, Dicranopteris, Phymatosorus, Oleandra, Nephrolepis, Asplenium, Blechnum, Adiantum, Pteris, Glychaenia, Cyathea/Alsophila/Hemitelia, Christella, Microsorum, Phymatosorus, Ophioglossum and *Salvinia.*

2. External morphological features of the following taxa:

Psilotum/Tmesipteris, Isoetes coromandelina, Ophioglossum, Schizaea, Marattia, Cibotium, Ceratopteris, Acrostichum, Dryopteris, Cheilanthes, *Woodwardia* and *Onychium.*

Field trip to different ecological terrain for submission of 4 specimen only (keeping in mind the importance of Biodiversity & Conservation of different species) from Bryophytes and Pteridophytes.

FIRST SEMESTER

UNIT: BOT/ThGL/105:
Gymnosperm, Palaeobotany and Palynology
(Theory 25 marks + Internal Asst.)

A. GYMNOSPERMS: (**Marks 10**)

Classification and economic importance. General account on the morphology, anatomy and reproduction of the following groups:

i) **Glossopteridales**- with special reference to Indian members; concept of angiosperm ancestor,

ii) **Cycadales**- with special reference to distribution of extant members; origin and evolution of leaves and megasporangiate fructification, Molecular phylogeny.

iii) **Coniferales** with special reference to Indian distribution; origin and evolution of seed-cone complex.

v) **Gnetales**. with special reference to distinction among the groups and molecular phylogeny.

B. PALEOBOTANY (Marks 8)

a. Geologic time scale, Fossils and fossilization process: Types, nomenclature, Techniques for studying fossil plants (ground thin section, peel technique, transfer technique and microfossil analysis), Importance and significance.

b. Radiometric dating: Principle and application of Relative and Absolute dating (C^{14}, Argon and Uranium dating).

c. Continental drift hypothesis and Plate Tectonics- concept, evidences, mechanism.

d. Indian Gondwana system- 3-fold division, megafloristic assemblages.

C. PALYNOLOGY: (**Marks 7**)

a. **Concept :** Symmetry; Polarity; Shape, classes; Sporoderm stratification, sporoderm ornamentation, Extraexinous wall material; NPC classification, LO analysis; Sporopollenin: physical and chemical nature, function; Pollen wall proteins, chemical markers of exine and intine.

b. **Application** : Palynology in oil exploration, Honey analysis and in detection and diagnosis of pollen/spore allergy.

Practical : (15 Marks)

1. Study of Vegetative and reproductive structure of representative member of Cycadales, Coniferales and Gnetales and others depending on availability:
   (For eg. *Cycas, Zamia, Pinus, Cedrus, Cupressus, Cryptomeria, Thuja, Araucaria, Cephalotaxus, Encephalartos, Tsuga, Taxodium, Ginkgo, Cunninghamia, Callitris, Cedrus, Podocarpus, Juniperus, Cryptomeria, Gnetum, Ephedra* and *Welwitschia).*

2. Study of gymnosperm fossils (slide and megafossils).

3. Pollen morphological study of different plant taxa.

4. Pollen slide preparation (temporary and permanent).

5. Study of Pollen in honey sample.

6. Analysis of peat samples.

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Semester II :

Full marks = 250 with 5 units (25 credit points including Practical).

Unit	Topic	Periods per week	Internal Assessment *	Theory	Practical	Full Marks	Credit points (Int.Assmt.+ Th + Pr)
BOT/ThGL/201.	**Cell Biology**	5 = 2 (Th) + 3 (Pr)	10	25	15 (3pds)	50	5 (1+2.5+1.5)
BOT/ThGL/202.	**Genetics**	5 = 2 (Th) + 3 (Pr)	10	25	15 (3pds)	50	5 (1+2.5+1.5)
BOT/ThGL/203.	**Molecular Biology**	5 = 2 (Th) + 3 (Pr)	10	25	15 (3pds)	50	5 (1+2.5+1.5)
BOT/ThGL/204.	**Plant Physiology**	5 = 2 (Th) + 3 (Pr)	10	25	15 (3pds)	50	5 (1+2.5+1.5)
BOT/ThGL/205.	**Biochemistry**	5 = 2 (Th) + 3 (Pr)	10	25	15 (3pds)	50	5 (1+2.5+1.5)
	5 units	Total 25 10 (Th) + 15 (Pr)	Marks 50	Marks 125	Marks 75	Total Marks 250	Total credit 25

*** One practical period = 3 hrs duration in each day. Therefore, 3 practical classes one for each of 201, 202, 203, 204 & 205. Total 5x3=15 Practical Classes per Week.**

SECOND SEMESTER

UNIT: BOT/ThGL/201

CELL BIOLOGY

(Theory 25 marks + Internal Asst. 10 = Total 35 marks + 15 for Practical, Total=50marks)

1. Prokaryotic cell & Eukaryotic cell and their compartmentalization.

2. Cell Structure and Function:

Extracellular matrix: biochemical composition and function (cell-matrix interaction); The Plasma membrane: biochemical composition, molecular organization (Phospholipid & Glycolipid composition, Fluid mosaic model) and function (ion uptake) and mobility

Cytoskeleton: microtubule structure, assembly and function (chromosome movement), The Nucleus: The nuclear envelope and nuclear pore complex — ultrastructure and function (traffic between the nucleus and the cytoplasm),

Nucleolus: ultrastructure and function (ribosome biogenesis),

Chromosomes: biochemical composition, molecular organization (nucleosomes and higher-order structures) and its regulation (role of histone modification); Centromere — types, kinetochore, molecular organization and function; Telomere — molecular organization and function,

Mitochondria: ultrastructure, genome, protein import and function (oxidative phosphorylation);

Chloroplasts: ultrastructure, genome, protein import and function (photophosphorylation), Endoplasmic reticulum: ultrastructure and function (protein folding and processing), Lysosomes: ultrastructure and function (phagocytosis) and other intracellular organalles.

3. Cell cycle & Regulation:

Overview on eukaryotic cell cycle-phases, Control mechanisms: role of cyclins and cyclin-dependent kinases; checkpoints and role of MPF; Apoptosis and programmed cell death: events and role of caspases; Cancer cell — properties and causes (oncogenes).

4. The Origin and Evolution of Cells:

The First cell; Origin of eukaryotes; Development of multicellular organisms;

Theories of organic evolution- Mutation theory, Synthetic theory; Evolution at molecular level-Rates of Molecular Evolution; Molecular Clock, Genome Evolution, Evolution of proteins, Evolution of nucleotide sequences; Speciation- Biological Species Concept, Reproductive Isolating Mechanisms, Modes of Speciation, Genetic Differentiation Associated with Speciation.

SECOND SEMESTER
UNIT: BOT/ThGL/202
GENETICS
(Theory 25 marks + Internal Asst. 10 = Total 35 marks + 15 for Practical, Total=50marks)

1. Extension of Mendelism and Gene Interaction:

Allelism; Gene-environment interactions; Penetrance and Expressivity; Epistasis; Pleiotropy; Continuous and Discontinuous Variations; Complementation test for alleles, Sex Determination and Sex-Linked Characteristics; Sex chromosomes.

2. Linkage, crossing over and gene mapping:

Linkage, crossing over; Molecular mechanism of recombination; chromosome mapping; three-point test cross, construction of genetic and physical map; Haploid mapping (tetrad analysis), LOD score, QTL mapping.

3.Transposable elements: Different types, importance. Ac-Ds, IS elements, P-elements and their significance.

4. Mutation: Basic concept & types; spontaneous and induced mutations; Luria Delbruk fluctuation test; physical and chemical mutagens; Chromosome Mutation: Numerical changes, Rearrangement of chromosome structure; Gene Mutation: Molecular basis of gene mutation, Ames test; Transposon mutagenesis, site-directed mutagenesis, environmental mutagenesis, *in vitro* mutagenesis, DNA damage and repair mechanism.

5. Population Genetics- Definition of populations, Allele frequency in a population, Genetic equilibrium, Hardy-Weinberg principle, barriers to gene flow and mechanism of speciation; Using highly polymorphic DNA sequences in DNA typing, Inbreeding and genetic consequences of self-pollination in plants.

SECOND SEMESTER

UNIT: BOT/ThGL/203

Molecular Biology

(Theory 25 marks + Internal Asst. 10 = Total 35 marks + 15 for Practical, Total=50marks)

1. **Structure of nucleic acids:** Details of chemistry of DNA molecule, Double helical structure, Conformation & Stability; Sugar puckering; Coiling & Packaging; Non-Watson pairing; Different forms of DNA: A,B,Z; their physical properties; Denaturation kinetics of DNA; Cot curves and their significance. Detailed 2D & 3D structure of RNA; Different types of RNA; RNA as genetic material.

2. **Perpetuation of genome:** The central dogma of molecular biology: Overview of replication, transcription, translation and reverse transcription. Structure and organization of genome: prokaryotic and eukaryotic. Organization and function of cpDNA and mtDNA, Role of genomic DNA, mitochondrial genome and chloroplastidal genome in Bar coding for Biodiversity study & Evolution; Mitochondrial DNA and male sterility.

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3. **Replication:** Brief account of DNA replication in prokaryotes. Semi conservative mode of replication, Differences in prokaryotic & eukaryotic replication. 6. Enzymes involved in DNA replication. DNA polymerase in prokaryotes (I, II, III) & eukaryotic DNA polymerases (α, € and $), Ligases. Primosome and Replisome.

4. **Transcription and regulation of gene expression**: Classical and modern concept of the gene. General features of transcription in Prokaryotes & Eukaryotes. Promoters and Transcription factors. Brief study of regulation of gene expression in prokaryotes (Lac-operon, Arabinose operon) and eukaryotes (promoters, transcription factors and enhancers); RNA processing in Eukaryotes (splicing, capping and polyadenylation). Regulation of transcription by noncoding RNA.

5. **Genetic code and Translation:** Salient features of Genetic Code. Codon assignment. Genetic code of mitochondria. Structure and role of tRNA as translational adapter. Structure of ribosome. Translation and factors involved in translation.

6. **DNA repair and Recombination:** Physical and chemical agents causing DNA damage and DNA methylation; Survival curve as evidence of repair. Reversal of UV damage in prokaryotes: photoreactivation, base excision and nucleotide excision repair, post replication repair, mismatch repair, SOS response. Homologous recombination (Holiday structure : RecBCD system); gene conversion; site specific recombination (lambda).

SECOND SEMESTER
UNIT: BOT/ThGL/204
PLANT PHYSIOLOGY
(Theory 25 marks + Internal Asst. 10 = Total 35 marks + 15 for Practical, Total=50marks)

1. **Phytosynthesis:** Light harvesting complexes; Bioenergetics of light reaction; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C_3, C_4 and CAM pathways.

2. **Respiration:** Glycolysis and Acetyl COA synthesis & control; Citric acid cycle and its regulation; plant mitochondrial electron transport, oxidative phosphorylation, Proton gradient and ATP synthesis; structure of ATP synthase in mitochondria; alternate oxidase; photorespiratory pathway; Gluconeogenesis; Glyoxylate cycle.

3. **Phyto-hormones:** Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action of Auxin, Gibberellins, Cytokinins, Ethylene and ABA, Brassinosteroid and Jasmonates.

4. **Developmental physiology :**
   i. **Sensory photobiology:** Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.
   ii. **Physiology of Senescence & Aging**: Senescence promoter, Whole plant & organ senescence; Environmental control on senescence.
   iii. **Dormancy & Germination:** Types of dormancy; seed viability; dormancy enforcement and termination, biochemical and molecular basis of dormancy, hormonal regulation of dormancy and germination, circadian clock and germination control.

5. **Solute transport and photoassimilate translocation**: Uptake, transport and translocation of water, ions, solutes and macromolecules from soil; Ion transporter-types, structure and function, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photoassimilates.

6. **Stress physiology:** Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses. LOX system for biotic and abiotic stress; Reactive oxygen species: formation, role and scavenging.

7. **Cell signaling:** Hormones receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, and regulation of signaling pathways, light signaling in plants.

SECOND SEMESTER
UNIT: BOT/ThGL/205
BIOCHEMISTRY
(Theory 25 marks + Internal Asst. 10 = Total 35 marks + 15 for Practical, Total=50marks)

1. Macromolecules:

i. **Carbohydrates:** Simple and conjugated sugars, nomenclature; structure; stereochemistry – Fischer projection, Haworth perspective, boat and chair conformation; mutarotation; glycoside formation; Derivative sugar; glycoproteins and proteoglycans.
ii. **Protein :** Hierarchy of protein structure, motifs and domains, torsion angle and Ramachandran plot, Forces stabilizing protein structure, fibrous proteins (keratins and collagen), globular protein; Protein folding: Leventhal paradox; Different models of Protein folding and concept of chaperones;
iii. **Lipid:** simple and conjugated lipid, different neutral & polar classes of membrane lipid, nomenclature of different fatty acids.

2. Enzymology and metabolism:
Enzyme activity and specificity, Constitutive and Induced enzymes; Active site, Activation energy, Reaction rate, Mechanism of action, Enzyme Kinetics; Derivation of Michaelis Menten equation; Lineweaver Burke plot; Multiple substrate reaction mode Enzyme inhibition: Reversible, irreversible with one example in each case.

3. **Nitrogen metabolism:** Structure and function of nitrogenase, Mechanism of nodule formation; Nitrate and ammonium assimilation; amino acid biosynthesis (all families).

4. **Lipid metabolism:** Biosynthesis and oxidation of fatty acids, regulation of FAS, Phospholipid synthesis and sterol synthesis.

5. **Protein synthesis:** Ribosomes; Mechanism of translation.

6. **Functional Genomics, Proteomics & Metabolomics :**
Preliminary concepts: BLAST, EST, SAGE; Sequencing, alignment and reconstruction for phylogenetic study; analysis of differential expression of gene, NIST library for structural identity of molecules etc.; Lipidomics concept.

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Semester II :

Full marks = 250 with 5 units (25 credit points including Practical).

Unit	Topic	Periods per week	Internal Assessment *	Theory	Practical	Full Marks	Credit points (Int.Assmt.+ Th + Pr)
BOT/ThGL/201.	**Cell Biology**	5 = 2 (Th) + 3 (Pr)	10	25	15 (3pds)	50	5 (1+2.5+1.5)
BOT/ThGL/202.	**Genetics**	5 = 2 (Th) + 3 (Pr)	10	25	15 (3pds)	50	5 (1+2.5+1.5)
BOT/ThGL/203.	**Molecular Biology**	5 = 2 (Th) + 3 (Pr)	10	25	15 (3pds)	50	5 (1+2.5+1.5)
BOT/ThGL/204.	**Plant Physiology**	5 = 2 (Th) + 3 (Pr)	10	25	15 (3pds)	50	5 (1+2.5+1.5)
BOT/ThGL/205.	**Biochemistry**	5 = 2 (Th) + 3 (Pr)	10	25	15 (3pds)	50	5 (1+2.5+1.5)
	5 units	Total 25 10 (Th) + 15 (Pr)	Marks 50	Marks 125	Marks 75	Total Marks 250	Total credit 25

*** One practical period = 3 hrs duration in each day. Therefore, 3 practical classes one for each of 201, 202, 203, 204 & 205. Total 5x3=15 Practical Classes per Week.**

1. Combined Practical syllabus of Units 201, 202 203 (Full Marks 15+15+15 =45) and

2. Combined Practical syllabus of 204 & 205 (Full Marks 15+15 = 30) were enclosed.

Experiments will be performed accordingly in Practical period of 5 (3+2) days per wk.

Combined experiments of unit BOT/ThGL/ 201, 202 & 203

(Cell Biology, Genetics & Molecular Biology)
PRACTICAL EXPERIMENTS : FULL MARKS 45 (15+15+15)
[Experiment demonstration 30 + viva 15] = 45 (Credit 4.5);
[9 periods per wk].

1. Different types of Microscopes and application in Cell Biology: (Demonstration in laboratory and through internet; Questions for viva)

Light microscopy: Fluorescence, Dark field and Phase-contrast microscopy; Electron microscopy: scanning, transmission; Atomic Force and Confocal microscope.

2. Plant Chromosome study: (from two plant sources)

i. Pre-treatment, Fixation, Preparation of stains

ii. Mitotic chromosomes preparation and staining, observation on different stages under light microscope; Calculation of Mitotic Index of the given sample and karyotyping.

iii. Meiotic chromosomes preparation and observation of different stages under light microscope.

iii. Treatment of chromosome with toxic chemicals and observation on abnormalities.

3. Nucleolus staining with hematoxylin and study under light microscope.

4. Study on Nucleic acid:

i. Isolation of Plasmid DNA (from plasmid-bearing strains of *E.coli*).

ii. Isolation of genomic DNA from plant (from young leaves).

iii. Spectrophotometric determination of concentration and purity of DNA.

iv. Comparative analysis on electrophoretic separation of plasmid DNA and plant Genomic DNA,

v. Estimation of DNA content (from synthetic/plant sample) through DPA method.

vi. Estimation of RNA content (from synthetic/plant sample) through Orcinol method.

vii. Denaturation profiling of DNA and Determination of tm value.

Combined experiments of unit BOT/ThGL/204 & 205.

(Plant physiology & Biochemistry)
PRACTICAL EXPERIMENTS: FULL MARKS 30
[Experiment demonstration 20 + viva 10] = 30 (Credit 3.0);
[6 periods per wk].

A. Studies on Photosynthesis & Respiration:

1. Extraction of Chlorophyll content by solvent system and spectrophotometric quantification from Leaf tissues of two different plants.

2. Demonstration of Hill Reaction.

3. Application of promoters and inhibitors on the rate of aerobic respiration.

B. Study of enzymes from plant systems:

1. Enzyme kinetics: Determination of Vmax, Km values on Urease activity (from synthetic Urease) and its expression by Lineweaver-Burk plot by double reciprocal transformation.

2. Assay and effect of promoter and inhibitor on Urease activity.

3. Assay for nitrate reductase in leaf tissues.

C. Analysis on Macromolecules:

1. Protein Analysis:

i. Separation of amino acids from a synthetic mixture by TLC and staining by Ninhydrin.

i. Extraction of Protein from plant leaves by precipitation method.

i. Preparation of Standard curve by Bradford's reagent with BSA.

ii. Estimation of extractable protein from leaves by the method of Bradford.

iii. Separation of proteins by polyacrylamide gel electrophoresis and determination of approximate MW.

2. Lipid analysis:

i. Extraction of lipid from mustard oil seeds.

ii. Chromatographic separation by TLC, iodine treatment and calculation of Rf.

D. Study on Hormone:

i. Colorimetric estimation of IAA by Salkowaski reagent

Syllabus for M.Sc in Botany

Semester III

Full marks=250 with 4units (BOT 301, 302, 303 & 304) from Core topic and

BOT 305 (1 unit for CBCS). [25 Credit point including Practical]

One unit CBCS paper BOT/Th(a/b/c/d)/305 from "Section CBCS" (50 Marks; 5 credit points)

Unit	Topic	Periods per week (Th + Pr)	Internal Assessment *	Theory	Practical	Full Marks	Credit points (Int.Assmt.+ Th +Pr.)
BOT/ThGL/301.	**Taxonomy of Angiosperm**	5 (2 Th + 3Pr)	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/302.	**Plant pathology**	5 (2 Th + 3Pr)	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/303.	**Plant Biotechnology**	5 (2 Th + 3Pr)	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/304.	**Plant resources & utilization**	5 (2 Th + 3Pr)	10	25	15	50	5 (1+2.5+1.5)
BOT/Th/305 (a/b/c/d)	CBCS paper***	5 4+1=5	10	40		50	5 (1+4.0)

One practical period = 3 hrs duration in each day. Therefore, one practical for each of 301, 302, 303 & 304. Total 4x3=12 Practical Classes per Week.

***** One topic to be opted from "Section CBCS"**

a. Chemical ecology: Insect-plant interaction; Bio pesticides

b. Biological methods & Instrumentation

c. Bioenergy sources and energy production

d. Horticulture, Aquaculture and Orchard management; Forest Management and Human-Animal conflict.

Units (a/b/c/d) from CBCS will be offered as per existing infrastructural facilities of the concerned departments.

THIRD SEMESTER

UNIT: BOT/ThGL/301

Taxonomy of Angiosperms

(Theory 25 marks + Internal Asst.)

1. **Systems of classification:** A brief history of classification; basics of classification by Cronquist (1981), Takhtajan (1997), working idea on APG IV (2016).

2. **Cladistics:** A brief account including definition and application.

3. **Diversity in angiosperms:** details of some major taxa: Magnollidae, Asteridae, Alismatidae, and Liliidae (*sensu* Cronquist 1981).

4. **Taxonomic Literature:** Dictionaries, Indices, Monographs, Manuals, Floras, Journals, and taxonomic websites.

5. **International Code of Nomenclature for Algae Fungi and Plants:** Basic Principles, articles, recommendations and special provisions; application of code with problems; nomenclature of cultivated and hybrid plants; taxonomic hierarchy.

6. **Herbarium & Botanic Gardens:** Herbarium methodology**;** Role of Botanic Gardens in the 21st Century.

7. **Systematic Data sources and Data mining**: Definition, Importance and Categories. Major areas of Biosystematic studies:

   (A) *Phytochemistry* (including Serology, Pigments & Secondary metabolites) in relation to taxonomy
   (B) *Palynology*: Reconstruction of past vegetation and bearing on phylogeny,
   (C) *Embryology*: Diversity in formation and structures of gametophytes, endosperm and ovule in relation to taxonomy
   (D) Cytology, genetics, breeding & Molecular Biology: Definition, determination of relationship through chromosomal studies, Protein & Nucleic Acids.
   (E) *Numerical Taxonomy* (Phenetic methods): Definition, Principles, methods, merits and demerits.
   (F) *Remote sensing & GIS*.

8. **Analysis of data:** A brief idea on commonly available software, clustering and construction of Dendrogram.

Practical : (15 marks)

1. Workout of plant specimens, drawing details of plant parts, describe in botanical terminology and identifying those up to species level using local floras and/or relevant taxonomic literature. [Plants with small and minute flowers may be selected, e.g. Peperomia pellucida, Amaranthus viridis, Pilea microphylla, Chenopodium album, Casuarina equisetifolia, Rungia pectinata, Magnolia champaca/ Nymphaea sp., Chrysopogon aciculatus, Commelina benghalensis/ C. diffusa. Tabernaemontana divaricata, Euphorbia hirta, Phyllanthus sp.etc.]
2. Identification of plants by matching in the HERBARIUM.
3. Preparation of Dichotomous Keys.
4. Preparation of temporary pollen slide
5. Field study for acquaintance with plants in their natural habitat and also in different phytogeographical regions. Field Note preparation.
6. Preservation of angiospermic plant specimens and preparation of Herbarium-sheets (20 in number). [**Collect only weedy plants locally. There are hundreds of weedy species available in the University campus, cultivated areas, gardens, road-sides, etc.]**

Students will be directly involved to prepare a HERBARIUM & mini BOTANIC GARDEN within the University campus.

***Suggested Readings*:**

1. Datta, S. C. 1988. *Systematic Botany*. Wiley Eastern Limited, New Delhi.
2. Singh, G. 2012. *Plant Systematics – Theory and Practice*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
3. Bhojwani, S. S. & Bhatnagar, S.P. : Embryology of Angiosperms. Vikash Publishing House, New Delhi.
4. Lawrence, G. H. M. 1964. *Taxonomy of Vascular Plants*. Oxford & IBH Publishers, Calcutta.
5. Naik, V. N. 1984. *Taxonomy of Angiosperms*. Tata McGraw-Hill Publishing Company Limited, New Delhi.
6. Stebbins, G.L. : Flowering Plant Evolution Above Species Level. Edward Arnold Ltd., London.
7. Davis, P. H. & Heywood, V. H. 1963. *Principles of Angiosperm Taxonomy*. Princeton, NJ: Van Nostrand.
8. Radford, A. E. 1986. *Fundamentals of Plant Systematics*. Harper & Row, London.
9. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., Donoghue, M. J. 2008. *Plant Systematics – A Phylogenetic Approach*. Sinauer Associates, Inc., Sunderland, Massachusetts USA.
10. Stuessy, T. F. 2008. *Plant Taxonomy – The Systematic Evaluation of Comparative Data*. Columbia University press, New York.
11. Simpson, M. G. 2010. *Plant Systematics*. Elsevier Academic Press, Amsterdam.
12. BSI: *Flora of India* (all volumes), Kolkata.
13. BSI: *Flora of West Bengal* (all volumes), Kolkata
14. Prain, D. 1903. *Bengal Plants* (2-vols). West, Newman & Co., London.
15. Hooker, J.D. 1872 – 1897. *The Flora of British India*. Vols. 1 – 7. L. Reeve & Co., Ltd. Ashford, Kent.
16. Stace, C. A. 1989. *Plant Taxonomy and Biosystematics*. Arnold Publishers, United Kingdom.
17. Johnes, S. B. & Luchsinger, A. E. 1987. *Plant Systematics*. McGraw-Hill. London.
18. Jain, S.K. & Rao, R.R. 1977. *A Handbook of Field and Herbarium Methods*. Today & Tomorrow's Printers and Publishers, New Delhi.
19. Sivarajan, V. V. 1991. *Introduction to the Principles of Plant Taxonomy*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

THIRD SEMESTER

UNIT: BOT/ThGL/302:

Plant Pathology

(Theory 25 marks + Internal Asst.)

1. Plant Disease Development: Penetration; Infection; Invasion of host tissue; Biochemical and molecular basis of pathogenesis; Relationship between pathogen and host and other related factor(s); Role of enzymes, Toxins and Hormones in pathogenesis.

2. Epidemiology of Plant Diseases: Detailed studies on fungal diseases of economically important crops; General idea of bacterial, viral and nematode diseases of plant system; Disease cycles and inoculum spread.

3. Plant Disease Detection: Disease forecasting; Molecular and immunological diagnosis.

4. Plant defense strategies: Structural and biochemical; pathogenesis related proteins; Reactive Oxygen Species; Role of secondary metabolites; Elicitors and Receptors; Hypersensitive reactions; Role of phytoalexin in plant defense; Mechanisms underlying systemic acquired resistance.

5. Plant disease control: Biological control and chemical control of phytopathogens; Modern approach of disease control by introduction of avirulence genes in control of plant pathogens.

6. Plant-Insect Interaction: Host & Pest; Tritrophic interaction in plant defense mechanism;

Practical : (15 marks)

1. Different Sterilization techniques; Types of Media and Methods of Media preparation for culture; Isolation of pathogens from diseased tissues; Demonstration Koch's postulate.

2. Artificial inoculation of plants with pathogens and assessment of disease development.

3. Histopathological studies of some foliar and root diseases by fungal pathogen of some important crops.

4. Comparison of protein contents of healthy and infected plant tissues.

5. Comparison of phenol contents of healthy and infected plant tissues.

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Suggested reading

1. Plant Pathology, 5th Edition – George Agrios. Academic Press
2. Molecular Plant Pathology - M. Dickinson. Bios Scientific Publishers, Taylor and Francis group , London and New York
3. Topics in Mycology and Plant Pathology - L.N. Nair, New Central Book agency(P) Ltd. Kolkata.
4. Plant Pathology -concepts and laboratory Exercises - Robert N. Trigiano, Mark T. Windham and Alan S. Windham eds., CRC Press.
5. A text book of Plant Pathology - A.V.S.S. Sambamurty
6. Plant Pathology - Mehrotra and Agarwal, Tata McGrow Hill
7. Molecular Plant Pathology: A practical approach, Vol. I & II- S.J. Gurr, M. J. Mc Phersson and D. J. Bowles, Eds., Oxford University Press

THIRD SEMESTER

UNIT: BOT/ThGL/303

Plant Biotechnology

(Theory 25 marks + Internal Asst.)

1. Basics of Gene Manipulation : Cutting and joining of DNA molecule; Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning vehicles: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Bacteriophage Lambda, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

2. Cloning strategies : Bacterial Transformation and selection of recombinant clones, PCR mediated Gene cloning; Chimeric Gene Construct preparation , Obtaining gene of interest by genetic selection from DNA libraries; complementation, colony hybridization.

3. Methods of gene transfer in plants : Explant preparation from different plant system; *Agrobacterium*-mediated gene transfer; Direct gene transfer by Microprojectile bombardment; Electroporation; Selection of transgenics using selectable marker and reporter genes (some examples: Luciferase, GUS, GFP); Analysis of Transgenics by PCR, Southern blot; Northern blot, Western blot techniques.

4. Plant Tissue Culture

a. History and Importance of Plant Tissue Culture; Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Culture Media, Nutrients; Protoplast isolation, culture and fusion, Hybridisation of protoplasts.

b. Tissue culture applications : Micropropagation, Androgenesis, Virus elimination, Secondary metabolite production, Haploids, Triploids and Hybrids for over growth and production; Cryopreservation; Germplasm Conservation, Synthetic Seed preparations.

5: Applications of Biotechnology

GM crops for insect/pathogen resistance/ herbicide tolerance/ Pest resistant (Bt-cotton); herbicide resistant plants (Round Up Ready soybean); Transgenic crops with improved quality traits (Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); Edible vaccines; Industrially important enzyme production (Aspergillase, Protease, Lipase); Gentically Engineered Products-Human Growth Hormone; Insulin ; Biosafety concerns of genetically engineered plants.

Practical : (15 marks) :

1. Preparation of MS medium, B5 media, Shoot initiation media; root induction media.
2. I*n vitro* sterilization and inoculation methods using leaf, shoot tip and nodal explants of tobacco. *Datura, Brassica* etc.

3. Isolation of plasmid DNA & Transformation of E.coli. bacteria.

4. Isolation of protoplasts from leaf tissue and culture in media.

5. Following techniques will be demonstrated by Y-tube or by ICT support.

a. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds.
b. Study of methods of gene transfer: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
c. Study of steps of genetic engineering for production of Bt cotton, Golden rice. photographs.

Suggested books :

Principles of Gene Manipulation, R.W Old & S.B. Primrose, Blackwell Science.

Plant Biotechnology, The genetic manipulation of plants.
By Adrian Slater, Nigel Scott, and Mark Fowler; ISBN: 9780199282616.

Plant Tissue Culture: Theory and Practice
By M. K. Razdan and S. S. Bhojwani.

THIRD SEMESTER

UNIT: BOT/ThGL/304

Plant Resources & Utilization.

(Theory 25 marks including Section A & B + Internal Asst.)

Section A {Marks 12} :

1. **Basic concept of Plant Resource Utilization :** Ecological perspective of resourceful plants; Concept of sustainable utilization; Domestication of plants.

2. **Crops & Forest product :** food, fodder, forage, medicinal and aromatic plants, sugar-juice, fibre-plants. Land races and Cultivars; Timber plants; Non-timber Forest Produces (NTFP); Bamboos, gums, dyes, decorative elements, etc.; Forest based-Tribal socio economic and cultural practices & Livelihood; Traditional Ethnobotanical exercise for medicinal plants.

3. **Horticultural & Floricultural Plants and other plant resources.** Rose, Tuberose, Marigold, Gladiolus, Gerbera as cash-crop; plants for cottage industries; for road-side trees, Gardening.

4. **Ecological Management:** Sustainability indicators; EIA & EMP. Futuristic approach.

5. **Conservation:** Need of Conservation; Concept of Protected Areas; CITES, IUCN Red List Categories.

A. Strategies for *in situ* conservation: international efforts, activities of IUCN, recognition of Hotspots, different types of Reserves (National Parks, Wildlife Sanctuaries and Biosphere Reserves).

B. Strategies for *ex situ* conservation: Principles and practices; *ex situ* conservatories (Botanic Gardens, Seed Banks, *in vitro* repositories and cryobanks).

Section B {Marks 13} :

1. **Drug –** a brief introduction, classification and phytochemistry of different drugs of plant origin. .
2. **Classification of Secondary metabolites of Plants and their medicinal properties:**
   Glycosides and glycosidal drugs; and glucosinolates;
   Alkaloids and alkaloidal drugs [Opium, *Cinchona*, Ergot, *Rauvolfia, Catharanthus sp.* – their medicinal properties and uses]
   Phenolics: Aloe, Capsicum.
   Steroidal compounds and **Cyanogenic glycosides.**

2. Other economically important plant product :

Volatile oils: Clove, *Mentha, Eucalyptus, Cinnamomum, Citronella*
Resins: origin, chemistry and uses
Wax : origin and uses.
Aroma product: Jasmine, Rose.

3. Different pathways of Secondary Metabolism :

Malonate pathway, Mevalonic acid pathway, Shikimate pathway, MEP pathway and pathway for nitrogen containing product.

Practical : (15 marks)

1. Identification of different forage, fibre, medicinal & aromatic and vegetable oil yielding plants and their useful parts (from fresh or herbarium)
2. Survey of NTFPs in nearby forests or other type of vegetation
3. Collection of wild-edible and medicinal plants from the surrounding areas, their scientific identification and processed into mounted Herbarium-sheets [about 10 sheets]
4. Visit to village markets to survey the marketing status of different wild (not in cultivation) plants/Visit to a Medicinal Plants Garden.
5. Extraction of plant secondary metabolites by solvents and qualitative tests for detection of alkaloids, phenolics, betacyanins, carotenoids, steroids.
7. Anatomical studies on powdered drugs : from a leaf or a stem part.
8. Chromatographic separation of drug of importance from mixture.

Suggested Literature;

(For Section A)

1. *The Wealth of India – Raw Materials Series*. CSIR publications, New Delhi.
2. Sharma, O.P. 1996. *Hill's Economic Botany*. Tata McGrow Hill, New Delhi.
3. Kocchar, S.L. 1998. *Economic Botany of the Tropics*. McMillan India Ltd., Delhi.
4. Pandey, B.P. 1999. *Economic Botany*. S. Chand & Co., New Delhi.
5. Das, A.P. & Pandey, A.K. 2007. *Advances in Ethnobotany*. Bishen Singh Mahendra Pal Singh, Dehra Dun.
6. Paroda, R.S. & Arora, R.K. 1991. *Plant Genetic Resources Conservation and Management*. IPGRI
7. Nair, M.N.B., Mohd. Hamami Sahri & Zaidon Ashaari (eds.) 1998. *Sustainable Management of Non-Wood Forest Products*. Sustainable management of non-wood forest products : proceedings of an international workshop. Universiti Putra Press, Malaysia.
8. Khare, C.P. 2007. *The Useful Plants of India*. Springer.

(For Section B) :

1. Evans W.C., 2002, Trease and Evan's Pharmacognosy, W.B. Saunders.

2. Harborne, J.B., 1998. Phytochemical Methods, Chapman and Hall.

3. Tyler V.E., L.R. Brady and J.E.. Robbers, 1988. Pharmacognosy, Indian Edition, K.M. Varghese Company, Bombay.

4. Plant Physiology & Biochemistry, Teiz & Zeiger, 2nd ed. 2014.

5. Biochemical methods, Sadasivam & Manikham, New age international, 1996.

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THIRD SEMESTER

BOT/Th/305 b

Biological methods and Instrumentation

1. Microscopic techniques:

Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, cryo-SEM, fluorescence and phase contrast microscope, different fixation and staining techniques for EM, freeze-etch and freeze fracture methods for EM, image processing methods in microscopy.

2. Biophysical Method:

Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy, Molecular structure determination using X-ray diffraction and NMR, Surface plasma resonance methods, Infrared and Raman spectroscopy.

3. Chromatographic techniques:

Principles of chromatography, high performance liquid chromatography, adsorption chromatography, partition chromatography, ion-exchange chromatography, size exclusion chromatography, affinity chromatography, gas chromatography. Concept of antigen, antibody, immunoblotting, fluorescence activated cell sorting (FACS), immune-affinity chromatography, Immunohistochemistry (IHC).

Gel Electrophoresis (SDS-PAGE), Second dimension Gel electrophoresis (2DE), Edman Degradation(amino acid sequencer)

4. Radioisotope techniques:

Nature of radioisotope, nature of radioactivity, detection and measurement of different types of radioisotopes, safety guidelines

5. Histochemical and Immuno-techniques:

Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow-cytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH, Concept of antigen, antibody, immunoblotting, fluorescence activated cell sorting (FACS), immune-affinity chromatography, Immunohistochemistry (IHC).

6. Centrifugation and Mass spectrometric techniques:

Introduction to centrifugation, sedimentation, types of centrifuges, preparative centrifugation, analytical centrifugation, ultra-centrifugation, Introduction to mass spectrometry, MALDI TOF/TOF analysis, ionization, mass analyzers, detectors, computing and database analysis.

7. Recombinant DNA and genetic analysis

Gene cloning and protein expression methods, protein analysis and detection of post translational modifications, semi-quantitative PCR and Real time PCR and microarray analysis, Molecular markers (RAPD, RFLP, AFLP, SSR).

THIRD SEMESTER

BOT/Th/305 d

Horticulture, Aquaculture and Orchard management; Forest Management and Human- Animal conflict

Economic importance and classification of horticultural crops and their culture and nutritive value, area and production, exports and imports, fruit and vegetable zones of India and of different states. Nursery management practices. Soil and climate.

Basics of aquaculture-definition and scope. History of aquaculture: Present global and national scenario. Aquaculture vs agriculture. Systems of aquaculture. Major candidate species for aquaculture: freshwater, brackish-water and marine.

Definition, importance, objectives of orchard management. Merits and demerits. Selection of location and sites. Planning of suitable kinds and variety of fruits.

Forest resources: economic and ecological importance of forests. Red Data book; ecological restoration; afforestation; social forestry; agro forestry. Brief account of Forest Conservation Act 1980, 1988.

Introduction; Kinds; Causes; Consequences; Preventative Measures. WWF reports.

Syllabus for M.Sc in Botany

Semester IV

Full marks = 250 with 3 units (unit BOT/ThGL/401, 402, 403) for Core topics,

One Unit BOT/Ths/404 A/B/C/D Special Paper

One unit BOT/PR/405 for Project/Review paper (50 Marks; 5 credit points)

Total 25 Credit points

Unit	Topic	Period per week	Internal Assessment *	Theory	Practical	Full Marks	Credit points (Int. Assmt.+ Th+Pr.)
BOT/ThGL/401	Anatomy & Pharmacognosy	5	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/402	Ecology & Environmental biology	5	10	25	15	50	5 (1+2.5+1.5)
BOT/ThGL/403	Biostatistics & Bioinformatics	5	10	25	15	50	5 (1+2.5+1.5)
BOT/ThS/404	**404 A/B/C/D****	5 (Th)	10	40	--	50	5 (1+4.0)
BOT/PR/405	**Project Work/ Review work**	**50 Marks; 5 credit points**					

Special Paper Options

**** One topic to be opted from the following:**

404 A. Diversity of Life forms & Conservation

404 B. Industrial & Clinical microbiology

404 C. Developmental Biology and Evolution.

404 D. Ethno botanical knowledge on therapeutics & Immunology.

Units (A/B/C/D) from Special Paper options will be offered as per existing infrastructural facilities of the concerned department.

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FOURTH SEMESTER

UNIT: BOT/ThGL/401

Anatomy & Pharmacognosy

(Theory 25 marks + Internal Asst.)

Anatomy :

1. Plant Growth :

Different types of Meristem; Organization of shoot and root apical meristems; Differentiation of primary and secondary plant body: epidermis, stomatal ontogeny, cuticle and epidermal appendages; secretory structures.

2. **Development of Plants :** Vascular elements; Branch & Leaf trace, branch & leaf gap; Intrastelar & Extrastelar secondary growth - vascular cambium, cork cambium; Periderm: structure and development; Anomalouus secondary growth

3**. Phylogeny and evolution** : Mechanical tissue elements; phylogeny of xylem and phloem elements, wood anatomy: nodal anatomy; Seasonal activity.

4. Reproductive plant anatomy: Floral vasculature

5. **Applied plant anatomy:** Brief idea on the application of anatomical studies in climatology, pharmacognosy, forensic science, archaeology and taxonomy.

Pharmacognosy :

1. Overview on Pharmacognosy: Definition and scope; Importance of Crude drug; Preparation of drugs for commercial market: Collection, harvesting, drying, garbling, packaging, storage and preservation.

2. Classification of plant drugs: Brief knowledge of different categories of drugs from plant resources producing carbohydrates, alkaloids, essential oils, resins and glycosides.

3. **Primary and Secondary Metabolites as Drugs** : A brief account on chemical nature of secondary metabolites, Biochemical pathway for generating medicinally important secondary metabolites.

4. **Some plant resources as Drug:** Macro - micro morphological features, constituents, adulterants, allied drugs and uses of the following plants - *Digitalis* (leaf drug); *Cinchona* (bark drug); *Cephaelis* (root and rhizome drugs); *Rauvolfia* (root and rhizome drugs); *Strychnos* (seed drug); *Syzygium* (flower drug) and *Coriandrum* (fruit drug).

Practical = 15 marks

Anatomy

1. Study of trichomes, sclereids, tracheids, vessels and sieve tube elements.
2. Study of laticifers, oil glands, resin canals, cystolith and crystals.
3. Study of different types of stomata (monocots and dicots).
4. Anatomy of bark and lenticels
5. Nodal anatomy: Study of unilacunar, trilacunar, multilacunar.
6. TS, TLS and RLS of woody plants

Pharmacognosy

1. Solvent extraction and Chemical tests for the detection of alkaloids, phenols, anthraquinones, cardenolides, anthocyanins, betacyanins, carotenoids.
2. Anatomical studies (under microscope) from some commercially available powder drugs.
3. TLC for isolation of compounds: Anthocyanin from cabbage and betacyanin from beet root.

4. Submission of Field record & Laboratory note book and 5 medicinal plants during practical examination.

Suggested readings

Plant Anatomy

1. Comparative Plant Anatomy- Carlquist, S. (1961).
2. An Introduction to Plant Anatomy- Eames, A.J. and MacDaniels, L.H. (1947).
3. Anatomy of Seed Plants- Esau, K. (1977).
4. Plant Anatomy (4th Edition) - Fahn, A. (1990).
5. Physiological Plant Anatomy- Haberlandt, G. (1914).
6. An Introduction to Plant Structure and Development- Charles, B. Beck (2010).
7. Integrative Plant Anatomy- Dickison, W.C. (2000).
8. Plant Anatomy- Mauseth, J.D. (1988).
9. Plant Anatomy (Part I and II) - Cutter, E.G.

Pharmacognosy

1. Bruneton J., 1999. Pharmacognosy, Phytochemistry, Medicinal Plants, Intercept Ltd., Paris.
2. Dewick P.M., 2002. Medicinal Natural Products: A biosynthetic approach, John Wiley & Sons Ltd.
3. Evans W.C., 2002, Trease and Evan's Pharmacognosy, W.B. Saunders.
4. Harborne, J.B., 1998. Phytochemical Methods, Chapman and Hall.
5. Houghton P.J. and A. Raman, 1998. Laboratory handbook for fractionation of natural extracts, Chapman and Hall.
6. Kokate C.K., 1991. Practical Pharmacognosy, Vallabh Prakashan, Delhi.
7. Samuelsson G., 1999. Drugs of naural origin: A text book of Pharmacognosy, Swedish Pharmaceutical Society, Swedish Pharmaceutical Press, Stockholm, Sweden.
8. Tyler V.E., L.R. Brady and J.E.. Robbers, 1988. Pharmacognosy, Indian Edition, K.M. Varghese Company, Bombay.
9. Vickery M.L. and B. Vickery, 1981. Secondary Plant Metabolism, The MacMillan Press Ltd.
10. Wallis T. 1967. Text Book of Pharmacognosy, J & A Churchill, London.24
11. Wagner H., S. Bladt and E.M. Zgainski (Translated by A. Scott) 1984, Plant Drug Analysis, Springer-Verlag.
12. Vermerris Wilfred & Nicholson Ralph, 2006, Phenolic compound Biochemistry

FOURTH SEMESTER
UNIT: BOT/ThGL/402
Ecology & Environmental Biology
(Theory 25 marks + Internal Asst.)

Ecology

1. Ecological principles :

Scope and development of ecological ideas and attributes;

2. Abiotic interactions: (Brief overview of the physical environment)

i. Effect of light, temperature, water and fire factors on vegetation patterns;

ii. Soil – origin & development, composition, types and properties.

3. Biotic interactions :

i. The niche concept (types; fundamental & realized niche)

ii. Plant adaptations;

ii. Ecotype and ecocline;

iii. Tolerance range;

iv. Interaction types (with models) – competition, predation, amensalism, commensalism, mutualism.

4. Population: Characteristics, growth models, population regulations, and life history strategies(*r*

and *K* selection); concept of metapopulation – demes and dispersal, interdemic extinctions.

5. Community: Definition of terminologies related to community ecology; Nature of community – discrete and continuum views; Community Structure and attributes; Succession – types and mechanism, models, climax concept.

6. Ecosystems :

i. Structural aspect;

ii Functional aspect –energy flow and biogeochemical cycles (with emphasis on their implications);

iii Concept of primary production – production on land and aquatic systems (forest, grassland, fresh water, estuarine and marine ecosystems with Indian perspective)

7. Biogeography (Brief overview): Major terrestrial biomes – forests, grasslands, deserts; Fresh water ecosystems (lotic & lentic); Wetlands – types & importance; Marine ecosystems.

***Environmental biology*:**

1. Brief overview on Natural resources; degradation and conservation.

2. Pollution studies :

i. Air, water, soil – types of pollutants, sources, effects and remedial measures;

ii. Ecotoxicology – types and effects;

iii. Biomonitoring.

3. Global environmental change: Green house effects, Global warming– causes and effects; Ozone depletion.

4. Sustainable development – Concept; National sustainable development strategies.

Practical: (15 marks)

1. Environmental factors analyses–

i. Measurements of water transparency (secchi disc), pH (pH paper/meter), dissolved solids. ii. Measurements of soil characters –

a. Physical – Texture (manual method), bulk density and porosity,moisture content, water holding capacity.

b. Chemical – Rapid field test for carbonate, nitrate and base exchange capacity.

Estimation of organic carbon % (Walkley& Black method).

2. Plant analyses –

i. Species and population responses –

a. Study of seed germination – effects of light and temperature.

b. Determination of root: shoot ratio with respect to length and weight. c. Plant adaptations in relation to water (hydrophytes, xerophytes) – morphological and anatomical characters (at least one species from each group).

d. Plant adaptations in relation to different soil conditions (mesophytes and halophytes) – morphological and anatomical characters.

e. study of plant interactions – mycorrhiza, parasites.

ii. Community studies –

a. Methods of sampling vegetation – Quadrates, Transects, Point frame methods.

b. Determination of minimum size of quadrate for herbaceous layer study (Species- Area curve method).

c. Determination of frequency, density, abundance of herbaceous layer. d. Determination of basal area of woody species

(preferably carried out during field trip).

e. Determination of Biological spectrum using Raunkiaer's life form classification

(preferably carried out during field trip).

3. Water analyses :

1. Determination of dissolved oxygen (Winkler's method)/ Determination of dissolved carbon dioxide (any one).
2. Determination of chloride content (Mohr's method)/ Determination of phosphate content.

(Stannous chloride method)- (any one)

Suggested Reading :

1. P N Michael – Ecology, CBS Publ. 2018

2. J S Singh, S P Singh, S R Gupta – Ecology Environmental Science and Conservation, S Chand Publ. 2014

3. C J Krebs – Ecology. The experimental analysis of distribution and abundance, (6^{th} Ed.), Pearson. 2009

4. T M smith and R L Smith – Elements of ecology,(9^{th} Ed.), Pearson. 2015
5. M G Barbour – Terrestrial plant ecology, Benjamin/Cummings Publ.

FOURTH SEMESTER
UNIT: BOT/ThGL/403

Biostatistics and Bioinformatics

(Theory 25 marks + Internal Asst.)

Biostatistics:

1. **Sampling and sample designs:** sample, population, parameters, classification and tabulation of data; Diagrammatic and Graphical presentation
2. **Measures of dispersion:** Range, Mean, Median, Mode; Normal distribution & Skewness; Standard Deviation, Standard Error; Binomial and poison distribution
3. **Correlation and regression analysis :**

   Spearman's rank correlation coefficient; Analysis of variance (ANOVA: one-way & Two-way)

Bioinformatics:

1. Bioinformatics and its application in biological research; Genomic data and data organization; information from nucleic acid and protein sequence.

2. **Biological databases** – Primary, Secondary databases; Structural database- SCOP, CATH, PDB; Resources- NCBI, DDBJ, JGI-IMG, EBI.

3. **Protein and Nucleic Acid Sequence Data Banks** – NBRF-PIR, SWISSPORT, Gen Bank, EMBL.

4. **Sequence analysis:** codon usage, tools for sequence data bank; Pair-wise alignment & Multiple alignment; Algorithm behind searching tools: BLAST, PSI-BLAST, PHI-BLAST.

5. **Concept of Phylogeny**: Rooted, Unrooted tree. Tree generation methods – UPGMA or Neighbor Joining. Bootstrapping and its importance.

6. **Homology modeling**: concept and importance in Biology

Practical: 15 Marks

1. Measurements of central tendency and dispersion
2. Determination of tests of significance
3. Statistics and Sampling, Student's t test, chi square X^2 test, F-test
4. Determination of relationship between variables using correlation and regression analysis
5. Analysis of statistical data through software such as Excel and SPSS
6. Retrieval of DNA/RNA/protein sequences from various primary and secondary databases.

7. Sequence alignment: database searches (BLAST), Pairwise Sequence Alignment and Multiple Sequence Alignment (Bioedit and ClustalW).
8. Phylogenetic tree construction, Bootstrapping (MEGA).
9. Codon Usage analysis (CodonW/ DAMBE)
10. Evaluation and Validation of protein models (Modeller)

Suggested Reading :

Biostatistics:

1. Auram Gold Stein- Biostatistics- An introductory
2. Rosner Bernard- Fundamentals of Biostatistics
3. Dr. P.K Banerjee-Introduction to Biostatistics

Bioinformatics:

1. T.K. Attwood and D.J. Parry-Smith, Introduction to Bioinformatics, Pearson Education Ltd., New Delhi, 2004.
2. David W Mount, Bioinformatics: Sequence And Genome Analysis, Cold Spring Harbor Press
3. Cynthia Gibas, Per Jambeck, Developing Bioinformatics Computer Skills
4. Andreas D. Baxevanis (Editor), B. F. Francis Ouellette (Editor), Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition, Wiley
5. Jin Xiong, Essential Bioinformatics, Cambridge University Press
6. John F. Peden, Analysis of Codon Usage
7. Andrew Leach, Molecular Modeling: Principles and Applications (2ndEdition), Addison Wesley Longman, Essex, England, 1996
8. David M Webster, Protein Structure Prediction: Methods and Protocols

Important links to download:

1. **CodonW:**https://sourceforge.net/projects/codonw/files/codonw/Win32-Executables-1.4.2/
2. **MEGA:** https://www.megasoftware.net/
3. **Modeller:** https://salilab.org/modeller/download_installation.html

FOURTH SEMESTER

UNIT: BOT/ThS/404 B

INDUSTRIAL, CLINICAL MICROBIOLOGY & IMMUNOLOGY

(Theory 40 marks + Internal Asst.)

Industrial microbiology

Introduction to industrial microbiology: Isolation, preservation and maintenance of industrial microorganisms, strain improvement. Crude and synthetic media; Kinetics of microbial growth and death. Types of fermentation: liquid state fermentation (surface and submerged) and solid state fermentation; Fermentation processes: Analysis of batch, Fed-batch and continuous bioreactors. Analysis of mixed microbial populations. Fermenter: Basic principle and function, design, types, components and their function. Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration. Downstream processing: introduction, removal of microbial cells and solid matter, foam preparation, precipitation, filtration, centrifugation, cell disruptions, liquid liquid extraction, chromatography. Enzyme immobilization and industrial application. Outlines of the bioprocessing of industrially important microbial products and their applications

Clinical microbiology

Normal microflora and host pathogen interaction. Pathogenesis: mechanisms of pathogenesis. Microbial toxins and their molecular action. Bacterial diseases, Viral diseases, Protozoan diseases, Fungal diseases, Prion diseases. Antimicrobial agents: General characteristics and mode of action. Antibiotic/Drug resistance. Vaccination.

Immunology

Fundamentals of Immunology -Innate Immunity and acquired immunity, Cells and organs of immunity, Antigen, Antibody, different classes of immunoglobulins and application of immunological techniques, Antigen-antibody interaction, T-cell and B-cell activation and maturation, MHC, Complement, Hypersensitivity, Autoimmunity, Vaccination.