

Syllabus and Regulations
for
2-Year, 4-Semester M. Sc. Course
in
BOTANY



Scottish Church College
Kolkata

Affiliated to
University of Calcutta

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Syllabus and Regulations for Two Years (4 Semester) M.Sc. Course in Botany

1. The examination for the degree of Master of Science (M.Sc.) shall consist of four semesters: Semester-I, Semester II, Semester III and Semester IV. Each Semester examination will be held after the completion of all the papers for that particular semester and before the next semester begins, commencing on such dates and time as will be decided by the College authority and will be duly notified. Total duration of the course is two years (hereafter, "course" refers to M.Sc. Course in Botany and "paper" refers to the individual papers). The duration of the semester shall be as follows ordinarily:

1st Semester	July - December
2nd Semester	January – June
3rd Semester	July – December
4th Semester	January – June

Course Structure

2. The courses shall comprise a total credit of 80 (Eighty), distributed over the four semesters.

3. The entire course of 1000 marks has been divided into 15 papers (C-1 to C-15). Each core paper is composed of a theoretical component and a practical component except C-8 & C-14. Special paper (C-15) is composed of theoretical component, practical component, project work and seminar. Special paper has to be opted by a candidate during the third semester. The examiners shall forward assessment in respect of every candidate to the principal / Controller of Examination / Coordinator P.G. Courses (as the case may be) for tabulation of the results.

The structure and curricula of the revised syllabus for the M.Sc. course in Botany applicable from the academic session 2010-2011 is stated below:

Course Structure

Semester	Duration	Marks			credit	Month of examination
		Theoretical	Practical	Total		
I	July-Dec	150	100	250	20	January
II	Jan-June	175	75	250	20	June
III	July-Dec	150	125	275	22	January
IV	Jan-June	100	125	225	18	June
Total	2 years	575	425	1000	80	

Theoretical Course

4(i) The theoretical part of a paper of 75 marks will be covered by total 100 lecture periods and for 50 and 25 marks, 50 and 25 lecture periods will be allotted.

(ii) The durations of examination for 75, 50 and 25 marks will be 4 hours, 2 hours and 1 hour respectively.

(iii) Questions will be set by internal teachers and guest lecturers, which will be moderated by a set of moderators for each paper. The set of moderators, as recommended by the P.G. Board of studies, should include at least one internal and one external moderator.

(iv) For the theoretical portion of each paper, questions will be set and the scripts examined by a set of at least two examiners appointed from among the teachers of the department offering the respective courses, including the guest teachers appointed by the appropriate authority of the college, on recommendation of the P.G. Board of studies in Botany.

Practical Courses

5(i) The practical part of a paper will consist of the following components: Experimental, laboratory Records, Viva-Voce, Internal assessment. The durations of examination for 50 marks and 25 marks will be 6 hours and 3 hours.

(ii) For the practical portion of each paper, the examinations would be held after the completion of curriculum at the end of each semester. However, evaluation of the practical will be based on continuous assessment as well as on the final viva-voce examination of the students on the experiments. The scripts will be evaluated by the internal examiners, appointed from the teachers (including guest teachers) of the department, as recommended by P.G. Board of studies.

(iii) . The students will be required to give a seminar based on a published paper or current topics at the end of fourth semester. A panel of examiners, comprising of both internal and external examiners shall evaluate the presentation.

(iv). The students will be required to prepare and submit a report on project work performed during fourth semester. A panel of examiners, comprising of both internal and external examiners will evaluate the project work.

(v) Grand Viva-Voce examination at the end of 4th semester will be conducted by a Board of Examiners consisting of External and Internal members.

Course Curricula

Semester I

Core papers	Theo.	Prac.	20 credits
C1: Phycology	25	25	(2+2)
C2: Microbiology	50	25	(4+2)
C3: Cell and Molecular Biology	25	25	(2+2)
C4 : Bryophytes, Pteridophytes Gymnosperms and Palaeobotany	50	25	(4+2)

Total marks: 250

Semester II

Core papers	Theo.	Prac.	20 credits
C5: Mycology and Plant Pathology	50	25	(4+2)
C6: Taxonomy of Angiosperms and Palynology	50	25	(4+2)
C7: Genetics ,Genomics and Proteomics	50	25	(4+2)

Supportive paper

C8: Instrumentation	25		(2+0)
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Total marks: 250

Semester III

Core papers	Theo.	Prac.	22 credits
C9. Plant Physiology and Biochemistry	50	25	(4+2)
C10. Phytochemistry and Pharmacognosy	25	25	(2+2)
C11. Plant Biotechnology	25	25	(2+2)
C12. Plant Anatomy and Developmental Biology	25	25	(2+2)
C13. Plant Ecology	25	25	(2+2)

Total marks: 275

Semester IV

Supportive paper		Theo.	Prac.	18 credits
C14: Computer applications and Bioinformatics		25	----	(2+0)
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C15: Special Paper				
Any one*	Special paper	75	50	(6+4)
	Project work	---	25	(0+2)
	Seminar	---	25	(0+2)
	Grand viva	---	25	(0+2)

Total marks: 225

* Special Paper

- Sp1. Applied Mycology and Molecular Plant Pathology
- Sp2. Cell Biology, Molecular Genetics and Plant Biotechnology
- Sp3. Plant Physiology, Biochemistry and Molecular Biology
- Sp4. Taxonomy of Angiosperms and Palynology

Eligibility for Admission

6. A candidate who has passed the 3-year B.Sc. Honours or equivalent examination in Botany and secured a minimum of 50% marks in aggregate (45% marks for reserved category) will be eligible to apply for admission to two-year four-semester M.Sc. course in Botany.

7. Any candidate from any other university or UGC recognized institution passed with any other course should bring an equivalence certificate from Calcutta University.

Eligibility for appearing in a Semester Examination

8. A candidate will be eligible to appear in a semester examination provided he/she has attended at least 75% of the lectures delivered and laboratory sessions conducted in that particular semester, after his/ her admission to the course.

Candidate whose attendance is less than 75% would have to repeat the semester.

9. All candidates who have secured the required percentage of attendance as defined in regulation 8 shall be called regular candidates.

Evaluation:

10a). A 6 (six) point grade system shall be followed for the purpose; details of which are laid down hereunder:

Numerical grade point	Grade	Remarks
8.00-10.0	A++	Outstanding
7.00-7.99	A+	Excellent
6.00-6.99	A	Good
5.50-5.99	B	Fair
4.00-5.49	C	Average
3.50-3.99	D	Below Average
0.00-3.49	E	Unsuccessful

(b). The following multiplication table shall be used for calculation for the exact grade points:

Marks between (excluding the end points)	Multiplication Factors
100-80	0.1
79-70	0.1
69-60	0.1
59-55	0.1
54-40	0.1
39-35	0.1
34-0	0.1

(c) Award of Grades

Example-1: if a candidate secures 63% marks in a particular paper, his/her grade point for the paper will be: $(6.00+0.1 \times 3)=6.3$

Example-2: if a candidate scores 64% in theory and 68% in practical in a 8-credit course (Theoretical-5credits+practical-3credits= total 8-credits), then his/her grade point for the course will be as follows:

$$\text{Grade point} = \frac{[5x (6.0+0.1x4) + 3x (6.5+0.1x3)]}{(5+3)} = 6.55$$

Example -3: if a candidate scores 68% in theory and 64% in practical in a 8-credit course (Theoretical-5credits+practical-3credits= total 8-credits), then his/her grade point for the course will be as follows:

$$\text{Grade point} = \frac{[5 \times (6.5 + 0.1 \times 3) + 3 \times (6.0 + 0.1 \times 4)]}{(5+3)} = 6.65$$

(i). The Semester Grade Point Average (SGPA) will be just the average of the grade points obtained in all the papers (Group-A and Group-B of a paper taken separately) of a particular semester. If the numerical grade points obtained by a candidate by C_i (here, $i=1$ to 3 , as there are 3 papers in each semester), the SGPA will simply be equal to $\sum C_i/3$ usually, as all the papers are of equitable weightage.

(ii) Cumulative Grade Point Average (CGPA) over four semesters shall be calculated by working out simple average of the SGPA for individual semesters.

(iii) On the basis of CGPA obtained by a candidate over four semesters, grade and class will be awarded as follows:

CGPA	Grade	Remarks	Class /Division
8.00 -10.00	A++	Outstanding	I (First Class)
7.00-7.90	A+	Excellent	I (First Class)
6.00 – 6.90	A	Good	I (First Class)
5.50-5.90	B	Fair	II (Second Class)
5.00-5.49	C	Average	II (Second Class)
4.00-4.99	D	Below Average	II (Second Class)
0.00-3.99	E	Unsuccessful	X (Fail)

(iv) Both SGPA and CGPA shall be rounded off to the second place of decimal and the rounded off value will be shown as such on the mark sheet.

(v) The mark sheet issued at the end of each semester shall include both the Grade Point Average (GPA) and the total marks obtained in each paper, as well as SGPA and the total marks obtained in that semester. The final mark sheet for the 4th semester shall also include the CGPA and the total marks obtained out of 1000 along with Grade and Class.

11. (a) If a candidate gets E in one or more paper(s), he/she shall be deemed to have failed in that/those paper(s) only and he/she shall be required to appear at the subsequent examination for that paper/those papers in a subsequent semester examination.

(b). **A candidate who has not cleared two consecutive semester will not be promoted to the next semester.**

(c). A candidate can appear a maximum number of two times (excluding, but immediately after, his/her regular appearance) to clear a particular paper or to clear a particular semester (for those who fail in aggregate), failing which he/she shall be dropped from the Rolls of the College/University.

12. **A candidate failing in all the courses (papers) in a semester examination shall have to repeat the entire semester examination.**

13. A candidate must secure at least 35% marks in each theoretical paper and at least 40% marks in each practical paper and a minimum aggregate of 40% (taking theoretical & practical marks separately) in any semester to qualify for the semester.

Candidates scoring 40% or more but below 60% marks in aggregate, shall be declared to have passed the examination and have been placed in the second class. Those scoring 60 % or more marks in the aggregate, shall be declared to have passed the examination and be placed in the first class. Class secured by a candidate shall be shown in the final mark sheet of 4th semester examination.

14. If a candidate gets E grade in one or more papers in a semester examination, his /her SGPA for that semester shall be temporarily withheld and Grade Point Withheld (GPW) shall be marked in place of SGPA on his/her mark sheet. Fresh mark sheet with duly calculated CGPA shall be issued to him/her when the candidate (Grade D or above) clears the paper/papers subsequently within the stipulated time frame.

15. If a candidate has one or more back papers (including those who fail in aggregate) in any semester, his/her CGPA shall remain incomplete (INC) till he/she clears all those back papers. The CGPA of such a candidate shall be marked "INC" on the mark sheet. Fresh mark sheet with duly calculated CGPA shall be issued only after he/she clears all those back papers subsequently within the stipulated time frame.

16. To be eligible for the award of ranks in order of merit, a candidate must pass all the four semester examinations at the first chance (as a regular candidate). The final merit list shall be prepared on the basis of CGPA (including all the four semesters) provided, however, that the candidates taking examinations of back papers shall be excluded from such merit list.

17. Separate mark sheets in prescribed formats given below shall be issued to the candidates for Semester-I, Semester-II, Semester-III and semester –IV examinations.

SEMESTER 1

C1. Phycology

Theory

Full marks: 25

Total periods: 25

1. **Evolution and Biodiversity of algae:** Algal diversity on the basis of different habitat and their conservation.
2. **Classification:** Basic and applied, criteria - pigments, reserve foods and flagella
3. **Phylogenetic Relationship of Pro- and Eukaryotic Algae:** Symbiosis theory- primary, secondary and tertiary endosymbiosis, fan-shaped phylogenetic tree.
4. **Cyanobacteria:** Genome and genetic properties, soil and rice field reclamation, heterocyst-ultra structure, biochemistry and nif-gene regulation, cyanobacterial bloom – ecological significance and its control.
5. **Prochlorophyta and Glaucophyta:** General feature, primitive characters and affinities.
6. **Dinophyta:** Red tides and toxins, bioluminescence, heterotropism.
7. **Cytomorphology and Ultrastructure of Algal Cell:** Flagellar motor, photoreceptor apparatus, nuclear division.
8. **Phytoplankton Ecology** – Types of phytoplanktons, primary production, species diversity index, physical environment (Light, Heat, Turbulance), chemical environment (Nitrogen, Phosphorus, Silicon, Carbon), nutrient uptake models (Michaelis - Menten and Monod, Droop model)

Practical

Full marks: 25

Total periods: 20

1. **Algal Diversity Study:** Identification of members of different groups (maximum 3 genera from each group) - Cyanobacteria , Bacillariophyta and Chlorophyta.
2. **Seaweed Identification:** *Enteromorpha*, *Ulva*, *Halimeda*, *Bryopsis*, *Caulerpa*, *Sargassum*, *Padina*, *Dictyota*, *Catenella*, *Gracilaria*.
3. Phytoplankton sampling and Identification.
4. Preparation of media for algal culture.

Suggested Reading:

1. C.Vanden Hock D.G.Mann & H.M.Jahns, Algae- An Introduction to Phycology Cambridge University Press.

2. H.C.Gangulee, Mosses of Eastern India & Adjacent Region vol1-3.
3. H.D.Kumar, Introductory Phycology, East West Press Pvt.Ltd.
4. K.S.Bilgrami, A Textbook of Algae, CBS Publications.
5. Linda E. Graham, Algae.
6. R.E.Lee, Phycology, Cambridge University Press.
7. B.R. Vashista, Algae, S.Chand & Co.

C2. Microbiology

Theory

Full marks: 50

Total periods: 50

1. **Microbial Diversity:** Phototrophic bacteria, chemolithotrophic bacteria, spirochaetes; rickettsias, chlamydias, mycoplasmas.
2. **Myxobacteria and Extremophiles:** Thermophilic, halophilic, acidophilic and alkalophilic bacteria, unculturable bacteria.
3. **Bacterial Growth:** definition, growth parameters, measurement of growth, synchronous growth, growth kinetics, factors affecting growth, batch and continuous culture.
4. **Differentiation:** Differentiation: endospore formation-cytological, physiological and genetic aspects, germination.
5. **Microbial Metabolism:** Outlines of biosynthesis of peptidoglycan, major amino acids and proteins, regulatory mechanisms in bacteria - induction, repression, feedback inhibition, catabolite repression and attenuation, manipulation of biochemical regulatory mechanisms for overproduction of metabolites, nitrogen metabolism: ammonification, nitrification, denitrification and nitrogen fixation.
6. **Plasmids:** Replication of plasmids, incompatibility of plasmids, plasmid library.
7. **Regulation of microbial gene expression:** Genetic recombination in bacteria, regulation of gene expression in prokaryotes, quorum sensing, regulation of gene expression in Eucarya and Archaea.
8. **Pathogenic properties of bacteria:** Toxins and extracellular enzymes; brief account of major human disease and their bacterial pathogens.
9. **Principles of chemotherapy:** General account of chemotherapeutic agents, sulfa drugs and antibiotics.

10. **Immunology:** History of immunology, innate and acquired immunity, humoral and cell mediated immunity, organ and cells involved in immunity, T cell and B cells; antigens: characteristics and types, adjuvants. Immunoglobulins: types, structure and properties.
11. **Virus:** Nomenclature and classification of viruses, taxonomy of eukaryotic viruses.
12. **The structure of viruses:** Morphology and ultrastructure.
13. **Viral genome:** viral replication; transcription and protein synthesis in DNA and RNA viruses.
14. **Viruses and diseases:** Cancer; HIV and Hepatitis (different types)

Practical

Full marks: 25

Total periods: 20

1. Preparation of culture media; methods of sterilization and aseptic methods.
2. Isolation of microorganisms from natural samples by dilution plating method.
3. Development of pure cultures by streak-plate and pour-plate methods.
4. Determination of morphological (simple and differential staining), physiological and biochemical characteristics of some selected isolated bacteria.
5. Turbidimetric estimation of bacterial growth, bacterial growth curves.
6. Isolation of *Rhizobium* from root nodule.
7. Determination of antibiotic sensitivity of some bacteria by disc diffusion method.
8. Staining: Gram staining, negative staining and endospore staining.
9. Biochemical estimation of bacteria-amylase, peroxidase, catalase etc.
10. Isolation of bacteriophage and determination of phage-titer.
11. Visit to some industries of microbiological interest.

Suggested Reading:

1. Ajit Kumar Banerjee & Nirmalya Banerjee, Fundamentals of Microbiology and Immunology, New Central Book Agency
2. Alcom, Alcom's fundamentals of Microbiology Jones & Bartlett
3. Atas, Principles of Microbiology Vol 1&2
4. Atlas & Bartha, Microbial Ecology, Pearson
5. Black, Microbiology, Willey
6. Games. G. Cappuchino, Microbiology-A laboratory manual, Pearson
7. Dubey & Maheshwari, Biotechnological Applications of Microorganisms, I.K. International Publishing House
8. H.G.Schlegel, General Microbiology, Cambridge University Press
9. John L.Ingraham & Catherine A. Ingraham, An introduction to Microbiology Thomson & Brooks/Cole
10. K.P.Talaro, Microbiology; Tata Mac-GrawHill
11. Larry Snyder Wendy & Champness, Molecular Genetics of Bacteria, ASN Press
12. M.Pelczar, Microbiology, Tata Mac-GrawHill

13. Micheal J.Waites & Neilt Morgan, Industrial Microbiology, Blackwell
14. N.S.Subba Rao, Soil Microbiology, Oxford & IBH Publication Company Pvt.ltd
15. Nancy Trun & Janine Trempy, Fundamental bacterial Genetics, Blackwell
16. Prescott, Industrial Microbiology, CBS Publications
17. Prescott, Microbiology vol 1&2 Tata Mac-GrawHill
18. R.P.Singh, Microbiology, Kalyani Publisher
19. Santhain, general Microbiology, Oxford
20. Sheela Srivastava & P.S.Srivastava, Understanding Bacteria, Springer
21. Simon Baker & Jane Nicklin, Instant Notes Microbiology, Tailor & Francis
22. Stanier Ingraham Wheelis & Painter, General Microbiology, Macmillan Press
23. Gerard. J. Tortora Turke & Case, An Introduction to Microbiology, Pearson

C3. Cell Biology

Theory

Full marks: 25

Total periods: 25

1. **Membrane Structure and Function:** Structure of membrane (plasma/biomembranes), models of membrane, lipid bilayer, membrane proteins: ion channels, ion pumps, diffusion, osmosis, active transport, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.
2. **Cell-Cell Interaction and signaling:** Cellular adhesions, adhesion receptors; intercellular junctions in plants and animals, Intracellular signal transduction, signaling molecules and cell surface receptors, neurotransmitters.
3. **Cell Organelles:** Mitochondrial DNA and male sterility, biogenesis of mitochondria, origin and evolution, chloroplast DNA and its significance, chloroplast biogenesis, origin and evolution.
4. **Nucleus:** Macromolecular trafficking, chromatin organization and packaging, higher order structure of chromatin, chromosomes, specialised chromosomes, nucleosome positioning.
5. **Ribosomes and Protein Synthesis:** Organization and biogenesis of ribosomes, ribosome structure and its significance in protein synthesis.
6. **Endo-membrane System and Cytoskeleton:** Structure and function of microbodies, golgi apparatus, lysosomes and endoplasmic reticulum, membrane maturation and specialization, nature of cytoskeleton, intermediate filaments, microtubules, cilia and centrioles, actin filaments, actin binding proteins, its role in motility.
7. **Cell cycle:** Introduction, phases, cell cycle control and regulation, retinoblastoma and E2F proteins, cytokinesis and cell plate formation, mechanism of programmed cell death (apoptosis).

8. **Cancer:** Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, application of apoptosis in cancer cell detection, therapeutic interventions of uncontrolled cell growth.

Practical

Full marks: 25

Total periods: 20

1. Staining of nucleolus.
2. Karyotype analysis.
3. Preparation of meiotic chromosomes.
4. Meiosis of simple/complex translocation heterozygotes.
5. Chromosome preparation following Feulgen staining.

Suggested Reading:

1. Alberts B., Molecular Biology of the Cell, Garland Science
2. Burton E. Tropp, Molecular Biology, Jones & Bartlett
3. Cooper & Hausman, The Cell-A Molecular approach, ASN Press
4. David O. Morgan, The Cell Cycle, Oxford University Press
5. David P. Clark, Molecular Biology, Elsevier
6. E.D.P. De Robertis & B.M.F. De Robertis, Cell & Molecular Biology, Lipincott Williams & Wilkins
7. George M. Malacinski, Essentials of Molecular Biology, Narosa Publishing House
8. Gerald Karp, Cell & Molecular Biology, Willey
9. Jayanta K. Pal, Fundamentals of Molecular Biology, Oxford University Press
10. Lodish & Berk, Molecular Cell Biology, Freeman
11. M. Gilmartin & Bowler, Molecular Plant Biology vol1&2, Oxford University Press
12. N. Vidyavati & D.M. Chetan, Molecular Biology, I.K. International Publishing House
13. Thomas D. Pollard, Cell Biology, Saunders
14. Robert F. Weaver, Molecular Biology, McGraw-Hill
15. Simon Roe, Protein Purifications Applications, Oxford University Press
16. Simon Roe, Protein Purifications Techniques, Oxford University Press
17. Sumitra Sen & Dipak Kumar Kar, Cytology & Genetics, Narosa Publishing House
18. T.A. Brown, Essential Molecular Biology, Oxford University Press
19. T.E. Creighton, Protein Function-A Practical Approach, Oxford University Press
20. T.E. Creighton, protein Structure, Oxford University Press
21. Turner & White, Instant Notes-Molecular Biology, Tailor & Francis
22. Watson & Baker, Molecular Biology of the Gene, Pearson
23. William H. Elliot & Daphne C. Elliot, Biochemistry & Molecular Biology, Oxford Univ. Press
24. Wilson K. & Walker J., Biochemistry & Molecular Biology, Cambridge University Press

C4. Bryophytes, Pteridophytes, Gymnosperms and Palaeobotany

Theory

Full marks: 50

Total periods: 50

Bryophyta

1. **Introduction**-Diversity in forms and values, ecology and conservation
2. **Classification of Bryophyte**-Traditional and current concepts.
3. **Ancestry and phylogeny:** Charophycean ancestry of bryophyte and phylogeny of the early land plants, characteristics, affinities and systematic position of Sphaerocarpaceae, Takakiales.
4. **Brief idea about:**
 - a. Fossil bryophyte.
 - b. Apogamy and apospory in bryophytes.
 - c. Vegetative mode of reproduction of bryophytes.
 - d. Growth forms and life forms of bryophytes.
 - e. Photoperiodism in bryophytes.
 - f. Bryophyte chemistry and taxonomic implications.
 - g. Cytogenetics of bryophytes.

Pteridophyta

1. **Introduction:** Distribution of pteridophytes in time and space, diversity of ferns in an ecological perspective, endemic and endangered pteridophytes and their conservation, an outline of the system of classification of ferns by Copeland (1947), PichiSarmoli (1977).
2. **Vegetative and reproductive organography, evolutionary significance of:** i) Early vascular plants (Rhyniopsida, Zosterophylloids, Trimerophytopsida) ii) Lycopsida (Isoetales), iii) Sphenopsida (Sphenophyllales).
3. **Karyology and affinity of:** Marattiaceae, Ophioglossaceae, Osmundaceae, Cyatheaceae, Polypodiaceae, Salviniaceae.
4. **General account:** Gametophyte types, biochemical aspects of gametophyte differentiation, antheridogens- chemical nature and mode of action, determination of femaleness in free sporing heterosporous plants, phytochemistry of pteridophytes, soral evolution in ferns.

Gymnosperms

1. **Introduction:** Distribution of gymnosperms in time and space, conservation of endangered and endemic taxa.
2. **Progymnosperms:** Concept of progymnosperms, vegetative morphology, stelar organization and reproductive structures of Aneurophytales, Archaeopteridales and Protopytales, the plexus progymnosperms as the progenitor of gymnosperms.
3. **Evolution towards seed habit:** Emergence of seed plants, preovules, hydrasperman reproduction, evolution of closed carpel, evidences from the ovulate fructifications of Glossopteridales, Corystospermales, Caytoniales, Bennettitales, Pentoxylales.
4. **General account of extant gymnosperms:** Vegetative morphology and reproductive biology of extant Cycadales, Coniferales, Ginkgoales, Taxales and Gnetales.

Palaeobotany

1. **Basic geological information related to palaeobotany:** Sedimentary rocks, taphonomy; dating the pages of earth history, nomenclature and reconstruction of fossil plants, stratigraphy, basic concepts of continental drift and plate tectonics.
2. **Origin and evolution of plant life forms:** The earliest environments, brief idea of origin of life, first prokaryotes, evolution of eukaryotes, geological records of algae (stromatolites, diatoms, dinoflagellates), fungi (endomycorrhiza and epiphyllous fungi) and bryophytes; their ecological significance.
3. **The colonization of land:** Environmental changes before terrestrialization, land adaptive features, evolution of land plants- different evidences, biogeographical distribution of early land plants (Silurian- early Carboniferous), earliest trees in the fossil record.
4. **Applied Palaeobotany:** Fundamentals of palaeofloristics, palaeogeography, palaeoecology and palaeoclimatology, ancient DNA and other fossil biomolecules and their potential in evolutionary research, stable isotopes and tree ring in reconstruction of palaeoclimate, organic deposits of commercial value- coal, petroleum- their origin and depositional environment; coal and petroliferous basins of India.

Practical

Full marks: 25

Total periods: 20

Bryophyta

1. Study of vegetative and reproductive structures of Hepatics (any 2), Antherotopsida (any 1) and Mosses (any 3).
2. Identification: Hepaticopsida, Antherotopsida and Bryopsida (any 10)

Pteridophyta

1. Study of general habitat, external and internal morphology of vegetative and reproductive structures (spore types, soral anatomy etc.) (any 6) among the following taxa: *Angiopteris*, *Lygodium*, *Oleandra*, *Nephrolepis*, *Asplenium*, *Blechnum*, *Adiantum*, *Christella*, *Cyathea*/*Microsorium*, *Phymatosorus*, and *Salvinia*.
2. Identification of the following taxa (any 10): *Psilotum*, *Isoetes*, *Lycopodium phlegmaria*/*squarrosum*, *Lycopodium selago*, *Ophioglossum*, *Botrychium*, *Marattia*, *Cibotium*, *Drynaria*, *Acrostichum*, *Selaginella bryopteris*, *Pteris vittata*, *Pyrrosia*, *Helminthostachys*, *Cheilanthes*, *Onychium*, *Hymenophyllum*, and *Ceratopteris thalictroides*.

Gymnosperms

1. Study of general habit, external and internal morphology with special reference to their male and female reproductive structures (Any 6): *Cycas*, *Ginkgo*, *Pinus*, *Cryptomeria*, *Thuja*, *Araucaria*, *Podocarpus*, *Cephalotaxus*, *Taxus*, *Ephedra*, *Gnetum*.
2. Study of leaf and wood anatomy of the following taxa: *Abies*, *Cryptomeria*, *Cupressus*, *Araucaria*, *Taxus* and *Gnetum*.
3. Identification of the following taxa (any 6): *Zamia*, *Encephalartos*, *Tsuga*, *Taxodium*, *Cunninghamia*, *Juniperus*, *Callitris*, *Agathis*, *Welwitschia*, *Sequoia* and *Metasequoia*, *Podophyllum*, *Larix*

Palaeobotany

1. Types of fossils, and modes of preservation.
2. Techniques of study of plant fossils: Thin section method (demonstration and study of prepared slides), peel techniques (demonstration and study of prepared peel sections); maceration of peat, lignite, coal (demonstration).
3. Systematic study of fossil plants through ages- Stromatolites, Precambrian biota, *Cooksonia*, *Rhynia*, *Zosterophyllum*, *Lepidodendron*, *Sigillaria*, *Lepidophlois*, *Sphenophyllum*, *Calamites*, *Sharmastachys*, members of Filicopsida- Coenopteridales members of Lyginopteridales, Medullosales, Glossopteridales: upright *Glossopteris* plant, *Vertebraria* root, Peltaspermales, Caytoniales, Bennettiales, Cycadales, Ginkgoales, Pentoxylales, Cordaitales, Coniferales, angiosperm fossils (to be studied in stratigraphic sequence).

Suggested Reading:

1. A.Rashid, An Introduction to Bryophyte, Vikas Publishing House
2. A.V.S.S.Sambamurty, A Textbook of Bryophytes, Pteridophytes, Gymnosperm & Angiosperms, I.K.International Publishing House
3. Bernard Goffinet & Jonathan Shaw, Bryophyte Biology, Cambridge University Press
4. Christopher J.Cleal & Barry A.Thomas, Introduction to Plant Fossils, Cambridge University Press
5. David Evans, Instant Notes-Plant Biology, Tailor& Francis
6. E.M.Gifford & A.S.Foster, Morphology & Evolution of Vascular Plants, Freeman
7. G.C.S.Clarke & J.G.Duckett, Bryophyte Systematics, Academic Press
8. James D.Mauseth, Botany-An Introduction to Plant Biology, Jones & Bartlett
9. O.P.Sharma, Textbook of Pteridophyta.
10. R.N.Chopra & P.K.Kumra, Biology of Bryophytes, New Age International Publishers
11. S.P.Bhatnagar & Alope Moitra, Gymnosperms, New Age International
12. T.N.Taylor & E.N.Taylor, The Biology & Evolution of Fossil Plants, Prentice Hall
13. B.R.Vashista, Bryophyte, Pteridophyte & Gymnosperm, S.Chand & Co.
14. W.N.Stewart & G.W.Rothwell, Paleobotany, Cambridge University Press

SEMESTER II**C5. Mycology and Plant Pathology****Theory****Full marks: 50****Total periods: 50****Mycology**

1. **Fungal diversity:** The diversity of fungi and fungus like organisms.
2. **Taxonomy of fungi:** Traditional taxonomic methods, molecular methods of fungal taxonomy.
3. **Fungal growth:** The growth of hyphae, kinetics of fungal growth, the effect of environment on growth, the aeration complex, carbon sources, nitrogen sources, hydrogen ion concentration, temperature, light, water availability.
4. **Sporulation:** Biochemical and molecular changes accompanying sporulation, hormonal, environmental and nutritional factors affecting sporulation, spore dormancy and physiology of spore germination.
5. **Fungal genetics:** Structure and organization of the fungal genome, Genetic variation in fungi.

6. **Ecology:** Habitat relationship, diversity and mode of living of the different ecological groups of fungi, viz., decomposers, parasites, predators and symbionts, fungi in biodeterioration.
7. **Medical mycology:** Mycoses, mycotoxicoses, allergies, veterinary mycology.
8. **Mycorrhiza:** General features of VAM and AM, Taxonomy and evolution of Glomales, physiological and ecological studies.
9. **Fungal biotechnology:** Fungi in food processing (soya products, cheese, SCP from yeast and mycelial fungi), secondary metabolites of economic importance in medicines (antibiotics eg. Penicillins, pharmacologically active compounds and ergot alkaloids) and agriculture (strobilurins and gibberellins).
10. **Basic principles and methods of mushroom cultivation:** Pure culture of mushroom, spawn production, different types of composts and their preparation, spawn run and techniques of cultivation, cultivation processes of *Agaricus* and *Volvariella*, Edible and poisonous mushrooms; nutritional and biological values of mushrooms.

Plant Pathology

1. **How pathogens attack plants:** Mechanical and chemical bases of attack - enzymes, toxins, growth regulators in disease development, physiological and molecular changes during recognition between host and pathogen.
2. **Genetics of plant diseases:** Genetics of virulence in pathogens and of resistance in host plants, plant breeding for disease resistance using tissue culture and genetic engineering techniques.
3. **How plants defend themselves against pathogens:** Preexisting structural and chemical defenses, induced structural and biochemical defenses, immunization of plants against pathogens; systemic acquired resistance, defense through genetically engineered disease resistant plants, defense through RNA silencing by pathogen derived genes.
4. **Environmental effects on the development of infectious plant disease:** Effect of temperature, moisture, wind, light, soil p^H and soil structure, effect on host plant nutrition, effect of herbicide and air pollutants.
5. **Control of plant diseases:** By eradication or reduction of pathogen inoculums, cross protection, biological control, chemical control, control through use of transgenic plants, integrated disease management and basic strategies and techniques of a successful IPM.
6. **Study of the following diseases** with special reference to occurrence, symptoms, predisposing factors, disease cycle and control measures.
 - a. Viral disease: Potato mosaic and leaf roll, Yellow vein mosaic of Bhindi.
 - b. Bacterial disease: *Pseudomonas* wilt of solanaceous vegetables.
 - c. Mycoplasma disease: Club root of crucifer.

- d. Fungal diseases : *Fusarium* wilt of tomato , blast of rice, red rot of sugarcane, anthracnose and soft rot of fruits, downey and powdery mildew of cucurbits.

Practical

Full marks: 25

Total periods: 20

1. Isolation of microbes from water, soil and air by culture plate technique.
2. Isolation of pathogen from diseased tissues (leaf, stem and fruit).
3. Preparation of monosporous and polysporous culture and sub culturing.
4. Tissue- culture from mushroom fruit body
5. Inoculation of healthy potted plants
6. Study of hyphal types and hyphal system.
7. Study of production of organic acid / alcohol / enzyme.
8. Study of fungal nuclei.
9. Biological control by dual culture technique.
10. Vegetative and reproductive structure of some macro and micro fungi.
11. Studies on some locally available crop diseases (symptoms, histopathology and diagnostic characters of the disease).
12. Preparation of spawn and cultivation of *Pleurotus* spp

Suggested Reading:

1. A.V.S.S.Sambamurty, A Tetbook of Plant Pathology, I.K. International Publishing House
2. Alexopoulos & Blackwell, Introductory Mycology, John Willey & Sons
3. B.C.Suman & V.P.Sharma, Mushroom Cultivation in India, Daya Publishing House
4. Carlos Alborto brusso, Mohamed Hijri, Mycorrhizal Biotechnology, Capital Publishing
5. D.P.Tripathi, Mushroom Cultivation. Oxford & IBH Publication Company Pvt.ltd
6. Elizabeth Moore & Landecker, Fundamentals of the Fungi, Prentice Hall
7. G.N.Agrios, Plant Pathology, Elsevier Academic Press
8. G.Rangashwami & A.Mahadevan, Diseases of Crop Plants in India, Prentice Hall of India Pvt.ltd
9. Ganguli & Deshmukh, Fungi-Multifaceted Microbes, Anamaya Publishers New Delhi
10. J.H.Skeritt, New Diagnostic in Crop Sciences, CAB International
11. Jim Deacon, Fungal Biology, Blackwell
12. K.G.Mukherji, Taxonomy & Ecology of Indian Fungi, I.K. International Publishing House
13. K.R.Aneja, Experiments in Plant Pathology, Microbiology & Biotechnology, New Age International Publishers
14. Nick Talbot, Molecular & Cellular Biology of Filamentous Fungi, Oxford University Press
15. P.D.Sharma, Fungi & Allied Organisms, Narosa Publishing House
16. R.S.Mehrotra & K.R.Aneja, An Introductory Mycology, New Age International
17. R.S.Singh, Plant Diseases, Oxford & IBH Publication Company Pvt.ltd

18. R.S.singh, Principles of Plant Pathology, Oxford & IBH Publication Company Pvt.ltd
19. R.T.V.Fox, Principles of Diagnostic Techniques in Plant Pathology, Panima Publishing Corporation
20. S.C.Sati, Recent Mycological Research, I.K. International Publishing House
21. S.K.Deshmukh, Biodiversity of Fungi, Oxford & IBH Publication Company Pvt.ltd
22. T.N.Kaul, Biology & Conservation of Mushrooms, Oxford & IBH Publication Company Pvt.ltd
23. Trigiano & Windham, Plant Pathology, CRC Press
24. Vinod kumar Jain, Laboratory Manual of Plant Pathology, Oxford University Press
25. John Webster, Introduction to Fungi, Cambridge University Press

C6. Taxonomy of Angiosperms and Palynology

Theory

Full marks: 50

Total periods: 50

1. **Introduction:** Definitions of terms, systematics, taxonomy, classification, identification, nomenclature, aims and scope of taxonomy, history and phases of taxonomy.
2. **Data sources of Taxonomy:** Concepts of character, relevance of embryology, phytochemistry, ultrastructure (plastids types) and molecular taxonomy (brief account of DNA Taxonomy).
3. **Tools of Taxonomy:** Collection and preparation of herbarium specimens and botanic gardens, important herbaria and botanic gardens in India and all over the world, important classical books and floras, GIS (geographic information system)-its importance and application in India and throughout the world.
4. **Biosystematics:** Definition, steps, categories, methods, relationship with classical taxonomy.
5. **Concepts of Taxonomical Hierarchy:** Species/genus/family and other categories, species concept-variation, isolation, speciation.
6. **Nomenclature:** Aims, principles and rules of ICN, addition and alteration of last four codes and recommendations, types, priority and its limitations, effective and valid publication, preliminary ideas about nomenclature of fossil, hybrid and cultivated plants, proposed biocodes and phylocodes.

7. **Concepts and Principles of Assessing Relationship:** Phenetics and numerical taxonomy-principles, philosophies, methods, merits and demerits.
8. **Evolutionary Concept:** Basic ideas about following terms-Plagiomorphy and Apomorphy, Parallelism and Convergence, Homology and Analogy, Monophyly and Polyphyly; Concept of Heterobathmy, Cline, Polarity, Anagenesis, Cladogenesis, Sympleiomorphy, Synapomorphy, Autopomorphy, Stasigenesis, Catagenesis, Paraphyly, Holophyly, Homoplasy, Phylogram, Dendrogram and Cladogram, cladistics method.
9. **Major systems of angiosperm classification:** Outlines of classification, philosophies and principles, relative merits and demerits of Takhtajan (1997), Thorne (2007) and APG; concepts of Palaeoherbs, eu-dicot etc.
10. **Appearance of Angiosperms:** Evidence for the first angiosperms: leaves, flowers and pollen grains, place of origin and radiation.
11. **Angiosperm diversity:** Salient features, evolutionary trends and phylogeny in Magnoliidae, Hamamelidae, Caryophyllidae, Asteridae, Alismatidae and Liliidae (Sensu Cronquist, 1988).
12. **Biodiversity:** Concepts, levels, measurement, megadiversity centers, hotspots status (with special reference to India); Concerns- extinction and threats (IUCN categories and its activities), conservation (in-situ and ex-situ), needs and methods.
13. **Palynology:** Branches of palynology, spore, pre-pollen and pollen morphology, wall chemistry, evolution of aperture types, palynology in relation to taxonomy
14. **Applied palynology:** Application of neopalynology and palaeopalynology.

Practical

Full marks: 25

Total periods: 20

1. Workout of plant specimens and description of vegetative and reproductive characters from representative locally available families.
2. Training in using local flora and other literature and herbaria for identification of specimens described in the classes.
3. Study of various taxa of a genus, location of key characters and preparation of keys at specific level.
4. Field excursion for familiarization with and study of vegetation types and flora of areas outside the state and training in collection and preservation methodologies.
5. Acetolysis method (demonstration), study of morphology of modern spores and pollen grains; pollen analysis of honey.

Suggested Reading:

1. A.A.Farooqi & B.S.Sreeramu, Cultivation of Medicinal & Aromatic Crops, Universities
2. A.P.Das, Germplasm Collection in Garden of Medicinal Plants, University of North Bengal

3. A.V.S.S.Sambamurty, Taxonomy of Angiosperms, I.K. International Publishing House
4. B.K.Verma, Introduction to Taxonomy of Angiosperms, PHI learning Pvt.Ltd
5. B.P.Pandey, Taxonomy of Angiosperms, S.Chand & Co
6. D.M. Bhat & V.S. Swamy, Nursery Manual for Forest Tree Species, Universities Press
7. S.S. Bhojwani & S.P. Bhatnagar, The Embryology of Angiosperms, Vikas Publishing House
8. C.A.Stace, Plant taxonomy & Biosystematics, Edward Arnold
9. Charles B.Beck, An Introduction to Plant Structure & Development
10. Davis P.H. & Heywood, Taxonomy,
11. Dennis J.Mackennaetal, Botanical Medicines, Viva books Pvt.Ltd
12. J.H. Chowdhery & D.S. Pandey, Plants of Indian Botanic Garden,
13. K.G.Mukherji, Frontiers in Plant Sciences,
14. Nursadh Ali, Medicinal Plant Cultivation, Mittal Publication
15. S.N. Pandey & S.P. Misra, Taxonomy of Angiosperms, Ane Books pvt.ltd
16. R.K.Sinha, Practical taxonomy of Angiosperms, I.K. International Publishing House
17. Raj Kumar Gupta, Textbook of Systematic Botany, CBS Publication
18. Samuel B.Jones & Arlene E.Luchsinger, Plant Systematics,
19. M.S. Swaminathan & S.L. Kochhar, An Atlas of Major flowering trees in India,
20. Tood F.Stuessy, Plant taxonomy-the Systemic Evolution of Comparative Data,
21. V.S.Rao, Principles of Weed Science, Oxford & IBH Publication Company Pvt.ltd
22. Y.S.Sreenivas,Seed Technology & Seed Pathology, Oxford University Press

C7: Genetics and Molecular Biology

Theory

Full marks: 50

Total periods: 50

1. **Genetic analysis:** Overview of genetic analysis, Epistasis analysis of pathways; suppressor/enhancer screens, forward and reverse genetics, evolution of the concept of the gene, genetic definition of the gene, complex gene-protein relationships.
2. **Deoxyribonucleic acid:** Structure and properties of DNA, aberrant structures, conformation of A,B,Z- DNA, melting and reassociation of DNA, cot curves, repetitive and unique sequences.
3. **DNA replication-** Mode of replication of circular and linear DNA molecules, DNA polymerases-types, structure and function, machinery of DNA replication in prokaryotes and eukaryotes, replication of nucleosomes, extra chromosomal replicons, DNA damage and repair mechanism, PCR and applications.
4. **Ribonucleic acid:** RNA processing– Processing of tRNA, rRNA, mRNA processing- G capping, intron splicing, polyadenylation, mRNA localization, RNA transport.
5. **Transcription in prokaryotes and eukaryotes:** Promoters, enhancers, transcription factors, initiation, elongation and termination of transcription in prokaryotes and eukaryotes.

6. **Gene expression:** Control of gene expression, control of gene expression in bacteriophage lambda, T-phages; RNA phages, regulation of prokaryotic gene expression (lac, his, trp operons and catabolite repression), regulation of gene expression in eukaryotes, heterochromatin in gene silencing.
7. **Genome organization in Eukaryotes:** Types of genomes, genetic features of eukaryotic nuclear genomes, euchromatin and heterochromatin, development of gene concept, gene replication, organization of structural and functional elements of chromosome-centromere, telomere, heterochromatin and telomerase, sex chromosomes in plants, special chromosomes in different eukaryotes.
8. **Mutation and Evolution:** Mutagenesis: Transposon mutagenesis, in vitro mutagenesis, site-directed mutagenesis, environmental mutagenesis, repair and retrieval systems; genome duplication and alterations and their role in evolution, genes and gene number, law of constancy and C-value paradox, karyotype evolution and banding pattern.
9. **Mobile genetic elements:** Structure and function of transposable elements and their role in evolution. extranuclear genetics.
10. **Genetic Integrity and Diversity :** Physical and chemical basis of equational separation of chromosomes, recombination, mechanism of recombination, role of Rec A & Rec BCD & enzymes, site specific recombination, chromosomal mapping and linkage groups, evolutionary significance of recombination; genetic control of recombination.
11. **Population Genetics:** Definition of populations, gene 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.
12. **Genomics:** Genomics- an overview, correlated genetic, cytological, physical maps of chromosomes in plants; map position based cloning of genes, RNA and protein assays of genome function, evolution of genome in cereal grasses.
13. **Genomic Sequencing:** Genomic tools, sequencing technology, sequencing strategies, sequence databases (ESTs, BAC ends, genomic etc.).
14. **Proteomics:** Relation between gene and protein, approaches for study of proteomics, types of proteomics, structural proteomics, functional proteomics.

Practical

Full marks: 25

Total periods: 20

1. Estimation of RNA and protein.
2. Isolation of plant genomic DNA and estimation of purity by spectrophotometry and agarose gel electrophoresis.
3. Protein isolation by Gel electrophoresis: SDS-PAGE

4. Test of Significance, simple correlation of regression and analysis of variance.
5. NCBI and BLAST searches & multiple alignments.

Suggested Readings:

1. Suzuki & Griffith, Introduction to Genetic Analysis, Freeman
2. Benjamin & Lewin, Gene VIII, Pearson
3. Peter J. Russel, I Genetics, Pearson
4. William S. Klug & Michael R. Cummings, Concepts of Genetics, Pearson
5. R.J. Brooker, Genetics-Analysis & Principles, McGraw-Hill
6. T.A. Brown, Genome 3, Garland Science
7. Hartwell & Hood, Genetics-From Genes to Genomes, McGraw-Hill
8. Benjamin Lewin, Gene IX, Pearson
9. Benjamin Lewin, Gene X, Pearson
10. J.F. Gaudry, Functional plant Genomics, Science Publisher
11. S.B. Primrose, Principles of Gene Manipulation & Genomics, Blackwell
12. Benjamin A. Pierce, Genetics-A Conceptual Approach, Freeman
13. Hartl & Jones, Analysis of Genes & Genomes, Jones & Bartlett
14. Sumitra Sen & Dipak Kumar Kar, Cytology & Genetics, Narosa Publishing House
15. Arthur M. Lesk, Introduction to Genomics, Oxford University Press
16. Jocelyn Krebs & Elliot Goldstein, Lewin's Essential Genes, Jones & Bartlett
17. Archana Sharma, plant Genome-Biodiversity & Evolution vol1&2, Oxford & IBH Publication Company Pvt.ltd
18. Albert Roberts, Essential Cell Biology, Garland Science
19. Rastogi & Pathak, Genetic Engineering, Oxford University Press
20. Fletcher & Hickey, Instant Notes-Genetics, Taylor & Francis
21. J.T. Hancock, Molecular Genetics, Viva books Pvt.Ltd
22. Erich Grotewold, Plant Functional Genomics
23. Alice Marcus, Genetics, MJP Publication

C8. Instrumentation

Theory

Full marks: 25

Total periods: 25

1. **Colorimetry:** Principles and application of colorimetry in biological system.
2. **Spectrometry:** Basic principle, double beam UV/VIS and IR spectrometers, atomic absorption spectrometer, principle and instrumentation of fluorescence spectrophotometer, applications, MALDI-TOF, LC-MS-MS, GC-MS.
3. **Chromatography:** HPTLC, Electrophoresis: Basic principles, types and application.

4. **Microscopy:**

- a. Optical microscopes, phase, confocal, tunneling, ultraviolet and interference microscope- their basic principles; types of lens; optical systems and ray diagrams- their applications in cell biology; fluorescence microscope; micro spectrophotometry of cells and tissues,
- b. Electron microscopy: Electromagnetism; theory of magnetic and electrostatic lenses and their focal length; limiting resolution and useful magnification; contrast formation; shadowing and staining technique; scanning and transmission electron microscopy; specimen preparation techniques; application of electron microscopy in cell and molecular biology, ultramicrotome

5. **Sophisticated Instruments:** Fluorescence activated cell sorter (FACS), Micro array, NMR, FRET.

Suggested Reading:

1. Jane Roskams, Lab Ref, I.K. International Publishing House
2. N.Kanan, Handbook of Lab Cultural Media, Reagents, Stains & Buffer, Panima Publishing Corporation
3. Sean R.Gallagher & Emily A.Willey, Current Protocol Essential Laboratory Techniques

SEMESTER III

C9. Plant Physiology and Biochemistry:

Theory

Full marks: 50

Total periods: 50

1. **Photosynthesis:** Light harvesting complexes, mechanism of electron transport, photoprotective mechanisms, CO₂ fixation- C₃, C₄, & CAM, bacterial photosynthesis.
2. **Respiration:** Citric acid cycle, plant mitochondrial electron transport & ATP synthesis, alternate oxidase, bacterial respiration, photorespiratory pathway.
3. **Nitrogen metabolism:** Nitrate and ammonium assimilation, amino acid biosynthesis.
4. **Sulfur metabolism:** Sulfate uptake, transport and assimilation, synthesis and function of glutathione and its derivatives.
5. **Plant growth regulators and elicitors (Natural and synthetic):** Biosynthesis, storage, transport and physiological effects and mechanism of action of auxin, gibberellins, cytokinins, ethylene, abscisic acid, brassinosteroids, polyamines, jasmonic acid and salicylic acid oligosaccharins, synthetic regulatory substances and their applied aspects, hormonal control of regeneration

6. **Sensory photobiology:** Structure, location and mechanism of action of phytochromes, cryptochromes and phototropins, photoperiodism and biological clocks, molecular mechanism of action of photomorphogenic receptors, signaling and gene expression.
7. **The flowering process:** Floral evocation and flower development- physiological, genetic and molecular aspects, floriculture analysis, role and mechanism of vernalization.
8. **Stress Physiology:** Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses, mechanism of resistance to biotic stress and tolerance to abiotic stress.
9. **Senescence:** Hormonal and environmental control, programmed cell death in life cycle of plants.
10. **Enzymology:** General aspects, allosteric mechanism, isozymes, kinetics of enzymatic catalysis, orders of reactions, Michaelis-Menten equation and its significance
11. **Lipid Metabolism:** Biosynthesis and oxidation of fatty acids.
12. **Proteins:** Conformation of proteins (Ramachandran plot, secondary, tertiary and quaternary structure, domains, motifs & folds), Protein synthesis and processing (ribosome, formation of initiation complex, initiation factors and their regulation ,elongation and elongation factors, termination, aminoacylation of t-RNA, t-RNA – identity, amino-acyl tRNA synthetase, translational, proof-reading, translational inhibitors, post-translational modification of proteins), Protein purification and characterization.
13. **Nucleic acids:** Composition, three dimensional Structures; T_m values & Cot curves, synthesis of nucleotides, nucleic acid recognition by proteins, DNA-RNA binding motifs in proteins and its molecular aspects.

Practical

Full marks: 25

Total periods: 20

1. Isolation of chloroplast and determination of Hill activity.
2. Determination of amylase activity of monocot seeds in different stages of germination
3. Assay of Catalase, Peroxidase and Ascorbic acid oxidase of seedlings growing in different environment.
4. Tetrazolium test of seed viability.
5. Colorimetric estimation: IAA, DNA, RNA, protein, amino acids, protein purification by salting and isoelectric precipitation.
6. Qualitative tests of sucrose, glucose, maltose and arabinose
7. Demonstration of instruments: Ultracentrifuge, Spectrophotometer, Spectrofluorometer, Liquid Scintillation counter, Scanning electron microscope, GLC, HPLC.
8. Complexometric method of analysis of calcium and magnesium.

Suggested Reading:

1. Taiz & Zeiger, Plant Physiology, Sinauer
2. Lehninger, Nelson & Cox, Principles of Biochemistry, Freeman

3. Buchanan & Jones, Biochemistry & Molecular Biology of Plants, I.K. International Publishing House
4. A.K. Ghosh & S. Mukherjee, Plant Physiology, New Central Book Agency
5. Lubert Stryer & Berg, Biochemistry, Freeman
6. P.S.Nobel, Physiochemical & Environmental Plant physiology, Elsevier
7. Hans-Walter-Heldt, Plant Biochemistry, Academic Press
8. Hames & Hooper, Instant Notes-Biochemistry, Tailor & Francis Group
9. Roodney Boyer, Biochemistry, Pearson
10. V.Verma, Textbook of Plant Physiology, Ane Books Pvt.Ltd
11. Voet & Voet, Principles of biochemistry, Willey
12. Gerhard Krauss, Biochemistry of Signal Transduction & Regulation, Willey
13. Salisbury & Ross, Plant Physiology, WADSWORTH
14. Garrett & Grisham, Biochemistry, Brooks-Cole
15. S.S.Narwal & R.Bogatek, Plant Biochemistry
16. S.C.Rastogi, Biochemistry, Tata Macgraw-Hill Education Pvt.Ltd
17. B.C.Joshi & Suresh C.Ameta, Chemistry of Natural Products, Himanshu Publishing
18. Narendra K.Gupta & Sunita Gupta, Plant Physiology, Oxford & IBH Publication Company Pvt.ltd
19. William G.Hopkins, Introduction to Plant Physiology, Willey
20. Thomas M.Devlin, Text book of Biochemistry with Clinical correlations, Willey
21. Florence k.Gleason, plant Biochemistry, Jones & Bartlett Learning
22. M.Amin, Active Transport in Plants, Capital Publishing Company
23. M. Riott, Essential Immunology, Oxford University Press
24. J.Kuby, Immunology, Freeman
25. Abul K. Abbas, Cellular & Molecular Immunology, Elsevier

C10. Phytochemistry and Pharmacognosy

Theory

Full marks: 25

Total periods: 25

1. **Introduction:** History and scope, classification and pharmacological action of plant drugs.
2. **Primary metabolites:** a) Proximate principle: Carbohydrates – starch, cellulose derivatives, gums; Lipids- saturated, unsaturated fatty acids and essential fatty acids. b) Preventive: Vitamins.
3. **Secondary metabolites:**
 - a. Origin: Brief account of acetate malonate, acetate mevalonate and shikimic acid pathway.
 - b. General accounts on official drugs: definition, properties, classification of a). Glycosides: general account, glycosidal drugs, cyanogenic glycosides and glucosinolate compounds. b). Alkaloids: definition, properties, classification; alkaloidal drugs (Examples- *Datura stramonium*, *Atropa belladonna*, opium, *Cinchona*, tea, ergot, *Rauvolfia*, *Holarrhena*, *Catharanthus* - constituents and uses)
 - c). Phenolic compound: types, biological activity, drugs - Senna, *Aloe*, *Hypericum*,

Capsicum. d). Resinous compounds: types, biological activity and pharmaceutical importance.

c. Methods of extraction, isolation and characterisation of secondary metabolites.

4. **Brief account on:** Antioxidant, Adaptogen, Excipients, Hallucinogen, Teratogen, Pesticides, Repellents, Fumigants, Pharmacokinetics, Pharmacodynamics, Polyvalency and Synergy.
5. **Volatile oils:** composition, biological activity of clove, *Mentha*, *Eucalyptus*, *Foeniculum*, *Cinnamomum*, citronella
6. **Quality control measures of plant drugs:** Brief account on quality control, quality assessment and quality testing of plant drugs.

Practical

Full marks: 25

Total periods: 20

1. Choice of solvent for extraction of alkaloids, phenols.
2. Chemical tests for the detection of alkaloids, phenols, anthraquinones, cardenolides, anthocyanins, betacyanins, carotenoids.
3. Extraction and chromatographic detection of some common plant drugs.(Alkaloids viz. Caffeine, Reserpine and Phenols).
4. Organoleptic and microscopic evaluation of selected powdered and whole plant drugs (organized) & Study of unorganized drugs – starches, gums, resins, Tragacanth and Galls. etc.
5. Quantitative Microscopy and Techniques of studying stomatal index, vein islet number, palisade ratio.

Suggested Reading:

1. Mohammad Ali, Textbook of Pharmacognosy, CBS Publication
2. Trease & W.C. Evans, Pharmacognosy, Saunders Elsevier

C11. Plant Biotechnology

Theory

Full marks: 25

Total periods: 25

1. **Recombinant DNA technology:** Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems, expression of recombinant proteins using bacterial and plant vectors, isolation of specific nucleic acid sequences, genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors, site directed mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms, gene targeting
2. **Molecular Breeding and development of hybrid cultivars:** Quantitative and qualitative traits, classes of molecular markers, detecting DNA polymorphisms (RFLP, RAPD, AFLP, ISSR), genetics of mapping molecular loci, specialized mapping techniques, genetic mapping, physical mapping, chromosomal mapping, QTL, mapping QTL with molecular markers, application of markers.

3. **Genetic engineering of plants:** Aims and strategies for development of transgenics with suitable examples, *Agrobacterium*- the natural genetic engineer, Ti - plasmid and expression of cloned genes, genetically engineered or genetically modified crops, methods of gene delivery, applications and achievements of GM crops, terminator gene technology intellectual property rights, possible ecological risks and ethical concerns.
4. **Single cell and Suspension culture:**, Single cell culture, initiation and growth, application of single cell culture.
5. **Haploid and Triploid culture:** General account and its applications in genetics and crop improvement.
6. **Protoplast culture and somatic hybridization:** Principle and scope of protoplast culture and somatic hybridization, nuclear and cytoplasmic hybrids, selection of hybrids, regeneration, possibilities, applications, limitations.

Practical

Full marks: 25

Total periods: 20

1. Plant tissue culture techniques –
 - a. Sterilization techniques
 - b. Media preparation.
 - c. Embryo culture, callus initiation and subculturing (micropropagation), chromosome from callus tissue.
2. Plasmid DNA isolation.
3. PCR amplification of DNA

Suggested Readings:

1. Amla Batra, Fundamentals of Plant Biotechnology, Capital Publication
2. Ashok Ganguli, Applied Biotechnology & Plant Genetics, Oxford University Press
3. B.N.Satyanarayana, Plant Tissue Culture Practices & New experimental Protocols
4. B.R.Glick & J.J.Pasternak, Molecular Biotechnology,
5. Bhojwani & Rajdan, Plant Tissue Culture, Panima Publishing Corporation
6. C.C.Giri & Archana Giri, Plant Biotechnology practical manual, I.K. International Publishing House
7. Chrispeels, Plant Genes & Crop Biotechnology, Jones & Bartlett
8. Darbhashwar Roy, Plant Cell Biotechnology, Narosa
9. Edwin F.George & Michael A.Hall, Plant Propagation Tissue Culture, Springer
10. H.D.Kumar, Modern Concepts Of Biotechnology, Vaikash
11. H.S.Chawla, Introduction to Plant Biotechnology, Oxford & IBH Publication Company Pvt.ltd

12. Hartmann & Kester, Plant Propagation-Principles & Practice, PHI
13. Iqbal Hussain, Fundamentals of Plant Breeding, Oxford Book Company
14. J.H.Schlegel, Dictionary of Plant Breeding, Viva books Pvt.Ltd
15. J.Hammond & V.Yusibov, Plant Biotechnology-New Product & Applications, Springer
16. Jogtand, Gene Biotechnology, Himalaya Publishing House
17. Kalyan Kumar De, Plant Tissue Culture, New Central Book Agency
18. Kreuzer, Recombinant DNA & Biotechnology, ASN Press
19. Kumar Das, Biodiversity Biotechnology & Traditional Knowledge, Narosa
20. Kumar, method in Plant Tissue Culture, Agrobios
21. Patro, Recent Trends In Biotechnology, Sonali Publishers
22. Prativa Pradhan, Plant Biotechnology, Author's Press
23. R.C. Dubey, Plant Biotechnology, S.Chand
24. Ranawat & Goyal, Molecular Biology & Biotechnology, S.Chand
25. Roy & Roy, Biodiverwsity & Biotechnology, New Central Book Agency
26. S.S. Purohit, Biotechnology, Student Edition
27. Sharma, Plant Embryology, Narosa
28. Singh & Chowdhury, Dictionary of Biotechnology, Jnanada Publishing
29. T.B.Jha & Biswajit Ghosh, Plant Tissue Culture, Universities Press
30. V.L.Chopra, Plant Breeding, Oxford & IBH Publication Company Pvt.ltd
31. William Pains, Biotechnology from A-Z, Oxford University Press

C12: Plant Anatomy and Developmental Biology

Theory

Full marks: 25

Total periods: 25

1. **General Aspects:** Novel features of plant growth and development, concepts of plasticity in plant development, analyzing plant growth.
2. **Shoot, Leaf and Root development-** Organization of Shoot Apical Meristem (SAM), control of cell division and cell-to-cell communication, molecular analysis of SAM, leaf development and differentiation, organization of Root Apical Meristem (RAM); cytohistological logical zonation of SAM, root hair and trichome development, cell fate and lineages.
3. **Seed germination and seedling growth-**Mobilization of food reserves during seed germination, tropism, hormonal control of seed germination and seedling growth.
4. **Differentiation of primary and secondary plant bodies-** Ontogeny, differentiation of sclerides, fibres and their control of differentiation, vascular cambium, factors influencing cambial activity.

5. **Physiological Plant Anatomy**-Anatomical response to mineral deficiency, response of plant to wounding and invasion of microorganisms.
6. **Plant anatomy in systematics and evolution:** Xylem evolution, wood anatomy, nodal anatomy, floral vasculature, mineral inclusion in systematics and evolution.
7. **Ecological anatomy:** Leaf and wood anatomy in ecological perspective, anatomical response to pollutants.
8. **Applied plant anatomy:** Application of anatomical studies in climatology, genetics and plant breeding, biomedical research and forensic science.

Practical

Full marks: 25

Total periods: 20

1. Cell types- trichomes, sclerides, tracheids, vessel members and sieve tube elements.
2. Secretory structures and cell inclusions- necteries, glandular hairs, oil glands, salt glands, resin canals, laticifers, cystolith and crystals.
3. Nodal anatomy- unilacunar , trilacunar, multilacunar.
4. Secondary phloem from TS, TLS, RLS of the bark and anatomy of lenticels.
5. Wood anatomy from TS, TLS, RLS of woods.
6. Study of shoot apical organization in pteridophytes, gymnosperms and angiosperms.
7. Anatomy of sun and shade leaves, xeromorphic leaves, succulent leaves, halophyte leaves, hydromorphic leaves.

Suggested Reading:

1. A.Fahn, Plant Anatomy, Aditya Bokks Pvt. Ltd
2. B.P.Pandey, Plant Anatomy, S.Chand & Co
3. Cutler & Botha, Plant Anatomy, Blackwell
4. D.Briggs & S.M.Walters, Plant Variation & Evolution, Cambridge University Press
5. Dr. G. Haberlandt, Physiological Plant Anatomy, Today & Tomorrows Book Agency
6. K.Esau, Anatomy of Seed Plants, John Willey & Sons
7. Pijush Roy, Plant Anatomy, New Central Book Agency
8. Ray F.Evart, Esau's Plant Anatomy, Willey
9. Streamns & Hoekstra, Evolution, Oxford University Press
10. William C.Dickinson, Integrative Plant Anatomy, Harcourt Academic Press

C13. Plant Ecology

Theory

Full marks: 25

Total periods: 25

1. **Introduction:** Concepts of habitat and ecological niche, limiting factors.
2. **Population Ecology:** Characteristics of population, intra and interspecific competition, life-history strategies (r and k selection)
3. **Community Ecology:** a) Concept of community and continuum, ordination, nature of communities, community structure and attributes, species diversity, dominance and their measurements. b) Vegetation developments, temporal changes, types and mechanism of succession (models), the climax concept.
4. **Ecosystem Ecology:** Structure and function, primary production, energy dynamics, biogeochemical cycles.
5. **Biogeographical Ecology:** Terrestrial (forest, grassland), aquatic (freshwater, marine), wetlands and mangroves.
6. **Applied Ecology:** Environmental pollution, climate change (green house effect, ozone hole)
7. **Ecological Disturbances:** Natural and anthropogenic causes with special reference to India

Practical

Full marks: 25

Total periods: 20

1. **Water analysis:** a. Determination of p^H , transparency, total solids (total dissolved solids + total suspended solids). b. Estimation of alkalinity, chloride, DO, free CO_2 , primary productivity.
2. **Soil analysis:** Determination of soil moisture content, water holding capacity, chemical properties of soil by rapid spot test, determination of organic matter, estimation of organic carbon percentage (Walkley Black's method).
3. **Plant analysis:** Comparative anatomical studies of polluted and unpolluted leaves, determination of leaf area injury, estimation of foliar dust deposition
4. **Community study:** a. Selection of sampling procedure- transect, Quadrat, Determination of minimum size and minimum number of Quadrat/transect. b. Analysis of community structure- density, frequency, abundance, basal area of woody species, diameter at breast height (DBH), relative density, relative frequency, relative basal area (RBA), important value index (IVI), estimation of above ground biomass and moisture content, determination of life forms by Raunkier's method.

Suggested Reading:

1. A.P.Das, Perspectives of Plant Biodiversity, Bishen Singh Mahendra Pal Singh

2. A.V.S.S.Sambamurty, N.S.Suvramaniyam, Ecology,
3. Ashish Ghosh, Biodiversity Conservation, APH Publishing House
4. Asthana & Asthana, Environment-Problem & Solution, S.Chand & Co
5. Chapman & Reiss, Ecology, Cambridge University Press
6. Deeksha Dave, S.S.Katewa, Textbook of Environmental Studies, Cenage
7. Dr.K.Raghavan & Nambiar, Textbook of Environmental Studies
8. E.P.Odum, Fundamentals of Ecology Brooks-Cole
9. Eug.Warming, Ecology of Plants, Biotech Books
10. Fox, The Ecology of Plants, Silvauer Associates Publishers
11. Learning
12. Mackenzie & Ball, Instant Notes-Ecology, Tailor & Francis
13. P.C.Joshi & Namita Joshi, Biodiversity & Conservation, APH Publishing House
14. Promod Tandon, Biodiversity & Its Significance, I.K. International Publishing House
15. Robert Ricklefs & Gary L.Miller, Ecology,
16. Sengupta, Biodiversity & Quality of Life, INSEE
17. Shukla & Chandel, A Textbook of Plant Ecology, S.Chand & Co.
18. R. Smith & T. Smith, Ecology & Field Biology, Benjamin Cummings
19. T.Pullaiiah, Biodiversity in India, vol 1-4, Regency Publication
20. Tiwari, Environmental Studies, I.K. International Publishing House
21. Verma & Agarwal, Environmental Biology, S.Chand & Co
22. Virendra Batra, Plant Ecology, Oxford University Press
23. W.P.Cunningham, Principles of Environmental Sciences, McGraw-Hill
24. Walter Lacher, Physiological Plant Ecology, Springer

SEMESTER IV

C15. Special Paper (Any one of the following four):

Sp1. Applied Mycology and Molecular Plant Pathology

Theory

Full marks: 75

Total periods: 100

Applied Mycology

1. **Cell cycle in yeast:** Cell cycle organization in yeast; cell cycle genetics in yeast, cyclins and cyclin-dependant kinases, regulation of G1-S and G2-M control points.
2. **Carbohydrate and energy metabolism in fungi:** Molecular analysis of carbon catabolite repression in filamentous fungi, nitrogen and lipid metabolism; polyamines in fungi (metabolism and functions), secondary metabolism in fungi.
3. **Signal transduction pathways in fungi:** Signal transduction pathways in fungi mediated by heteromeric G proteins, morphogenetic signaling pathways in *Candida albicans*.

4. **Heat shock proteins** and stress responses in fungi.
5. **Gene manipulation of fungi by transformation:** Gene regulation in yeast and mycelial fungi; application of functional genomic techniques in fungal research; extra chromosomal and transposable genetic elements in fungi.
6. **Fermentation technology:** Liquid and solid state fermentation.
7. **Heterologous gene expression in yeast and filamentous fungi.**
8. **Bioremediation and biodegradation:** Fungi in bioremediation, Wood degradation by brown rot and white rot fungi, enzymatic mechanisms for cellulose degradation by fungi
9. **Mushroom biology:** Physiology and biochemistry; genome analysis and genetic improvement of edible mushrooms; techniques for molecular characterization; medicinal value of mushrooms, role in HIV treatment, diseases of mushrooms, biocontrol of insect pest in mushroom beds.

Plant Pathology

1. **Epidemiology:** Role of host, pathogen and environment in development of epidemics modeling of plant disease and computer simulation, new tools in epidemiology, disease warning systems.
2. **Physiology and biochemistry of infected plants:** Effect of viral, bacterial and fungal infection on translocation, photosynthesis, respiration, cell permeability, transcription and translocation.
3. **Signaling in plant disease resistance mechanisms:** Signaling pathways involving salicylic acid, jasmonates, ethylene, Map kinases (MAPK), increase in cytosolic calcium, oxidative burst; nitric oxide (NO), low molecular weight signaling molecules, RNA as a signal, interplay of downstream signaling pathways (EDS1 and NDR1 pathways, role of NPR1).
4. **Antimicrobial compounds in plants:** Plant chemicals (phenolics) involved in resistance, phytoalexins (biosynthesis, role in defence mechanism, detoxification, elicitors of phytoalexins, manipulation of phytoalexin synthesis in plants), pathogenesis related proteins, defence related enzymes.
5. **Biological control by biotechnological methods:** Physiological and molecular basis of competition, predation, parasitism and antibiosis including the nature of biomolecules involved in these mechanisms, use of hyperparasites and hypovirulence plasmid in disease management.
6. **Molecular diagnosis of plant pathogens:** Use of antibodies (polyclonal antibodies, monoclonal antibodies, recombinant DNA techniques), serological tests (ELISA, immunofluorescence, lateral flow techniques), nucleic acid based techniques (identification of pathogen specific markers, hybridization techniques, PCR based techniques, gene array based techniques), protein analysis; fatty acid profiles (FAME analysis).

7. Disease management:

- a. Quorum sensing and type III secretion system in bacterial plant pathogens for disease management, interactions between plant and virus proteomes in susceptible host (new targets for antiviral strategies).
- b. Transgenic approaches for crop protection: Pathogen derived resistance, plantibodies, overexpressing defence genes, use of cloned resistance genes, engineering broad spectrum resistance, resistance based on antagonistic microbes.

Practical

Full marks: 50

Total periods: 40

Practical based on theory paper.

Suggested Reading:

1. A.V.S.S.Sambamurty, A Tetbook of Plant Pathology, I.K. International Publishing House
2. Alexopoulos & Blackwell, Introductory Mycology, John Willey & Sons
3. Aulay Mackenzie, Instant Notes-mathematica & Statistics for life Scientists, Tailor & Francis Group
4. B.C.Suman & V.P.Sharma, Mushroom Cultivation in India, Daya Publishing House
5. Carlos Alborto brusso, Mohamed Hijri, Mycorrhizal Biotechnology, Capital Publishing
6. D.P.Tripathi, Mushroom Cultivation. Oxford & IBH Publication Company Pvt.ltd
7. Elizabeth Moore & Landecker, Fundamentals of the Fungi, Prentice Hall
8. G.N.Agrios, Plant Pathology, Elsevier Academic Press
9. G.Rangashwami & A.Mahadevan, Diseases of Crop Plants in India, Prentice Hall of India Pvt.ltd
10. Ganguli & Deshmukh, Fungi-Multifaceted Microbes, Anamaya Publishers New Delhi
11. J.H.Skeritt, New Diagnostic in Crop Sciences, CAB International
12. Jim Deacon, Fungal Biology, Blackwell
13. K.G.Mukherji, Taxonomy & Ecology of Indian Fungi, I.K. International Publishing House
14. K.R.Aneja, Experiments in Plant Pathology, Microbiology & Biotechnology, New Age International Publishers
15. Nick Talbot, Molecular & Cellular Biology of Filamentous Fungi, Oxford University Press
16. P.D.Sharma, Fungi & Allied Organisms, Narosa Publishing House
17. R.S.Mehrotra & K.R.Aneja, An Introductory Mycology, New Age International
18. R.S.Singh, Plant Diseases, Oxford & IBH Publication Company Pvt.ltd
19. R.S.singh, Principles of Plant Pathology, Oxford & IBH Publication Company Pvt.ltd
20. R.T.V.Fox, Principles of Diagnostic Techniques in Plant Pathology, Panima Publishing Corporation

21. S.C.Sati, Recent Mycological Research, I.K. International Publishing House
22. S.K.Deshmukh, Biodiversity of Fungi, Oxford & IBH Publication Company Pvt.ltd
23. T.N.Kaul, Biology & Conservation of Mushrooms, Oxford & IBH Publication Company Pvt.ltd
24. R.N. Trigiano & M.T. Windham, Plant Pathology, CRC Press
25. Vinod Kumar Jain, Laboratory Manual of Plant Pathology, Oxford University Press
26. J. Webster, Introduction to Fungi, Cambridge University Press

Sp2. Cell Biology, Molecular Genetics and Plant Biotechnology

Theory

Full marks: 75

Total periods: 100

1. **Techniques in cell biology:** Blotting technique-Northern, Southern and Western, Immunotechnique, Flow cytometry.
2. **Molecular Evolution:** Evolution of gene structure, protein domains, ribozyme and RNA World, micro RNA, si RNA and importance of RNAi in differentiation and evolution, evolution of major phyletic lines; antiquity of introns, transposable elements evolution and horizontal transfer, molecular clock, molecular phylogeny.
3. **Microscopic Techniques:** Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, confocal Microscopy.
4. **Radiolabelling Techniques:** Properties of different types of radioisotopes normally used in Biology, their detection and measurement; incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.
5. **Genetic Transformation:** Cloning vectors, vector construction, protoplast system (Electroporation and PEG) biolistic system, screenable and selectable markers and their use, chloroplast transformation, marker-free methodologies, gene stability, inheritance and differential expression of transgenes in plants.
6. **Polymorphism and Sequence:** Protein sequencing methods, detection of post-translation modification of proteins, DNA sequencing methods, strategies for genome sequencing, methods for analysis of gene expression at RNA and protein level, large scale expression analysis, such as micro array based techniques, isolation separation and analysis of carbohydrate and lipid molecules, RFLP, RAPD, AFLP, ISSR, SSR, SNP, techniques.
7. **Molecular Breeding for biotic stress tolerance:** Fungal resistance, insect resistance, virus resistance, transgenes, pyramiding and integrated pest management (IPM).
8. **Weed management:** Implications of herbicide resistant crops.
9. **Pest management in crop plants:** Biopesticides, built-in plant protection (Bt Technology) safety and environmental issues
10. **Molecular Breeding for abiotic stress tolerance:** Stress regulated gene expression, osmotic stress signaling, application in salt, cold and drought tolerance in plants.

11. **Biofortified crops:** Improvement of micro nutrients in food crops e.g. iron and provitamin A enriched rice, vitamin E maize, protein improvement in rice and potato etc.
12. **Plants as biofactories-** Concept of bio-pharming; renewable biofuel production in plants.
13. **Economic and social aspects of biotech-crops:** *ex- ante* analysis and commercial release of GM crops, environmental aspect of GM crop management and regulatory system of transgenic crops.
14. **Genes controlling flower development in plants:** Mendelian genetics to molecular sequence, the steps of flower development – genes are implicated, Mendelian genes define the commitment to flowering, Mendelian genes define floral organ identity; Cloning commitment to flowering and flower organ genes, MADS –box genes, analysing gene expression with *in situ* hybridization, molecular expression of floral commitment genes, molecular expression of floral organ genes.
15. **Gene discovery in plant metabolism:** Genetic characterization of molecular mechanism driving plant natural product biosynthesis, combinatorial biochemistry and metabolomes.
16. **Organogenesis:** Process, developmental sequences, mechanism of action of plant hormones, multiple hormonal control on organogenesis.
17. **Embryogenesis:** Mechanisms that establish cell fate in the embryo, role of phytohormone in embryogenesis, somatic embryogenesis-structural and developmental ontogeny, physiological and biochemical aspect of somatic embryogenesis.
18. **Micropropagation:** Methods and stages of clonal propagation; production of virus-free plants, virus-free assessment methods, genetic assessment by RAPD and ISSR markers, Field evaluation, certification for quality plants, packaging technology and transport methods.
19. **Somatic cell genetics:** Somaclonal variation, genotypic and phenotypic variations in cell cultures and in regenerated plants, origin, types, chromosomal and genetic basis of somaclonal variation, applications in crop improvement.

Practical

Full marks: 50

Total periods: 40

Practical based on theory paper.

Suggested Reading:

1. B. Alberts, Molecular Biology of the Cell, Garland Science
2. Burton E. Tropp, Molecular Biology, Jones & Bartlett
3. Cooper & Hausman, The Cell-A Molecular approach, ASN Press
4. David P. Clark, Molecular Biology, Elsevier
5. E.D.P. De Robertis & B.M.F. De Robertis, Cell & Molecular Biology, Lipincott Williams & Wilkins

6. George M. Malacinski, Essentials of Molecular Biology, Narosa Publishing House
7. Gerald Karp, Cell & Molecular Biology, Willey
8. Jayanta K. Pal, Fundamentals of Molecular Biology, Oxford University Press
9. Lodish & Berk, Molecular Cell Biology, Freeman
10. M.Gilmartin & Bowler, Molecular Plant Biology vol1&2, Oxford University Press
11. N.Vidyavati & D.M.Chetan, Molecular Biology, I.K. International Publishing House
12. Robert F.Weaver, Molecular Biology, McGraw-Hill
13. Simon Roe, Protein Purifications Applications, Oxford University Press
14. Simon Roe, Protein Purifications Techniques, Oxford University Press
15. T.A.Brown, Essential Molecular Biology, Oxford University Press
16. T.E.Creighton, Protein Function-A Practical Approach, Oxford University Press
17. T.E.Creighton, protein Structure, Oxford University Press
18. Turner & White, Instant Notes-Molecular Biology, Tailor & Francis
19. Watson & Baker, Molecular Biology of the Gene, Pearson
20. William H.Elliot & Daphne C.Elliot, Biochemistry & Molecular Biology, Oxford Univ. Press
21. K. Wilson & J. Walker, Biochemistry & Molecular Biology, Cambridge University Press
22. David O.Morgan, The Cell Cycle, Oxford University Press
23. T.D. Pollard, Cell Biology, Saunders
24. Sumitra Sen & Dipak Kumar Kar, Cytology & Genetics, Narosa Publishing House

Sp3. Plant Physiology, Biochemistry and Molecular Biology

Theory

Full marks: 75

Total periods: 100

1. **Membrane transport and translocation of water and solutes:** Comparison of xylem and phloem transport, root – microbe interactions in facilitating nutrient uptake, membrane transport proteins, solute transport: passive and active solute transport.
2. **Signal transduction:** Overview, receptors and G-proteins, phospholipid signaling, role of cyclic nucleotides, calcium - calmodulin cascade, diversity in protein kinases and phosphatases, specific signaling mechanisms, two component sensor-regulator system in bacteria and plants, sucrose sensing mechanism.
3. **Cytosolic carbon metabolism:** Biosynthesis of storage and structural carbohydrates and their regulation, hexose monophosphate ‘junction and sink source’ relations in cytoplasm.
4. **Protein sorting and vesicle traffic:** Machinery of protein sorting, targeting to mitochondria, plastids, peroxisomes, ER, vacuoles, protein modification in golgi apparatus.
5. **Nitrogen metabolism:** N₂ fixation enzymology and genetics, regulation of nitrogen metabolism.
6. **Protein:** Protein purification, characterization, methods for the determination of amino acid sequences in proteins.

7. **Proteomic analysis:** Protein databases, alignment of protein sequence and structures, prediction of coiled-coil, Leucine Zipper and PEST region, secondary structure prediction by neural network models, comparative three dimensional protein structure modeling.
8. **Immunology:** Antigen structure and function of different classes of immunoglobulins, primary and secondary immune response, humoral and cell mediated immunity, mechanism of the immune response, effector mechanisms, application of immunological techniques, plant immune response.
9. **Regulation and Gene expression in plants:** Plant gene structure and expression, regulatory mechanisms- control of transcription, post transcriptional control of gene expression, other regulatory mechanisms.
10. **Instrumentation:** Paper, thin layer and column chromatography, molecular exclusion, ion exchange, partition, adsorption and affinity chromatography, HPLC and GLC, Electrophoresis: PAGE, SDS-PAGE, isoelectric focusing and 2D Radioisotope techniques.
11. **Alkaloids and Phenols:** Classification, biosynthesis, benefits of polyphenols, phenolic antioxidants, biotechnological applications of alkaloids, ecological significance.
12. **Plasmid:** Classification, replication and maintenance.
13. **Genomics:** Definition, aspects of genomics, analyzing a genome, computer tools.
14. **Food security and Biosafety:** Molecular characterization of transgenic events, Food and biosafety, Risk assessment, IPR and transboundary movement of biotech seeds and materials, Economic impact of transgenic crops.
15. **Metabolomics:** Networking and application.

Practical

Full marks: 50

Total periods: 40

Practical based on theory paper.

Suggested Reading:

1. Rashid. Molecular physiology and biotechnology of flowering plants. Narosa
2. Abul K. Abbas, Cellular & Molecular Immunology, Elsevier
3. B.C.Joshi & Suresh C.Ameta, Chemistry of Natural Products, Himanshu Publishing
4. Buchanan & Jones, Biochemistry & Molecular Biology of Plants, I.K. International Publishing House
5. Florence k.Gleason, plant Biochemistry, Jones& Bartlett Learning
6. G.C. Garrett & Grisham, Biochemistry, Brooks-Cole
7. George M. Malacinski, Essentials of Molecular Biology, Narosa Publishing House
8. Gerhard Krauss, Biochemistry of Signal Transduction & Regulation, Willey
9. A.K. Ghosh & S. Mukherjee, Plant Physiology, New Central Book Agency
10. D. Hames & N.Hooper, Instant Notes-Biochemistry, Taylor & Francis Group
11. Hans-Walter-Heldt, Plant Biochemistry, Academic Press
12. J.Kuby, Immunology, Freeman

13. Leninger, Nelson & Cox, Principles of Biochemistry, Freeman
14. M. Riott, Essential Immunology, Oxford University Press
15. M.Amin, Active Transport in Plants, Capital Publishing Company
16. Narendra K.Gupta & Sunita Gupta, Plant Physiology, Oxford & IBH Publication Company Pvt.ltd
17. P.S.Nobel, Physiochemical & Environmental Plant physiology, Elsevier
18. R.M. Twyman. Advanced Molecular Biology: Aconcise reference. Viva Books Private Limited.
19. Roodney Boyer, Biochemistry, Pearson
20. S.C.Rastogi, Biochemistry, Tata Macgraw-Hill Education Pvt.Ltd
21. S.S.Narwal & R.Bogatek, Plant Biochemistry
22. Salisbury & Ross, Plant Physiology, WADSWORTH
23. Simon Roe, Protein Purifications Applications, Oxford University Press
24. Simon Roe, Protein Purifications Techniques, Oxford University Press
25. Stryer & Berg, Biochemistry, Freeman
26. T.E.Creighton, Protein Function-A Practical Approach, Oxford University Press
27. T.E.Creighton, protein Structure, Oxford University Press
28. Taiz & zeiger, Plant Physiology, Sinauer
29. Thomas M.Devlin, Text book of Biochemistry with Clinical correlations, Willey
30. V.Verma, Textbook of Plant Physiology, Ane Books Pvt.Ltd
31. Voet & Voet, Principles of biochemistry, Willey
32. William G.Hopkins, Introduction to Plant Physiology, Willey
33. William H.Elliot & Daphne C.Elliot, Biochemistry & Molecular Biology
34. K. Wilson & J. Walker, Biochemistry & Molecular Biology, Cambridge University Press

Sp4. Taxonomy of Angiosperms and Palynology

Theory

Full marks: 75

Total periods: 100

1. **History of taxonomy in India:** Contribution of W. Roxburgh, N. Wallich, J.D. Hooker, C.B. Clarke, G. King, D. Prain, K.P. Biswas, D. Chatterjee, H. Santapau
2. **Taxonomic Literature:** Definition with examples of classical books, general index, flora and manual, revision and monograph, icons, bibliography, catalogue, encyclopaedia, dictionary, glossary, important journals of India and abroad
3. **International Code of Nomenclature:** Algae, Fungi and Plants (ICN): addition and changes in latest code. principles; typification, priority, effective and valid publication, Name changes, rejection, citation, nomenclature of hybrids. Appendices: general account.

4. **Phenotypic plasticity:** definition, causes, methods of study, role of vegetative morphology, phytochemistry, serology, SEM, TEM, and plant molecular biology in Taxonomy, DNA barcoding, e-Taxonomy, nuclear DNA, chloroplast DNA, mitochondrial DNA.
5. **Centers of origin and diversity of cultivated plants:** Indian centers of wild plant genetic resources, role of IBPGR and NBPGR.
6. **Vegetation of India:** Classifications; description of himalayan, peninsular and desert vegetation, major phytochoria of the world after Takhtajan (1987): idea about Kingdom and Subkingdom
7. **Flora of India:** Composition, bio-geographic evolution, endemism.
8. **General account:** Cosmopolitan families, tropical families, temperate families and discontinuous families, migration and dispersal of plants.
9. **Taxonomy and General account:** parasites and insectivorous plants.
10. **Biodiversity:** Concept, kinds/levels, importance, methods of study, concern, protection from depletion.
11. **Conservation:** Principles, causes of threats and categories of threatened plants (IUCN), methods of assessment, strategies of conservation-*in situ* and *ex situ*; concept and types of protected areas; role of botanic gardens and gene banks.
12. **Special issues:** IPR issues and aims of gene flow, biopiracy
13. **Palynology:** scope; branches, structure, types and evolution of pollen grains; applications/importance.
14. **Application of modern technologies in taxonomy:** GIS and applications in Botany, Remote sensing - definition, basic principles, data used in image interpretation.
15. Ethnobotany: Different disciplines and branches, importance, IK and TK (Indigenous and traditional knowledge) and bioprospecting.

Practical

Full marks: 50

Total periods: 40

Practical based on theory paper

Suggested Reading:

1. A.A.Farooqi & B.S.Sreeramu, Cultivation of Medicinal & Aromatic Crops, Universities
2. A.P.Das, Germplasm Collection in Garden of Medicinal Plants, University of North Bengal

3. A.P.Das, Perspectives of Plant Biodiversity, Bishen Singh Mahendra Pal Singh
4. A.V.S.S.Sambamurty, Taxonomy of Angiosperms, I.K. International Publishing House
5. Ashish Ghosh, Biodiversity Conservation, APH Publishing House
6. B.K.Verma, Introduction to Taxonomy of Angiosperms, PHI learning Pvt.Ltd
7. B.P.Pandey, Taxonomy of Angiosperms, S.Chand & Co
8. D.M. Bhat & V.S. Swamy, Nursery Manual for Forest Tree Species, Universities Press
9. S.S. Bhojwani & S.P. Bhatnagar, The Embryology of Angiosperms, Vikas Publishing House
10. C.A.Strace, Plant taxonomy & Biosystematics, Edward Arnold
11. Charles B.Beck, An Introduction to Plant Structure & Development, Cambridge University Press
12. P.H. Davis & V. H. Heywood, Taxonomy, Today's & Tomorrow's Printers
13. Dennis J.Mackennaetal, Botanical Medicines, Viva books Pvt.Ltd
14. Iqbal Hussain, Fundamentals of Plant Breeding, Oxford Book Company
15. J.H.Chowdhery & D.S.Pandey, Plants of Indian Botanic Garden, BSI
16. K.G.Mukherji, Frontiers in Plant Sciences, I.K. International Publishing House
17. Nursadh Ali, Medicinal Plant Cultivation, Mittal Publication
18. P.C.Joshi & Namita Joshi, Biodiversity & Conservation, APH Publishing House
19. S.N. Pandey & S.P. Misra, Taxonomy of Angiosperms, Ane Books pvt.ltd
20. Press
21. R.K.Sinha, Practical taxonomy of Angiosperms, I.K. International Publishing House
22. Raj Kumar Gupta, Textbook of Systematic Botany, CBS Publication
23. Samuel B.Jones & Arlene E.Luchsinger, Plant Systematics, McGraw-Hill
24. Sengupta, Biodiversity & Quality of Life, INSEE
25. Swaminathan & Kochhar, An Atlas of Major flowering trees in India, Macmillan
26. Tood F.Stuessy, Plant taxonomy-the Systemic Evolution of Comparative Data, Columbia University Press
27. V.S.Rao, Principles of Weed Science, Oxford & IBH Publication Company Pvt.ltd
28. Y.S.Sreenivas,Seed Technology & Seed Pathology, Oxford University Press

C14. Computer applications and Bioinformatics

Theory

Full marks: 25

Total periods: 25

1. **General ideas:** Components of a digital computer, block diagram of digital computer-detail of input units, output units, central processing unit pointing devices, fast input devices. Secondary storage devices, types of digital computer, generation of digital computer, organization; low level and high-level language: binary number system (Operations on Binary number system-Addition, Substraction (1's complement and 2's complement), Multiplication, structured computer organization: operating system as resource manager.

2. **Windows-basic concepts and commands:** Operating System: LINUX, UNIX, Windows, Word processing, Spreadsheets, computer graphics and presentation software.
3. **Language:** Artificial vis-a-vis Natural language low and high level languages -the basic concepts, Functions and structured programming- Top down approach, Character Processing Network and Internet introduction and applications, bottom up approach, object oriented programming, algorithm and introduction to programming, features of an algorithm flowcharts.
4. **Networking:** Network, routers, switches, server client architecture, multimedia characteristics, elements, applications, LAN, VAN, Internet
5. **System security:** Virus and firewall, IT act.
6. **Bioinformatics:**
 - a. Applications and prospects, genome and protein information resources, sequence analysis, multiple sequence alignment, homology and analogy, pattern recognition, analysis package, biological sequences databases: NCBI,EMBL, DDBJ, PIR, Swiss Prot.
 - b. PAM-% accepted mutation, BLOSSUM, blocks of amino acid substitution form, scoring matrices, protein 3D structure visualization.
 - c. Biological databases retrieval system: Methods of phylogeny, softwares, molecular phylogeny, application in drug discovery, structure and activity relationship (SAR) and quantitative structure and activity relationship (QSAR).

Suggested Reading:

1. A. Goel, Computer Fundamentals, Pearson
2. Harisha S, Fundamentals of BioInformatics, I.K. International Publishing House
3. M.Lesk, Introduction to BioInformatics, Oxford University Press
4. P.K.Sinha, Introduction to Computer Science, P.H.Z
5. Parish & Twyman, Instant Notes- BioInformatics, Tailor & Francis

